ACTION OF THE CONVENING AUTHORITY

The report of the accident investigation board, conducted under the provisions of AFI 51-307, that investigated the 22 August 2023 mishap on Melrose Air Force Range, New Mexico, involving CV-22B, T/N 17-0077, assigned to the 27th Special Operations Wing, Cannon Air Force Base, New Mexico, complies with applicable regulatory and statutory guidance and on that basis is approved.

TONY D. BAUERNFEIND
Lieutenant General, USAF
Commander

MAY 2 0 2024

Date

United States Air Force Accident Investigation Board Report

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION

CV-22B, T/N 17-0077
MELROSE AIR FORCE RANGE, NEW MEXICO
22 AUGUST 2023

On 22 August 2023, at 2129:37 Mountain Standard Time (MST), while transitioning from a hover to forward flight following aerial gunnery training, the mishap aircraft (MA), a CV-22B, tail number 17-0077, impacted the ground with the landing gear retracted after losing power from the right engine. The incident occurred west of the Jockey impact area on Melrose Air Force Range (MAFR), New Mexico. The aircraft was assigned to the 27th Special Operations Wing at Cannon AFB, New Mexico and was piloted by the mishap crew (MC) assigned to the 20th Special Operations Squadron. One member of the MC, Mishap Flight Engineer 1 (MFE1), was injured when he struck his head and was transported to a local civilian hospital for treatment and was subsequently released early the next morning. There were no fatalities or damage to civilian property and estimated cost of damage to the MA was $2,068,884.

The MC was completing a local training sortie in and around MAFR that consisted of support for a joint terminal attack controller (JTAC) team during a full mission profile, a periodic flight evaluation for Mishap Flight Engineer 2, and aerial gunnery recurrency training for MFE1. The MC departed Cannon AFB at 2008 MST, completed infiltration of the JTAC team then performed unilateral training before proceeding to Jockey. Following completion of aerial gunnery training at Jockey, the MC raised the landing gear and began a slow transition from a hover to forward flight. As MFE1, with significant slack in their night vision goggle (NVG) battery pack cable, moved to sit down in the Flight Engineer (FE) seat the right engine control lever (ECL) was moved from FLY to OFF, commanding the right engine to shut down. Without the power required to maintain flight, the MA descended towards the ground at a rate in excess of 1,200 feet per minute before impacting the ground. The MA slid on its belly across the ground over 360 ft before coming to a stop.

The Accident Investigation Board (AIB) President found by a preponderance of the evidence that the cause for the mishap is attributed to MFE1 unintentionally and unknowingly shutting down the right engine by his NVG battery cable looping over the knob of the right ECL and moving it from the FLY to OFF position while attempting to sit down in the FE seat. Additionally, the AIB President found by a preponderance of the evidence the following factors, substantially contributed to the mishap: (1) Mishap Aircraft Commander failed to guard the ECLs, (2) Inattention of the aircrew during a critical phase of flight, (3) Failure of real-time risk assessment, and (4) Lack of procedural guidance.

United States Air Force Accident Investigation Board Report

SUMMARY OF FACTS AND STATEMENT OF OPINION
CV-22B, T/N 17-0077
MELROSE AIR FORCE RANGE, NEW MEXICO
22 AUGUST 2023

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

5Ws – Who, What When, Where, and Why

AIB – Accident Investigation Board

AC – Aircraft Commander

ADC – Area Defense Counsel

ADO - Assistant Director of Operations

AFB – Air Force Base

AFI – Air Force Instruction

AFMAN – Air Force Manual

AFSOC – Air Force Special Operations Command

AFTO – Air Force Technical Order

AFTTP – Air Force Tactics, Techniques, and Procedures

AGL – Above Ground Level

AIE – Alternate Insertion/Extraction

ALS – Advance Life Saving

AO – Authenticating Official

ASOS – Air Support Operations Squadron

BDOC – Base Defense Operations Center

BLS – Basic Lab Support

C – Degrees Celsius

CAL - Caliber

CAP – Commanders Awareness Program

CASEVAC – Casualty Evacuation

CAT – Crisis Action Team

CC – Commander

CCIR – Command Communication Information Requirement

CD – Deputy Commander

CDU – Center Display Unit

CE – Civil Engineering

CEP – Communication Ear Plugs

Civ ACF – Civilian Assistant Chief of Fire

COA – Course of Action

COMAFSOC – Commander, Air Force Special Operations Command

CONUS – Continental United States

CoS – Chief of Staff

CRM – Crew Resource Management

CSEL – Combat Survivor Evader Locator

CT – Computed Tomography

CT – Continuation Training

CUI – Controlled Unclassified Information

DA – Density Altitude

DAFI – Department of the Air Force Instruction

DO – Director of Operations

DoD – Department of Defense

DNIF – Duties Not Including Flying

DS – Director of Staff

DSN – Defense Switch Network

EOC –Emergency Operations Center

EAPS – Engine Air Particle Separator

ECL – Engine Control Lever

ECP – Engine Control Panel

ELT – Emergency Locator Transmitter

EMS – Emergency Medical Services

EOD – Explosive Ordinance Disposal

EMT – Emergency Medical Technician

EP – Emergency Procedures

ER – Emergency Room

ETL – Effective Translational Lift

EVAL – Evaluation

FADEC – Full Authority Digital Engine Control

FAC – Formation Aircraft Commander

FCP – Formation Copilot

FE – Flight Engineer

FEMA – Federal Emergency Management Agency

FLIR – Forward-Looking Infrared

FMP – Full Mission Profile

FOD – Foreign Object Debris

FPM – Feet Per Minute

FS – Flight Surgeon

ft – Feet

FTU – Flight Training Unit

g – Gravitational Force Equivalent

GAF – Ground Assault Force

GPS – Global Positioning System

GS – General Schedule

GSC – Glasgow Coma Scale

HCE – Hard Clutch Engagement

HCM – Human Capital Management

HFACS – Human Factor Analysis and Classification System

HLZ – Helicopter Landing Zone

HRS – Hours

IAP – Integrated Avionics Processor

IC – Incident Commander

ICS – Intercommunications System

IDMT – Independent Duty Medical Technician

IFE – In-Flight Emergency

IMDS – Integrated Maintenance Data System

INFIL - Infiltration

IP – Initial Point

ISB – Interim Safety Board

ITR – Individual Training Records

JTAC – Joint Terminal Attack Controller

LMR – Land Mobile Radio

KVADR – K-Series Voice and Data Recorder

MA – Mishap Aircraft

MAC – Mishap Aircraft Commander

MAFR – Melrose Air Force Range

MAJCOM – Major Command

MC – Mishap Crew

MCP – Mishap Copilot

MDG – Medical Group

MEF – Mission Execution Forecast

METTC – Mission, Enemy, Terrain, Troops, Time and Civil

MFD – Multifunction Display

MFE1 – Mishap Flight Engineer 1

MFE2 – Mishap Flight Engineer 2

MFE3 – Mishap Flight Engineer 3

MFR – Memorandum for Record

MGRS – Military Grid Reference System

MGT – Measured Gas Temperature

MSG – Mission Support Group

MST – Mountain Standard Time

MTF – Medical Treatment Facility

MX – Maintenance

NCOIC – Noncommissioned Officer in Charge

NCORP – Noncommissioned Officer Retraining Program

NGc – Air mass flow limiting

NIPR – Non-Secure Internet Protocol Router

NM – New Mexico

NOTAMS – Notices to Airmen

NVG – Night Vision Goggles

OGV – Standardization and Evaluation

OPREP – Operations Report

OPS - Operations

ORM – Operational Risk Management

PA – Public Affairs

PCS – Permanent Change of Station

PL – Precautionary Landing

PRMC – Plains Regional Medical Center

Qm – Mast Torque

RADAR – Radio Detection and Ranging

RAPCON – Radar Approach Control

RCO – Range Control Officer

RI – Range Inspector

RO – Range Officer

RPM – Revolutions Per Minute

RTB – Return to Base

SDC – Shaft Driven Compressor

SE – Safey

SEL – Senior Enlisted Leader

SFD – Standby Flight Display

SFOR – Senior Fire Officer on Range

SGP – Chief of Aerospace Medicine

SIB – Safety Investigation Board

SIM - Simulator

SIRFC – Suite of Integrated Radio Frequency Countermeasures

SLAP – Solar Lunar Almanac Prediction

SME – Subject Matter Expert

SOAMXS – Special Operations Aircraft Maintenance Squadron

SOB – Souls on Board

SOF – Special Operations Forces

SOG – Special Operations Group

SOMXG – Special Operations Maintenance Group

SOP – Standard Operating Procedure

SOS – Special Operations Squadron

SOTES – Special Operations Test and Evaluation Squadron

SOTU – Special Operations Task Unit

SOW – Special Operations Wing

TAR – Technical Assistance Request

TCL – Trust Control Lever

TCTO – Time Compliance Technical Order

TDY – Temporary Duty

T/N – Tail Number

TO – Technical Order

UCMJ – Uniform Code of Military Justice

UNILAT – Unilateral

UPT – Undergraduate Pilot Training

VSLED – Vibration Structural Life and Engine Diagnostics

TTO – Tactical Takeoff

VTO – Vertical Takeoff

VTOL – Vertical Takeoff and Landing

VVI – Vertical Velocity Indicator

WPS – Weapons Squadron

WST – Weapon Systems Trainer

SUMMARY OF FACTS
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION

CV-22B, Tail Number (T/N) 17-0077
MELROSE AIR FORCE RANGE, NEW MEXICO
22 AUGUST 2023

1. AUTHORITY AND PURPOSE

a. Authority

On 7 September 2023, Lieutenant General Tony D. Bauernfeind, Commander, Air Force Special Operations Command (COMAFSOC), appointed Colonel Patrick DuBe as the Accident Investigation Board (AIB) President to investigate a 22 August 2023 CV-22B Osprey aircraft accident involving one CV-22B aircraft T/N 17-0077 (Tab II-3). On 18 September 2023, the Pilot Member was replaced (Tab II-5). On 20 October 2023, the Recorder was replaced (Tab II-7). The AIB conducted their investigation at Cannon Air Force Base (AFB), New Mexico, and Hurlburt Field, Florida, from 23 October 2023 to 20 December 2023, in accordance with Air Force Instruction (AFI) 51-307, *Aerospace and Ground Accident Investigations*, Chapter 12 (Tab AA-82 to AA-83). The following board members were appointed: Legal Advisor (Major), Medical Member (Major), Pilot Member (Major), Maintenance Member (Master Sergeant), Flight Engineer Subject Matter Expert (Master Sergeant), Aviation Psychologist Subject Matter Expert (Major) and Recorder (Captain) (Tab II-3 to II-7).

b. Purpose

In accordance with AFI 51-307, *Aerospace and Ground Accident Investigations,* 18 March 2019, this AIB conducted a legal investigation to inquire into all the facts and circumstances surrounding this Air Force aerospace accident, prepare a publicly releasable report, and obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative action (Tab AA-14). This investigation was an accident investigation, conducted pursuant to Chapter 4 of AFI 51-307 (Tab AA-33 to AA-36).

2. ACCIDENT SUMMARY

On 22 August 2023, at 2008:58 Mountain Standard Time (MST), the mishap aircraft (MA), a CV-22B, T/N 17-0077, assigned to the 27th Special Operations Wing (SOW), Cannon AFB, New Mexico, piloted by the mishap crew (MC) assigned to 20th Special Operations Squadron (SOS) departed Cannon AFB for a local training sortie in and around Melrose Air Force Range (MAFR) (Tabs K-3, K-20 to K-21, and FF-3 to FF-4). The general depiction of the route is shown in figures 2-1 and 2-2 (Tabs K-3, K-20 to K-21, Z-95, Z-97, and FF-3 to FF-4). The MC consisted of Mishap Aircraft Commander (MAC), Mishap Copilot (MCP), Mishap Flight Engineer 1 (MFE1), Mishap Flight Engineer 2 (MFE2), and Mishap Flight Engineer 3 (MFE3) (Tab K-3). Following completion of aerial gunnery training at Jockey, the MC raised the landing

gear and began a slow transition from a hover to forward flight (Tabs N-76, R-10.3, R-11.3, R-16.3, and FF-3 to FF-4). At 2129:26 MST, as MFE1, with significant slack in his night vision goggle (NVG) battery pack cable, moved to sit down in the FE seat the right engine control lever (ECL) was moved from FLY to OFF, commanding the right engine to shut down (Tabs N-76, EE-6, FF-3 to FF-4, and FF-7). The MA, without the power required to maintain flight, began a descent toward the ground from 190 feet (ft) above ground level (AGL) at a rate approaching 1500 ft per minute (FPM) (Tab FF-3 to FF-4). At 2129:37 MST, the MA impacted the ground with the landing gear retracted (Tab FF-3 to FF-4 and FF-6). After impact, the MA slid on its belly across the ground over 360 ft before coming to a stop (Tabs R-19.3 and FF-3). The MC performed an emergency shutdown and egressed the MA (Tabs N-77, R-11.3, R-16.4, R-19.3, and V-7.6). One mishap crew member, MFE1, was injured when he struck his head on the Control Display Unit and was transported to Plains Regional Medical Center (PRMC) emergency department in Clovis New Mexico for treatment, and subsequently released early the next morning (Tabs R-16.5, and DD-3 to DD-4). MFE1's NVG battery pack cable was also found to be ripped from the NVG mount connector port (Tab EE-9 and EE-18). There were no fatalities or damage to civilian property and the estimated cost of damage to the MA was $2,068,884 (Tab P-3).

Figure 2-1. Mishap Sortie Route of Flight, Enroute (Tab Z-95)

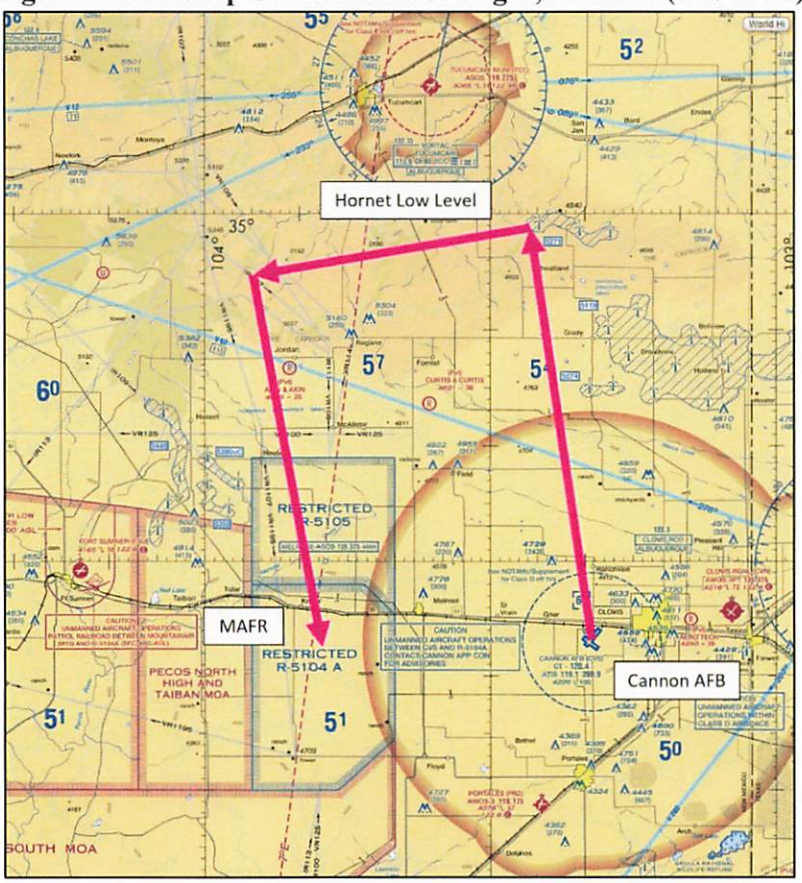
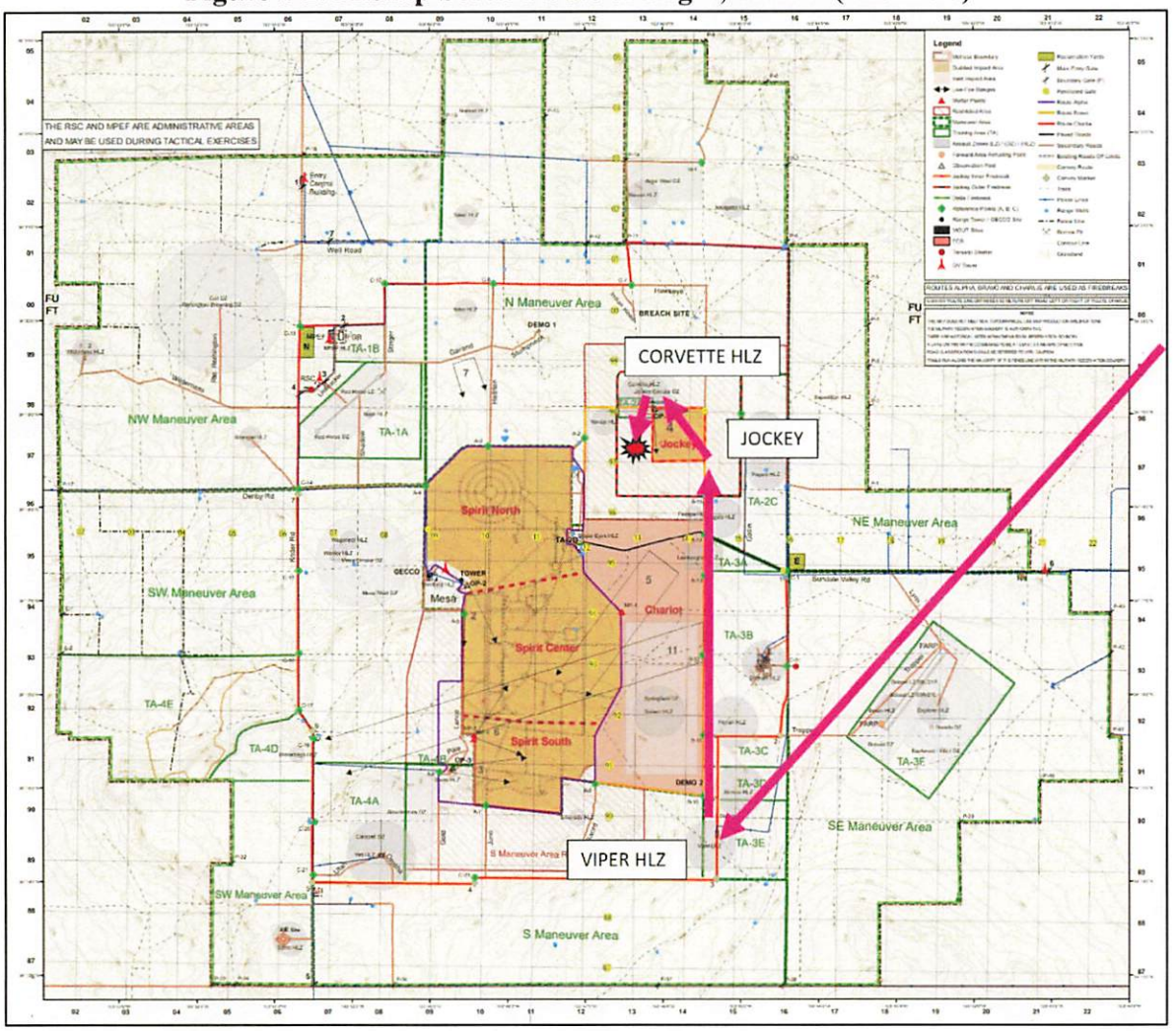


Figure 2-2. Mishap Sortie Route of Flight, MAFR (Tab Z-97)



3. BACKGROUND

a. Air Force Special Operations Command

Air Force Special Operations Command (AFSOC) provides Air Force special operations forces (SOF) for worldwide deployment and assignment to regional unified commands (Tab CC-3). The command's SOF are composed of highly trained, rapidly deployable Airmen, conducting global special operations missions ranging from precision application of firepower to infiltration, exfiltration, resupply and refueling of SOF operational elements (Tab CC-3). The command's core missions include battlefield air operations; agile combat support; aviation foreign internal defense; information operations/military support operations; precision strike; specialized air mobility; command and control; and intelligence, surveillance, and reconnaissance (Tab CC-3).

b. 27th Special Operations Wing

The 27 SOW's core missions include close air support, agile combat support, information operations, precision strike, forward presence and engagement, intelligence surveillance and reconnaissance operations, and specialized mobility (Tab CC-5). The wing is made up of four groups, 26 squadrons, four Aircraft Maintenance Units, one group-level detachment and several wing staff and support agencies (Tab CC-5). As the owning unit at Cannon AFB, New Mexico, the 27 SOW also supports several tenet units on the base (Tab CC-5).

c. 27th Special Operations Group

The 27th Special Operations Group (SOG), located at Cannon AFB, New Mexico, accomplishes global special operations taskings as an Air Force component member of the United States Special Operations Command (Tab CC-7). The 27 SOG conducts infiltration/exfiltration, combat support, tilt-rotor operations, helicopter aerial refueling, close air support, unmanned aerial vehicle operations, non-standard aviation, and other special missions (Tab CC-7). The group directs the deployment, employment, training, and planning for Cannon's operational and operational support squadrons (Tab CC-7).

d. 27th Special Operations Maintenance Group

The 27th Special Operations Maintenance Group (SOMXG), is responsible for all flight line, back shop and ammunition maintenance in support of the 27 SOG's mission (Tab CC-9). The 27 SOMXG conducts quality maintenance for five different types of aircraft across four squadrons, seven defense contractor groups, and 1,400 Air Commando maintainers (Tab CC-9). The group manages over 90 facilities while also providing contract oversight of civilian maintenance on three Non-Standard Aviation program aircraft types (Tab CC-9).

e. 20th Special Operations Squadron

The 20 SOS assigned to the 27 SOG, Cannon AFB, New Mexico, provides flexible vertical lift for United States Special Operations Command (Tab CC-11).

f. 727th Special Operations Aircraft Maintenance Squadron

The 727th Special Operations Aircraft Maintenance Squadron (SOAMXS), assigned to the 27 SOMXG, executes global Special Operations taskings as an Air Force component member of United States Special Operations Command (Tab CC-13). The 727 SOAMXS organizes, trains, and equips personnel in the maintenance and sustainment of CV-22B Osprey tilt-rotor aircraft as well as the MQ-9 Reaper remotely piloted aircraft (Tab CC-13).

g. CV-22B Osprey

The CV-22B Osprey is a tilt-rotor aircraft that combines the vertical takeoff, hover, and vertical landing qualities of a helicopter with the long-range, fuel efficiency and speed characteristics of a turboprop aircraft through the use of its rotating nacelles (Tabs BB-71 and CC-15). The mission of the CV-22B is to conduct long-range infiltration, exfiltration, and resupply missions for SOF (Tab CC-15). The CV-22B is able to takeoff with its nacelles vertical (90-degree position) to perform a vertical takeoff (VTO) or with nacelles slightly forward (80-degree position) to accelerate forward while climbing to affect a faster departure, this is known as an 80 Tactical Takeoff (TTO) (Tab AA-494 to AA-495). "Power" developed by the CV-22B proprotor system

to produce lift and thrust comes from the torque applied to the proprotor mast and is measured as percent mast torque (Qm) (Tab BB-71). The MA was accepted into the Air Force inventory on 28 December 2016 and arrived at Cannon AFB on 19 May 2021 (Tab U-117 to U-122, and U-131). The MA had recorded a total of 718.7 flight hours over its lifetime prior to the mishap sortie (Tabs D-12, U-3, and Y-15).

h. Melrose Air Force Range

The MAFR training area is located approximately 25 miles west of Cannon AFB and covers approximately 70,000 acres (Tab CC-18). Operations on MAFR also cover an area of 2,500 square miles of airspace (Tab CC-18). MAFR is used for training such as air to ground, small arms, and electronic combat (Tab CC-18). The range has 35 helicopter landing zones (HLZ), including Corvette and Viper HLZs, 15 drop zones, 3 dirt landing zones, and 5 target impact areas, to include Jockey (Tab S-5 and S-7). Air and ground operations on the range are managed by controllers stationed in a control tower located near the center of the range (Tab S-5 and V-21.2). Medical, emergency, and supportive services are provided on MAFR by United States Government and contracted entities co-located on the range (Tab CC-18 and CC-31). The remote location of MAFR limits its organic emergency response capabilities and additional first responder resources are dispatched from Cannon AFB or sourced through the local community (Tab V-26.2).

4. SEQUENCE OF EVENTS

a. Mission

The MA, callsign HAVOC 54, was the wingman aircraft as part of a planned formation sortie with another CV-22B, HAVOC 53 (Tabs K-19, K-27, R-6.2, and V-16.1). The formation planned to complete infiltration and exfiltration of a team of nine joint terminal attack controller (JTAC) personnel in support of a full mission profile (FMP), MFE2's periodic flight evaluation, MFE1's aerial gunnery recurrency training, and formation continuation training (Tabs K-19, K-27, and R-6.2). The sortie was to consist of low-level flight training, formation and single-ship approaches to a landing/hover at Viper, Ferrari, Sprint, and Firestorm Helicopter Landing Zones (HLZ) on MAFR, and single-ship aerial gunnery training at Jockey (Tabs K-19, K-28, and R-6.2). MFE3 was to perform as the evaluator for MFE2's evaluation and instructor for MFE1's aerial gunnery recurrency training which would require multiple flight engineer (FE) position changes, commonly known as "seat swaps", throughout the sortie (Tabs K-3, K-19, and R-18.3).

The flight authorizations for HAVOC 53 and HAVOC 54 were created, reviewed, and signed by the 20 SOS Assistant Director of Operations (ADO) two days prior to the mishap (Tab V-13.3, V-14.5, and V-18.1). The 20 SOS/ADO is one of five members in the 20 SOS authorized to serve as the Authenticating Official (AO) for flight authorizations (Tabs V-13.3, V-14.5, V-18.1, AA-698 to AA-701, and HH-69). The AO reviewed crew composition, qualifications, recent flying time, and currencies before signing the flight authorization; no deficiencies were noted following the mishap (Tabs K-13, V-18.1, and Y-17 to Y-24).

b. Planning

Mission planning occurred from 21 to 22 August 2023 and was performed by crew members from HAVOC 53 and HAVOC 54 with the MAC coordinating directly with the JTAC team to discuss training requirements, mission profile, and contracts between the different entities operating in the FMP (Tab V-7.6 to V-7.7, V-11.3 to V-11.4, and V-16.1). The MC arrived at the squadron between 1400 to 1600 MST on the day of the mishap to finalize mission planning products (Tabs V-8.3, V-9.3, DD-10, DD-22, DD-34, DD-46, and DD-58).

The MC utilized the 20 SOS Operational Risk Management (ORM) worksheet which includes multiple planning factors and risk assessment considerations, to include mission, environment, troops, mission complexity, among others that affect the perceived risk of the mission (Tab K-27). Risks are assessed separately as either low, medium, high, or extreme, which are then aggregated to indicate an overall risk assessment for the mission (Tab K-27). The MAC completed the ORM worksheet for the formation and marked all areas as "low" except for *Supporting Forces* and *Aircraft Performance* which were marked as medium (Tab K-27). *Performance*, *Unfamiliar User*, and *Dynamic Profile* were self-identified as the top risks for the mission (Tab K-27). Risk mitigating factors for the identified top risks were annotated as well on the ORM worksheet (Tab K-27). *Aircraft Performance* was to be mitigated by managing the fuel load to obtain safe one engine inoperative performance margins by set mission events in the sortie (Tab K-27). *Unfamiliar User* was to be mitigated by conducting a static demonstration and safety briefing for the CV-22B prior to the mission and ensuring the JTACs were secured in cabin seating during all portions of the flight (Tab K-27). *Dynamic Profile* mitigation efforts included FMP mission injects and on-call taskings performed by a single CV-22B with other formation participants on standby support and attending the instructor only (white cell) briefing (Tab K-27). The back of the ORM worksheet contains sections to document approvals, waivers, and squadron specific items and if they are approved, identifies crew members who are scheduled to perform an evaluation, recurrency, upgrade, or certification training, and documents the AO's overall assessment of risk and potential benefit of the mission (Tab K-28). Under squadron specific items, *80TTO/VTO* approval was requested and approved (Tab K-28). MFE2 was identified as receiving an evaluation from MFE3 (Tab K-28). The MAC assessed the overall risk for the mission to be at the high end of "low" and the ORM worksheet was signed by both himself and the Formation Aircraft Commander (FAC) in HAVOC 53 (Tab K-27). There were several items that were not identified on the ORM worksheet (Tab K-27). *Weapons/Live Fire*, which required an instructor in this instance, was not identified as a risk nor was MFE1 identified as non-current for aerial gunnery under *Currency* (Tabs K-27, V-10.2 to V-10.3, and Y-24). MFE1 was not identified as receiving *Recurrency* training in aerial gunnery from MFE3 on the back of the ORM worksheet (Tabs K-28, V-10.2 to V-10.3, and Y-24). *Illumination* was not identified as a risk based on 29% lunar illumination, however a predicted overcast cloud layer and moonset occurring part way through the planned sortie would result in increased difficulties using NVGs (Tabs F-3, K-27, and W-11). Lastly, *Crew Compliment* with multiple seat swaps was not identified as a risk despite planned crew position changes between MFE1 and MFE2 (Tabs K-27, R-16.2 to R-16.3, and R-19.2).

The formation mission briefing was conducted at the 20 SOS by the FAC to only the crews of HAVOC 53 and HAVOC 54 using a slide show and included forecast weather, Notices to Airmen, route of flight, mission priorities and timelines, and ORM (Tabs R-6.1 to R-6.2 and V-10.3 to V-10.4). The crew briefing was performed in accordance with the CV-22 briefing guide (Tabs V-7.6 to V-7.7, V-10.3 to V-10.4, and V-13.1). Following the formation briefing, the crews of

HAVOC 53 and HAVOC 54 separated and conducted individual crew briefings, led by the FAC and MAC respectively, that covered crew coordination and emergency procedure considerations (Tabs V-7.6 to V-7.7, V-10.3 to V-10.4, and V-13.1). At the conclusion of the aircrew briefings, the FAC and MAC briefed the 20 SOS Operations Officer (DO), as the AO, on the mission (Tabs R-2.2, V-7.7, and V-13.6). They identified risks using the 20 SOS ORM worksheet and the 20 SOS/DO reviewed crew currencies, qualifications, and composition (Tabs K-27, V-13.4 to V-13.5, and V-13.7). The 20 SOS/DO assessed the overall risk of the mission at the low side of "medium" and gave verbal guidance to both FAC and MAC to not press or rush in support of the FMP (Tabs K-28, R-2.1 to R-2.2, and V-13.5). Maintenance issues with the second CV-22B aircraft scheduled for the sortie made it unavailable for the mission and the MA was the only available aircraft for the sortie (Tabs R-6.2, V-11.2, and V-16.1). The crews of HAVOC 53 and HAVOC 54 executed a single-ship "bump" plan where the MA would be shared (Tabs R-6.2, V-11.2, and V-16.1). HAVOC 54's pilots, MAC and MCP, would fly the MA for the first half of the sortie with HAVOC 53's flight engineers, MFE1, MFE2, and MFE3 (Tabs R-6.2, V-8.3, V-11.2, and V-16.1). The MC would then transfer the MA to the remaining aircrew members (Tabs R-6.2, V-11.2, and V-16.1).

c. Preflight

The MA landed at Cannon AFB at 1928 MST to begin the transfer of the MA to the MC, following a 4.8-hour sortie that consisted of a MAFR orientation, terminal area training, and aerial gunnery at Jockey flown by another 20 SOS aircrew (Tabs N-3, R-25.1, Y-15 to Y-16, and FF-3 to FF-4). The MC arrived at the MA at approximately 1930 MST as it was being prepared for refueling (Tabs N-5 to N-6, R-20.3, and R-24.3). The MA was refueled and transferred to the MC following a face-to-face handover brief (Tabs N-8, N-15, and R-25.1). The MC was informed the MA had an overheating mission computer and a lateral airspeed exceedance; neither of which required maintenance action or were a factor in this mishap (Tabs N-8, N-15, and R-25.1). Following turnover, MAC was stationed in the left pilot seat, MCP was stationed in the right pilot seat, MFE1 was positioned in the tail scanner position, MFE2 was stationed in the cockpit FE seat, and MFE3 was positioned in the cabin area to conduct the evaluation of MFE2 (Tabs K-3, R-11.1, R-16.1, R-19.2, and R-22.1). The MC completed all remaining ground operations in accordance with the applicable checklists with no significant anomalies (Tabs N-11 to N-29, R-6.2, R-19.2, and R-22.2). The MC started the MA's engines at 1958MST, elected to depart 30 minutes early with concurrence of the JTAC team, taxied to Romeo taxiway at 2006 MST, and completed all applicable checklists and associated procedures (Tabs N-30 and FF-3 to FF-4).

d. Summary of Accident

The MC departed from Cannon AFB on 22 August 2023 at 2008 MST by an 80TTO from Romeo taxiway (Tabs R-6.2 to R-6.3 and FF-3 to FF-4). Following the departure from Cannon AFB, the MC completed infiltration of the JTAC team at Viper HLZ then performed unilateral training at Corvette HLZ before proceeding to Jockey (Tabs N-30 to N-70, R-6.2 to R-6.4, and FF-3). The MC did not review the HLZ surveys prior to mission execution (Tabs V-6.9, V-8.5, and Y-3). Of note, Corvette HLZ was administratively closed due to an expired survey (Tabs Y-3, and AA-705 to AA-706). All other events were in accordance with applicable guidelines and regulations, were uneventful and not relevant to this mishap (Tabs N-30 to N-70 and FF-3 to FF-4).

As the MC approached Jockey and MFE2 prepared the GAU-21 for aerial gunnery, the JTAC team contacted the MC to request exfiltration from Viper HLZ (Tabs N-70 to N-72, V-7.8 to V-7.9, V-8.2, and V-10.2). The MAC responded that the MC was unable to perform the exfiltration at the time as they were still completing their unilateral training requirements (Tabs N-72 and V-7.8). MFE1 informed the MC that there was 12 minutes of fuel remaining before they would have to depart and proceed directly to Cannon AFB (Tab N-72). MAC queried MFE3 on how much time was required to complete all gunnery training and was told by MFE3 that they would need 5 minutes (Tabs N-72, R-6.3, V-7.9, and V-10.6). MFE3 then requested as a change to the original briefed plan to perform hovering shooting, where the pilot in control would set up in a hover on the west side of Jockey while the aerial gunnery was performed to assist in expediting the training (Tabs N-72, R-6.4, and V-10.2 to V-10.3). MAC cleared MFE1 to leave his position in the front of the MA and move towards the aft for aerial gunnery retraining (Tab N-74). MFE2 armed the GAU-21 and prepared to fire as the MCP established a hover over the western edge of Jockey after which the FEs completed aerial gunnery (Tabs N-73 to N-76, R-6.4, V-8.2, V-9.2, and V-10.2). The current weight of the MA and atmospheric conditions (temperature and pressure) resulted in the MA requiring approximately 76% Qm to hold the hover (Tab FF-3). Following completion of aerial gunnery, MFE1 moved towards the front of the cabin (Tabs N-76, R-6.5, R-16.3, and V-10.3). MFE2 and MFE3 called the range clear of any fires and MAC contacted the JTAC instructor on the radio to begin coordination for exfiltration (Tabs N-76 and R-6.5). MFE1 called that he was going to step up into the cockpit at 2129:19 MST and then entered a moment later (Tabs N-76 and FF-3 to FF-4).

MAC directed MCP, who was at the controls, to "make a nice easy right turn" (Tab N-76). MFE1 closed and secured the FE seat behind him (Tabs N-76 and R-16.3). MCP moved nacelles forward to 78-degrees, began a slight climb with forward acceleration, and he called "gear up" for the landing gear to be retracted (Tabs N-76, R-6.5, R-11.3, V-8.2, and FF-3 to FF-4). MAC moved the landing gear handle to the UP position at 2129:24 MST as MFE1 was still getting situated in the cockpit (Tabs N-76, R-6.5, R-11.3 V-8.2, and FF-3 to FF-4). As MFE1 entered the cockpit, MAC did not make an attempt to guard the ECLs or any other switches through physical blocking or any other method; they were unfamiliar with any techniques for guarding cockpit switches and controls from FEs entering or exiting the cockpit while acting as the non-flying pilot (Tab V-12 to V-13). MFE1 released the FE seat from its stowed position and bent forward to allow the seat to unfold into position (Tabs R-16.3 and V-6.4). MFE1's helmet had a large loop created from the slack in the low-profile battery pack cable and a single piece hook/pile retention patch (Tabs Z-91 and EE-9).

Figure 4-1. FE clearance from ECL while entering cockpit (Tab Z-91)

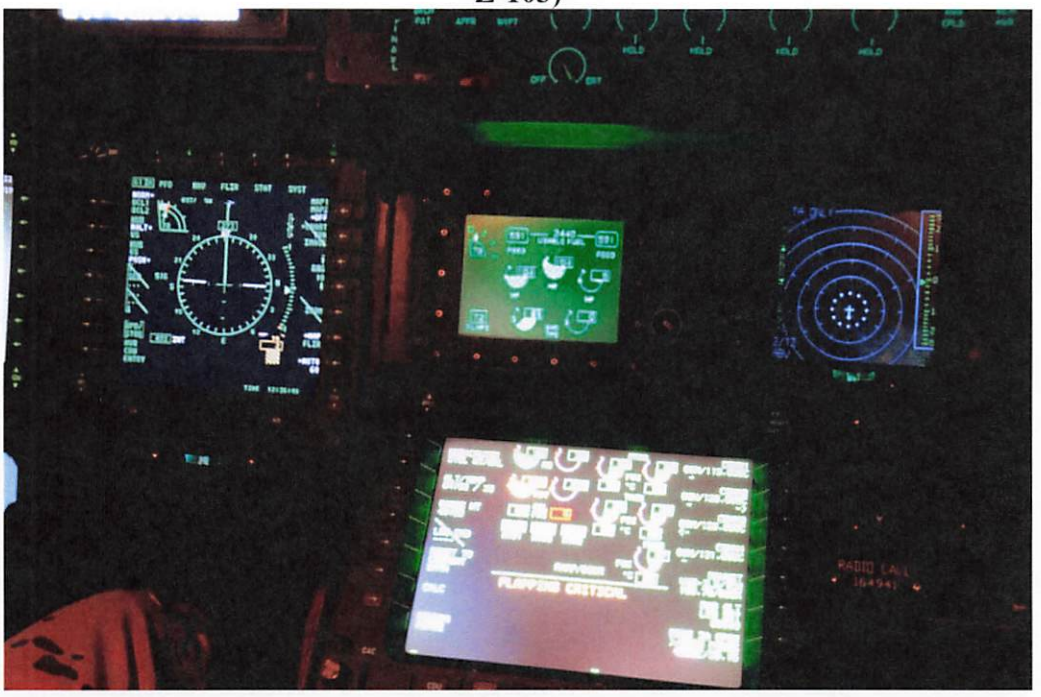
At 2129:26 MST, as the MA was at 190 ft AGL and 20 knots ground speed, the right ECL was moved backwards out of the FLY position to the OFF position within 0.5 seconds, bypassing 2 detents, and commanded a controlled shutdown of the right engine (Tab FF-3 to FF-4, and FF-7). MAC and MFE1 stated the ECL did not move out of the FLY position; MCP, MFE2, and MFE3 had no knowledge of the ECL movement (Tabs V-6.7, V-7.13, V-8.12, V-9.10, and V-10.10). The MA was unable to generate the power required to maintain the hover with one engine inoperative (53% Qm available vs the 76% Qm required) and began to descend towards the ground (Tab FF-3). MCP observed an increasing descent rate on his vertical velocity indicator and attempted to command more power from the MA by moving the Thrust Control Lever (TCL) to the full forward position (Tabs R-6.5, R-11.3, and FF-3). As the descent rate increased past 600 FPM, the MC received the audible "Sink Rate" warning at 2129:28 MST indicating the aircraft was descending vertically at a potentially unsafe rate; as designed no other warnings, cautions, or advisories were displayed by the system (Tabs R-6.5, R-11.3, BB-71, and FF-3 to FF-4). Upon hearing the "Sink Rate" warning, MFE1 looked at MAC's flight displays and observed an increasing descent rate on the Vertical Velocity Indicator (VVI) and continued watching the VVI until the eventual impact with the terrain; MFE1 made no verbal calls or announcements to the rest of the MC through the remainder of the mishap (Tab V-6.8 and V-6.21 to V-6.23). MCP announced "Power's all in. Power's all in, bird's coming down" to inform the MC that he was unable to arrest the descent despite commanding full power from the MA (Tabs N-76 and R-11.3). The MA's sink rate increased and approached a 1,500 FPM descent rate before stabilizing in a 1,200 FPM descent towards the ground (Tab FF-3). As the MA approached 30 ft AGL, MAC called "power…power…power" and moved his hand to the TCL to ensure that it was full forward (Tabs N-76, R-6.5, and FF-3). MCP responded with "power's full in" (Tabs N-76, R-6.5, and R-11.3).

MAC attempted to pull the nose of the aircraft up to reduce forward groundspeed at approximately 10 ft AGL (Tabs R-6.5 and FF-3). This combined with the MA entering ground effect reduced the descent rate to approximately 800 FPM just prior to the MA impacting the ground (Tab FF-3).

Figure 4-2. Simulator Recreation, ECL to OFF in hover (Tab Z-99)

Figure 4-3. Simulator Recreation, ECL to FLY prior to impact (Tab Z-101)

Figure 4-4. Simulator Recreation, FLAPPING CRITICAL posts following impact (Tab Z-103)



e. Impact

The MA made first impact with the ground west of Jockey at approximately 2129:37 MST (Tab FF-3 to FF-4). The impact location was comprised of loose soil covered by 1- to 2-ft-tall grass, sagebrush, mesquite, yucca, and cholla cacti plants (Tabs Y-9, Z-5, and Z-19). The MA impacted the terrain with 40 knots ground speed on a 272-degree heading with the nacelles at 78-degrees 10-degrees nose up and with the wings near level (Tab FF-3 and FF-6). The MA recorded the force of the initial impact to be 2.6 gravitational force equivalent (g) (Tab FF-3). The impact on the ramp caused both ramp hydraulic actuators to bend and the mount to the left actuator on the ramp side to break (Tab Z-29 to Z-33). The right vertical stabilizer and right nacelle scraped across the ground and received light damage (Tab Z-35 to Z-37). Within 0.5 seconds after the MA made its initial impact with the ground, the right ECL was rapidly moved forward from the OFF position to FLY (less than 0.2 seconds) and commanded the right engine to restart (Tab FF-3 to FF-4 and FF-7). No members of the MC stated they moved the ECL back to fly or were aware of the movement of the ECL (Tabs V-6.7, V-7.13, V-8.12, V-9.10, and V-10.10).

MAC and MCP reduced the TCL to the full aft position just before the MA "skipped" once across the ground at 4 ft AGL before making a second, stronger impact, measured by the MA to be approximately 4 g, where the MA stayed on the ground as it continued its slide (Tabs R-6.5 and FF-3). The antennae, lights, nose landing gear doors, and the Forward-Looking Infrared (FLIR) turret positioned on the bottom of the MA were crushed, destroyed, and spread along the skid path (Tab Z-11, Z-25 to Z-27, Z-39 to Z-43, and Z-61 to Z-71). The jolt caused by the impact with the ground caused MAC or MCP to inadvertently apply full right pedal for approximately three seconds, causing the MA yaw right approximately 50-feet after the first impact point (Tab FF-3). Partway through the rotation, the FLIR turret separated from the MA and came to rest 20 feet from the nose while the right main landing gear door was damaged and pulled away from the drag strut (Tab Z-27, Z-45, and Z-47). The MA came to a full stop approximately 360-ft away from the initial impact point and on a 051-degree heading, 139-degrees right of its heading at initial impact (Tab FF-3). The MA stayed intact apart from the destroyed/separated antennae, lights, nose landing gear doors, forward external cargo hook bay doors, and FLIR turret (Tab Z-5 to Tab Z-9 and Z-19). The Crash Position Indicator did not activate for this mishap as the maximum impact recorded of 4 g was below the 5 to 7 g activation threshold for the device (Tabs AA-879 to AA-880 and FF-3).

Figure 4-5. MA Final Position (Tab Z-19)

Figure 4-6. MA Skid Path, Impact Point looking at MA (Tab Z-41)

Figure 4-7. MA Skid Path, MA looking at Impact Point (Tab Z-39)

Figure 4-8. MA and FLIR Turret (Tab Z-27)

Figure 4-9. MA Damage, Right Vertical Stabilizer (Tab Z-37)

Figure 4-10. MA Damage, Right Lower Nacelle (Tab Z-35)

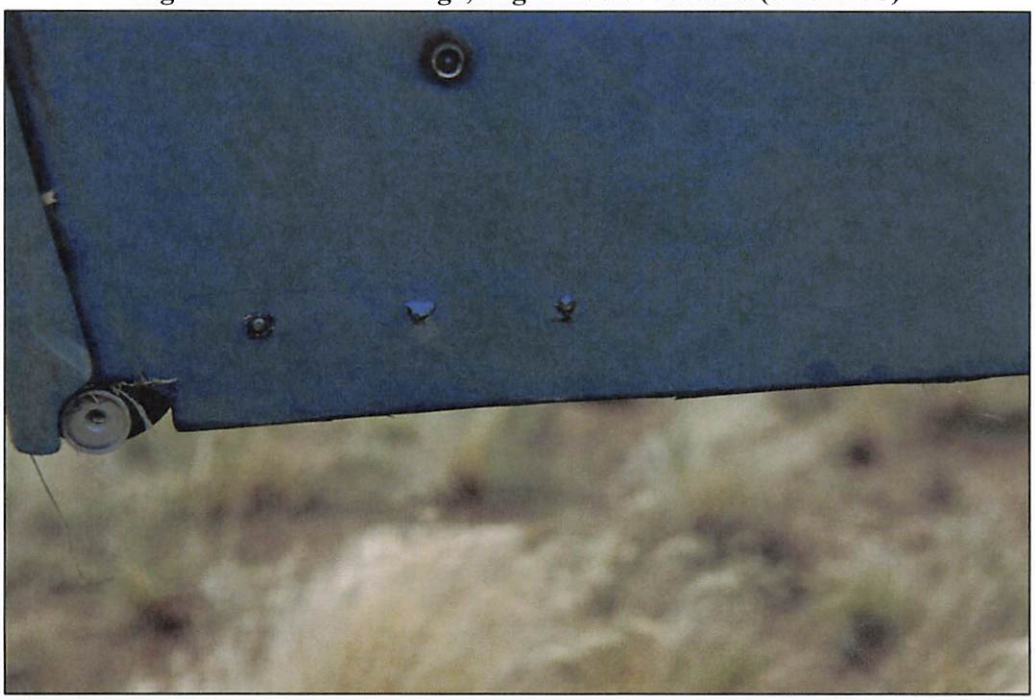


Figure 4-11. MA Damage, Right Gear Door (Tab Z-47)

Figure 4-12. MA Damage, Right Ramp Actuator (Tab Z-73)

f. Egress and Aircrew Flight Equipment

MAC commanded the MC to perform an emergency shutdown which was executed by MFE1 (Tabs N-77, R-11.3, R-16.4, R-19.2, and V-7.6). Of note, as MAC gave the command to perform the emergency shutdown the right engine speed and temperature both began to increase, signifying the engine was continuing its restart (Tab FF-3 to FF-4). At the completion of the emergency shutdown, the MC conducted an emergency egress from the aircraft (Tabs R-11.3, R-16.4, R-19.2, and V-7.6). Aircrew flight equipment maintainability, serviceability, and inspections were not a factor in this mishap (Tab G-81 to G-86, G-405 to G-410, G-557 to G-562, G-573 to G-578, and G-579 to G-583). MFE1's NVG low-profile battery pack cable was found to be ripped from the NVG mount connector port with pieces of the cable connector found within the port (Tab EE-3, EE-9, and EE-18). The cable connector pieces within the cable port and the testimony from MFE1 that they were performing NVG aerial gunnery prior to the mishap both indicates the cable was attached to the NVG mount at the time of the mishap (Tabs V-6.7, EE-9, and EE-14).

Figure 4-13. MFE1 Helmet with severed NVG cable (Tab EE-3)

Figure 4-14. MFE1 Helmet Battery Cable Connector Pieces in NVG Mount Connector Port (Tab EE-9)

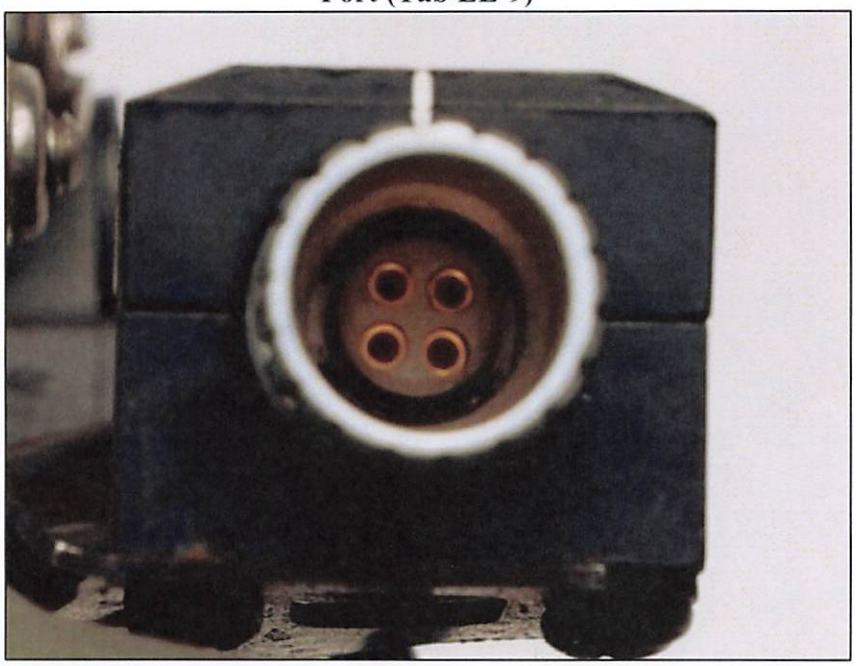
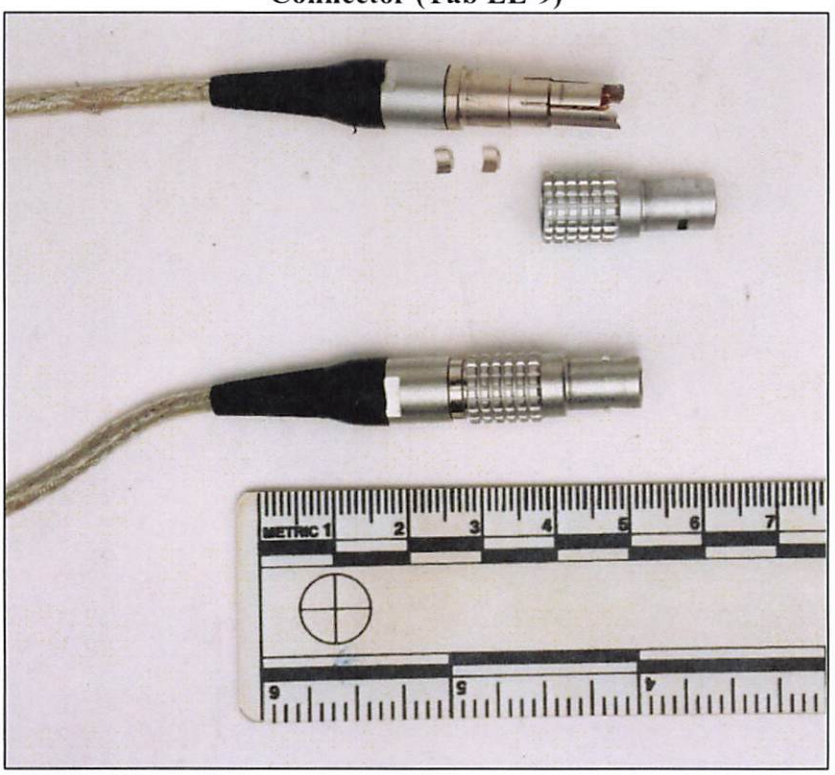


Figure 4-15. MFE1 NVG Batter Cable Connector compared to Exemplar Cable Connector (Tab EE-9)



g. Search and Rescue

The comprehensive timeline below was constructed using interviews and memorandums provided by multiple members involved in the recovery effort.

22 Aug 2023. Following the egress from the MA and conducting a head count, the MC attempted to contact MAFR controllers and 20 SOS leadership using their personal cell phones (Tab V-7.15 to V-7.16, V-8.7, and V-18.1). MCP attempted to contact MAFR control tower using numbers provided by the 20 SOS however none of the three phone numbers were answered (Tab V-8.7 to V-8.8). MAC attempted to contact 20 SOS/DO and the 20 SOS Operations Desk without success (Tab R-6.5 to R-6.6). MAC contacted Formation Copilot (FCP) on his personal cell phone (Tabs R-6.5 to R-6.6, V-11.1 to V-11.2, and V-16.1). FCP was waiting in the squadron for the upcoming crew swap of the MA from HAVOC 54 to HAVOC 53 (Tab R-6.5 to R-6.6). MAC passed to FCP that they were in a "really hard crash landing" on MAFR and directed him to notify 20 SOS/ADO, and 20 SOS/DO (Tabs R-6.5, V-7.16 to V-7.17, V-11.2, and V-18.1). MAC instructed MCP to contact MAFR tower (Tabs R-6.5 and V-7.16 to V-7.17).

At 2144 MST, 20 SOS Commander (CC) was contacted by 20 SOS/ADO and notified of a "precautionary landing with emergency shutdown of the engines" (Tab V-14.2 to V-14.3 and V-18.1). Range Officer (RO) reported that FCP called MAFR tower to relay that HAVOC 54 had to perform a "precautionary emergency landing" just west of Jockey with "five souls on board" (Tab V-21.1 to V-21.2). He reported the MC was unable to contact MAFR tower by radio due to the MA being unpowered and that the MC did not require medical support (Tab V-21.3). FCP also passed MAC's cell phone number to the tower (Tab V-21.3). RO dispatched the Range Inspector to the area just west of Jockey to locate the MC and evaluate them for minor injuries (Tab V-21.3). Senior Fire Officer on Range (SFOR) by chance overheard the radio call from the range fire station and contacted the tower, who communicated SFOR was not needed (Tab V-15.2 and V-21.3). SFOR injected and said he was required to respond to all emergencies and proceeded to Jockey (Tab V--15.2 and V-21.3). SFOR and the Range Medics reported to the tower they were unable to locate the MA (Tab V-21.3 and V-25.1). The MC reported that at no point did anyone consider using survival signaling devices to indicate their location (Tab V-6.13, V-7.15, V-8.7, V--9.6, and V-10.7).

At 2150 MST, RO called the Chief Range Officer to inform him that a CV-22B shut down near Jockey and relayed the information passed by FCP (Tab V-21.3). RO and Range Control Officer (RCO) continued to attempt to contact MAC via cell phone but the landlines in the tower would not connect (Tab V-21.3). Neither SFOR or the Range Medics were unable to initially locate the MA or MC (Tab V-15.2 and V-21.3). At 2152 MST, 27 SOG/CC received a call from 20 SOS/CC relaying a "precautionary landing" of a CV-22B on MAFR (Tab V-3.2). 20 SOS/CC was unsure of the cause at that point and went to the squadron to gather additional information, coordinate with maintenance, and ensure security forces support to guard the MA overnight (Tab V-3.1). 20 SOS/CC relayed there was no action or support needed by the group or wing at the time as the 20 SOS operations desk was undertaking necessary coordination (Tab V-3.1). 27 SOG/CC sent a text to 27 SOW/CC, relaying the "precautionary landing" and the coordination for security forces was underway (Tab V-3.1).

At 2205 MST, RO reported that multiple attempts were made to reach the other aircraft and ground crews on the range to determine the MA's location with no response from any party (Tab V-21.3). Two additional aircrews participating in the FMP on MAFR the night of the mishap did not report hearing these calls (Tabs V-16.3 and V-22.1). At 2215 MST, RCO contacted MAC on his cellphone (Tab V--10.8 and V-21.3). MAC passed the MA grid coordinates confirming he was able to put the aircraft down outside of the impact area (Tab V-21.3). When queried on the necessity of medical support, MAC initially said the crew only had bumps and bruises and no medical assistance was necessary, however after further pressing by the RO, MAC reluctantly agreed to have medical personnel dispatched to the scene due to a perceived hesitancy of closing the range (Tab V-5.1, V-7.16, V-21.3, V-21.3, and V-24.2). RO contacted SFOR with the MA's updated location (Tab V-21.3). At 2225 MST, MAFR tower initiated their medical emergency checklist (Tab V-21.3). At 2232 MST, RCO stopped range operations and announced the stoppage on multiple radio frequencies; this call was acknowledged by all parties on MAFR (Tab V-16.3, V-21.3, and V-22.1).

At 2248 MST, 20 SOS/CC emailed wing leadership notifying them of a "hard landing" (Tab V--1.10 to V-1.11 and V-14.2 to V-14.3). 27 SOG/CC was copied on an email from 20 SOS/CC to the 27 SOW/CC relaying a CV-22 "hard landing" and containing the who, what, when, where, and why (5Ws) (Tab V-1.10 to V-1.11). The email reported damage to gear doors and FLIR turret but the extent of overall damage was unclear (Tab V-1.10 to V-1.11 and V-3.1 to V-3.2). The email also relayed that four crewmembers were ambulatory with no serious injuries (Tab V-1.10 to V--1.11 and V-3.1 to V-3.2).

At 2253 MST, SFOR and the Range Medics arrived on scene (Tab V-21.2). At 2300 MST, SFOR reported the MA was shutdown, on the ground, and in the dark (Tab V-15.2 to V--15.3 and V-21.3). SFOR observed that the MC was in a group, ambulatory, and communicating with responders (Tab V-15.2 to V-15.3). The two Range Medics relayed that they were continuing to assess MFE1 for a potential head injury, but the remainder of the MC declined assessment (Tab V-21.3 and V-23.1). SFOR reported that the MA landed wheels up and had noticeable external damage (Tab V-15.2 to V-15.3 and V-21.3). SFOR declared an emergency and reported that the MA was "fire safe" over the MAFR radio frequency (Tab V-15.2 and V--21.3). SFOR assumed the role of Incident Command and recommended Emergency Operations Center (EOC) stand-up to the civilian Assistant Chief of Fire (Civ ACF) at Cannon AFB (Tab V-15.2 and V--21.3). At an unknown time, the two Flight Surgeons (FS), who were on the range for an unrelated exercise, arrived on scene to provide additional medical support in an advisory capacity as instructed by their exercise flight commander for a short period of time before leaving (Tab V-19.1, V-21.3, V-23.1, and V-25.1). The FSs reported that all but one of the MC declined assessment and denied injuries (Tab V-19.1, V-23.1, and V-25.1). The FSs also reported the MC were in a group and minimally communicated with the responders (Tab V-19.1, V-23.1 and V--25.1). At this point in time, no medical personnel involved were aware of the MA velocity as it hit the ground or that the MFE's were unrestrained (Tab V-5.1, V-19.1, V-25.1, V-26.3, V-26.10, V-26.13, V-27.1). The missing information hindered the medic's ability to make a proper decision to transfer the MC for emergency evaluation (Tab V-5.1, V-19.1, V-25.1, V-26.2 to V-26.3, V-26.5, V-26.10, V-26.13, V-27.1).

At 2303 MST, 27 SOG/CC received a text from 20 SOS/CC relaying that the 5Ws email was sent, alerting 27 SOG/CC to check his email (Tab V-1.10 to V-1.11 and V-3.1). Upon reading the email, 27 SOG/CC then contacted 27 SOW/CC on his personal phone, discussed the email, and relayed that he had spoken to 20 SOS/CC earlier and was only tracking a "precautionary landing" (Tab V--1.10 to V-1.11 and V-3.1). 27 SOG/CC also reported that the aircraft damage reported in the email was new information (Tab V-3.1). At 2308 MST, 27 SOW/CC and 27 SOG/CC discussed standing up the Crisis Action Team (CAT) but ultimately decided it was unnecessary based on the information they received (Tab V-2.2). 27 SOW/CC and 27 SOG/CC discussed the need to ensure all ambulatory personnel received any necessary medical attention and to begin preparing a Command Communication Information Requirement (CCIR) message (Tab V-2.2 and V-3.1). At 2312 MST, 27 SOW/CC responded to 20 SOS/CC's email and directed a draft Commander's Discretion CCIR based on suspected aircraft damage (Tab V-2.2 and V-14.1).

At 2315 MST, the Range Medics requested coordination through MAFR tower of an ambulance for MFE1's transportation to the PRMC with a rendezvous at Gate 6 to MAFR to swap patient from the Range Medic control to civilian emergency response (Tab V-21.4 and V--23.1). The Range Medics cleared remaining aircrew to return to base (Tab V-19.1 and V-25.1). At 2316 MST, RO called 911 from the tower landline requesting an ambulance be dispatched to Gate 6 to transport MFE1 with a potential head injury following an aircraft emergency landing to the PRMC (Tab V-12.4 and V--21.3). The 911 call was answered by the Fire Dispatch airman at Cannon AFB, whom the RO reported seemed very confused about where MAFR was located (Tab V-21.3). No call was made by the airman in Fire Dispatch requesting medical support (Tab V-21.3 to V-21.4, V-24.3, V-26.4, V-26.8, and V-26.11).

At approximately 2320 MST, SFOR contacted Civ ACF via cell phone providing information related to a "hard landing" mishap, he reported the MA fell 150 ft out of sky, recommended activating EOC (Tab V-26.2). Civ ACF made the recommendation to transport all MC due to the mechanism of injury but was told the MC were already gone (Tab V-26.2). Civ ACF presented to Cannon AFB Fire Dispatch and instructed the airman on duty to call 27 CE/CC, the Fire Chief Deputy, and make all notifications per dispatch checklist (Tab V-26.3). He then instructed the airman to inform individuals "there is no fire danger, no critical life-threatening injuries and recommend standing up the EOC." (Tab V-26.3). At 2323 MST, RO updated the Chief Range Officer and notified 27th Special Operations Mission Support Group CC of the crash (Tab V-21.3).

At 2326 MST, 20 SOS/CC emailed and called wing leadership with the update that MFE1 was being transported to PMRC "out of an abundance of caution for concussion concerns" (Tab V-1.9 to V-1.10, V-3.3 and V-8.18 to V-8.19). 27 SOG/CC called Command Post to confirm that security forces had been dispatched to watch the MA overnight and check the status of the CCIR (Tab V-3.2). Command Post relayed that security forces were on scene with the Range Medics and that they were awaiting information from 20 SOS for CCIR completion (Tab V-3.2). 27 SOG/CC called 20 SOS/CC to discuss the status of injured personnel enroute to the PRMC, inquire on any updates to the extent of reported aircraft damage, and status of the CCIR message (Tab V-3.2). 20 SOS/CC relayed that the referral to PRMC was "very precautionary", the First Seargent was escorting the member, and would provide updates (Tab V-3.2). 20 SOS/CC said that he was being told that there was more extensive damage to the MA than previously reported and that the FLIR turret was detached from the aircraft (Tab V-3.2). 27 SOG/CC and 20 SOS/CC

discussed immediate actions to be taken (toxicology, lock down flight and maintenance records) in anticipation of a safety investigation (Tab V-3.2). 27 SOG/CC called 27 SOW/CC to relay the additional information on suspected damage to the aircraft (Tab V-3.3). At 2346 MST, the 27 SOG/CC was copied on an email from the 27 SOW/CC to COMAFSOC making initial report of incident (Tab V-3.3).

At 2352 MST, the two Range Medics arrived at Gate 6 to stage until the civilian ambulance arrived (Tab V-21.4 and V-23.1). At 2359 MST, the two Range Medics informed the tower that neither Clovis nor Portales emergency medical services were dispatched and did not receive a request for an ambulance (Tab V-15.3 to V 15.4 and V-21.4). Two Range Medics directly coordinated with Clovis emergency medical services to send a civilian ambulance to transport the MFE1 to the emergency department at Clovis (Tab V-21.4 and Tab V-23.1). The two Range Medics requested permission to leave the range to meet the civilian ambulance through SFOR and RO (Tab V-15.4 to V-15.5, V-21.4, and V-23.1).

23 Aug 2023. At 0003 MST, RO approved the Range Medics to leave MAFR to transfer MFE1 off the range (Tab V-21.4 and V-23.1). At 0010 MST, RO updated the Chief Range Officer (Tab V-21.4). At 0028 MST, 27 SOG/CC was copied on an email from 20 SOS/CC to 27 SOW/CC providing a draft Operations Report (OPREP) Rule 2 language regarding the incident (Tab V-1.6 to V-1.7 and Tab V-3.2). 27 SOG/CC reviewed the email and had no additional inputs (Tab V-1.6 to V-1.7 and Tab V-3.2).

Around 0030 MST, 20 SOS/CC attempted to contact a FS (Capt FS), who he was familiar with, on his cell phone (Tab V-14.5). Capt FS was not on call the night of the mishap and missed the call as his phone was on do-not-disturb (Tab V-27.2). 20 SOS/CC contacted 27th Special Operations Medicine Readiness Squadron CC who provided the phone number for Chief of Aerospace Medicine (SGP) on call (Tab V-14.5 and V-27.2). SGP was notified of the mishap with one injury transferred to the PRMC via call-phone by 20 SOS/ADO and 20 SOS/CC (Tab V-14.5, and V-27.2). At 0032 MST, RO reported a representative from 20 SOS arrived for the transportation of the remaining MC at Gate 1 (Tab V-21.4). At 0035 MST, MFE1 transfer between the Range Medics and a civilian ambulance was completed off MAFR (Tab V-21.4 and V-23.1). At 0039 MST, RO called 911 from the same landline previously used to determine where the original 911 call was routed; the call connected to Cannon AFB Fire Dispatch (Tab V-21.4). The Fire Dispatch airman seemed unaware of the previous 911 call and no further action was taken at that time (Tab V-12.4 and V-21.4). At 0043 MST, 27 SOW/CC sent an email to the Command Post with multiple base leaders copied providing a draft OPREP Rule 2 MISHAP notification for processing (Tab V-3.3). 27 SOW/CC learned there was significant damage to the MA undercarriage and gear (Tab V-2.2). The gear was suspected to be in transit during impact (Tab V-2.2). 27 SOW/CC provided draft OPREP Rule 2 Mishap notification to the 27 SOW Command Post for processing (Tab V-2.2). At 0045 MST, 27 SOW/CC provided email notification to AFSOC leadership on the hard landing and the need to send one member to the PRMC for evaluation (Tab V-2.2). The email was acknowledged by the AFSOC Deputy Commander (Tab V-2.2). At 0058 MST, RO reported that the Range Medics arrived back at MAFR (Tab V-21.4).

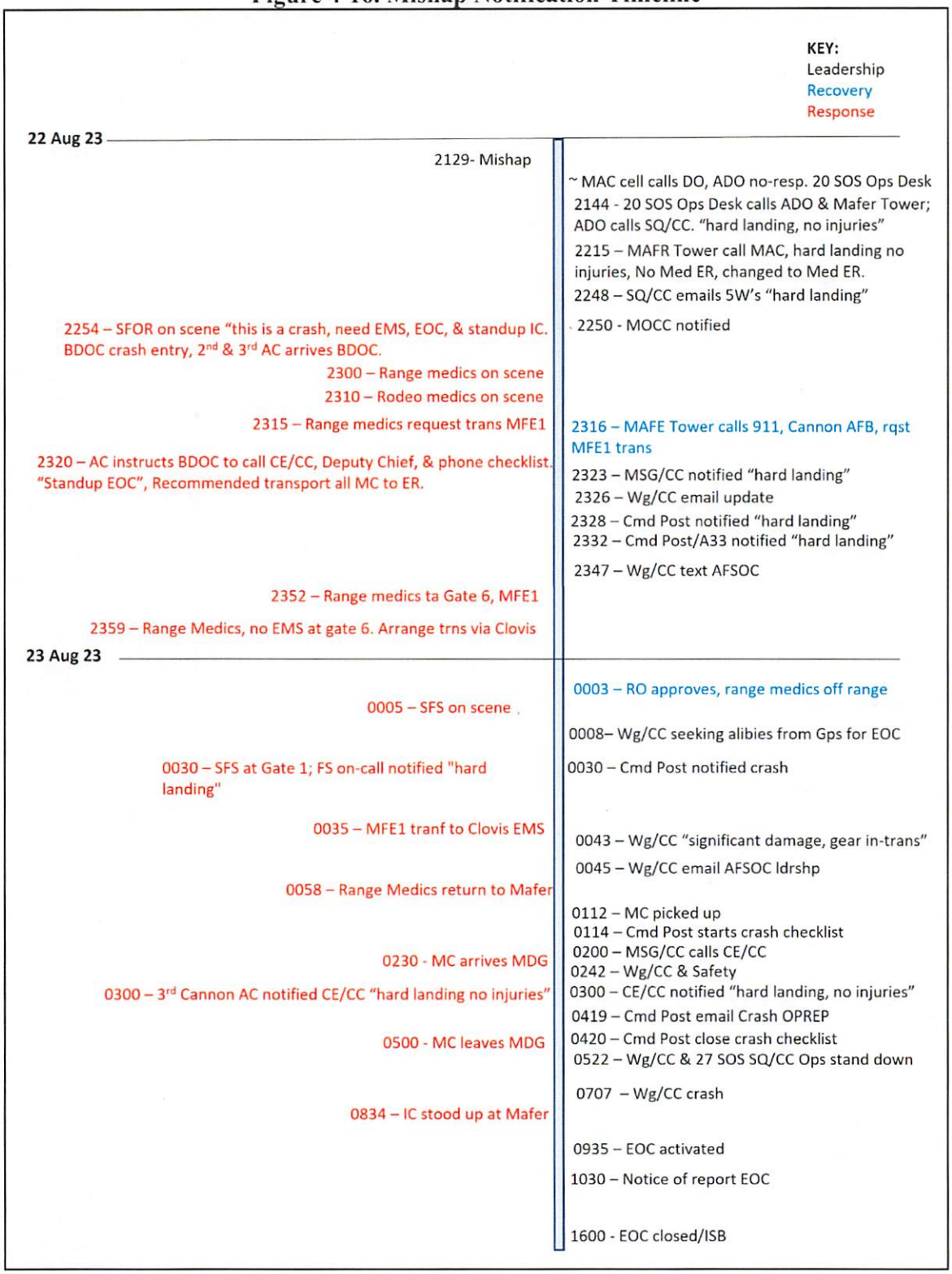
At 0112 MST, the Command Post messaged SOW leadership of crashed aircraft (Tab V-4.1). The 20 SOS crew vehicle left the MA (Tab V-21.4). At 0150 MST, 20 SOS/CC informed 27 SOW

and 27 SOG leadership of a "hard landing" with no life-threatening injuries, one-member was enroute to PRMC for possible concussion, and security forces were enroute to secure the site (Tab V-3.2). At 0230 MST, the MC, minus MFE1, arrived at the Cannon AFB Medical Treatment Facility (MTF) for mishap labs and 72-hours/7-day histories (Tab V-5.1). At 0242 MST, 27 SOW/CC had a phone call with AFSOC Chief of Staff to ensure accurate reporting to Headquarters Air Force (Tab V-2.2). At 0500 MST, the MC, minus MFE1, left the MTF (Tab V-5.2). Again, no medical personnel involved were made aware of the MA velocity as it hit the ground or that the MFEs were unrestrained (Tab V-5.1, V-19.1, V-25.1, V-26.3, V-26.10, V-26.13, and V-27.1). The missing information hindered their ability to make a proper decision to transfer the MC for emergency evaluation (Tab V-5.1, V-19.1, V-25.1, V-26.2 to V-26.3, V-26.5, V-26.10, V-26.13, and V-27.1).

At 0522 MST, 20 SOS/CC emailed 27 SOW/CC to provide an update on the status of MFE1 (Tab V-1.4 to V-1.5 and V-3.3). Sometime after leaving the MTF, the MC, minus MFE1, presented to the 20 SOS/CC's office and discussed the position change of MFE1 and sink rate warning (Tab V-14.16). Based on the information provided by the MC to the 20 SOS/CC, he asked the MC "do you think he might have bumped his head? Do you think we might have, you know, bumped the ECL?" (Tab V-14.16).

At 0637 MST, the 27 SOG/CC called the 20 SOS/CC to discuss his immediate plan for the unit, provide perspective, discussed potential follow-on actions, confirmed the member at PRMC was released, and that all crew were undergoing toxicology testing (Tab V-3.3). The 20 SOS/CC provided updates on the status of securing mishap records (Tab V-1.10 to V-1.11 and V-3.2). At 0655 MST, the 27 SOG/CC called the 27 SOW Safety Officer to discuss the need for an Interim Safety Board (ISB) and to discuss appropriate immediate actions based on anticipation of being named board President (Tab V-1.3 to V-1.4 and V-3.3). 27 SOG/CC scheduled a 0815 MST ISB in-brief (Tab V-3.3). At 0707 MST, 27 SOW/CC appointed the 27 SOG/CC to serve as ISB President and verbalized clear understanding this was a "crash, not a hard landing" (Tab V-3.3). At 0815 MST, 27 SOG/CC was in-briefed as the ISB President and began putting together a team (Tab V-3.3). At 0823 MST, 27 SOW/CC attended in-person meeting to discuss standing up CAT and EOC (Tab V-2.3). He directed the standing up of the EOC and dispatched security forces to secure the site and establish a cordon (Tab V-2.3). At 0823 MST, 27 SOW/CC made the decision to stand up the EOC but not the CAT (Tab V-2.3). At 0908 MST, 27 SOW/CC texted the SOW O-6/E-9 leadership teams to communicate mishap facts (Tab V-2.3). At 0935 MST, 27 SOMXG/CC inquired with 27 SOW/CC about standing up EOC, who then approved and activated the EOC at that time (Tab V-2.3 and V-26.2). Civ ACF took over as Incident Command and initiated appropriate checklists (Tab V-26.4). Civ ACF made calls to the MC instructing them to seek medical attention due to the mechanism of injury (Tab V-26.2). At 1030 MST, the notice to report to the EOC was sent out (Tab V-26.11). At 1600 MST, the EOC was shut down and the scene transferred to the ISB President (Tab V-26.2).

Figure 4-16. Mishap Notification Timeline



h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

The purpose of the Air Force Technical Order (AFTO) 781 series form is to document maintenance discrepancies (Tab AA-707 to AA-852). A thorough review of active and historical AFTO Form 781As and 781K for T/N 17-0077 showed 39 open entries (Tab U-5 to U-8 and U-11 to U-80). Per Technical Order (TO) 00-20-1, paragraphs 4.2 to 4.4, which explains the condition of the aircraft based on the symbols entered, and 5.15.1 to 5.15.1.7, 781K documentation instructions, there were no entries which would have endangered the safe operation of the MA (Tab AA-707 to AA-852).

A review of the MA historical files, to include Time Compliance Technical Order (TCTO) status, AFTO Forms 95, major inspection packages and archived data in the Integrated Maintenance Data System was accomplished (Tab D-4, D-6 and D-8 to D-10). There were seven open TCTOs, none of which were overdue or restricted the MA aircraft from flying (Tab D-8). There is no evidence that TCTO compliance or aircraft forms documentation were relevant in this mishap.

b. Inspections

At the time of mishap, the MA had 718.7 accumulated flight hours, and it was not overdue for any major inspections (Tabs U-3 to U-9 and Y-15 to Y-16). The next major required inspection was a Phase C inspection due at 840 flight hours (Tab U-5 to U-8). The next required time change item was an 800-flight hour time change of the left and right input quills due in 81.3 flight hours (Tab U-5 to U-8). The MA was also in the range (+/- 10%) for it's 35-, 70-, and 140-hour inspections (Tab U-5 to U-8). AFTO Form 781H, dated 20230820, indicated a preflight inspection was conducted on the MA prior to its last flight (Tab U-3 to U-4). The Exceptional Release, a review of the active aircraft forms, was documented prior to the first sortie of the day on 22 August 2023 (U-11 to U-24).

c. Maintenance Procedures

Maintenance personnel were familiar with all applicable TOs, Air Force Manuals (AFMAN), and AFIs (Tab T-115 to T-146). Left Full Authority Digital Engine Control (FADEC) A, left FADEC B, right FADEC A, and right FADEC B had software changes that were implemented in accordance with TCTO 2J-T-AE1107C-532 (Tab AA-853 to AA-860). These changes included: Measured Gas Temperature scaling corrections, overhead mitigations and reducing the number of "nuisance" issues (stall detection, torque lane difference faults, power limiting and FADEC on limit annunciations) (Tab U-95 to U-96). Removal, installation, and follow-on maintenance was conducted by maintenance personnel in accordance with CV-22 Interactive Electronic Technical Manuals and TCTO 2J-T-AE1107C-532 (Tab AA-853 to AA-860). The software update was done

by a Rolls-Royce Field Service Representative in accordance with service bulletin AE1107C73-038, which is based on TCTO 2J-T-AE1107C-532 (Tab U-81 to U-84, U-97 to U-98, and AA-853 to AA-860). Maintenance personnel conducted all maintenance procedures in accordance with applicable TOs, AFIs, and guidance (Tab AA-109 to AA-492 and AA-707 to AA-852).

d. Maintenance Personnel and Supervision

A thorough review of training and qualifications records revealed that all personnel involved with the MA flight preparation and maintenance prior to flight were properly trained, qualified and supervised (Tab T-115 to T-146). There is no evidence to suggest that the training, qualifications, and maintenance personnel supervision were a factor in this mishap.

e. Fuel, Hydraulic, and Oil Inspection Analyses

Hydraulic fluid and engine oil, but not fuel, samples were taken from the MA after the mishap (Tab U-99 to U-116). Fluid samples taken from the midwing gearbox, the left and right proprotor gearboxes, and the left and right tilt axis gearboxes contained a discrepancy with allotted parameters for water content (Tab AA-879 to AA-880). Although there was a discrepancy, per T.O. 33-1-37-3 exceeded water content would require respective oil and filter changes once discovered by maintenance personnel (Tab AA-879 to AA-880). Of note information from technical data, in accordance with 1V-22(C)B-2-DB-1 SSS 2900, hydraulic samples should be taken immediately after aircraft flight while proprotors are still turning for all components or under auxiliary power unit operations for certain components; due to the nature of the mishap this was not possible (Tab AA-868). There is no evidence that suggests fuel, hydraulic fluid, or oil were factors in this mishap.

f. Unscheduled Maintenance

Since the last inspection, which was a 56-day inspection performed on 13 August 2023, the following unscheduled maintenance tasks were performed (Tab U-53 to U-80):

From the active 781A's: An inlet Foreign Object Debris (FOD) inspection was performed with no defects noted on 22 August 2023 (Tab U-23 to U-24). The GAU-21 and GAU-21 300 round kit was removed on 22 August 2023 (Tab U-23 to U-24).

From the 781A dated 20230815 – 20230822, the results are as follows: the Electronic Comp Assembly was operationally checked on 15 August 2023, the operational check was bad; a Suite of Integrated Radio Frequency Countermeasures (SIRFC) operational check was done due to the Line Replaceable Unit-1 (LRU) receiver/processor being removed and replaced on 15 August 2023, the operational check was bad; SIRFIC A1 Card was replaced on 15 August 2023; an operational check for the right engine air particle separator (EAPS) starter control valve was done on 15 August 2023 due to filter being replaced, operational check was good; GAU-21 300 round kit installed on 16 August 2023; GAU-21 installed was installed 16 August 2023; the shaft driven compressor (SDC) filter was replaced due to an austere inspection on 17 August 2023; the

environmental control unit filter was replaced due to an austere inspection on 17 August 2023; the cabin air return barrier filter was replaced due to an austere inspection on 17 August 2023; a basic postflight inspection was accomplished on 17 August 2023; Engine inlet FOD inspection was done on 18 August 2023; Austere inspection was completed on 17 August 2023; the GAU-21 and GAU-21 300 round kit was removed on 17 August 2023; hydraulic system 3 was depressurized and required bleeds on due to replacing the right EAPS hydraulic control valve filter on 18 August 2023; right EAPS start control valve filter was replaced due to a delta-P indicator being popped on 17 August 2023; leak and operational checks were good; left and right FADECs A and B, four components total, were removed and reinstalled for TCTO 1940, a software update, on 17 August 2023; a follow-on ground run was done on 18 August 2023; replaced broken nut plate on panel 6RI6 on 17 August 2023; left anti-ice valve was replaced, leak checked, and operationally checked on 18 August 2023 (Tab U-25 to U-52).

The results from the 781A's dated 20230731 – 20230815 are as follows: one click stud was rebounded on the flight engineer seat rail on 7 August 2023; a ground run was performed due to the removal of both fuel management units on 1 August 2023, no defects were noted; an engine inlet FOD inspection was performed on 1 August 2023, no defects were noted; the flight control computer battery operational check was done 1 August 2023, no defects were noted; an engine inlet FOD inspection was performed on 14 August 2023, no defects were noted; the lower strut mount for panel 6R03 was replaced on 3 August 2023, due to being worn; 6R03 was removed and the upper strut clevis was replaced by sheet metal on 6 August 2023; a 56-day inspection was completed on 13 August 2023, this inspection includes, lubrication of the nose landing gear trunnion pin, drag strut, and actuator; an external initiator inspection; a lubrication of main landing gear components; lubrication of the nose landing gear drag strut/actuator and shock strut; a primary conversion actuator flush for inner and outer ball screw bearing; SIRFC cards A1, A2, A4, A8, A9, A11, and A13 removed for troubleshooting another aircraft on 6 August 2023; the SDC was removed for cannibalization on 3 August 2023; an SDC was reinstalled on 8 August 2023; the forward LRU-2 and -3 were removed for troubleshooting on 7 August 2023 and reinstalled 9 August 2023; LRU-1 was cannibalized from the MA to another aircraft on 8 August 2023; LRU-1 was installed on 9 August 2023; the SDC oil was service on 8 August 2023; an SDC was leak and operational check was performed on 10 August 2023; a basic postflight inspection was performed on 14 August 2023; an austere landing inspection was accomplished on 15 August 2023, this inspection included the replacement of the SDC filter, environmental control unit filter, and cabin air return barrier filter; the right EAPS control valve filter was replaced due to the differential pressure indicator being popped on 14 August 2023; hydraulic system three was bled, repressurized, and leak checked on 14 August 2023 (Tab U-52 to U-80).

This review concluded that there was no evidence to suggest that unscheduled maintenance had any impact on the mishap or functionality of the MA.

6. AIRFRAME

a. Structures and Systems

The MA impacted the ground with its landing gear retracted; due to impact and the accompanying skid, most of the known damage is centered around the bottom of the aircraft (Tab Z-7 to Z-11).

The FLIR turret, cargo ramp, upper and lower cabin door area, vertical stabilizer fairing, right main landing gear door, and forward external cargo hook bay doors sustained damage (Tab Z-29, Z-33, Z-37, Z-45 to Z-49, Z-63 to Z-71, and Z-77 to Z-83).

The FLIR turret, which provides a thermal image that enables a pilot to take-off, navigate at low altitudes and land in total darkness, was found crushed and separated approximately 20 feet from the nose of the aircraft (Tabs Z-27, Z-63 to Z-71, Z-77, and AA-866).

The cargo ramp assembly sustained damage during the mishap (Tab Z-13 to Z-16). Actuator fittings are mechanically connected to each side beam of the ramp assembly which allows for movement and mechanically connects the cargo ramp assembly and actuators (Tab Z-29 to Z-75). On the MA, the left ramp actuator fitting was sheared, and both the left and right ramp actuators suffered bent rods and rod ends (Tab Z-29 to Z-75). Further assessment of the ramp assembly and associated components is required to determine the full extent of damage to the ramp as a result of the mishap. There is no evidence that the ramp assembly or associated components had any impact on the mishap or the functionality of the MA.

Main cabin door coaming provides an aerodynamic contour and an environmentally sealed enclosure to the fuselage portion of the aircraft (Tabs Z-81 to Z-83 and AA-863). The MA sustained cracks to the upper forward coaming of the upper main cabin door and lower aft coaming of the lower main cabin door (Tabs Z-81 to Z-83 and AA 862). Evaluations on the extent of damage are still ongoing.

Three horizontal cracks were sustained to the right inboard SIRFC receive antenna fairing located on the right inboard bottom trailing edge of the right vertical stabilizer (Tabs Z-53 to Z-55, Z-73, and AA-865 to AA-867).

AFTO Form 781A/Ks do not show any previous defects with the aforementioned damaged systems, although total extent of damage to the underside of the aircraft and components located in that area are still under investigation (Tab U-5 to U-8 and U-11 to U-24).

b. Engine Control Panel and Engine Control Lever

The Engine Control Panel (ECP) is located on the overhead console; within the panel are the left and right ECLs, a rotor brake, and three illuminated pushbutton switches. Each ECL control has mechanical stops, a CRANK/START gate, and discrete detents for OFF, CRANK, START, and FLY (Tab AA-880). The OFF and FLY position detents require additional force to move the lever out of the positions (Tab AA-880). To move the lever between the CRANK and START position requires an inward force (Tab AA-880). The CRANK/START gate is also meant to prevent inadvertent engine shutdown when the ECL is moved from FLY to START (Tab AA-880). The ECLs require less than five pounds force to move (Tab AA-880). Post mishap, the ECP was removed and sent to the original equipment manufacturer, BAE Systems, for testing to verify operating condition and check for any faults (Tab D-5). Testing indicated no malfunctions with

the ECP or ECL (Tab D-5). All other systems were working within allowable limits at the time of mishap (Tab D-5).

c. Evaluation and Analysis

Vibration/Structural Life and Engine Diagnostics and K-Series Voice Data Recorder were recovered post mishap with no missing data or relevant faults (Tab FF-3 to FF-4 and FF-6 to FF-7). Data was then submitted to the Safety Board, Accident Board and CV-22 Program Engineers for analysis, data indicates that all systems and equipment were operating normally at the time of the mishap (Tab FF-3 to FF-4 and FF-6 to FF-7).

7. WEATHER

a. Forecast Weather

The 27th Special Operations Support Squadron Weather Flight provided the mission execution forecast on 22 August 2023 at 1200 MST (Tab F-3 to F-7). Weather at Cannon AFB was forecast at departure to have surface winds from 120-degrees at 6 knots with a temperature of 30-degrees Celsius (C) and visibility was expected to be at least 7 statute miles with a broken cloud layer at 9000 ft AGL (Tab F-3 to F-4). Weather at MAFR was forecast for the period of operations to have surface winds from 120-degrees at 6 knots with a temperature of 31C and visibility was expected to be at least 7 statute miles with a broken cloud layer at 9,000 ft AGL (Tab F-4). Area thunderstorms were forecast to occur earlier in the day, but no hazardous weather was forecast during the period of flight (Tab F-3 to F-6).

b. Observed Weather

Observed weather at the time of the mishap was similar to the forecast. Weather for departure was observed at Cannon AFB to have winds from 100-degrees at 4 knots with a temperature of 28C and visibility was unlimited with skies clear of clouds (Tab W-3 to W-8). At the time of the mishap, MAFR surface observations measured winds from 120-degrees at 6 knots with a temperature of 29C and visibility was unlimited with an overcast cloud layer at 13,000 ft AGL (Tab W-3 to W-10). The MA measured and recorded winds on MAFR prior to the mishap to be from approximately 114-degrees to 122-degrees at 15-18 knots and a temperature of 34C; these measurements were taken at 200-300 ft AGL in airplane mode and with nacelles at 80-degrees (Tab FF-1). Observations from other aircraft operating on MAFR at the time of the mishap stated that the sky was clear of clouds (Tab V-17.1 and V-22.1). Sunset was 1932 MST and moonset was 2245 MST on the day of the mishap (Tab W-3 to W-8). Lunar illumination at the time of the mishap was 37%, however due to the approaching moonset, ground illumination was calculated to be approximately 6 millilux (Tab W-11). For reference at MAFR, 0% lunar illumination (or the moon elevation being below the horizon) has approximately 0.5 millilux or ground illumination while 100% lunar illumination with the moon at 45 degrees elevation and 180 degrees of azimuth would have approximately 190 millilux ground illumination (Tab W-13).

c. Space Environment

Not applicable.

d. Operations

Based on the forecasted and actual observations made by ground stations, the weather was within operational limits for the crew, aircraft, airfield, and the training area (Tabs F-3 to F-7, W-8, and W-10). Actual weather observations made by the MC using MA onboard systems had temperatures higher than expected for the planned mission and winds to be stronger than expected (Tab FF-3). Prior to the mishap, the MC was performing hover operations on a heading of 270-degrees, combined with the system calculating the winds while in airplane mode and at 80-nacelle to be from 114-degrees to 122-degrees at 15-18 knots (Tab FF-3). As a result, the MC was operating with an effective tailwind of approximately 14 knots (Tab FF-3). This placed the MA within the published tailwind avoid region (Tabs BB-71 and FF-3). Crews may operate within an avoid region, but they are directed to limit exposure to brief transient periods and reduce aggressive maneuvering; the MC spent four minutes hovering within this avoid region and was not transitory (Tabs BB-71 and FF-3).

8. CREW QUALIFICATIONS

There was no evidence indicating either crew qualifications or training deficiencies were a factor in this mishap.

a. Mishap Aircraft Commander (MAC) – Pilot in Left Pilot Seat

MAC was a current and qualified CV-22B pilot with 638.5 hours of military flying time prior to the mishap (Tab T-4 to T-5). He was initially qualified as a CV-22B pilot on 27 July 2021 and certified as a Mission Aircraft Commander on 14 March 2023 (Tabs T-6 and G-3). He had 388.8 total hours in the CV-22B aircraft; 225.2 primary hours, 131.6 secondary hours, and 32 other hours (Tab T-3). MAC had 206.9 total hours in the CV-22B simulator; 138.1 primary hours, 66.1 secondary hours, and 2.7 other hours (Tab T-3). Additionally, he had 136.8 hours of NVG time in the CV-22B aircraft and 69.4 hours of NVG time in the CV-22B simulator (Tab T-3 to T-4).

MAC's flight time for the 90 days prior to the mishap are shown in table 8-1.

Table 8-1. MAC 30 Day, 60 Day, and 90 Day Flight Hours (Tab T-19 to T-20)

	Total Hours	CV-22B	CV-22B Simulator
Last 30 Days	8.8	8.3	0.5
Last 60 Days	36.7	31.7	5
Last 90 Days	36.7	31.7	5

b. Mishap Copilot (MCP) – Pilot in Right Pilot Seat

MCP was a current and qualified CV-22B pilot with 478.3 hours of military flying time prior to the mishap (Tab T-22). He was initially qualified as a CV-22B pilot on 17 December 2021 (Tab T-23). MCP had 232.7 total hours in the CV-22B aircraft; 139.7 primary hours, 87.6 secondary hours, and 5.4 other hours (Tab T-21). MCP had 211.2 total hours in the CV-22B simulator; 150.3 primary hours, and 60.9 secondary hours (Tab T-21). Additionally, he had 101.6 hours of NVG time in the CV-22B aircraft and 63.5 hours of NVG time in the CV-22B simulator (Tab T-21 to T-22).

MCP's flight time for the 90 days prior to the mishap are shown in table 8-2.

Table 8-2. MCP 30 Day, 60 Day, and 90 Day Flight Hours (Tab T-35 to T-36)

	Total Hours	CV-22B	CV-22B Simulator
Last 30 Days	16.8	14.3	2.5
Last 60 Days	21.8	14.3	7.5
Last 90 Days	21.8	14.3	7.5

c. Mishap Flight Engineer (MFE) 1 – Flight Engineer in Cockpit

MFE1 was a current and qualified CV-22B flight engineer with 431.7 hours of military flying time prior to the mishap (Tab T-37). He was initially qualified as a CV-22B flight engineer on 16 June 2022 (Tab G-5). MFE1 had 307.3 total hours in the CV-22B aircraft; 287.6 primary hours, 0.7 secondary hours, and 19 other hours (Tab T-37). MFE1 had 51 total hours in the CV-22B simulator; 47.3 primary hours, 0.2 secondary hours, and 3.5 other hours (Tab T-37). Additionally, he had 62.3 hours of NVG time in the CV-22B aircraft (Tab T-37).

MFE1's flight time for the 90 days prior to the mishap are shown in table 8-3.

Table 8-3. MFE1 30 Day, 60 Day, and 90 Day Flight Hours (Tab T-39 to T-40)

	Total Hours	CV-22B	CV-22B Simulator
Last 30 Days	15	9.5	5.5
Last 60 Days	51	40.5	10.5
Last 90 Days	56.5	43.5	13

d. Mishap Flight Engineer (MFE) 2 – Flight Engineer Tail Scanner

MFE2 was a current and qualified CV-22B flight engineer, apart from being non-current for aerial gunnery, with 435.9 hours of military flying time prior to the mishap (Tab T-41). He was initially qualified as a CV-22B flight engineer on 25 May 2022 (Tab G-563). MFE2 had 313.9 total hours in the CV-22B aircraft; 296.8 primary hours, 2.9 secondary hours, and 14.2 other hours (Tab T-41). MFE2 had 75.6 total hours in the CV-22B simulator; 73.6 primary hours, and 2.0 other hours (Tab T-41). Additionally, he had 70.6 hours of NVG time in the CV-22B aircraft (Tab T-41).

MFE2's flight time for the 90 days prior to the mishap are shown in table 8-4.

Table 8-4. MFE2 30 Day, 60 Day, and 90 Day Flight Hours (Tab T-43 to T-44)

	Total Hours	CV-22B	CV-22B Simulator
Last 30 Days	17.7	17.7	0
Last 60 Days	53.5	46	7.5
Last 90 Days	62.2	54.7	7.5

e. Mishap Flight Engineer (MFE) 3 – Flight Engineer Evaluator

MFE3 was a current and qualified CV-22 flight engineer with 2863.7 hours of military flying time prior to the mishap (Tab T-46). He was initially qualified as a CV-22 flight engineer on 27 July 2017 and certified as a Flight Examiner on 22 October 2021 (Tab T-47). He had 1275.3 total hours in the CV-22B aircraft; 979.6 primary hours, 5.3 secondary hours, 213.6 instructor hours, 19.4 evaluator hours, and 57.4 other hours (Tab T-45). MFE3 had 269.8 total hours in the CV-22B simulator; 212.4 primary hours, 2.5 secondary hours, 28.7 instructor hours, 2.2 evaluator hours, and 24 other hours (Tab T-45). Additionally, he had 906.9 hours of total NVG time, 542.2 hours across several C-130 variants, 354.2 hours in the CV-22B aircraft and 10.5 hours of NVG time in the CV-22B simulator (Tab T-45 to T-46). Finally, he had 407.9 hours total combat time with 69.5 hours of combat time in the CV-22B (Tab T-45 to T-46).

MFE3's flight time for the 90 days prior to the mishap are shown in table 8-5.

Table 8-5. MFE3 30 Day, 60 Day, and 90 Day Flight Hours (Tab T-101 to T-102)

	Total Hours	CV-22B	CV-22B Simulator
Last 30 Days	20.5	18	2.5
Last 60 Days	44.6	42.1	2.5
Last 90 Days	60.6	55.6	5

9. MEDICAL

a. Qualifications

Based on all available medical information, the MC appeared medically qualified for flying duties at the time of the mishap (Tab DD-135 to DD-144). The MC was current on their fly-Periodic Health Assessment (Tab DD-135 to DD-144). The MC had current physiological training (Tab DD-145 to DD-154). There is no evidence to suggest that any member of the MC had a medical condition, illness, or performance-limiting condition that would have caused or contributed to the mishap (Tab DD-135 to DD-144).

b. Health

The outpatient medical and dental records were reviewed for the MC (Tab DD-3 to DD-4 and DD-135 to DD-144). The MC were overall in good health (Tab DD-3 and DD-135 to DD-144). MAC possessed an AFSOC approved flying class II waiver for vision (Tab DD-3 and DD-197 to DD-198). MFE2 and MFE3 sought medical attention at the Cannon AFB MTF for minor injuries consistent with an aircraft crash while unrestrained during MA's impact with the ground (Tab DD-3). MAC and MCP sought medical attention at the MTF for minor injuries consistent with an aircraft crash while restrained during MA's impact with the ground (Tab DD-3). MFE1 was urgently transported, evaluated, and released for a minor head, neck and back injury with subsequent follow up care at the MTF (Tab DD-3 to DD-4). MFE1 continues to follow-up with physical therapy and flight medicine for post-concussive symptoms, neck and back pain; the extent of disability has not been determined (Tab DD-3 to DD-4). MFE1's injuries were consistent with an aircraft crash while unrestrained during MA's impact with the ground (Tab DD-3 to DD-4).

c. Pathology

The Defense Health Agency performed a Forensic Toxicology Examination, in accordance with Department of the Air Force Instruction (DAFI) 91-204, paragraph 2.6.4., of the blood and urine of the MC and mishap maintainers for the presence of abnormal levels of drugs of abuse, ethanol, and carbon monoxide (Tabs AA-500 to AA-501, and DD-101 to DD-134). Blood and urine tests were performed on 31 individuals (Tab DD-101 to DD-134). There were 28 negative results and 3 positives (Tab DD-101 to DD-134). MAC had a positive result for codeine, norcodeine, and thebaine that was validated by the AFSOC Medical Review Officer (Tab DD-201). Forensic toxicologist reports indicate MAC's results were likely from poppy seed ingestion and were not contributory to the mishap (Tab DD-155 to DD-166). Two toxicologists provided extensive evidenced-based literature to support this finding (Tab DD-167 to DD-196). Two mishap maintainers tested positive for amphetamines, but these results were adjudicated by an AFSOC Medical Review Officer to be negative due to legal prescriptions (Tab DD-199 to Tab DD-200).

d. Lifestyle

There is no evidence to suggest lifestyle factors were a factor in the mishap (Tab DD-3 and DD-5 to DD-64).

e. Crew Rest and Crew Duty Time

AFI 11-202v3 AFSOCSUP, *General Flight Rules*, 4 April 2023, paragraph 3.1, states, "Commanders and supervisors will ensure aircrew are provided a 12-hour rest opportunity prior to beginning the flight duty period (Tab AA-105). Crew rest is free time and includes time for meals, transportation, and an opportunity for at least 8 hours of uninterrupted sleep (Tab AA-105). Crew rest cannot begin until after the completion of official duties. Crew rest is compulsory for aircrew members prior to performing any duties involving aircraft operations and is a minimum of 12 non-duty hours before the flight duty period begins." (Tab AA-105). The 72-hour and 7-day histories of the MC indicate that each crewmember had the opportunity for at least 8 hours of uninterrupted sleep and there is no evidence to suggest inadequate crew rest was a factor in the

mishap (Tab DD-5 to DD-64). There were no 72-hour and 7-day histories performed on the maintenance members by the ISB or Safety Investigation Board (Tab AA-497 and AA-504).

10. OPERATIONS AND SUPERVISION

a. Operations

The operations tempo at the 20 SOS was relatively high with the unit supporting 49 above wing level events between January and August 2023 (Tabs V-7.18, V-13.4, V-14.6, and HH-3). Additionally, the unit had recently been tasked to deploy a Special Operations Task Unit (SOTU) requiring approximately one-third of the unit (Tab V-13.4, and V-14.6). MFE1, MFE 2, and MCP were originally slated to deploy with the SOTU, however MCP was pulled off the deployment due to a decrease in the needed number of crews (Tab V-6.16, V-8.10, and V-9.7). Both MFE1 and MFE2 needed events on the mishap sortie in preparation for their deployment (Tab V-8.3). In conjunction with the relatively high operations tempo, more than half of the squadron identified an unevenness in work-life balance, which was very low compared to other members within the Air Force (Tab HH-36 to HH-37). Additionally, nearly half of the officer corps within the squadron identified moderate to high stress levels (Tab HH-52 to HH-53). Lastly, members within the unit explicitly stated that both Bold Moves and Noncommissioned Officer Realignment Program resulted in the reduction of CV-22 crew member experience levels (Tab V-4.6 to V-4.7 and V-13.7). Although the above merits consideration, there is no evidence that the operations tempo was a factor in the mishap.

b. Supervision

Two days prior to the mishap, the mission was authorized by 20 SOS/ADO and a review of flight training records showed MAC, MCP, MFE2, and MFE3 were current and qualified to participate in the scheduled sortie (Tabs K-3, V-13.3, V-14.5, V-18.1 and Y-17). 20 SOS/ADO was 1 of 5 members of the unit designated as an AO and had the authority to authorize the mission (Tabs AA-698 to AA-701 and HH-69). MFE1 required an instructor for aerial gunnery and MFE3 filled that role (Tabs K-3 and Y-17). 20 SOS/DO approved the sortie on the day of the mishap based on the ORM worksheet (Tabs K-27 and V-13.6). The risk for the mission was identified on the high side of "low" (Tabs K-27 and V-13.6).

11. HUMAN FACTORS ANALYSIS

a. Introduction

The AIB considered all human factors relevant to this mishap, as prescribed in the Department of Defense (DoD) Human Factors Analysis and Classification System (HFACS) 8.0 (Tab AA-505 to AA-537). The DoD HFACS 8.0 is a framework that identifies potential areas of assessment during an accident investigation and lists potential human factors that can play a role in an aircraft mishap (Tab AA-507 to AA-508). A human factor is any environmental, technological, physiological, psychological, psychosocial, or psychobehavioral factor a human being experiences that contributes to, or influences, performance during a task (Tab AA-505 to AA-537).

The framework is divided into four main categories: Acts, Preconditions, Supervision, and Organizational Influences (Tab AA-510 to AA-537). Each category is subdivided further into related human factor subcategories (Tab AA-510 to AA-537). The main categories allow for a complete analysis of all levels of human error and demonstrate how such errors may interact together to contribute to a mishap (Tab AA-510 to AA-537). The AIB reviewed a substantial amount of evidence during its investigation, to include, but not limited to, cockpit voice recorder, transcripts, video recordings, and witness interviews. The human factors relevant to this mishap are defined below (Tab AA-505 to AA-537).

There was no recorded mechanical, electrical, hydraulic, or flight control system faults during the mishap sortie for the MA (Tabs D-3 to D-10 and U-3 to U-132). The following three human factors contributed to the mishap: Organizational Influences, there is no written standard for FE movement during critical phases of flight or a standard dictating the method to secure the NVG battery pack cable to aircrew helmets used in the CV-22B; Preconditions, the MC failed to perceive unintentionally pulling the right ECL off in the dark as a threat as there were no documented events in the past; Acts, due to performance and judgement errors, MFE1 unintentionally deactivated the right ECL while he was getting into the seat during a critical phase of flight (Tabs Z-89 to Z-93, AA-107 to AA-108, AA-575 to AA-654, and DD-65 to DD-84).

Figure 11-1. Human Factors Flowchart

Organizational Influences (Contributing Factor 1)	
Organizational Policy, Procedures or Process Issues OP000:	OP003 Provided Unclear, Impractical, or Inadequate Policy, Procedural Guidance:

↓

Preconditions (Contributing Factor 2)	
Mental Awareness Conditions PC100:	PC101 Inattention:
Adverse Physiological Conditions PC300:	PC314 inadequate Adaptation to Darkness:
Physical Environment PE100:	PE101 Environmental Conditions Affect Vision:
Technological Environment PE200:	PE201 Restrain System and/or Seat Problem and
	PE206 Workspace Limitations Affected by Performance:

↓

Acts (contributing Factor 3)	
Performance/Skill Based Errors AE100:	AE101 Unintended Deactivation:
	AE107 Rushed a Necessary Action:

↓

Mishap

b. Acts

Performance/Skill Based Errors AE100: Errors that occur when the aviator's execution of a routine or highly practiced task related to a procedure, training or proficiency was performed incorrectly and resulted in a mishap (Tab AA-509). MFE1 executed a routine task (moving into

the cockpit and FE seat) during a critical phase of flight (while the MA was transitioning from hover to forward flight) (Tabs R-16.3, Z-89 to Z-93, and AA-107 to AA-108).

(1) AE101 Unintended Activation or Deactivation: When an individual's movements inadvertently deactivate controls when there is not intent to do so and result in a mishap (Tab AA-510). MFE1's decision to enter the cockpit during a critical phase of flight resulted in the right ECL inadvertently being moved to the OFF position (Tabs Z-89 to Z-93 and AA-107 to AA-108).

(2) AE107: Rushed or Delayed a Necessary Action: When the mishap individual took the correct action as dictated by the situation but performed the action too quickly which resulted in the mishap (Tab AA-510). The error results from ineffective training related to movement during critical phases of flight (Tab AA-107 to AA-108). MFE1 was rushing to move into the FE seat during a critical phase of flight; specifically, the transition from hover to forward flight (Tabs Z-89 to Z-93 and AA-107 to AA-108). While not prohibited, movement during this phase of flight is not formally trained (Tabs V-11.5 and AA-107 to AA-108).

Judgement and Decision-Making Errors (AE200): When the individual pursued an inappropriate course of action after unintentionally failing to accurately assess a situation, which resulted in a mishap (Tab AA-511). MFE1 pursued an inappropriate course of action after unintentionally failing to accurately assess the situation by entering the cockpit during a critical phase of flight; specifically, the transition from hover to forward flight (Tabs N-75 and AA-107 to AA-108).

(1) AE201 Inadequate Real-Time Risk Assessment/Action: When the mishap individual through inexperience proceeded with the wrong course of action based by misjudging the situation on an ineffective real-time assessment of immediate hazards during execution of a task, which resulted in a mishap (Tab AA-511). MFE1 through inexperience, proceeded with the wrong course of action based on an effective real-time assessment of a hazard during execution of movement to the FE seat during a critical phase of flight by misjudging changes in the surrounding environment (Tabs N-75, Z-89 to Z-93, and AA-107 to AA-108).

c. Preconditions

Mental Awareness Conditions PC100: When the mishap individual experienced a failure in attention management which negatively affected the mishap individual's perception and resulted in an unsafe act (Tab AA-512 and AA-513). MFE1 failed to perceive the threat of unintentionally moving an ECL to the OFF position while entering the FE seat as there is no record of this happening before (Tabs V-6.6 and Z-89 to Z-93).

(1) PC101 Inattention: When the mishap individual did not maintain a state of situational awareness to properly act upon available information, resulting in an unsafe act (Tab

AA-512 and AA-513). This may have been due to a perceived absence of threat from the environment (Tab AA-512 and AA-513). MFE1 failed to perceive the threat of unintentionally moving an ECL to the OFF position while entering the FE seat as there is no record of this happening before (Tabs V-6.6 and Z-89 to Z-93).

Adverse Physiological Conditions PC300: When an individual experienced a physiologic condition that compromised performance and resulted in a hazardous condition (Tab AA-515). MFE1's NVGs had just been deactivated, which did not permit his eyes enough time to adjust to the darkness (Tab DD-65 to DD-84). As MFE1 transitioned to the FE seat, he would have been limited in his ability to properly discern his surroundings (Tabs F-3 and DD-65 to DD-84).

(1) PC314 Inadequate Adaptation to Darkness: When dark-adaptation negatively affected the individual's performance and resulted in a hazardous condition (Tab AA-517). MFE1's NVGs had just been deactivated, which did not permit his eyes enough time to adjust to the darkness (Tabs V-6.23 and DD-65 to DD-84). As MFE1 transitioned to the FE seat, he would have been limited in his ability to properly discern his surroundings (Tabs F-3 and DD-65 to DD-84).

Physical Environment PE100: Conditions related to the immediate physical surrounding which negatively affect individual performance, resulting in an unsafe act (Tab AA-518 to AA-519). The sortie was at night with low illumination requiring the MC to utilize NVGs (Tab W-11).

(1) PE101 Environmental Conditions Affect Vision: When conditions such as lighting/illumination impeded clear viewing or vision that resulted in a hazardous condition (Tab AA-519). MFE1's NVGs had just been deactivated, which did not permit his eyes enough time to adjust to the darkness (Tabs V-6.7 and DD-65 to DD-84). As MFE1 transitioned to the FE seat, he would have been limited in his ability to properly discern his surroundings (Tabs W-11 and DD-65 to DD-84). MAC and MCP were wearing their NVGs during MFE1's transition into the cockpit and FE seat (Tabs R-7.3 and DD-65 to DD-84). Due to the darkness inside the MA and the location of the ECLs, MAC and MCP failed to recognize the right ECL was moved out of FLY (Tabs V-6.7, W-11 and DD-65 to DD-84).

Technological Environment PE200: When workspace design conditions result in an unsafe act (Tab AA-520). The MA's ECLs are located at the top center of the cockpit and are 57 inches from the floor (Tab Z-89 and Z-91). The FE seat folds down and spans 28 inches wide and 23 inches long in the cockpit entryway (Tab Z-89).

(1) PE201 Restrain System and/or Seat Problem: When the design of a seat impeded occupant performance, which resulted in an unsafe act (Tab AA-520). The FE seat is in a narrow portion of the cockpit requiring the FE to contort their body to take a seat and secure their restraints safely (Tab Z-89). This combined with the MFE1's height of 75 inches fully dressed out, weighing 240 pounds, and the location of the

ECLs created an environment conducive to inadvertent ECL movement (Tabs Z-23, Z-87 to Z-93, EE-4 to EE-10, and EE-15 to EE-27).

(2) PE206 Workspace Limitations Affected by Performance: When conditions of a workspace configuration/design negatively affect performance, which resulted in an unsafe act (Tab AA-521). The FE seat is in a narrow portion of the cockpit requiring the FE to contort their body to take a seat and secure their restraints safely (Tab Z-89). This combined with the MFE1's height of 75 inches fully dressed out, weighing 240 pounds, and the location of the ECLs created an environment conducive to inadvertent ECL movement (Tabs Z-23, Z-87 to Z-93, EE-4 to EE-10, and EE-15 to EE-27).

d. Supervision

This section does not apply (Tab AA-523).

e. Organizational Influences

Organizational Policy, Procedures or Process Issues OP000: Latent failures whereby flaws in an organization's safety management system to include standards, policies, and procedural guidance (Tab AA-529 to AA-530). There is no written guidance dictating FE movement during critical phases of flight (Tab AA-107 to AA-108). There is no written standard dictating the method to secure the NVG battery pack cable to aircrew helmets for CV-22 flight (Tab AA-578 to AA-579).

(1) OP003 Provided Unclear, Impractical, or Inadequate Policy, Procedural Guidance: When written standards/checklists for normal or abnormal/emergency conditions are incorrect or ineffectively disseminated for safe operations throughout the organization resulting in hazardous conditions or unsafe acts throughout the field (Tab AA-530). There is no written guidance dictating FE movement during the critical phases of flight (Tab AA-107 to AA-108). There is no written dictating the method to secure the NVG battery pack cable to aircrew helmets for CV-22 flight (Tab AA-578 to AA-579).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publicly Available Directives and Publications Relevant to the Mishap

(1) AFI 51-307, *Aerospace and Ground Accident Investigations,* 18 March 2019

(2) DAFI 91-204, *Safety Investigations and Reports,* 10 March 2021, Air Force Special Operations Command, *Supplement*, 18 October 2021

(3) DAFMAN 11-401, *Aviation Management*, 14 December 2020, Air Force Special Operations Command, *Supplement*, 7 January 2022

(4) AFI 13-217, *Drop Zone and Landing Zone Operations*, 10 May 2007, Air Force Special Operations Command, *Supplement*, 20 February 2020

(5) AFMAN 11-2CV-22, Volume 3, *CV-22 Operations Procedures,* 13 September 2021

(6) AFI 21-101, *Aircraft and Equipment Maintenance Management,* 16 January 2020, Air Force Special Operations Command, *Supplement,* 24 November 2020

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

b. Other Directives and Publications Relevant to the Mishap

(1) Combat Fundamentals CV-22, Air Force Tactics, Techniques, and Procedures 3-3.CV-22, 11 February 2022

(2) TM 12S10-2AVS9-2, Image Intensifier Set, Night Vision, Type AN/AVS-9, 18 May 2023

(3) 2J-T-AE1107C-523, Accessory Change No. 1940, 28 April 2023

(4) IV-22(c)B-2-DB-1, 13 October 2023

(5) TM 33-1-37-3, Joint Oil Analysis Program Manual, Volume, Laboratory Analytical Methodology and Equipment Criteria (Aeronautical), 30 April 2018, *incorporating change 3*, 15 June 2022

(6) TO 00-20-1, *Aerospace Equipment Maintenance Inspection Documentation, Policies and Procedures,* 6 September 2019

(7) Quattro's SGP-earls, *updated* August 2022

(8) DoD HFACS 8.0, *Human Factors Analysis and Classification System*, 25 May 2022

(9) 20th Special Operations Squadron, CV-22 Standard Operating Procedures, 1 May 2012

(10) 20th Special Operations Squadron, CV-22 Osprey Inflight Guide, 31 January 2023

(11) A1-V22AC-AFM-000/1V-22(C) B-1, *NATOPS Flight Manual, CV-22 Tiltrotor,* 15 October 2022

(12) A1-V22AC-AFM-500/1V-22(C) B-1CL-1, *NATOPS Pilot/Engineer Pocket Checklist, CV-22 Tiltrotor,* 15 October 2022, *Incorporating Change IC 33*, 20 December 2022

(13) A1-V22AC-AFM-510/1V-22(C) B-1CL-2, *NATOPS Scanner's Flight Crew Pocket Checklist, CV-22 Tiltrotor,* 15 October 2022, *Incorporating change IC 4*, 10 February 2022

(14) A1-V22AC-AFM-000/1V-22(C) B-1-1, *NATOPS Flight Manual Performance Data Supplement, CV-22 Tiltrotor,* 15 February 2021, *Incorporating change*, 1 December 2022

c. Known or Suspected Deviations from Directives or Publications

(1) TO 1V-22(C)B-1, *NATOPS FLIGHT MANUAL, CV-22B TILTROTOR*, 15 Oct 22, page 4-48

(2) AFI 13-217 AFSOCSUP, DROP ZONE AND LANDING ZONE OPERATIONS, 20 February 2020, paragraphs 3.14, 3.18-3.20

As the MC established a hover on the west edge of Jockey with a heading of 270-degrees at 150 ft AGL, MAC noted the winds measured by the MA and displayed to the MC to be approximately from 130-degrees at 8 knots. Several minutes earlier the MA measured the winds to be from approximately 115-degrees at 15 knots. This measurement was taken while the aircraft was in straight and level, non-accelerating flight with nacelles while in airplane mode; these conditions provide for a more accurate estimate of winds. Per 1V-22(C)B-1, Airspeed Limits for Flight at 85-degree Nacelle and Above, the MC were operating the MA in a published avoid region. Crews are directed to limit exposure to winds in avoid regions to brief transient periods. Winds in the avoid region off the tail can degrade handling qualities and increase pilot workload to control aircraft pitch, roll, and yaw. Strong tail winds also increase the time required to accelerate to a safe airspeed in the event of the loss of an engine.

The MC did not review the HLZ survey for Corvette HLZ during the pre-mission crew brief or prior to utilizing Corvette HLZ prior to the mishap. Corvette HLZ had been closed since 13 May 2023 after the expiration of the survey.

DUBE.PATRICK Digitally signed by DUBE.PATRICK.

15 December 2023

PATRICK J. DUBE
Colonel
President, Accident Investigation Board

STATEMENT OF OPINION

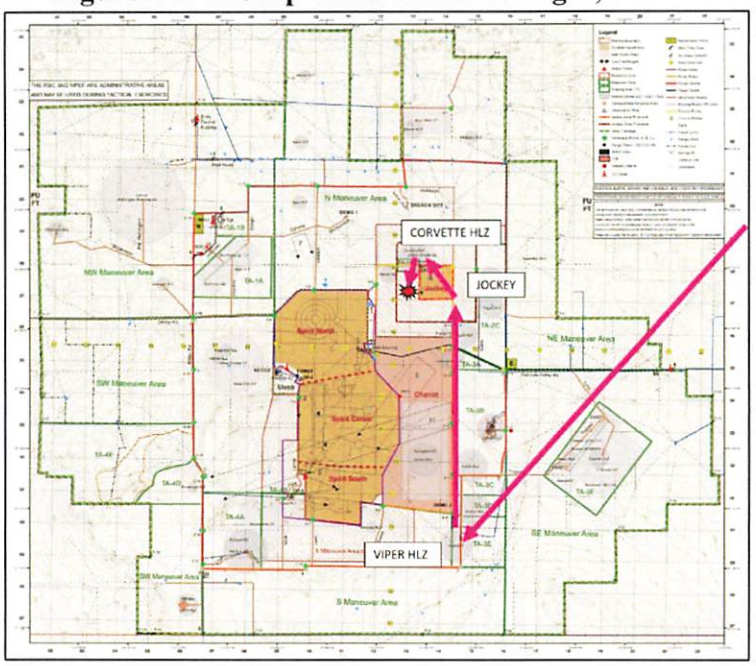
CV-22B, T/N 17-0077
MELROSE AIR FORCE RANGE, NM
22 AUGUST 2023

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

1. OPINION SUMMARY

On 22 August 2023, at approximately 2129 Mountain Standard Time (MST), while transitioning from a hover to forward flight, the mishap aircraft (MA), a CV-22B, Tail Number (T/N) 17-0077, lost power from the right engine and crashed on its belly with the landing gear up. The incident occurred on Melrose Air Force Range (MAFR), New Mexico, west of the Jockey impact area (figure 1-1). The MA was assigned to the 27th Special Operations Wing (27 SOW) at Cannon Air Force Base (AFB), New Mexico. The mishap crew (MC) was assigned to the 20th Special Operations Squadron (20 SOS). The MC consisted of the Mishap Aircraft Commander (MAC), the Mishap Copilot (MCP), Mishap Flight Engineer 1 (MFE1), Mishap Flight Engineer 2 (MFE2), and Mishap Flight Engineer 3 (MFE3). There was no damage to civilian property or any fatalities, however one MC member required emergent evaluation. MFE1 was transported to a local civilian hospital for evaluation after striking his head on the center display unit (CDU) during the initial impact and was subsequently released early the next morning.

Figure 1-1. Mishap Sortie Route of Flight, MAFR



The MC were accomplishing a local training sortie to complete a flight evaluation for MFE2, aerial gunnery recurrency for MFE1, and supporting Joint Tactical Air Controllers (JTACs) during an exercise on MAFR. The MC departed Cannon AFB, inserted the JTACS at Viper helicopter landing zone (HLZ), completed simulated alternate insertion/extraction (AIE) training at Corvette HLZ, and then proceeded to Jockey. The MA came to a hover at 150 feet (ft) above ground level (AGL) on the west edge of Jockey while MFE1, MFE2, and MFE3 completed night vision goggle (NVG) aerial gunnery training. After shooting, MFE1 began transitioning back into the Flight Engineer (FE) seat in the cockpit between the MAC and MCP. While doing so, the loop of MFE1's NVG battery cable caught on the right engine control lever (ECL), pulled the ECL from the FLY position to the OFF position, and shut off the right engine. Simultaneously, the MA began a transition from hover to forward flight and the aircraft experienced a loss of lift and received a sink rate warning. The aircraft descended from 190 ft AGL at a rate approaching 1,500 ft per minute (FPM) and impacted the ground with the landing gear up 100 meters west of Jockey. The MA bounced then skidded to a stop (figure 1-2). The MA traveled approximately 360 ft from the first point of impact to the final resting point. The MC performed an emergency shutdown and egressed the MA.

Figure 1-2. CV-22B, T/N 17-0077 Crash Site

I find by a preponderance of the evidence the cause for the mishap is attributed to MFE1 unintentionally and unknowingly shutting down the right engine by his NVG battery cable looping over the knob of the right ECL, and moving it from the FLY to OFF position while attempting to sit down in the FE seat. The MA did not have enough forward air velocity or altitude to continue flight with one engine inoperative. Additionally, I find by a preponderance of the evidence the following factors substantially contributed to the mishap: (1) MAC failed to guard the ECLs, (2) Inattention of the aircrew during a critical phase of flight, (3) Failure of real-time risk assessment, and (4) Lack of procedural guidance.

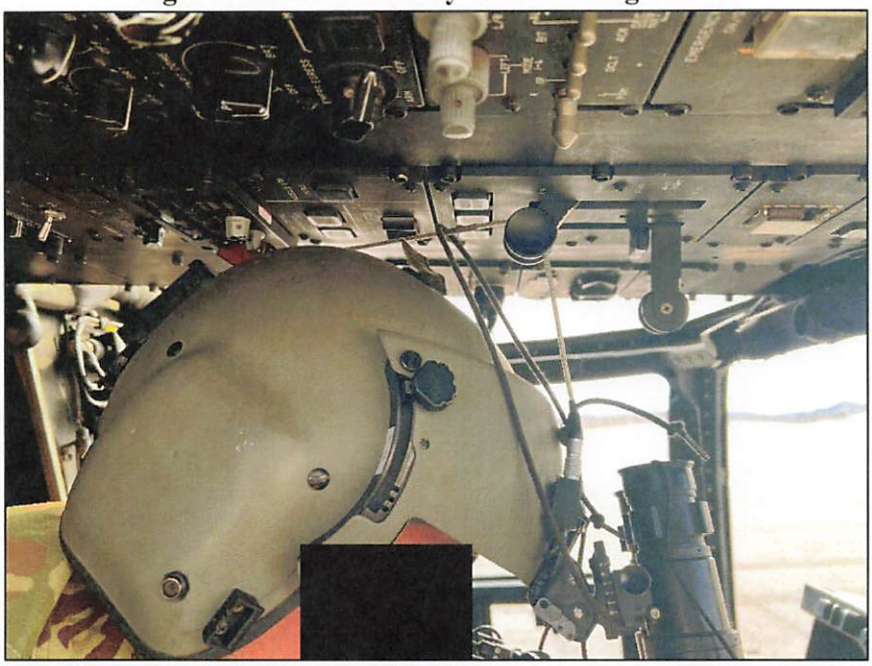
I developed my opinion by analyzing available flight data from the Vibration Structural Life and Engine Diagnostics (VSLED), Flight Data Recorder, Cockpit Voice Recorder, the mishap animation, witness testimony, engineering analysis, Air Force directives and guidance, and Air Traffic Control and MAFR audio recordings. Additionally, the AIB's pilot member used the CV-22B Weapon Systems Trainer (WST) simulator to recreate the mishap as well as fly multiple scenarios.

2. CAUSE

a. MFE1's NVG Battery Pack Cable Shut Down the Right Engine

I find by a preponderance of the evidence the mishap was caused by MFE1 when he unintentionally snagged the right ECL with the NVG cable looped over the top of his helmet and unknowingly pulled the right ECL from FLY to OFF and shut down the right engine (Figure 2-1).

Figure 2-1. NVG Battery Cable on Right ECL



While bending forward, the low-profile battery pack cable on MFE1's helmet caught the right ECL. At 2129:26 MST, as MFE1 attempted to sit down and the MA was at 190 ft AGL and 20 knots ground speed (airspeed was too low to register), the right ECL was moved backwards out of the FLY position to the OFF position within 0.5 seconds. His movement caused the ECL to bypass two detents, and commanded the right engine to perform a controlled shutdown. With the loss of engine power, the MA was unable to generate enough thrust to maintain altitude and began to descend. MCP noticed their Vertical Velocity Indicator (VVI) was starting to show the descent and moved the thrust control lever (TCL) to the full forward position to command full power from the MA. With a single engine, the MA was only able to develop 53% mast torque (Qm), significantly less than the 76% Qm previously required to maintain the hover and the descent rate continued to increase. As the descent rate increased and passed 600 FPM, the MC heard the aural "Sink Rate" warning at 2129:28 MST. The MCP announced to the MC that "Power's all in. Power's all in, bird's coming down", which verified to the crew that they were commanding full power from the MA and was unable to arrest the descent. The MA stabilized in a 1,200 FPM descent towards the ground. As the MA approached 30 ft AGL, the MAC called "power…power…power" as he moved his hand to the TCL to ensure that it was full forward and the MCP confirmed "power's full in." MAC pulled the cyclic aft in an attempt to reduce forward airspeed at approximately 10 ft AGL; this and the aircraft entering ground effect caused the descent rate to decrease to approximately 800 FPM just prior to impact with the ground.

The MA made first impact with the ground at approximately 2129:37 MST just west of Jockey. The MA impacted with 40 knots ground speed on a 272-degree heading with the nacelles at 78-degrees and 10-degrees nose up with the wings near level. The impact of the MA ramp on the ground caused both ramp hydraulic actuators to bend and the mount to the left actuator on the ramp

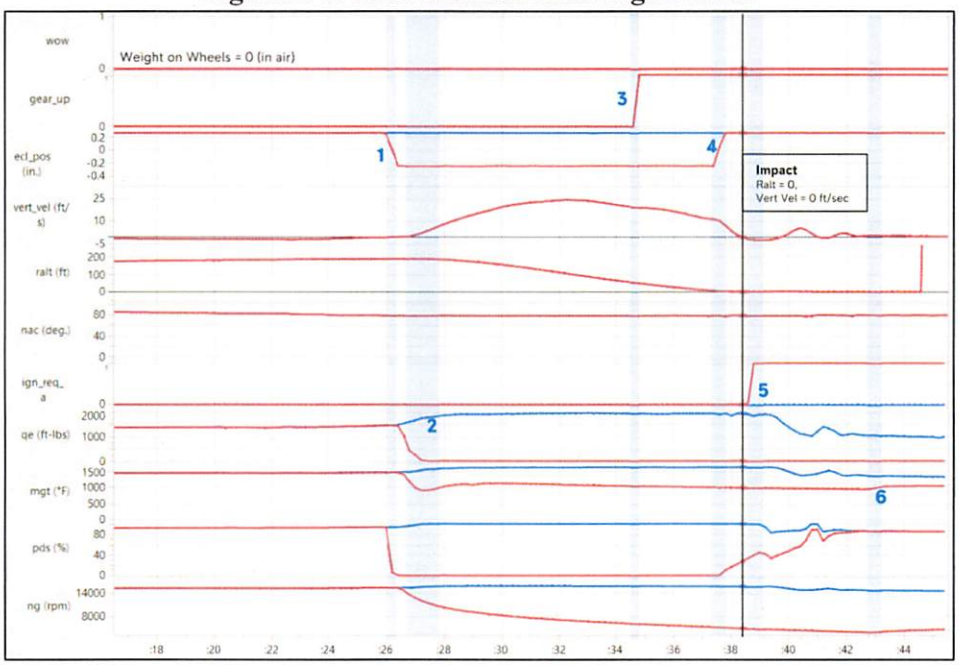
side to break. The right vertical stabilizer and right nacelle also contacted the ground and received light damage. As the MA made initial impact with the ground, the ECL was moved forward into the FLY position within 0.2 seconds as MFE1, still snagged on the ECL, was thrown forward. MFE1's forward momentum ripped the NVG battery cable out of the NVG mount connector port on the front of his helmet as the ECL reached the forward stop. The movement of the ECL to the FLY position commanded the right engine to restart, as recorded by VSLED. The MC reduced the TCL to the full aft position just before the MA "skipped" once across the ground before making a second larger and final impact. The antennae, lights, nose landing gear doors, and the Forward-Looking Infrared (FLIR) turret positioned on the bottom of the MA were crushed, destroyed, and spread along the skid path. The jolt caused by the impact with the ground caused MAC or MCP to inadvertently apply full right pedal for approximately 3 seconds, causing the MA to begin right yaw 50 ft after the first impact point. Part way through the rotation, the FLIR turret separated from the MA and came to rest 20 ft from the nose of the MA and the right main landing gear door was damaged and pulled away from the drag strut. The MA came to a full stop approximately 360 ft away from the initial impact point and on a 051-degree heading, 139-degrees right of its initial heading (Figure 2-2).

Figure 2-2. Mishap Aircraft Skid Path

All MC members were interviewed numerous times and questioned about what they recalled from the mishap. MAC and MFE1 stated the ECL did not move out of the FLY position; MCP, MFE2, and MFE3 had no knowledge of the ECL movement. MCP was focused outside the cockpit on the approaching ground, on the controls attempting to fly the aircraft, and unsure of the cause of loss of lift. MFE2 and MFE3 heard the sink rate warning, observed the rush of the ground and braced for impact. The testimonies from MAC and MFE1 do not match with physical and electronically recorded evidence. MAC and MFE1's testimonies stated MAC raised his right hand

to check that the ECLs were fully forward in the fly position following the sink rate warning. MFE1 stated he did the same immediately following MAC. VSLED data and audio recordings indicate that the right ECL was pulled to the OFF position as MFE1 moved into the FE seat and remained in the OFF position until the first impact with the ground. VSLED data shows the exact position of the ECL and displayed the expected indications on the engine during a commanded shutdown through manipulation of the ECL (Figure 2-3). The flight deck microphone captured the audible click of the ECL as it traveled to the OFF position and corresponds with the VSLED data. There are no indications or warnings in the CV-22 when an ECL is moved to OFF while in flight. All evidence and technical analysis shows that the MA and all subsystems, including the Engine Control Panel, engine, and Flight Control systems, were fully functional and operating normally at the time of the mishap and that this was not a mechanical error but rather a human error.

Figure 2-3. ECL Position and Engine Data



Evidence shows MFE1 remained snagged on the ECL throughout the mishap sequence. After MFE1 inadvertently and unknowingly shut down the engine, he froze and fixated on the VVI after hearing the sink rate warning. VSLED data shows the exact timestamp of the movement back into FLY and the engine instrumentation as the engine began its start sequence.

MFE1 was not secured in the FE seat and was thrown forward on impact while his NVG battery pack cable was snagged on the ECL, moving the ECL back into the FLY position 0.25 seconds after initial impact with the ground. This resulted in his head and neck being yanked backwards to the extreme of flexion and extension, as documented by his immediate and follow-up medical treatment after the mishap. After the NVG battery pack cable broke, MFE1's forward momentum forced him to slam his face into the CDU. Medical testimony and aviation psychologist testimony

point to the likelihood of a concussion and memory lapse of the event. Engineering analysis found that MFE1's NVG low-profile battery pack cable was ripped from the NVG mount connector port with pieces of the cable connector found within the port (Figures 2-4 and 2-5). Analysis of the right ECL found adhesive residue within the narrow channel of the knob that was consistent with adhesives found on items commonly used by aircrew (i.e., tape, hook and pile tabs).

MFE1's testimony supports the evidence of remaining snagged on the ECL. FEs in the CV-22 focus on the instrumentation inside the cockpit when transitioning in and out of a hover and routinely call out VVI readings and altitudes to the pilots. In the moments leading up to the mishap, MFE1 did not make any callouts to the pilots. His testimony stated he stared at the VVI and their rate of descent which was between 1,300-1,500 FPM. He was fixated on their rate of descent but said nothing to the crew. In his testimony, MFE1 did not recall looking at anything other than the VVI on MAC's multifunction display. The lack of MFE1's verbal callouts was abnormal and combined with his sole recollection of only the VVI supports that he froze and fixated on the VVI while snagged on the right ECL.

Figure 2-4. Broken NVG Connector

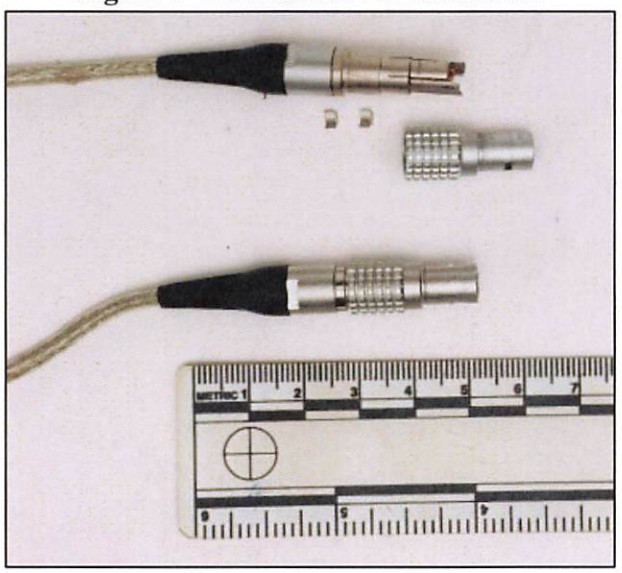
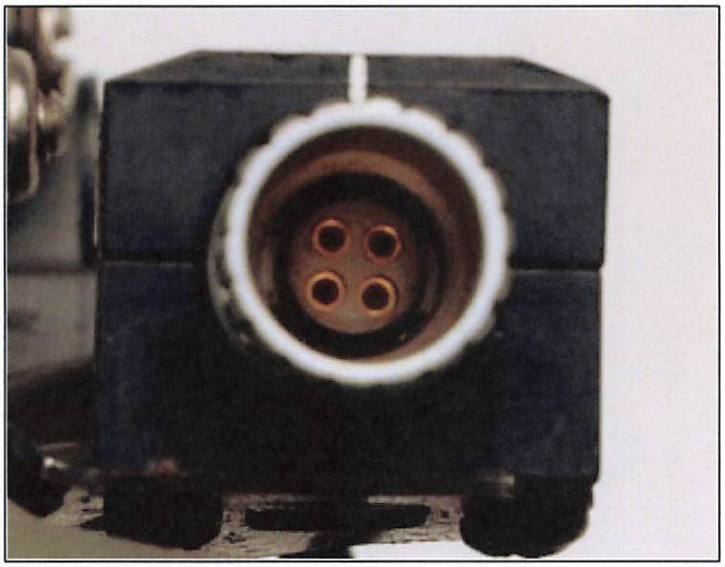


Figure 2-5. Broken NVG Connector Pieces in NVG Mount Port



The AIB pilot member ran multiple simulations in a CV-22 WST recreating the accident (Figure 2-6). Had the ECL been returned to the FLY position at any time prior to impact, it alone would not have prevented the mishap. Engine restart time requirements and limitations would have prevented the engine from providing useful power until the MA was already unrecoverable. The only variables that the AIB found that would have prevented impact with the ground were to begin at a higher altitude AGL, a higher forward airspeed, or have a headwind component of at least 10 knots.

Figure 2-6. Simulator Recreation, ECL to OFF in Hover

Combined, these facts provide by a preponderance of the evidence that MFE1 inadvertently pulled the ECL to the OFF position with the NVG cable on his flight helmet while getting into the FE seat. There is no evidence to support the claim by MAC and MFE1 that they checked the ECL during the mishap sequence.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

a. MAC Failed to Guard the ECLs

MAC failed to guard the ECLs while MFE1 was transitioning into the FE seat. The failure to guard the ECLs allowed MFE1's NVG cable to snag the right ECL and subsequently shut off the engine. In numerous interviews with experienced FEs and pilots, they affirmed that the non-flying pilot will often guard the ECLs when both pilots and FEs are getting into their seats while in flight. MAC acknowledged hearing the technique of guarding the ECLs when pilots get in their respective seats and only ever guarded the ECLs when a pilot was performing a seat swap in flight, not FEs. Additionally, all interviewed experienced CV-22 aviators and MC knew the potential of snagging an ECL. However, no one interviewed confirmed this has ever occurred in flight. I find by a preponderance of the evidence that the MAC failing to guard the ECLs substantially contributed to the mishap.

b. Inattention of the Aircrew During a Critical Phase of Flight

Although critical phases of flight are not clearly defined in Department of the Air Force Instructions (DAFI) or Air Force Tactics, Techniques, and Procedures (AFTTP), CV-22 aircrew generally define the following events as critical phases of flight: takeoff, landing, terrain following low-level, tiltrotor air-to-air refueling, and hover operations. Hover operations are considered a critical phase of flight as it generally falls within a flight regime where the loss of a single engine will result in the aircraft being unable to maintain flight. The combination of insufficient power available from the remaining engine and low forward air velocity results in a descent towards the ground. Hover operations may include AIE, helocast, gunnery, and slow flight. In the case of the MA, the accident occurred during hover operations. The crew decided to hover on the west end of Jockey to complete aerial gunnery. MFE3, who served as both an instructor and evaluator during the mission, made the recommendation to MAC to fire from a hover. The recommendation was made to decrease the amount of time necessary to adequately complete gunnery training and continue with the mission profile. Hover fire was not preplanned or briefed by the MC.

Hover firing, although permitted by DAFI and AFTTP, is not the most utilized employment method. However, the size limitation of Jockey can necessitate hover firing when training timelines are compressed. After the crew completed gunnery training, they were in a low energy state and below a safe airspeed for operating with a single engine. Matters were complicated more by MFE1 deciding, and MAC allowing, MFE1 to get into the seat engineer position during this critical phase of flight. MAC and MFE1 did not maintain a state of situational awareness to properly act upon available information, resulting in an unsafe act. The unsafe act was MFE1 getting into the seat while below a safe single engine airspeed. He could have performed his seat engineer duties while standing in the tunnel, just aft of the FE seat position, until the aircraft was above a safe single engine airspeed.

Additionally, both MAC and MFE1 failed to perceive the threat of unintentionally pulling the right ECL to the OFF position during movement into the seat due to inattention. I find by a preponderance of the evidence that MFE1's inattention of the proximity of his helmet with the ECLs combined with the lack of awareness that his helmet was snagged on the right ECL was a substantially contributing factor to the mishap.

c. Failure of Real-Time Risk Assessment

Failure of real-time risk assessment by MAC and MFE1 was evident in the act of MFE1 getting into the seat during a critical phase of flight. Both members should have foreseen this and waited for the position change until above a safe single engine airspeed. Both MAC and MFE1 displayed ineffective risk assessment of the criticality of the ECL when an engineer is entering the flight deck. Although MAC stated he knew the technique of guarding the ECLs when pilots are performing a seat swap, he did not do so while MFE1 was getting into the seat. Additionally, MFE1 failed to assess the risk of snagging his helmet on the ECL.

During the pre-mission briefing on the day of the mishap, MAC identified winds that could affect mission operations during the sortie. MAC expected winds at MAFR to be 125-degrees at 15 knots and trending to 140-degrees at 15 knots. Prior to starting aerial gunnery, the MC had ample opportunities to note the actual wind conditions on the range, as the system is most accurate when level and in airplane mode and unreliable with nacelles above 60-degrees. Aircraft systems captured the winds prior to the mishap at 115-degrees at 15 knots while in airplane mode. The crew had a left quartering tailwind and thought the tailwind was 8 knots overall when in fact the tailwind component alone was approximately 14 knots. This placed the MA within the published tailwind avoid region. Crews may operate within an avoid region, but they are directed to limit exposure to brief transient periods and reduce aggressive maneuvering; the MC spent four minutes hovering within this avoid region and was not transitory. MAC failed to assess or acknowledge the actual winds while hovering. This failure of real-time risk assessment by MAC is a contributing factor to the mishap. Although the MAC could have directed a slight heading change while in the hover to stay within prescribed limitations, this would have kept a higher risk level for hover operations. During simulation recreation runs in the WST, the AIB pilot member was able to effectively recover the aircraft and prevent a crash after the right ECL was placed in OFF when the aircraft did not have a tailwind component.

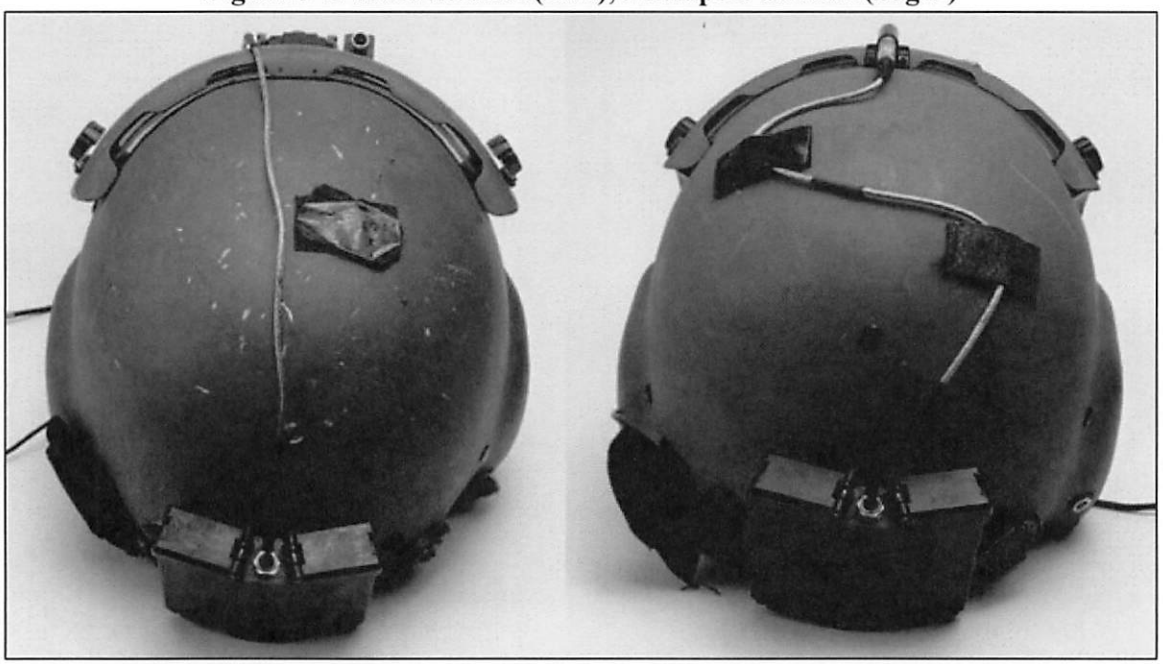
I find by a preponderance of the evidence that the real time risk assessment of the MC was a substantially contributing factor to the mishap.

d. Lack of Procedural Guidance

There are several areas that lack procedural guidance which are substantially contributory to the mishap. Position changes in the aircraft are a necessity, however there is no DAFI or AFTTP guidance that mandates procedures or risk mitigation factors while doing so during a critical phase of flight. Additionally, there are no documented techniques or procedures for guarding critical

components during seat swaps. Through various interviews, it is evident CV-22 aircrew members are exposed to various techniques for guarding critical components, but there is not a set standard nor procedures explaining how, what, or when to guard. More experienced aircrews routinely guard the TCL and ECLs, but as experience wains in younger aircrew, these techniques are less widely shared, learned, and incorporated into daily flight operations. Lastly Technical Order (TO) 12S10-2AVS9-2, *Image Intensifier Set Night Vision, Type AN/AVS-9*, provides guidance to life support technicians on how to install night vision goggle equipment on aircrew helmets. However, there is no specific guidance or direction to tack or stow excess NVG battery cable slack on the helmet. The TO includes a note that states, "units may use sticky back hook/pile tape to stow excess low profile battery pack cable on the top of the helmet to prevent the potential snagging of the cable." Additionally, the note in the TO specifically identified the snagging hazard of the battery cable. On inspection of multiple aircrew helmets within the unit of the MC the board found various configurations of hook/pile tape. No two helmets were configured the same; some had one piece of hook/pile tape, while others had two, and others had none (Figure 3-1). MFE1's helmet only had one piece of hook/pile tape and the length of excess cable protruding from the top of the helmet enabled the helmet to snag the ECL. I find by a preponderance of the evidence that the lack of procedural guidance is a substantially contributing factor to the mishap.

Figure 3-1. MFE Helmet (Left), Exemplar Helmet (Right)



4. CONCLUSION

I find by a preponderance of the evidence the cause for the mishap is attributed to MFE1 unintentionally and unknowingly shutting down the right engine. MFE1 sat down with his NVG battery cable hooked on the ECL and the aft movement pulled the ECL from the FLY position to the OFF position which commanded the right engine to shut down. The MA did not have enough

forward velocity or altitude to continue flight with one operative engine. Additionally, I find by a preponderance of the evidence the following factors substantially contributed to the mishap: (1) MAC failed to guard the ECLs, (2) Inattention of the aircrew during a critical phase of flight, (3) Failure of real-time risk assessment, and (4) Lack of procedural guidance.

DUBE.PATRICK Digitally signed by DUBE.PATRICK.

15 December 2023

PATRICK J. DUBE
Colonel
President, Accident Investigation Board

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