ACTION OF THE CONVENING AUTHORITY

The report of the accident investigation board, conducted under the provisions of AFI 51-307, that investigated the 29 November 2023 mishap near Yakushima, Japan, involving CV-22B, T/N 10-0054, assigned to the 353d Special Operations Wing, Kadena Air Base, Japan, complies with applicable regulatory and statutory guidance and on that basis is approved.

TONY D. BAUERNFEIND
Lieutenant General, USAF
Commander

6 JUN 24
Date

UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

CV-22B, T/N 10-0054

21st SPECIAL OPERATIONS SQUADRON
353rd SPECIAL OPERATIONS WING
YOKOTA AIR BASE, JAPAN

LOCATION: YAKUSHIMA ISLAND, JAPAN

DATE OF ACCIDENT: 29 NOVEMBER 2023

BOARD PRESIDENT: BRIGADIER GENERAL MICHAEL E. CONLEY

Conducted IAW Air Force Instruction 51-307

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION

CV-22B, T/N 10-0054
YAKUSHIMA ISLAND, JAPAN
29 NOVEMBER 2023

On 29 November 2023, at approximately 1440 local time (L), mishap aircraft (MA), a CV-22B aircraft, tail number (T/N) 10-0054, impacted the water approximately one-half mile off the coast of Yakushima Island, Japan, while participating in a joint inter-operability exercise. The MA was operated by the 21st Special Operations Squadron (21 SOS), 353rd Special Operations Wing (353 SOW), Yokota Air Base (AB), Japan. The eight-member Mishap Crew (MC) included five CV-22B aircrew members from the 21 SOS, one Direct Support Operator (DSO) from the 43rd Intelligence Squadron, Detachment 1, Yokota AB, Japan, and two medical personnel from the 1st Special Operations Squadron (1 SOS), Kadena AB, Japan. The MA was destroyed and all crewmembers sustained fatal injuries upon impact. The remains of seven crewmembers were recovered in the subsequent search and recovery. The remains of the eighth crewmember were not recovered, despite an extensive 43-day, multi-national search.

The MC aborted their planned mission after multiple advisories and a caution displayed in the MA cockpit, indicating a "Land as Soon as Possible" condition. The MC diverted towards Yakushima Airport (RJFC) located approximately 60 miles east of the MA's position. While on final approach to the runway, at approximately 800 feet above ground level (AGL), the MA experienced a sudden materiel failure that put the MA into an immediate left roll, resulting in the MA rolling twice and impacting the water.

The Accident Investigation Board (AIB) President (BP) found, by a preponderance of the evidence, the mishap was caused by a catastrophic failure of the left-hand Proprotor Gearbox that created a rapidly cascading failure of the MA's drive system, resulting in an instantaneous asymmetric lift condition that was unrecoverable by the MC. The BP further found, by the preponderance of evidence, Mishap Pilot's (MP) decisions were causal, as they prolonged the mishap sequence and removed any consideration of an earlier landing at a different divert location.

In addition, the BP found, by the preponderance of the evidence, the following factors substantially contributed to the mishap: (1) Inadequate Risk Management; and (2) Ineffective Crew Resource Management. These factors, when considered together, substantially contributed to an insufficient sense of urgency throughout the entire mishap sequence, beginning with the first PRGB cockpit advisory approximately 49 minutes prior to aircraft impact.

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 by the United States or by any person referred to in those conclusions or statements.

SUMMARY OF FACTS AND STATEMENT OF OPINION
CV-22B, T/N 10-0054
YAKUSHIMA ISLAND, JAPAN
29 NOVEMBER 2023

ACRONYMS AND ABBREVIATIONS

A1C	Airman First Class
A3	Operations
A4	Logistics, Engineering & Force Protection
AB	Air Base
AC	Aircraft Commander
ACC	Air Combat Command
ACC	Awaiting Component Change
ACWS	Aircraft Caution Warning System
ADAPT	Alcohol Drug Abuse Prevention and Treatment
ADCC	Assistant Dedicated Crew Chief
ADCON	Administrative Control
ADO	Assistant Director of Operations
AFB	Air Force Base
AFCMRS	Air Force Combined Mishap Reduction Survey
AFE	Aircrew Flight Equipment
AFETS	Air Force Engineering and Technical Services
AFI	Air Force Instruction
AFIS	Aerodrome Flight Information Service
AFMAN	Air Force Manual
AFRL	Air Force Research Laboratory
AFSEC	Air Force Safety Center
AFSOC	Air Force Special Operations Command
AFTO	Air Force Technical Order
AIB	Accident Investigation Board
AIE	Alternate Insertion Extraction
AMC	Airborne Mission Commander
AMC	Air Mobility Command
AMU	Aircraft Maintenance Unit
AO	Action Officer
AO	Authorizing Official
APU	Auxiliary Power Unit
ARCT	Air Refueling Time on Target
ARD	Aircraft Reported Discrepancies
ARMS	Aviation Resource Management
ASD	Average Sortie Duration
ATC	Air Traffic Control
AVI	Avionics
BP	Board President
BPO	Basic Post-Flight
Capt	Captain
CASEVAC	Casualty Evacuation
CAUT	Caution
CDC	Career Development Courses
CDU	Control Display Unit
CENTCOM	Central Command
CFM	Career Field Manager
CHUB	Chart Update Bulletin
Col	Colonel
CONOP	Concept of Operations
CRM	Crew Resource Management
CSAR	Combat Search and Rescue
CSARTE	Combat Search and Rescue Task Element
CSS	Commander Support Staff
CST	Combat Survival Training
CT	Continuous Training
CUT	Cross-Utilization Training
CV	Cargo/Transport, Vertical/Short Takeoff and Landing Aircraft
CV	Vice Commander
DAFI	Department of the Air Force Instruction
DCC	Dedicated Crew Chief
DCOM	Deputy Commander
DD	Delayed Discrepancies
DLO	Desired Learning Objectives
DNIF	Duties Not Including Flying
DoD	Department of Defense
DO	Director of Operations
DSIU	Drive System Interface Unit
DSO	Direct Support Operator
ECS	Environmental Control System
EDRE	Emergency Deployment Response Exercise
EE	Electrical Environmental
EICAS	Engine Instrument Crew Alerting System
EFB	Electronic Flight Bag
EFDP	Enlisted Force Distribution Panel
EP	Emergency Procedure

EPB	Enlisted Performance Brief
EPR	Enlisted Performance Report
EPS	Emergency Power System
ER	Exceptional Release
ERAC	Electronic Rapid Action Change
ESB	Executive Sterring Board
ETIC	Estimated Time in Completion
ETP	Equal Time Point
F(p)	Failed to Post
FA	Flight Authorization
FAD	Force Activity Dissimulator
FADEC	Full Authority Digital Engine Control
FCC	Flight Control Computer
FCF	Functional Check Flight
FCIF	Flight Crew Information File
FE	Flight Engineer
FHP	Flying Hour Program
FL	Flight Lead
FRC	Fleet Readiness Center
FSR	Field Service Rep
FST	Fleet Support Team
ft	Feet
FY	Fiscal Year
G21	GUNDAM 21
G22	GUNDAM 22
G23	GUNDAM 23
GPS	Global Positioning System
HAF	Headquarters Air Force
HCE	Hard Clutch Engagement
HCM	Hours per Co-pilot per Month
HEED	Helicopter Emergency Egress Device
HLZ	Helicopter Landing Zone
HPW	High Performance Waveform
HRS	Hours
IAW	In Accordance With
IBR	Intelligence Broadcast Receiver
ICDS	Interconnecting Drive System
ICS	Intercommunication Systems
I's & E's	Inlets and Exhausts
IFEUG	Instructor Flight Engineer Upgrade
IMDS	Integrated Maintenance Data System
INDOPACOM	Indo-Pacific Command
IP	Instructor Pilot
IQA	Input Quill Assembly
IS	Intelligence Squadron
JCN	Job Control Number
JCS	Joint Chiefs of Staff
JCET	Joint Combined Exchange Training
JOG	Joint Operational Graphics
JTF	Joint Task Force
JTF-IP	Joint Task Force Indo-Pacific
JTWS	Joint Threat Warning System
KMZ	Keyhole Markup Zip
KTL	Key Task Listing
KVDAR	K-Series Voice and Data Recorder
kts	Knots
L	Local Time
LH	Left-Hand
LOC	Letter of Counseling
LPU	Life Preserver Unit
LOS	Line of Sight
Lt Col	Lieutenant Colonel
LZ	Landing Zone
MA	Mishap Aircraft
MAC	Mission Aircraft Commander
MC	Mishap Crew
Maj	Major
MAJCOM	Major Command
MAP	Mishap Additional Pilot
MAR	Maintenance Assistance Request
MAT	Mission Auxiliary Tank
MDS	Mission Design Series
MFD	Multi-Functional Displays
MFF	Military Free Fall
MFR	Memorandum for Record
MOA	Military Operating Area
MAT	Mission Auxiliary Tank
MCAS	Marine Corps Air Station
MCP	Mishap Co-pilot
MDSO	Mishap Direct Support Operator
MFD	Multi-Function Displays
MFF	Military Free Fall
MILAIR	Military Aircraft
MOCC	Maintenance Ops Control Center
MP	Mishap Pilot
MQTP	Maintenance Qualification Training Program
MRT	Maintenance Recovery Team
MS	Mishap Sortie
MSMAFE	Mishap Special Mission

	Aviator Flight Engineer
MSMATS	Mishap Special Mission Aviator Tail Scanner
MSOFME	Mishap Special Operations Forces Medical Element
MSL	Mean Sea Level
MWGB	Mid-Wing Gearbox
NATOPS	Naval Air Training and Operating Procedures Standardization
NCO	Noncommissioned Officer
NCOIC	Noncommissioned Officer in Charge
ND	Nose Down
NFM	Naval Air Training and Operating Procedures Standardization Flight Manual
NM	Nautical Miles
NOTAM	Notices to Air Missions
NP	Power Turbine Speed
NR	Proprotor Speed
NVGs	Night Vision Goggles
NVM	Non-Volatile Memory
O-6	Colonel
OAI	Operations, Activities & Investments
OCO	Overseas Contingency Operations
OCONUS	Outside the Continental United States
OG	Operations Group
OJT	On-the-job-training
ONC	Operational Navigational Charts
O&M	Operation and Maintenance
OPB	Officer Performance Brief
OPCON	Operational Control
OPR	Officer Performance Report
ORM	Operational Risk Management
OT&E	Organize, Train & Equip
P&S	Planes and Scheduling
PA	Public Affairs
PAC	Power Assurance Check
PAD	Professional Aircrew Development
PACAF	Pacific Air Forces
PACOM	Pacific Command
PCA	Permanent Change of Assignment
PCN	Pavement Classification Number
PCS	Permanent Change of Station
PE	Personal Evaluation
PED	Personal Electronic Device
PEX	Patriot Excalibur
PHA	Periodic Health Assessment
PL	Precautionary Landing
PR	Personnel Recovery
PRD	Pilot Reported Discrepancy
PRGB	Proprotor Gearbox
QA	Quality Assurance
Qe	Torque
QR	Quality Review
R2	Remove and Replace
RAP	Ready Aircrew Program
RH	Right-Hand
RJFC	Yakushima Airport
RJFG	Tanegashima Airport
RJFM	Miyazaki Airport
RJOI	MCAS Iwakuni
RJTY	Yokota AB
RMC	Rescue Mission Commander
RMWS	Ramp Mounted Weapon System
ROC	Rehearsal of Concepts
RPM	Revolutions Per Minute
RRC	Rolls-Royce Corporation
RSM	Removable Storage Module
RTB	Return-To-Base
RTM	Ready Aircrew Program Task Memo
S/N	Serial Number
SAP	Special Access Program
SAR	Search and Rescue
SARM	Squadron Aviation Resource Management
SAMS-ESA	Specialized Automated Suite Enhanced Situational Awareness
SATCOM	Satellite Communications
SCI	Special Experience Indicator
SECDEF	Secretary of Defense
SEI	Special Experience Indicator
SEL	Senior Enlisted Leader
SELO	Stan/Eval Liaison Officer
SERE	Survive, Evade, Resist, Escape
SIB	Safety Investigation Board
SIM	Simulator
SMA	Special Mission Aviator
SNCO	Senior Noncommissioned Officer
SOAMXS	Special Operations Aircraft Maintenance Squadron

SOCKOR	Special Operations Command Korea
SOCOM	Special Operations Command
SOCPAC	Special Operations Command Pacific
SOF	Supervisor of Flying
SOF	Special Operations Forces
SOFME	Special Operations Forces Medical Element
SOIDMT	Special Operations Independent Duty Medical Technician
SOP	Standard Operating Procedures
SOS	Special Operations Squadron
SOSS	Special Operations Support Squadron
SOW	Special Operations Wing
SSRA	System Safety Risk Assessment
ST	Special Tactics
SVTC	Secure Video Teleconference
TAGB	Tilt-Axis Gearbox
TAR	Technical Assistance Request
TAAR	Tiltrotor Air-to-Air Refueling
TBA	Training Base Area
TCCC	Tactical Combat Casualty Care
TCI	Time Change Item
TDI	Time Domain Interval or Time Distribution Index
TDY	Temporary Duty
TCTO	Time Compliance Technical Order
TF	Terrain Following
TFTR	Total Force Training Record
T/N	Tail Number
TO	Technical Order
TODO	Technical Order Distribution Office
TPC	Tactical Piloted Chart
TRB	Training Review Board
TS	Tail Scanner
TS	Top Secret
TSN	Time Since New
TSOC	Theater Special Operations Command
TSR	Time Since Repair
TTP	Tactics, Techniques & Procedures
UEI	Unit Effectiveness Inspection
UMD	Unit Manning Document
USFJ	United States Forces Japan
VFR	Visual Flight Rules
VR	Virtual Reality
VSLED	Vibration Structural Life and Engine Diagnostic
VTC	Video Teleconference
WIC	Weapons Instructor Course
WST	Water Survival Training
Z	Zulu

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 30 November 2023, Lieutenant General Tony D. Bauernfeind, Commander Air Force Special Operations Command (AFSOC) appointed Brigadier General Michael E. Conley to conduct an Accident Investigation Board (AIB) for the 29 November 2023 mishap involving the Mishap Aircraft (MA), GUNDAM 22 (G22), a CV-22B aircraft, tail number (T/N) 10-0054, near Yakushima Island, Japan (Tabs Y-3 to Y-4, and EE-81). The MA was assigned to the 21st Special Operations Squadron (21 SOS), 353rd Special Operations Wing (353 SOW) (Tab EE-17, and EE-104). The investigation was conducted at Marine Corps Air Station (MCAS) Iwakuni, Japan; Yokota Air Base (AB), Japan; and Hurlburt Field, Florida (Tab DD-41). Lieutenant General Bauernfeind appointed the following board members to assist in the investigation: Medical Member (Lieutenant Colonel), Medical Member Two, Human Performance (Lieutenant Colonel), Pilot Member (Major), Legal Advisor (Major), Special Mission Aviator Member (Chief Master Sergeant), Maintenance Member One (Senior Master Sergeant), Maintenance Member Two (Master Sergeant), and Recorder (Technical Sergeant) (Tab Y-3 to Y-9, and Y-11).

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.

2. ACCIDENT SUMMARY

On 29 November 2023, at approximately 1440 local time (L), while participating in a joint inter-operability exercise, the MA, a CV-22B aircraft, T/N 10-0054, crashed in the water approximately one-half mile off the coast of Yakushima Island, Japan (Tab EE-9). The aircraft was operated by 21 SOS, 353 SOW, Yokota AB, Japan (Tab EE-17, and EE-104). The eight members of the mishap crew (MC) consisted of five CV-22B aircrew members from the 21 SOS, including the Mishap Pilot (MP), Mishap Co-pilot (MCP), Mishap Additional Pilot (MAP), Mishap Special Mission Aviator Flight Engineer (MSMAFE), and Mishap Special Mission Aviator Tail Scanner (MSMATS), along with two medical personnel from the 1st Special Operations Squadron (1 SOS), 353 SOW, Kadena AB, Japan, including the Mishap Special Operations Forces Medical Element 1 (MSOFME1) and Mishap Special Operations Forces Medical Element 2 (MSOFME2), and one member from the 43rd Intelligence Squadron, Detachment 1 (43 IS, Det 1), Yokota AB, Japan, Mishap Direct Support Operator (MDSO) (Tab EE-85 to EE-95). The MA was destroyed and all eight crewmembers sustained fatal injuries upon impact (Tabs P-3, and X-3 to X-9). The remains of seven crewmembers were recovered in the subsequent search and recovery (Tab EE-81). The eighth crewmember was not recovered, despite an extensive 43-day, multi-national search effort (Tab EE-81). After impact, most of the aircraft wreckage sank to the sea floor in approximately

100 feet of water (Tab EE-37). Extensive salvage operations were able to recover many key components of the MA; however, due to the extensive damage from impact, duration of time underwater, and strong sea currents, recovery of all components of the MA was not possible (Tab V-28.7).

3. BACKGROUND

a. Air Force Special Operations Command

AFSOC's primary mission is to provide Air Force special operations forces (SOF) for worldwide deployment and assignment to geographic Combatant Commands (Tab CC-3). It is 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 (Tab CC-3). The command's core missions include mobility, precision strike, air-to-ground integration, and intelligence, surveillance, and reconnaissance (Tab CC-3). The command's special tactics squadrons combine combat controllers, tactical air control party members, special reconnaissance airmen and pararescuemen with other services' SOF to form versatile joint special operations teams (Tab CC-4). AFSOC has more than 20,800 active-duty, Air Force Reserve, Air National Guard, and civilian personnel (Tab CC-4). The command's active duty and Reserve component flying units operate various aircraft, including the CV-22B Osprey, AC-130J gunships, MC-130J Commando IIs, MQ-9 Reapers, U-28 Dracos, and C-146A Wolfhounds (Tab CC-4). The command's forces are organized under six active-duty wings, one Reserve wing, two National Guard wings, and several direct reporting units (Tab CC-4).

b. 353rd Special Operations Wing

353 SOW, located at Kadena AB, Japan, is comprised of approximately 1,000 Airmen and is the only AFSOC unit in the Pacific (Tab CC-9). The 353 SOW comprises the United States Air Force's special operations air component of the Special Operations Command Pacific (SOCPAC), a subunified command to the United States Pacific Command (Tab CC-7). The 353 SOW plans and executes general war and contingency operations using advanced aircraft, tactics, and techniques to infiltrate, exfiltrate, resupply, and support SOF (Tab CC-9). The primary peacetime responsibility of the 353 SOW is to oversee the training and maintenance of its assigned units (Tab CC-7). The wing ensures the combat readiness of these units through comprehensive involvement in numerous theater exercises and training activities throughout the Pacific (Tab CC-7 to CC-8).

c. 21st Special Operations Squadron

The 21 SOS is located at Yokota AB, Japan (Tab V-27.2). 21 SOS flies the CV-22B Osprey (Tab CC-10). Its mission is to conduct long-range infiltration, exfiltration and resupply missions for SOF (Tab CC-10). The CV-22B is equipped with integrated threat countermeasures, terrain-following radar, forward looking infrared sensor and other advanced avionics systems that allow it to operate at low altitude in adverse weather conditions and medium to high-threat environments (Tab CC-10).

d. 753rd Special Operations Aircraft Maintenance Squadron

The 753rd Special Operations Aircraft Maintenance Squadron (753 SOAMXS) is located at Yokota AB (Tab V-11.2). 753 SOAMXS maintains the CV-22B Osprey, a tiltrotor 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 fixed-wing aircraft (Tab CC-12).

e. 1st Special Operations Squadron

The 1 SOS flies the MC-130J Commando II (Tab CC-10). Its mission is clandestine, or low visibility, single or multi-ship, low-level air refueling for special operations helicopters and tiltrotor aircraft, and infiltration, exfiltration, and resupply of SOF by airdrop or airland intruding politically sensitive or hostile territories (Tab CC-10). The squadron also has an embedded, deployable Special Operations Forces Medical Element (SOFME) team (Tab BB-58).

f. 43rd Intelligence Squadron, Detachment 1

Detachment 1 of the 43 IS provides dedicated, real-time threat warning and enhanced situational awareness in support of AFSOC (Tab CC-13). The unit serves as the conduit between the Air Force Intelligence, Surveillance, and Reconnaissance community and provides support to the mission (Tab CC-13).

g. Companies and Organizations

(1) Bell

Headquartered in Fort Worth, Texas, Bell is a wholly owned subsidiary of Textron Inc. (Tab CC-17). In April 1982, Bell and Boeing Rotorcraft Systems formed Bell-Boeing, which ultimately designed and developed the V-22 Osprey (Tab CC-17). As of 31 January 2024, the company delivered over 400 V-22 aircraft, accumulating more than 600,000 flight hours (Tab CC-17). Bell's responsibility over the CV-22B consists of manufacturing and integrating the wing, transmissions, empennage, and rotor systems, as well as integrating the aircraft's Rolls-Royce engines (Tab CC-17).

(2) Boeing

Boeing Defense, Space & Security is part of the Boeing Company, with its corporate headquarters located near Washington, D.C. (Tab CC-18). Rotary and tiltwing aircraft produced and/or serviced by Boeing include the AH-6, AH-64, CH-47, MH-139, and V-22 (Tab CC-18). Boeing first started its development of tiltwing aircraft in 1956 and continued its testing on tiltrotor models into the 1960s and 1970s (Tab CC-18). Boeing manufactures and integrates the fuselage, cockpit, avionics, and flight-control systems of the CV-22B (Tab CC-18).

(3) Rolls-Royce

Rolls-Royce Corporation (RRC), headquartered in Indianapolis, Indiana, is a subsidiary of Rolls-Royce North America, Inc. (Tab CC-19). The V-22 Osprey is powered by the Rolls-Royce AE 1107C engine, part of the AE engine line that began as a powerplant for the V-22 tiltrotor aircraft (Tab CC-19).

(4) Naval Air Systems Command

Established in 1966 as the successor to the Navy's Bureau of Naval Weapons, the Naval Air Systems Command (NAVAIR) is headquartered in Patuxent River, Maryland, with military and civilian personnel (Tab CC-20). NAVAIR's mission is to deliver integrated air warfare capabilities to enable the fleet to compete, deter, and win – tonight, tomorrow and in the future (Tab CC-20).

(5) Program Management Authority 275 – V-22 Joint Program

NAVAIR's subordinate Program Management Authority 275 (PMA-275), located at Patuxent River, Maryland manages the cradle to grave procurement, development, support, fielding, and disposal of the tiltrotor program systems for Marine Corps medium-lift assault support, the Air Force's SOF long-range infiltration, exfiltration and resupply, and the Navy's vertical replenishment and carrier onboard delivery missions (Tab CC-22).

h. CV-22B Osprey

The CV-22B Osprey is a tiltrotor 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 fixed-wing aircraft (Tab CC-15). The mission of the CV-22B is to conduct long-range insertion, extraction, and resupply missions for SOF (Tab CC-15). This versatile, self-deployable aircraft offers increased speed and range over other rotary-wing aircraft, enabling AFSOC aircrew to execute long-range special operations missions (Tab CC-15). The CV-22B can takeoff vertically and, once airborne, the nacelles (engine and proprotor group) on each wing can rotate into a forward position (Tab CC-15). The CV-22B is equipped with integrated threat countermeasures, terrain-following radar, a forward-looking infrared sensor, and other systems that allow it to operate in austere conditions (Tab CC-15).

(1) Background

The Air Force CV-22B is the special operations variant of the Marine Corps MV-22 Osprey (Tab CC-15). The first two test aircraft were delivered to Edwards Air Force Base (AFB), California, in September 2000 (Tab CC-15). The 58th SOW at Kirtland AFB, New Mexico, began CV-22B aircrew training with the first two production aircraft in August 2006 (Tab CC-15). The first operational CV-22B was delivered to AFSOC in January 2007 (Tab CC-15). Initial operational capability was achieved in 2009 (Tab CC-15 to CC-16).

Figure 1. CV-22B in Helicopter Mode (Tab Z-3)

Figure 2. CV-22B in Airplane Mode (Tab Z-3)

(2) General Characteristics

The CV-22B's primary function is enabling SOF long-range insertion and extraction and resupply (Tab CC-16). Bell and Boeing are primarily responsible for building the CV-22B, and the propulsion system is provided by two Rolls-Royce Liberty AE1107C engines capable of more than 6,200 shaft horsepower per engine (Tab CC-16). The aircraft has a length of 57'- 4", a height of 22'- 1", and a wingspan of 83'- 10" (Tab CC-16). The proprotors have a diameter of 38 feet each (Tab CC-16). The CV-22B has a maximum gross weight of 60,500 pounds, a maximum speed of 280 knots, and a maximum altitude ceiling of 25,000 feet (Tab CC-16). The aircraft has a maximum combat range of 500 nautical miles (NM) with one internal auxiliary fuel tank (Tab CC-16). The CV-22B is crewed by four personnel including a pilot, co-pilot and two special mission aviators (Tab CC-16). The aircraft is equipped with a .50-caliber machine gun on its ramp and can carry 24 personnel that are seated, 32 personnel without seats or 10,000 pounds of cargo (Tab CC-16). The Air Force purchased 54 aircraft costing $91.9 million per aircraft (Tab CC-16).

(3) CV-22B Crew Positions

1) Aircraft Commander/Pilot

The aircraft commander (AC) is in command of all aircrew members and responsible for all persons aboard the aircraft (Tab B-34). The AC is responsible for the welfare of their crew and the safe accomplishment of the mission (Tab B-34). The AC is the final authority for accepting a waiver affecting the crew, mission, or aircraft (Tab B-34). The AC is charged with keeping the applicable commander informed of mission progress and difficulties (Tab B-34). The AC will ensure detailed and thorough mission planning, including detailed map and intelligence study to evaluate and determine best (and feasible alternative) routes (Tab DD-51).

2) Co-pilot

The co-pilot assists the pilot in operation of controls and equipment, on the ground and in the air, and operates the aircraft in flight upon instructions from the pilot (Tab DD-51). Co-pilots should be familiar with the duties of the pilot and other crewmembers so that they may perform their duties in the absence of a complete crew complement (Tab DD-51).

3) Special Mission Aviator Flight Engineer

The special mission aviator (SMA), referred to as flight engineer (FE) in the naval air training operating procedures standardization (NATOPS) flight manual (NFM), performs pre-mission and preflight duties, and assists in mission planning (Tab DD-51). The FE is responsible for computing weight and balance and determining takeoff and landing data, to include mission power requirements (Tab DD-51). The FE normally reads and performs checklist items (Tab DD-51). The FE monitors and operates aircraft systems, navigation, communication, and mission related avionics (Tab DD-51). The FE reports abnormal conditions to the pilot, and recommends and takes corrective actions, to include immediate action emergency procedures (EP) (Tab DD-51 to DD-52). The FE monitors fuel status, keeps the pilot advised of fuel status, and operates air refueling and fuel systems (Tab DD-52).

4) Special Mission Aviator Tail Scanner

An additional SMA, acting as the tail scanner (TS), performs hoist operations, aerial gunnery, passenger, cargo, and vehicle loading, litter attendant, and airdrop duties (Tab DD-52). The TS helps keep the aircraft clear of obstructions during taxi and landings (Tab DD-52). The TS is also primarily responsible for loading secure communications equipment and operating mission systems and radios (Tab DD-52).

(4) Additional Crew Positions

1) Direct Support Operator

The Direct Support Operator (DSO) prepares and distributes operational intelligence information to the crew; monitors employment of other assigned air assets and operations, and processes, exploits, analyzes, and disseminates signals intelligence information in an airborne environment (Tab BB-54 to BB-55).

2) Special Operations Forces Medical Element

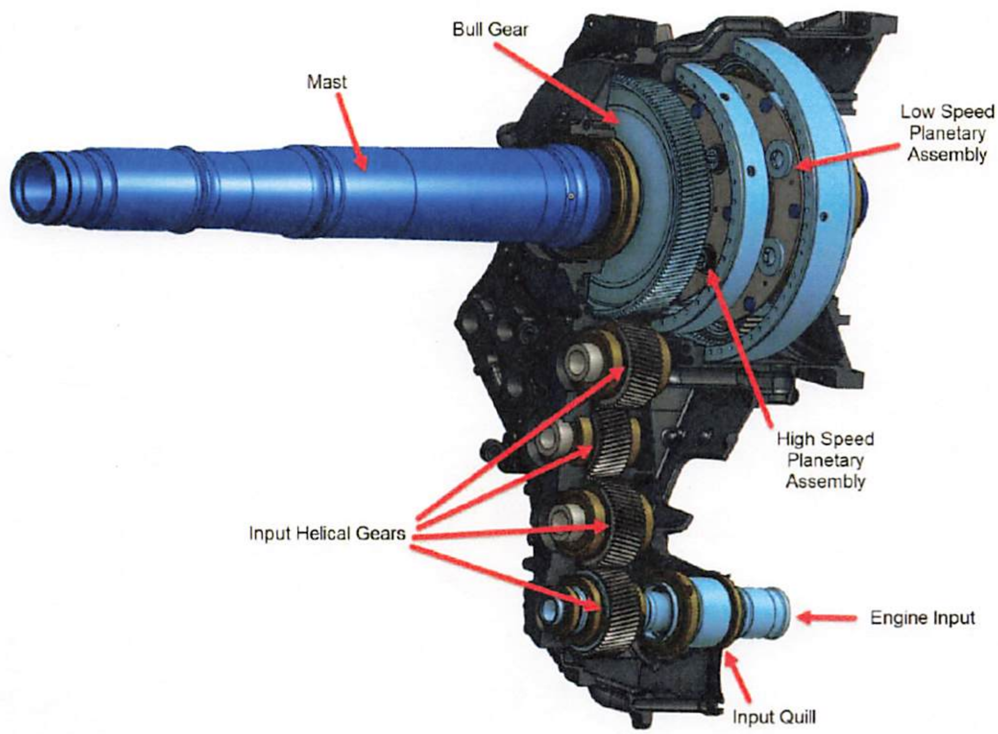
SOFMEs are deployable medical teams attached to operational flying squadrons (Tab BB-58). They provide base operational support and medical coverage for high-risk operations and training activities, to include initial trauma care, stabilization and resuscitation, Advanced Trauma Life Support, Advanced Cardiac Life Support, prolonged casualty care, and casualty evacuation (CASEVAC), as requirements dictate (Tab BB-58).

i. Relevant Aircraft Components

(1) Proprotor Gearbox (PRGB) and Drive System Overview

The CV-22B has two proprotor gearboxes (PRGB), one mounted in each nacelle (Tab DD-7). The PRGB transmits power and provides speed reduction from the engine to the proprotors (Tab DD-7).

Figure 3. PRGB Schematic (Tab J-356)



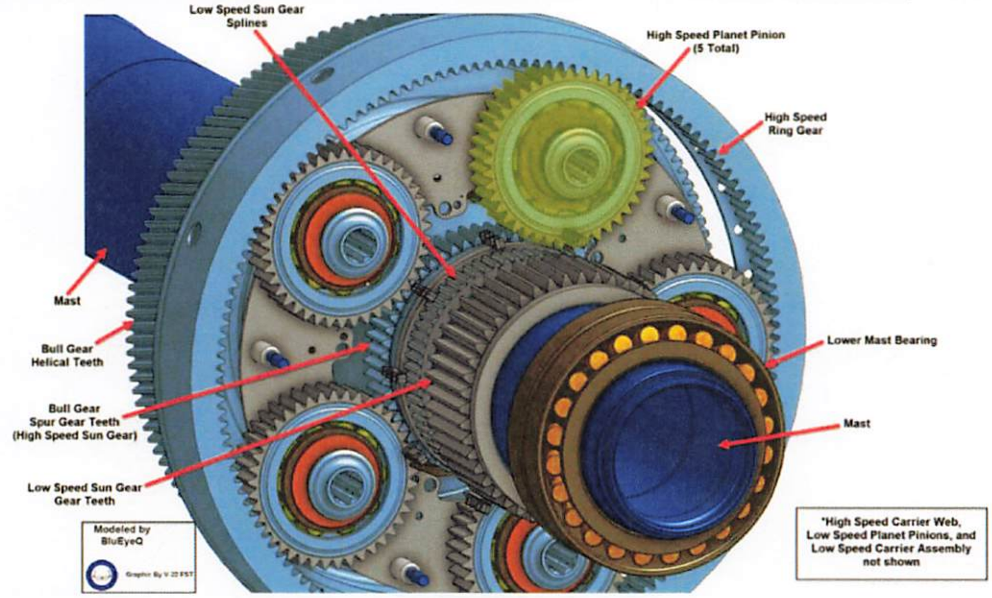
While all engines are operating, torque is supplied to each PRGB directly from their respective side's engine (Tab DD-7). The left-hand and right-hand PRGBs are essentially mirror images of each other, except that the left-hand PRGB has an extra idler gear to provide counterclockwise rotation of the left-hand proprotor, while the right-hand PRGB turns clockwise (Tab DD-7). The PRGB has two independent and separate lubrication systems (Tab DD-7). A primary lubrication system is integral to the PRGB, and a secondary emergency lubrication system provides 30 minutes of operation if the primary drops below 30 pounds per square inch oil pressure (Tab DD-7). Each PRGB has chip detectors, used to detect ferrous particles (Tab DD-7).

The PRGB is designed to receive power from the same side engine via the input quill, which is where the clutch assembly is housed (Tab J-355). The clutch assembly transmits the power into the PRGB through the input helical gears (four in left-hand PRGB and three in right-hand PRGB) to the helical gear set on the bull gear (Tab J-355). The bull gear helical gear set also meshes with the interconnect helical idler gear, which meshes with the interconnect helical gear to power the pylon driveshaft (part of the interconnecting drive system (ICDS)) (Tab J-355). In the event of a same side engine failure, this design allows the opposite side's engine to power the PRGB by transferring power through the ICDS/pylon driveshaft to the interconnect gears and then the bull gear helical gear set (Tab J-355). When both engines are operating, it is possible for the bull gear to be driven simultaneously by both the input helical idler gear (from the same side engine) and interconnect helical idler gear (from the opposite side engine) to receive additional power from the opposite side engine (Tab J-355).

The bull gear has a second gear set of spur gear teeth on the aft portion of the gear which serves as the sun gear for the high-speed planetary gears (Tab J-355). As the bull gear is driven from the forward helical gear set, the aft spur gear set drives the high-speed planet pinions (Tab J-355). The high-speed pinons are also meshed with the high-speed ring gear (fixed to the PRGB housing), and thus, drive the high-speed carrier assembly (Tab J-355).

Power is then transferred through a set of splines on the high-speed carrier in mesh with the low-speed sun gear's forward splines (Tab J-355). The low-speed sun gear aft gear set then drives the low-speed planet pinions (Tab J-355). The low-speed planet pinions are also meshed with the low-speed ring gear (which is fixed to the PRGB housing), and thus, drive the low-speed carrier assembly (Tab J-355). The low-speed carrier has splines which mesh with splines on the PRGB mast (Tab J-355). Note that the mast is positioned through the centers of the bull gear, high-speed carrier assembly, and low speed carrier assembly, but is driven only by the low-speed carrier assembly (Tab J-355). As the low-speed carrier drives the mast, the mast drives the respective proprotor (Tab J-355). This PRGB gear train provides an increase in torque and reduction in speed from the engine to the mast (speed ratio of 37.798 to 1) (Tab J-355).

Figure 4. PRGB Schematic – HS Sun Gear Mesh with HS Planet Pinions (Tab J-359)



(2) PRGB Chip Detection and Reporting

The PRGB chip detection system provides a visual indication to flight crew if it detects ferromagnetic debris in the gear oil (Tab J-228). Each PRGB contains three chip detectors (Tab J-228). The PRGB chip detectors can be removed and inspected for debris during maintenance actions (Tab J-228). PRGB chip detectors are monitored by the Drive System Interface Unit (DSIU), and the DSIU announces when conductive debris are captured at the detector electrodes (Tab DD-7, and J-224). The system has the capability to "burn off" debris by passing electrical current through the electrodes (Tab DD-7, and J-224). When conductive debris makes contact with the magnetic sensor pickup, the chip burn circuit is automatically activated and attempts to burn off debris (Tab DD-7).

1) PRGB CHIP BURN

The "PRGB CHIP BURN (L, R)", is a visual only advisory that posts to the control display unit (CDU) any time a chip is detected and is successfully burned off by a detector (Tab DD-52). The advisory remains visible until a crewmember depresses the Acknowledgement (ACK) button (Tab DD-52, and J-339).

The NFM describes "PRGB CHIP BURN" as: chips and/or debris have been detected in associated PRGB and burned off (Tab DD-52). If three consecutive chip burn advisories post during one continuous flight, the result is a change in landing criteria to "Land as Soon as Practical" (Tab DD-52).

2) PRGB CHIPS

The "PRGB CHIPS (L, R)" caution is an auditory and visual post to the CDU any time a chip fails to burn off for 3 consecutive automatic chip burn attempts (Tab DD-52, and J-339).

The NFM describes "PRGB CHIPS" as: PRGB chip detector 1, 2 or 3 is indicating unburnable chips (Tab DD-52). If after receiving PRGB CHIPS there are normal secondary indications, then a crew should "Land as Soon as Possible" (Tab DD-52). If there are abnormal secondary indications, then the crew should "Land Immediately" (Tab DD-52).

j. Emergency Procedure Landing Criteria

Many of the EPs identified in the NFM are associated with a warning, caution, or advisory message displayed in the cockpit (Tab DD-53). A warning is signaled by master alert lights, red text on the multi-function display (MFD), and voice warning announcement (Tab DD-53). A caution is signaled by a master alert light, yellow text on the CDU, and an audible tone (Tab DD-53). An advisory is displayed as white text on the CDU without an associated tone (Tab DD-53). The NFM guides aircrew through corrective procedures beginning with maintaining aircraft control, followed by analyzing the situation, then taking proper action (Tab DD-53). Analyzing the situation includes observing and evaluating the appropriate systems' status layers, audible indicators or malfunctions and visual inspection of aircraft state, and all other reasonable means of properly identifying the nature of the emergency before acting (Tab DD-53). The amount of time available and the nature of the malfunction dictate how rapidly corrective action should be taken (Tab DD-53). The words "immediately," "possible," and "practical" define the urgency with which a landing must be made, in descending order of severity (Tab DD-53).

(1) Land as Soon as Practical

"Land as Soon as Practical" means extended flight is not recommended (Tab DD-53). The landing site and duration of flight is at the discretion of the pilot-in-command (Tab DD-53). If any condition exists with NATOPS directed landing criteria, before deciding whether to continue the mission, aircrew should consider factors such as threat, remote location, local repair capability, practicality of maintenance recovery team launch, remaining aircraft system redundancy, mutual support, or other relevant factors (Tab B-36).

(2) Land as Soon as Possible

"Land as Soon as Possible" is defined as executing a landing at the nearest available area in which a safe landing can be made (Tab DD-53). When emergencies are encountered while flying over water, the determination of landing as soon as possible is at the discretion of the pilot (Tab DD-53). Factors of sea state, weather, communication, survival equipment and the location of other aircraft, ships, and land will assist the pilot in deciding to land as soon as possible or to proceed on to a point where survival and rescue are enhanced (Tab DD-53). In either case, the pilot should fly in such a way as to affect an immediate landing, if required (Tab DD-53)

(3) Land Immediately

"Land Immediately" is defined as executing a landing without delay (Tab DD-53). Continued operation of the aircraft is extremely hazardous (Tab DD-53). If over water, conduct a controlled ditching without delay (Tab DD-53). Controlled ditching procedures prepare the aircraft for a water landing when an emergency precludes continued flight (Tab DD-53). After landing, consider conducting an emergency shutdown (Tab DD-53). The primary consideration is to assure the survival of occupants (Tab DD-53).

k. K-Series Voice, Audio, and Data Recorder

K-Series Voice, Audio, and Data Recorder (KVADR) provides semi-permanent record of flight data in non-volatile memory (NVM) (Tab DD-6). The KVADR is designed to withstand conditions associated with an aircraft crash, including penetration, fire, salt water, and fire extinguishing agents (Tab DD-6). The KVADR is installed in the mid-wing area with an underwater acoustic beacon mounted to the top surface (Tab DD-6). A cockpit area microphone provides continuous cockpit area audio that is recorded in the KVADR (Tab DD-6).

l. Vibration Structural Life and Engine Diagnostic

Vibration Structural Life and Engine Diagnostic (VSLED) is an aircraft health monitoring system that records vibration, temperature, and stress monitoring on the aircraft structures, gearboxes, and engine components (Tab DD-7). VSLED sensors are mounted on the engines, interconnected drive shafts, PRGBs, and areas in each nacelle (Tab DD-7). VSLED sensor status is provided, but the data is not available to the aircrew during flight operations (Tab DD-7). The aircraft's VSLED data is downloaded at the end of a flight for post-flight processing using a Comprehensive Automated Maintenance Environment Optimized Ground Station (Tab DD-6).

4. SEQUENCE OF EVENTS

a. Planning for Joint Inter-Operability Exercise

The MC was participating in a United States Indo-Pacific Command (INDOPACOM) authorized joint inter-operability exercise (Tab DD-43). The exercise's purpose was to integrate United States SOF, operating under the command of SOCPAC, with other United States military units (Tab-DD-43). Units from the 353 SOW regularly participate in joint exercises across the Indo-Pacific (Tab V-35.3).

Joint mission planning was conducted in accordance with standards; however, the majority of planning was conducted remotely (Tab V-32.6). The MP was the lead planner for air integration of all participants (Tab DD-43). The MP was also dual-hatted as AC and the Airborne Mission Commander (AMC), responsible for command of his own aircraft as well as command of the other airborne participants in the exercise (Tab DD-43). In the months leading up to the exercise, weekly planning meetings were held via secure video teleconference to coordinate roles, responsibilities, timing, and communication plans (Tabs V-32.6, and DD-43). A mass briefing was held remotely on 28 November 2023 with all key exercise participants (Tab DD-44).

b. Mishap Aircraft Configuration

The MA was in a typical configuration for the crew complement, planned duration of the flight, and for flight over water (Tab B-35). In the cockpit, the MP was in the left pilot seat, the MCP was in the right pilot seat, and the MSMAFE was in the FE seat (Tab V-28.7 to V-28.8). All three aircrew in the cockpit were secured in their respective seats with 5-point harnesses (Tab DD-45 and V-28.7 to V-28.8). In the cabin, a Forward Mission Auxiliary Tank (FWD MAT) was installed in the front cargo compartment, which provided an additional 430 gallons of fuel (Tab DD-45, K-15, and U-106 to U-129). The Ramp Mounted Weapon System (RMWS) mount was installed on the left side of the MA's ramp; the .50 caliber gun was removed and secured on the aft side of the FWD MAT (Tabs Z-7, and DD-45). The DSO equipment was installed on the MA's left side in an alternate position aft of the FWD MAT (Tabs V-1.3 to V-1.4, V-18.5, and V-21.5). The MSMATS was positioned on the ramp near the RMWS mount and secured to the aircraft by an Eagle Combat Integrated Armor Carrier System with the Advanced Crew Tether System harness (Tab DD-45). The 20-person life raft was stowed on the right side of the aircraft ramp and secured by a 5K cargo strap, a standard position for over-water flights (Tab V-12.7, V-17.6, V-18.5 to V-18.6, and V-21.3). Typical operating procedures would place the MDSO and one of the MSOFMEs in seats on the aircraft's left side, behind the MAT (Tab DD-45). The MAP and other MSOFME would be positioned on the aircraft's right side, behind the MAT (Tab DD-45).

Figure 5. Typical Aircraft Configuration (Tabs Z-7, and DD-44)

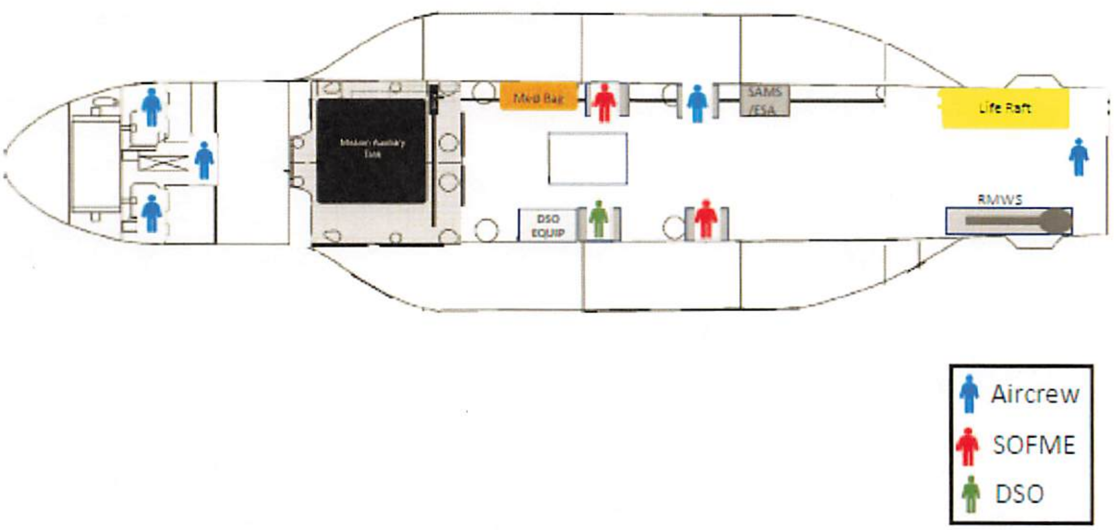


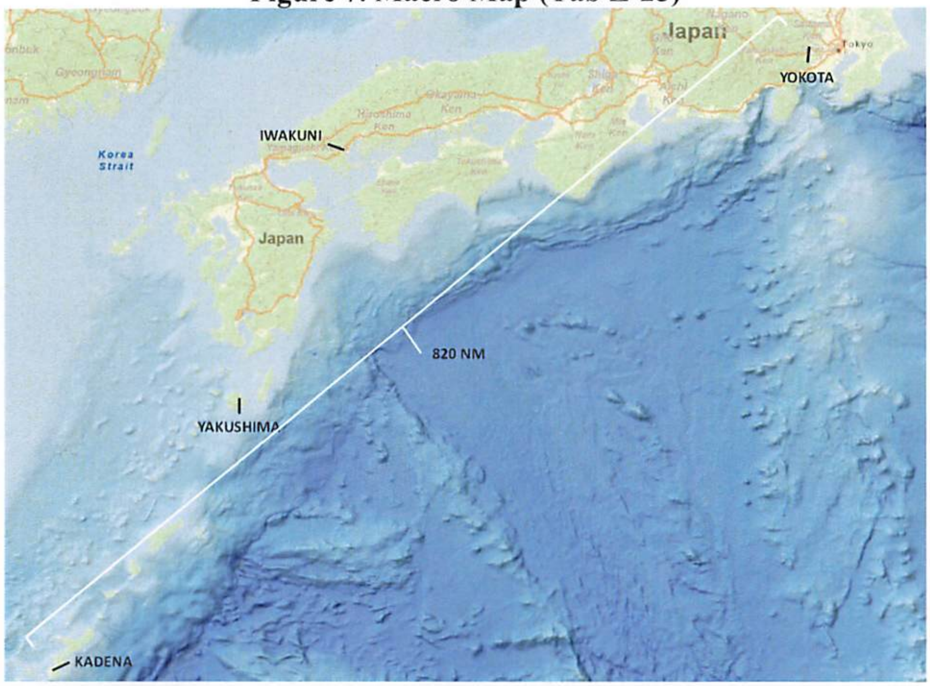
Figure 6. Aircraft Configuration (AIB Re-creation) (Tab Z-17)

c. CV-22B Mission

There were two CV-22B aircraft participating in the exercise (Tab DD-47). The 21 SOS's Director of Operations (DO) was the Authorizing Official on the Flight Authorization and the Operational Risk Management (ORM) form for the mission (Tabs K-3, and AA-19 to AA-20). GUNDAM 21 (G21) and G22 (MA), a two-ship formation, were the primary aircraft and crews in the exercise; GUNDAM 23 (G23) was a non-participating flying spare aircraft, postured to swap aircraft with one of the primary crews or provide maintenance support if required (Tab R-67). G21 had a crew of five, including an additional pilot and a 10-person SOF team onboard to conduct a military free fall (MFF) water jump (Tabs R-9, V-32.7, and DD-45). MA had an eight-person crew, which included the MP, MCP, MSMAFE, MSMATS, MAP, MDSO, MSOFME1, and MSOFME2 (Tabs K-3, and DD-45). The MAP was onboard as a relief pilot for the last leg of the flight between Kadena AB and Yokota AB (Tabs R-10, and V-35.6). The MDSO was onboard to provide inflight intelligence support (Tabs BB-54 to BB-55, and V-1.4). MSOFME1 and MSOFME2 were onboard to provide primary medical coverage for the water jump (Tabs K-3, and II-52). G23 had a basic crew of three, with a five-person maintenance team onboard (Tabs AA-45, and DD-45).

The planned mission was to takeoff from Yokota AB at 1100L, conduct tiltrotor air-to-air refueling (TAAR) with a KC-130J at 1245L, then proceed south over water between mainland Japan and Okinawa, Japan for exercise integration (Tab DD-47). During the planned three-hour overwater portion of the flight, G21 would drop the MFF jumpers, while the MA provided medical coverage (Tabs V-12.5 to V-12.6, and DD-45). After the exercise was complete, they would land at Kadena AB to refuel and swap out ACs for the flight back to Yokota AB, with a final land time of 2200L (Tab DD-46).

Figure 7. Macro Map (Tab Z-25)



d. CV-22B Planning

The CV-22B mission planning was conducted in accordance with standard operating procedure (Tabs V-20.3, BB-44 to BB-47, and DD-46). Prior to generating flight authorizations for the mission, squadron leadership validated the crew's currency, proficiency, and medical clearances through standardized AFSOC processes (Tab V-32.3). The removable storage modules were loaded with the flight plans, communication plan, and a divert airfield flight plan (Tab DD-45). The CV-22B formation/crew brief was conducted at the 21 SOS on 28 November 2023 using PowerPoint and in accordance with flight crew checklists (Tabs BB-66 to BB-74, and DD-44). During this briefing, the MC reviewed the mission, situation, weather forecast, Notices to Air Missions (NOTAM), flight plans, crew duties and responsibilities, and the risk assessment (Tabs R-19, and DD-46). The ACs used the CV-22B ORM worksheet (v6.2) to identify risk factors for the formation's mission (Tab AA-19). The top four risks for the mission were identified as: 1) Higher Headquarters mission/complexity, 2) non-proficient airdrop, 3) greater than 12-hour crew day, and 4) pressure (Tab AA-19). The crews also identified the following mitigation factors for each respective risk: 1) thorough Concept of Operations, 2) multiple training events prior to mission, 3) planned crew change for last four hours of the mission, and 4) large enroute times prior to and after mission events (Tab AA-19). The three ACs signed the worksheet with an overall risk assessment of "medium" (Tab AA-19). The authorizing official, the 21 SOS/DO, concurred with the risk factors and risk mitigation factors; however, he assessed the mission to be lower in risk and approved by signing the worksheet as "low-medium" for overall risk (Tab AA-20).

e. Preflight

The evening prior to the flight, the MP, acting in his role as the AMC, deliberately decided to have the formation takeoff 30 minutes earlier than originally planned due to forecasted headwinds that were expected to increase flight time and fuel burn rate (Tab V-20.3 and V-32.7). Additionally, the AMC added a refueling stop at MCAS Iwakuni to reduce mission risk in the event the TAAR was unable to be executed (Tab R-132). At mission show time, the SMAs were sent to the aircraft to begin preflight inspections, while the pilots reviewed updated NOTAMs and the weather forecast (Tab R-6, and R-132). The crews retrieved their assigned aircrew flight equipment (AFE) and filed flight plans in accordance with standard operating procedures prior to stepping to the aircraft (Tabs B-39 to B-41, AA-3 to AA-5, and DD-46).

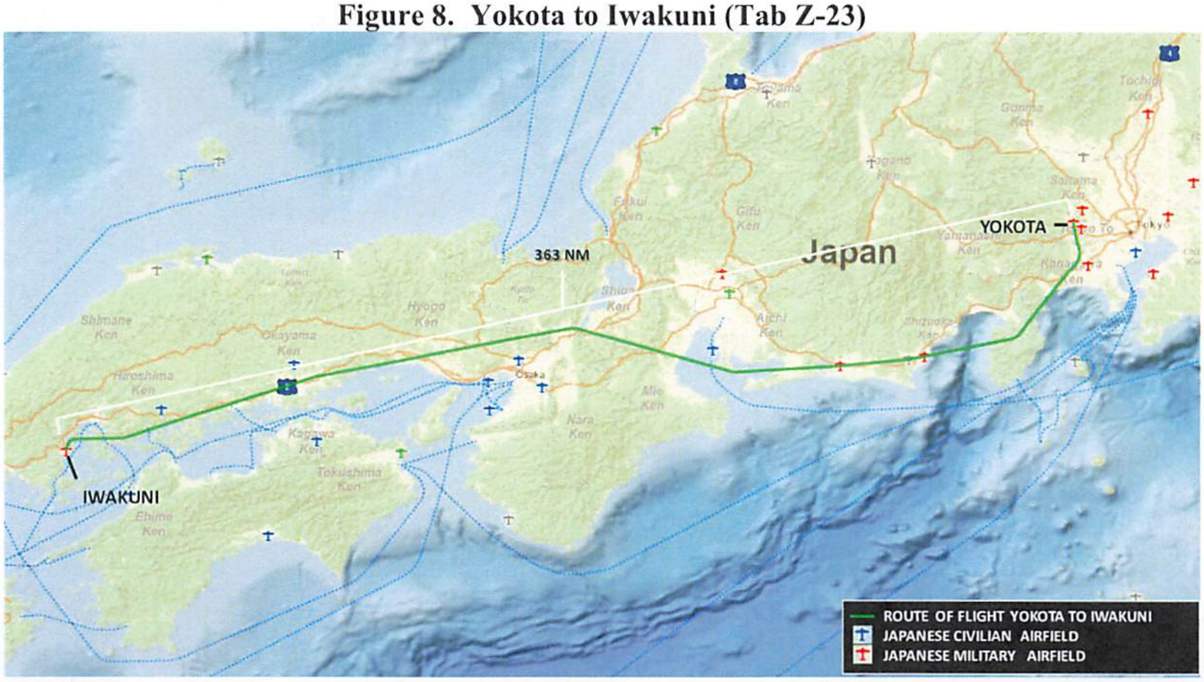
G21's departure was delayed due to a radio communication equipment error with their SOF team (Tab V-20.4). G21, the formation lead, cleared the MA to takeoff ahead of them as a single-ship under instrument flight rules (Tab V-20.4). During takeoff from Yokota AB, the MA experienced the first EP of the mishap sortie (MS), "MISSION CMPTR 1 FLT" (Tab DD-47). This occurs, due to a software glitch, when the backup computer automatically takes over while the primary computer restarts, referred to as a "warm-start" (Tab DD-47). This EP was displayed visually on the CDU and audibly with a master caution tone and necessitated the MC to complete a 29-step checklist while flying to MCAS Iwakuni, which was completed without issue (Tab DD-47).

f. Summary of Accident

(1) Phase I: Yokota AB to MCAS Iwakuni

The MA took off from Yokota AB at 1043L and flew 384 NM to the planned stop at MCAS Iwakuni, with a 60-70 knot headwind out of the west at their cruise altitude of 10,000 feet mean sea level (MSL) (Tab DD-47). The MC flew a straight-in visual approach to Runway 20, touching down at 1231L (Tabs DD-47, and II-9). G21 followed approximately 10 minutes behind MA (Tab V-20.4).

Figure 8. Yokota to Iwakuni (Tab Z-23)



(2) Phase II: Ground Operations at MCAS Iwakuni

At Iwakuni, after exiting the runway at taxiway F, the MA experienced a second mission computer warm-start (Tab II-11). The MC verbally acknowledged the warm-start alert and continued via taxiway F2 to the hot pits, an area for re-fueling without shutting down (Tab II-11 to II-12). When the aircraft stopped in the hot pits, the MSMATS exited the MA to prepare for refueling operations while the MSMAFE ran the refuel checklist (Tab II-13). The MP monitored fuel flow while discussing departure sequencing and timing with the KC-130Js for air-refueling (Tab II-18 to II-20). The MCP and the MSMAFE ran the checklist for the second warm-start (Tab II-13 to II-15). While refueling, the MA experienced a third warm-start, which caused the Intelligence Broadcast Receiver (IBR) connection to drop, a system required for the MC to receive intelligence information (Tabs DD-47, and II-15).

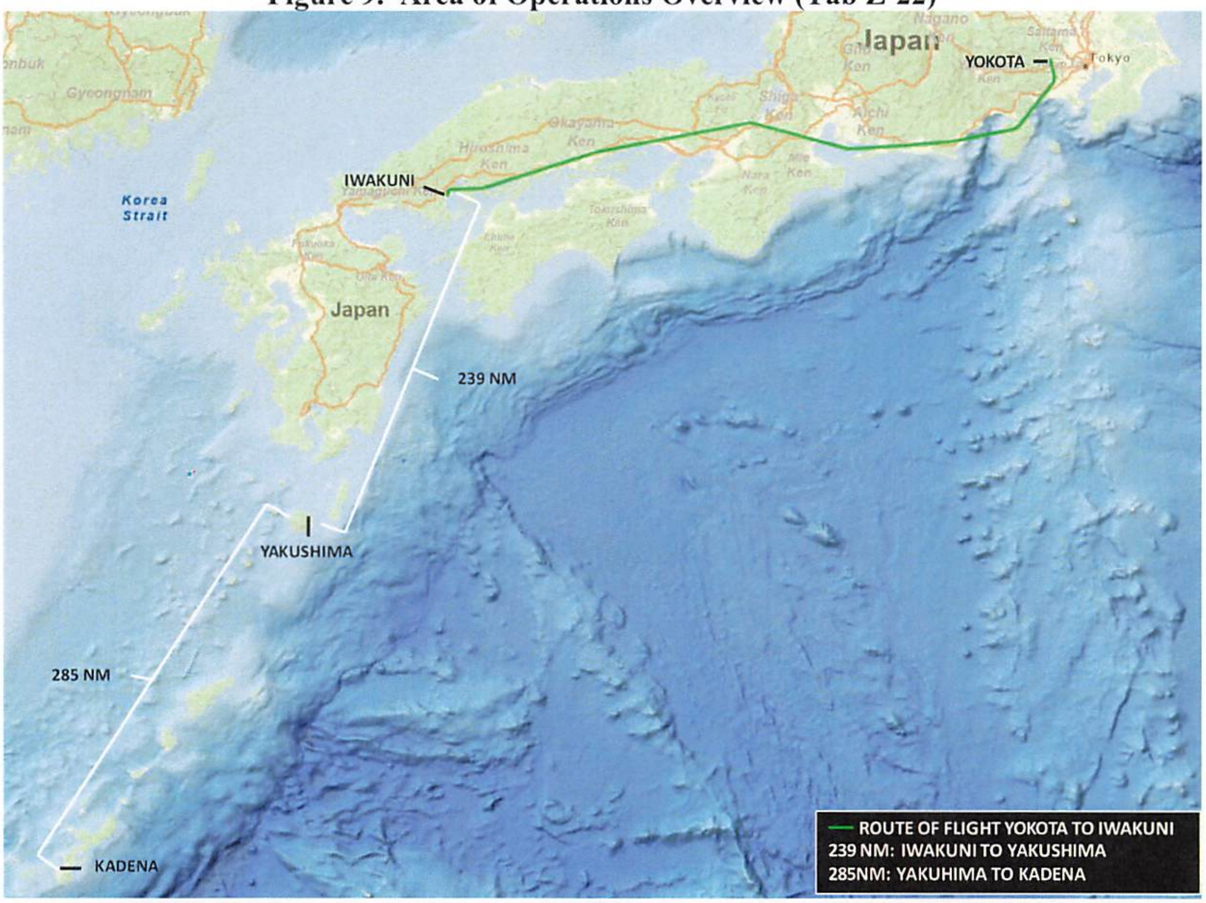
During the time on the ground at MCAS Iwakuni and while the MP was coordinating mission events with other exercise participants, the MA experienced multiple system advisories, mostly associated with the warm-start, to include: a blade fold control unit periodic built-in-test failure, a Global Positioning System (GPS) receiver failure, an exhaust deflector fail, a radio-frequency jammer failure, and an infrared jammer failure (Tab II-14 to II-17). The MC also nearly over-filled a feed tank due to a ground refuel-defuel panel fail (Tab II-17). While some of these additional failures were associated with the mission computer fault, they require additional crew attention (Tabs DD-47 and II-14 to II-17). As the MC worked all these issues over a busy intercom system, there was also an abundance of radio traffic on the MCAS Iwakuni air traffic control (ATC) frequency (Tab II-13 to II-28). Once both aircraft were refueled, the formation taxied via taxiway F toward the runway (Tabs DD-47, and II-25 to II-29). During the time on the Ground at MCAS Iwakuni, and continuing through the remainder of the mission, the MC repeatedly talked over each other on both the ICS and radio (Tabs DD-47, II-22, II-25, II-38, II-44, and II-62).

(3) Phase III: MCAS Iwakuni to Yakushima

The formation took off from taxiway A, southbound at 1309L via a 75-degree nacelle short takeoff (Tabs DD-47, and II-28 to II-29). After takeoff by the formation, the flying spare aircraft, G23, and its crew, was one hour in trail (Tab DD-45 and DD-47). The formation climbed to a cruise altitude of 8,000 feet MSL and the MSMATS began troubleshooting the IBR (Tabs AA-3, DD-45 and DD 47-48, and II-41 to II-44). Approximately 40 minutes after takeoff and in the vicinity of Miyazaki International Airport, the MC received a left-hand PRGB CHIP BURN emergency advisory on the CDU (there is no associated tone for this advisory) (Tabs DD-47, and II-46). The MSMAFE appropriately acknowledged, clearing the advisory on the CDU (Tab II-47). Twenty-three seconds later, a second left-hand PRGB CHIP BURN advisory posted and was again acknowledged by the MSMAFE (Tabs DD-47 to DD-48, and II-46).

During the three minutes following the second chip burn advisory, the MP continued coordination with other exercise participants on new flight routing, before having any discussions with the MC about the advisories (Tab II-46). The new flight routing took the formation westward from their briefed route to facilitate TAAR timing (Tab DD-47). The MP then verbally acknowledged the left-hand PRGB CHIP BURN advisory and checked the maintenance flight summary page to verify that two chip burns had occurred (Tab II-47). The MSMAFE reviewed the PRGB chip checklist and briefed the MC on the progression of a chip burn (Tab II-47 to II-48). The MP acknowledged the MSMAFE's information and queried the MC on whether anyone had ever experienced a chip burn in the aircraft; only the MP and MSMATS attested to having seen an actual chip burn advisory (Tab II-48). The MCP inquired on the status of current landing criteria and the MP stated that they had not yet met landing criteria (Tab II-48). The MSMAFE informed the MC that he would continue to monitor and review checklists and proceeded to verbally review checklists for the secondary indications listed for PRGB chips (Tab II-47 to II-49). The MSMATS and MSMAFE then continued to discuss troubleshooting the IBR (Tab II-49).

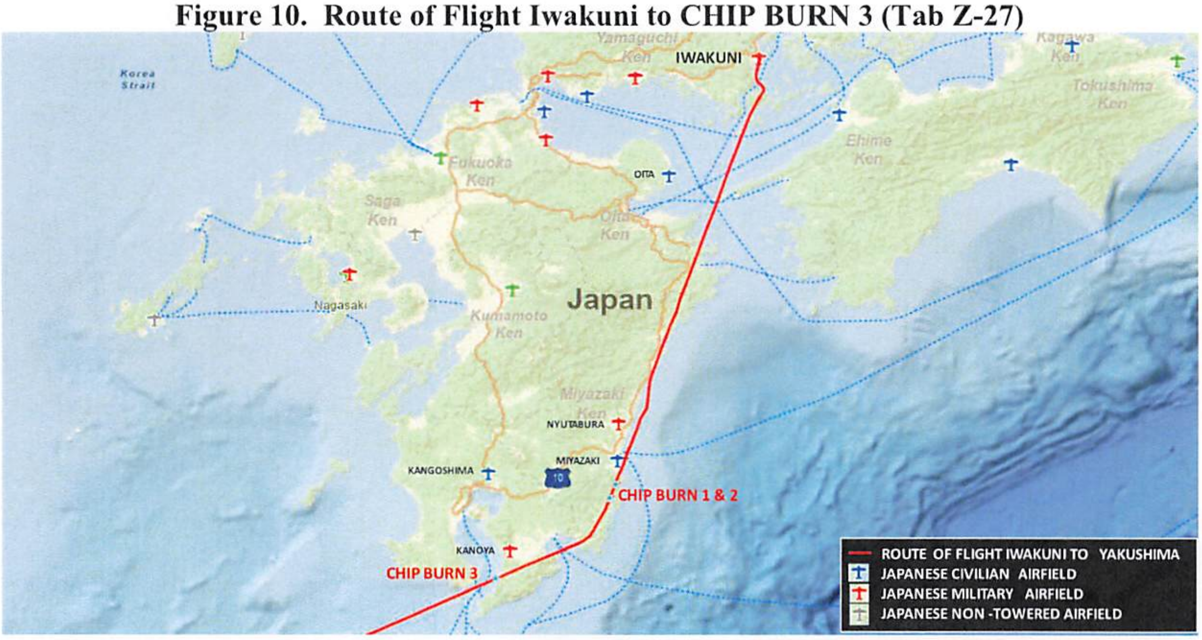
Figure 9. Area of Operations Overview (Tab Z-22)



The MCP suggested the MP use the line of sight (LOS) tool on the nearest divert airfield (Tab II-48). The LOS tool draws a line between the aircraft symbol on the MFD and the designated position and displays a real-time range and bearing on the dual digital map system (Tab DD-48). The MP declined the suggestion and elected to use the ForeFlight application on his electronic flight bag (EFB), which provides an automatic relative position to the nearest airport (Tabs BB-52, and II-48). Filters can be set for the nearest airport function using a minimum runway length; the 21 SOS used 4,000 feet as a planning factor (Tab V-35.5). The MC did not change ForeFlight settings to more detailed aviation charts or changing chart scale on the Multi-Function Displays in the cockpit to search for other options (Tab DD-48).

As the formation approached the southern tip of mainland Japan, 12 minutes after the second chip burn advisory, the MSMAFE announced a third left-hand PRGB CHIP BURN advisory and the MP verbally acknowledged (Tabs DD-48, and II-51). MSMAFE notified the MC that per NFM guidance, they were now in "Land as Soon as Practical" criteria and confirmed there were no secondary indications (Tab II-51). The MP marked the time for the third chip burn advisory and told the MC to monitor the times to see if their frequency increased and to continue monitoring for secondary indications (Tab II-52). The MC discussed that eventually the nearest airfield would be on Okinawa, but at that moment, the MA was still approximately 300 NM from Okinawa, all over open water (Tabs DD-48 and II-48). The MC did not discuss the actual nearest airfield, Kanoya AB, which was approximately 10 miles behind their current position (Tabs Z-27 and DD-48). The MP called G21 on the formation interplane frequency to communicate they had three PRGB CHIP BURN advisories but planned to continue the mission (Tab II-52). During that radio transmission, five minutes after the third left-hand PRGB CHIP BURN advisory, a fourth left-hand PRGB CHIP BURN advisory posted (Tab II-52). The IBR was receiving information, but aircraft mission systems were still not operational, so the MSMAFE left his seat to assist the MSMATS in troubleshooting the IBR connection (Tabs DD-48, and II-54).

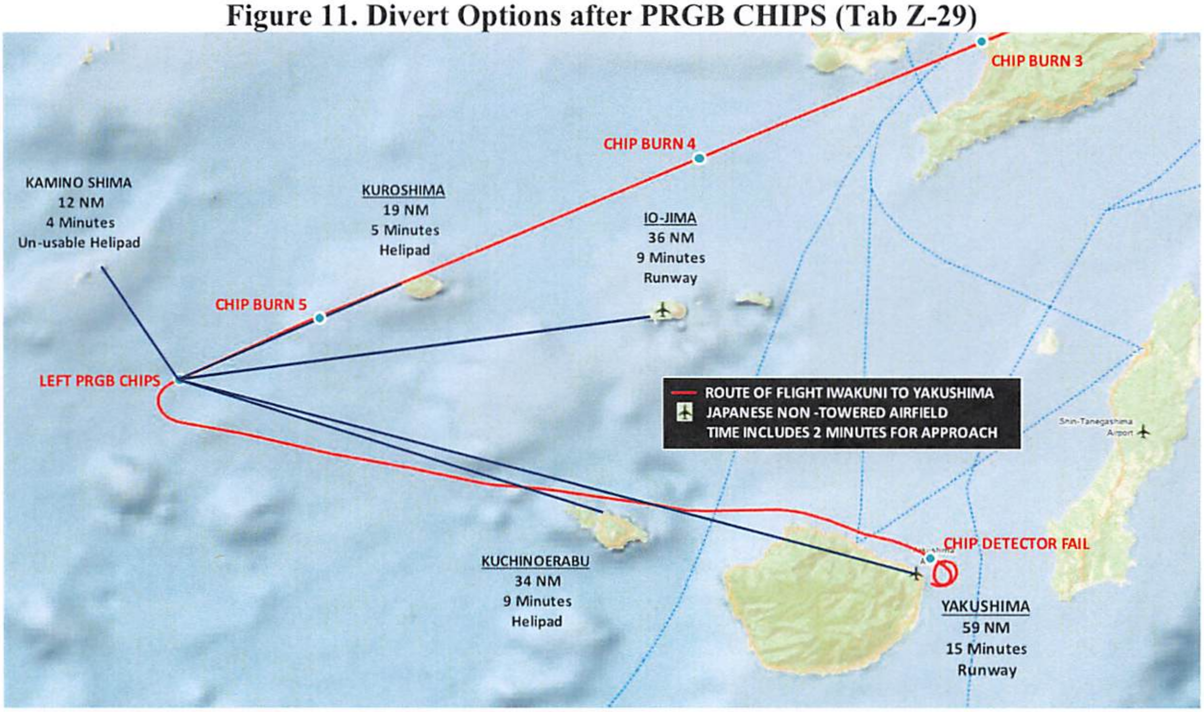
Figure 10. Route of Flight Iwakuni to CHIP BURN 3 (Tab Z-27)



After the fourth left-hand PRGB CHIP BURN advisory, the MC checked alternate electronic rendezvous equipment on the KC-130J, rectified the IBR connection, discussed time associated from the MFF location to Kadena AB, and discussed experience with chip burns and chips (Tab II-52 to II-55). Ten minutes after the fourth chip burn advisory, a fifth left-hand PRGB CHIP BURN advisory posted, then the MSMAFE climbed back into his cockpit seat (Tab II-52 to II-55). Three minutes after the fifth chip burn advisory, the "L PRGB CHIPS" caution posted, along with a master caution tone (Tab II-55). The MP verified with the MSMAFE that they were now dealing with "land as soon as possible" criteria and then radioed G21, "we've got chips" (Tab II-55). The MP then passed the aircraft controls to the MCP and directed a turn to a heading of 111 degrees towards Yakushima, their closest planned divert field (Tab II-56). The MSMAFE referenced the PRGB chips checklist, scanned for secondary indications and then asked for the radio frequency for Yakushima airport (Tab II-56). The MCP verbalized they had about 11 minutes until they would arrive overhead Yakushima airport and stated he would continue to fly the aircraft while the MP made applicable radio calls (Tab II-56 to II-57). Over the interplane radio, G21 asked over the interplane radio if they wanted mutual support, but the MP directed them to continue with the mission (Tab II-56). The MP then radioed the Deputy Mission Commander to transfer mission command responsibilities, followed by a radio call to G23 directing the maintenance team be flown to meet them at Yakushima airport (Tab II-58).

At this time, closer divert possibilities existed, including a vertical landing option at Kuroshima, and a roll-on landing option at Satsuma-IoJima Airport, which is represented in Figure 11 (Tab Z-29). Four minutes after the PRGB CHIPS caution post, without further discussion of divert options, the MC began a gradual descent to 1,000 feet MSL to setup the MA for entry into the aircraft traffic pattern at Yakushima airport (Tabs DD-49, and II-58).

Figure 11. Divert Options after PRGB CHIPS (Tab Z-29)



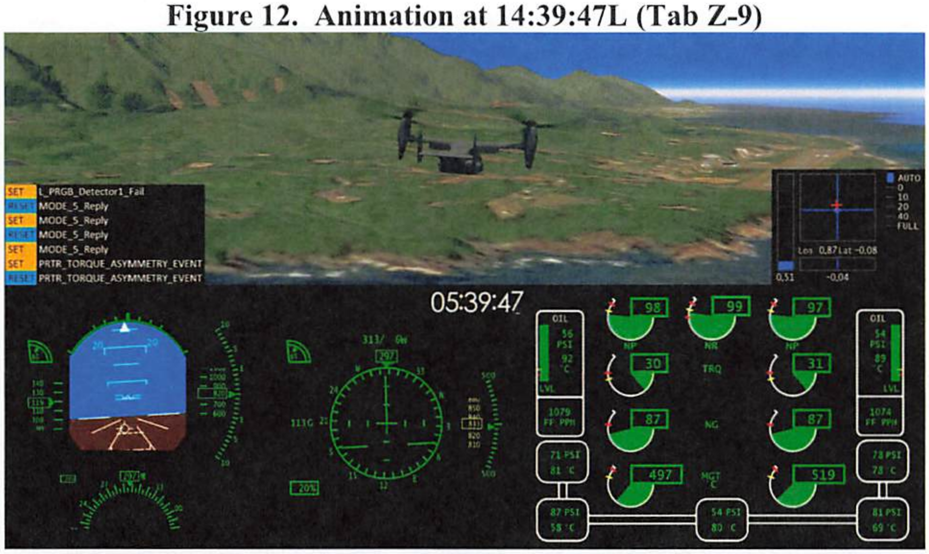
Yakushima Airport does not have an operating control tower and receives aerodrome flight information service (AFIS) remotely from Kagoshima Airport (Tab BB-110 to BB-111). ATC Operations Officers provide AFIS to support operations, but do not provide pilots with takeoff and landing clearance (Tabs BB-111 and EE-113).

As the MA approached Yakushima, the MP made a transmission on Yakushima Radio (118.65 MHz) that they were inbound for landing but received no response (Tab II-60). As they got closer, the MC heard radio traffic on the Yakushima Radio frequency, indicating an aircraft was taxiing for takeoff on Runway 32 (Tabs EE-112 to EE-113, and II -61). On initial contact with Yakushima Radio, when the MP requested to land on runway 32, the airport Operations Officer asked if they were in an "emergency situation" (Tabs EE-112, and II-62). The MP responded, "Affirm" (Tab II-62). Of note, this was the first time in the mishap sequence that the term "emergency" was used in MC conversations or external radio calls (Tab II-62). The airport Operations Officer advised that they should hold due to traffic on the runway (Tab II-62). Although the MC could not audibly discern the radio call to hold, the MP directed the MCP to hold near the approach end of Runway 32 for the departing traffic (Tab II-62). The MA then posted a CHIP DETECTOR FAIL advisory on the CDU, indicating a chip detector failure occurred (Tab II-63). The MP commented that he was no longer worried since he assumed the previous warnings were errors due to a faulty chip detector (Tabs DD-49, and II-63). The MP next directed the MCP to "do one more big, right-hand loop and come in and just set up for landing," after which the MSMAFE verbally reminded the MC that the "L PRGB CHIPS" advisory was still posted, and the MP acknowledged (Tab II-63). Shortly afterwards, when the commercial aircraft began its takeoff roll, the MCP turned the MA towards the runway, starting a normal approach from traffic pattern altitude of 1,000 feet MSL (Tabs DD-49, and II-63).

g. Impact

During the Before Landing Checklist, MCP briefed an "airland" approach to the ground (i.e., land vertically like a helicopter) (Tabs DD-49, and II-62). Two minutes prior to landing, the MCP slowed the aircraft and brought the nacelles up in preparation for landing (Tab DD-49).

Figure 12. Animation at 14:39:47L (Tab Z-9)

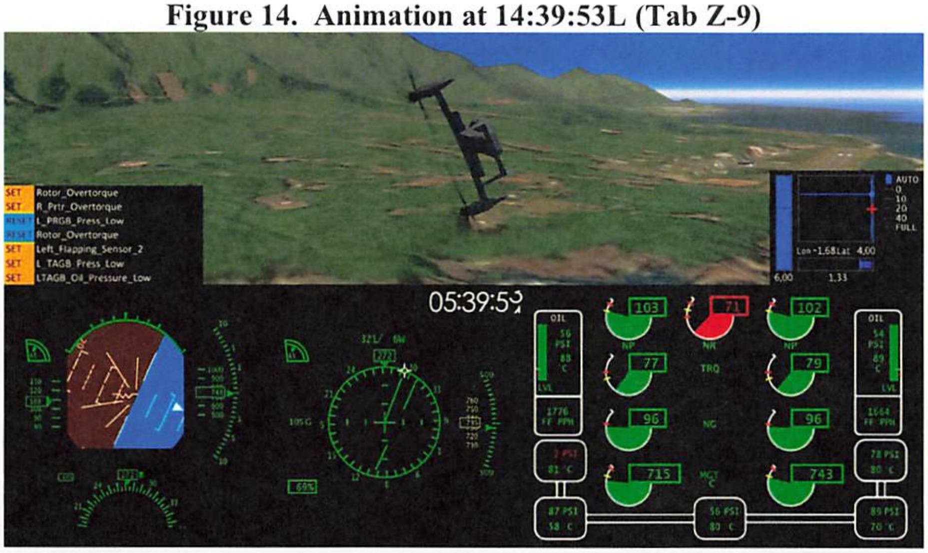


Within the last six seconds of data, cascading failures in short succession were recorded by the KVADR (Tab DD-49). Audible engine surges could be heard in the ambient recording from the cockpit microphone, followed by an auditory master caution tone (Tab DD-49). Left-hand PRGB oil pressure rapidly dropped with an associated, "L PRGB OIL PRESS LOW" caution, followed by a voice warning, "DRIVESHAFT FAILURE, DRIVESHAFT" (Tabs DD-49, and II-64).

Figure 13. Animation at 14:39:50L (Tab Z-9)

Approximately one-half mile from the approach end of runway 32, the MA was at 785 feet, 106 knots ground speed, with nacelles at 66 degrees, flaps set to auto, and the landing gear retracted, as shown in Figure 15 (Tab DD-49 to DD-50). Every step of the Before Landing Checklist was completed except the extension of the landing gear (Tab II-58). At 14:39:53L (5:39:53Z), 49 minutes after the first left-hand PRGB CHIP BURN advisory posted, the MA abruptly rolled left and rapidly exceeded 90 degrees angle of bank (Tab DD-50). The KVADR's last record was at 5:39:53Z (14:39:53L) depicted in Figure 16 below (Tab Z-9). The thrust control lever was all the way forward at full power (Tab DD-50). The cyclic was 1.6 inches forward of center and full right, the rudder was 1.3 inches right (Tab DD-50). The MA rolled inverted and continued to roll to the left, the left nacelle caught on fire, and an object separated from the MA and fell to the water to the right of the aircraft flight path (Tab DD-50). The MA disappeared from radar at 14:40L (5:40Z) (Tab EE-9). The MA impacted the water upright, nose down, and rolling left (Tab DD-50).

Figure 14. Animation at 14:39:53L (Tab Z-9)



h. Egress and Aircrew Flight Equipment

All required AFE was in compliance with inspection requirements and appropriately documented by current and qualified AFE technicians (Tabs B-39 to B-40, and T-979 to T-1082).

There was no evidence of attempted egress by the MC or activation of individual emergency equipment (Tab X-3). All individually issued AFE items that were recovered were intact and unused, with no evidence of deficiency or malfunction (Tab X-3). The orange flotation cell from a life preserver unit from one of the MC was released from the carrier but it was determined this occurred during the mishap sequence (Tabs X-3). It was verified that the inflation tab was not pulled, and the auto-inflation air cylinder was still pressurized (Tab X-3, and Z-129).

A 20-man LRU-34/A life raft was onboard the MA at the time of the mishap; the carrying case was found at the bottom of the ocean, still attached to the MA (Tab S-5). During the impact sequence, the life raft separated from the carrying case, which pulled the inflation handle (Tab DD-50). The life raft was found empty, upside down, and floating on the water's surface (Tab Z-5).

i. Search and Rescue

At approximately 1447L, the Japan Coast Guard received report of the mishap and quickly dispatched watercraft and aircraft to the area to begin search and rescue operations (Tab EE-9). Within 48 hours of the accident, the search had expanded to include a combination of air, surface, and subsurface exploration of the water and coastline, as well as assets of the United States Ship Carl Vinson and its air wing, divers, unmanned vehicles, and search and rescue experts (Tab EE-103). Intensive search, rescue, recovery, and salvage efforts were conducted for 43 days, alongside the Japan Coast Guard, Japan Self-Defense Forces, local law enforcement, and Japanese civilian volunteers (Tab EE-81 to EE-83). The search was conducted in accordance with a US-Japan personnel recovery memorandum of understanding (Tab BB-37 to BB-38). Search, rescue and recovery operations included more than 1,000 personnel, 46 aircraft, 23 maritime vessels and 21 unmanned aerial and underwater systems searching more than 60,000 square kilometers of the ocean's surface, 69 square kilometers of the ocean floor, and 90 kilometers of coastline (Tab EE-81 to EE-83).

j. Recovery of Remains

The search and recovery for the MC was lengthy and extensive due to location, depth, dispersion of wreckage in the water, and because of the specialized equipment and dive teams required for operations (Tab EE-81 to EE-83). All recovered personnel underwent autopsy and toxicology analysis by an Armed Forces Medical Examiner (Tab X-3 to X-8). All personal effects and AFE gear were released to the respective mortuary affairs teams for disposition and subsequent release to the units and families (Tab X-3).

(1) Recovery of Mishap Direct Support Operator

MDSO was recovered unconscious from the surface of the water by locals in boats approximately 2 hours after the mishap on 29 November 2023 (Tab EE-9). He was transported to Port Anbo, Yakushima Island, and was later confirmed deceased at approximately 1720L (Tab EE-17). MDSO was next transported to Joint Base Pearl Harbor-Hickam, Hawaii, and then escorted to the Defense Prisoner of War/Missing in Action Accounting Agency for postmortem examination (Tab X-6 to X-7).

(2) Recovery of Mishap Additional Pilot

MAP was found submerged, outside the fuselage on the left side and recovered by US military divers on 4 December 2023 (Tabs EE-83, and V-29.8). He was transported to Yokota AB and then released to mortuary affairs for postmortem examination, which occurred on 7 December 2023 (Tab X-6).

(3) Recovery of Mishap Special Operations Forces Medical Element 2

MSOFME2 was found submerged, outside the fuselage on the left side and recovered by US military divers on 4 December 2023 (Tabs EE-83, and V-28.7). He was transported to Yokota AB and then released to mortuary affairs for postmortem examination which occurred on 7 December 2023 (Tab X-8).

(4) Recovery of Mishap Co-pilot

MCP was found in the submerged cockpit, strapped in the right pilot's seat and recovered by US military divers on 5 December 2023 (Tabs EE-85, and V-28.7). He was transported to Yokota AB and then released to mortuary affairs for postmortem examination which occurred on 8 December 2023 (Tab X-4 to X-5).

(5) Recovery of Mishap Special Mission Aviator Flight Engineer

MSMAFE was found submerged, strapped in the FE seat, which separated from the main fuselage on the right side and was recovered by US military divers on 5 December 2023 (Tabs EE-83, and V-29.8). He was transported to Yokota AB and then released to mortuary affairs for postmortem examination which occurred on 8 December 2023 (Tab X-5).

(6) Recovery of Mishap Special Mission Aviator Tail Scanner

MSMATS was found submerged, near the rear of the fuselage and recovered by US military divers on 5 December 2023 (Tabs EE-83, and V-28.7). He was transported to Yokota AB and released to mortuary affairs for postmortem examination which occurred on 9 December 2023 (Tab X-5 to X-6).

(7) Recovery of Mishap Pilot

On 10 December 2023, MP was found submerged and strapped in the left pilot's seat approximately 200 meters south of the main wreckage (Tab V-28.8). He was recovered by United States military divers, transported to Yokota AB and released to mortuary affairs for postmortem examination which occurred on 11 December 2023 (Tabs EE-83, V-28.8, and X-4).

(8) Recovery Efforts for Mishap Special Operations Forces Medical Element 1

MSOFME1 was not located, nor recovered despite widespread search efforts (Tab EE-81). Duty status was changed from Duty Status-Whereabouts Unknown to Deceased on 4 December 2023 along with the seven other MC when rescue operations transitioned to recovery operations (Tab EE-97).

5. MAINTENANCE

a. Forms Documentation

(1) General Definitions

Air Force Technical Order (AFTO) 781 series forms and a computer database known as Integrated Maintenance Data System (IMDS) document Air Force aircraft maintenance and inspection histories (Tab U-2717, and U-3251). In addition to scheduling and documenting routine maintenance actions, these mechanisms allow aircrews to report aircraft discrepancies, and maintenance personnel to document the actions taken to resolve the reported issues (Tab U-2722, U-2900, and U-3265). Furthermore, the AFTO 781 forms and IMDS provide the ability to research past aircraft problems to troubleshoot and solve new maintenance discrepancies more effectively (Tab U-2722, and U-3260).

Active AFTO 781 series forms are those that are currently in use by maintenance personnel to record aircraft condition, repairs, and airworthiness (Tab U-2746). Active discrepancies are those that have not yet been corrected by maintenance personnel (Tab U-2746).

Inactive AFTO 781 series forms contain uncleared discrepancies that are carried forward to a new form, then retained for historical purposes (Tab U-2751).

Maintenance personnel use Time Compliance Technical Orders (TCTOs) to process system changes, usually aircraft part upgrades, which must be accomplished within a specific time and by a specific date (Tab U-2784). A TCTO may also direct inspections or adjustments to equipment or parts already installed on the aircraft or those of ground support equipment (Tab U-2784). A Time Change Item (TCI) is a designated part to be replaced at specified intervals (Tab U-2793). TCIs encompass routine maintenance actions which require components to be removed and replaced at a given number of flight hours or calendar days (Tab U-2784). The primary objective of the time-change replacement program is to achieve maximum utilization of components consistent with the economic operation of aerospace equipment without jeopardizing flight or operational safety (Tab U-2793).

Active discrepancies are those that have not been corrected by maintenance personnel (Tab DD-3). These discrepancies are evaluated to determine whether they affect the airworthiness (Tab DD-3). Airworthiness describes whether an aircraft is suitable for flight (Tab DD-3). Within the AFTO 781 forms and IMDS, symbols are used on maintenance documents to make important notations instantly apparent (Tab U-2740). The symbols indicate the condition, fitness for flight or operation, servicing, inspection, and maintenance status of the aerospace vehicle or equipment (Tab U-2740).

A Red X, "X", indicates that an aircraft is considered unsafe or in an unserviceable condition (Tab U-2740 to U-2741). The unsatisfactory condition must be corrected, and the symbol cleared before flying the aircraft (Tab U-2740 to U-2741).

A Red Dash, "-", indicates an unknown condition of the equipment (Tab U-2741). A more serious condition may exist (Tab U-2741 to U-2742). The aircraft is still flyable (Tab U-2741 to U-2742).

The Red Diagonal, "/", indicates a discrepancy exists on equipment but is not sufficiently urgent or dangerous to warrant the aircraft's grounding or discontinued use (Tab U-2742).

(2) Active Forms

According to IMDS, on the day of the mishap there were twenty active AFTO 781 aircraft maintenance discrepancies consisting of zero Red X "X" discrepancies, one Red Dash "- "discrepancy, and 19 Red Diagonal "/" discrepancies (Tab DD-3 to DD-5). None of the discrepancies indicated the aircraft was unsafe or in an unserviceable condition, and the discrepancies did not warrant the aircraft's grounding or discontinued use (Tab DD-7)

The active AFTO 781 series forms binder which accompanied the MA was not recovered post mishap and all existing active IMDS entries were reviewed for accuracy and completeness (Tabs D-3, and U-3 to U-962). Documentation errors were observed but did not pose a safety of flight issue and did not impact airworthiness (Tab U-2740 to U-3235).

(3) Historical Forms

A thorough review of the complete aircraft historical file was conducted to include TCTO status, significant historical data, major inspection documentation and archived data within the IMDS (Tab U-3 to U-238, and U-269 to U-962). The review analyzed historical records from the last 180 days to the day of the mishap (Tab U-269 to U-756). Documentation errors were observed but did not pose a safety of flight issue and did not impact airworthiness (Tab U-3 to U-238, and U-269 to U-962).

b. Inspections

(1) Preflight Inspection

The preflight inspection is a flight preparedness inspection done in accordance with the Mission Design Series (MDS) specific technical order or maintenance manual (Tab U-2725 to U-2726). The inspection includes visually examining the aerospace vehicle and operationally checking certain systems and components to ensure there are no serious defects or malfunctions (Tab U-2725 to U-2726).

On 28 November 2023, at 1800 local, maintenance personnel conducted the last scheduled preflight inspection, which is valid for 72 hours, and was still valid when the MA took off for the mission on 29 November 2023 (Tabs U-156, and DD-6). The maintenance documentation confirms that inspections were accomplished in accordance with governing maintenance directives (Tabs U-3 to U-238, U-269 to U-756, and DD-6).

(2) Hourly Inspections

Hourly inspections are items designated by technical orders or maintenance manuals, that are to be inspected or tested at a specific hourly period (Tab DD-6). The last hourly inspection maintenance actions documented were the 35-hour left-hand and right-hand proprotor hub mast nut torque checks, a 35-hour proprotor blade inspection, and a 70-hour inspection—no defects were noted (Tabs U-375 to U-379, and DD-6).

(3) Phase Inspections

Phase inspections occur at hourly intervals for the life of an aerospace vehicle (Tab U-2727). Phases are completed upon accrual of the number of flying hours specified in the applicable MDS specific maintenance manual (Tab U-2727). Phase inspections are scheduled at equal intervals throughout the total inspection cycle regardless of when the inspections are accomplished (Tab U-2727). The CV-22B has a 280-hour phase inspection cycle (Tab DD-6). The last phase inspection on the MA was a "Phase C" inspection (Tab U-333 to U-474). During a phase inspection, chip detectors and other components are inspected (Tab DD-6). The last time this was accomplished, no defects or debris were noted (Tab DD-6). Aside from phase inspections, PRGBs are not inspected for debris unless there is a chip burn or chips detected (Tab DD-6). All maintenance directives, inspections and actions were documented (Tab U-333 to U-474). Documentation errors were noted but did not pose a safety of flight issue and had no bearing on the mishap (Tab U-333 to U-474). The MA functional check flight (FCF) was released from phase on 11 October 2023 (Tab U-919 to U-927, and U-2746 to U-2747). The MA flew 34 flights (including the MS), totaling 67.6 flight hours from the last "Phase C" inspection to the day of the MS (Tab U-269).

c. Maintenance Procedures

Prior to launching an aircraft, maintenance actions and procedures must be completed and documented to include servicing, preflight, exceptional release (ER), and verification of inspections (Tab DD-6). Documentation of these actions is required within the AFTO 781 forms and IMDS (Tab U-2734). The most common servicing actions are fueling, cleaning, tire servicing, and oil servicing (Tab DD-6). Preflight inspections are completed and documented prior to flight (Tab U-2725). Typical maintenance operations accomplish servicing and preflight inspections concurrently (Tab DD-6). Once completed, a production superintendent reviews the AFTO 781 forms and IMDS for accuracy and conducts a visual inspection of the aircraft to ensure there is no maintenance action that would affect airworthiness of the aircraft (Tabs U-2775, and DD-6). After the review and last visual inspection, the production superintendent releases the aircraft to aircrew for flight by signing an ER (Tab U-2775). The ER serves as a certification that the authorized individual who enters their signature has reviewed the active forms to ensure the aerospace vehicle is safe for flight (Tab U-2775).

At the end of the flying period, additional actions are required (Tabs U-2726, and DD-6). A post-flight inspection is completed to verify airworthiness of the aircraft (Tabs U-2726, and DD-6). Flight hours are tallied to keep track of aircraft and engine operating time (Tab U-2780, and U-2783). Aircraft and engine operating times are recorded in the AFTO 781 forms and IMDS to ensure tracking of scheduled time change components and inspections (Tab DD-6).

Maintenance procedures on the MA were performed in accordance with applicable technical orders and instructions at the time of the mishap (Tabs U-3 to U-962, and DD-6).

d. Maintenance Personnel and Supervision

753 SOAMXS is responsible for the maintenance and repairs of the CV-22B assigned to Yokota AB (Tab DD-5). Maintenance personnel and supervisors indicated they had a very good working relationship with the 21 SOS (Tab V-7.1 to V-10.5, and V-33.1 to V-34.110). Maintenance supervision was engaged in daily maintenance activities and actively involved in the repair and launch of aircraft (Tab V-7.1 to V-10.5).

Maintenance personnel statements indicated all preflight activities were normal and all personnel involved in the preflight and launch of the MA were experienced and qualified (Tabs U-1097 to U-2739, V-7.1 to V-10.5, and V-33.1 to V-34.110). A thorough review of individual military training records and special certification roster for all personnel who performed maintenance on the MA indicated proper training on all tasks accomplished (Tab U-1097 to U-2739).

Following the mishap, blood samples were taken from maintenance personnel and no members tested positive for improper substances (Tab X-9).

e. Fuel, Hydraulic Fluid, and Oil Analyses

Hydraulic fluid and oil samples were pulled from a consolidated servicing point within the 753 SOAMXS maintenance area at Yokota AB (Tab DD-5). The servicing point has 55-gallon drums of hydraulic fluid, engine oil and gearbox oil that are used to fill aircraft servicing equipment used to service the fleet (Tab DD-5).

(1) Fuel

Post-mishap, fuel samples were taken for testing from the fuel trucks that refueled the MA on 29 November 2023 at Yokota AB and MCAS Iwakuni (Tab U-971 to U-989). Aerospace Fuels Laboratory tested the fuel from the truck at Yokota AB and Petroleum Products Laboratory tested the fuel from the truck at MCAS Iwakuni (Tab U-971 to U-989). All fuel samples tested within limits and were free from contamination (Tab U-971 to U-989).

Prior to the incident, all routine scheduled fuel analysis reports from Yokota AB and MCAS Iwakuni were reviewed; all tested within limits and were free from contamination (Tab U-971 to U-989).

(2) Hydraulic Fluid

A hydraulic fluid sample was taken post-mishap from the consolidated servicing point drum at Yokota AB and was sent to the Air Force Petroleum Office Laboratory at Wright-Patterson AFB, Ohio (Tab D-699 to D-700). The sample tested was within required limits; a particulate contamination test was not run (Tab D-699 to D-700). Although the particulate contamination was not tested, there is no documentation if the MA hydraulic systems were serviced with the sampled barrel (Tab DD-5).

(3) Gearbox Oil

Gearbox oil samples are taken on a 91-day interval to inspect for water content (Tab DD-6). The last 91-day oil samples analyses were completed on 7 September 2023 prior to the mishap (Tab U-243 to U-247). All gearboxes were within required limits for water content (Tab U-243 to U-247). Additionally, gearbox oil sample was taken post-mishap and was sent to the Air Force Petroleum Office Laboratory at Wright-Patterson AFB, Ohio (Tab D-697 to D-698). The gearbox oil sample was within required limits and free of contamination (Tab D-697 to D-698).

(4) Engine Oil

An engine oil sample was taken post-mishap at Yokota AB and was analyzed by the Air Force Petroleum Office Laboratory at Wright-Patterson AFB, Ohio (Tab D-695 to D-696). The sample failed specification requirements for the viscosity, testing .02 square millimeters per second below the minimum requirement, and having a flash point 2 degrees Celsius below the minimum requirement (Tab D-695 to D-696). Although the oil sample did fail two portions of the testing, there is no documentation to show whether the MA engines were serviced with oil from the sampled barrel (Tab DD-5).

f. Unscheduled Maintenance

The last scheduled maintenance inspection was completed on 11 October 2023 (Tab U-333 to U-474). Between the 280-hour "Phase C" inspection and the mishap, aircrew reported 10 discrepancies resulting in unscheduled maintenance (Tab U-795 to U-927). Each discrepancy was reported during debrief and documented in IMDS (Tab U-795 to U-927). Maintenance personnel performed maintenance on each discrepancy and cleared discrepancies after performing operational checks (Tabs U-3 to U-131, and DD-6). The discrepancies resulting in unscheduled maintenance did not involve the MA's PRGB (Tabs U-3 to U-131, and DD-6). (Tab U-795 to U-927). Operational checks passed with exception of the twenty open discrepancies previously noted (Tabs U-3 to U-131, and DD-6).

A review of IMDS and historical AFTO 781 maintenance records over the 180 days preceding the mishap did not identify noteworthy items or maintenance issues beyond those already described (Tab U-271 to U-758). Additionally, a review of the MA's performance for the 180-day period prior to the mishap revealed the MA flew 36 of 37 scheduled sorties, of which 26 of 36 sorties flown landed with zero to minor discrepancies and amassed 143.3 flight hours (Tab U-269). Finally, a review of the V-22 Virtual Technical Assistance and Maintenance Program, which is used to request Fleet Support Team (FST) engineering assistants, indicated a total of 15 technical assistance requests were made during the 180-day period (Tab U-248 to U-268). All 15 requests were answered, and maintenance completed with no defects (Tab U-248 to U-268). One technical assistance request remained open for maintenance inspection every 70 flight hours and was last completed on 16 November 2023 with no defects (Tab U-356, and U-379).

6. AIRFRAME

a. Historical Risk Analyses

Over a period of years, NAVAIR's PMA-275 conducted several PRGB-related safety assessments (Tab DD-53). These safety assessments found the likelihood of PRGB internal component failure to be remote or improbable, but also indicated that total loss of aircraft and crew were possible, should PRGB internal components fail (Tab DD-53). Safety assessments produced data on manufacturing techniques, failure rates, and design and process improvements, as well as data relevant to extended flight over open water (Tabs V-36.5 to V-36.6 and DD-53).

Some safety assessments resulted in PMA-275 implementing program-wide changes to obviate or sufficiently mitigate the risk of PRGB internal component failure (Tab DD-53). But program-wide changes, such as changes requiring conservative aircraft operations in certain circumstances, were not always implemented, or were implemented in a manner that did not stress the severity of the risk (Tabs V-36.5, and DD-53 to DD-54). Additionally, aircrew training on how to react to PRGB indications was not modified (Tab DD-54). The findings of PRGB safety assessments also were not always communicated to the military services, limiting opportunities for service-specific changes to documentary guidance and training based on each service's assessment of risk (Tabs V-36.4 to V-36.5 and DD-54).

b. Structures and Systems

(1) V-22 Drive System Engineering Investigation

The left-hand PRGB, right-hand PRGB, left-hand tilt-axis gearbox (TAGB), right-hand TAGB, and mid-wing gearbox (MWGB) were sent to Fleet Readiness Center (FRC) East for engineering investigation by FST (Tab J-354). The engineering investigation concluded the following: the loss of controlled flight resulted from an asymmetric loss of drive to the left-hand proprotor due to failure of the left-hand PRGB, serial number (S/N) A-65, high-speed planetary section (Tab J-453). The exact root cause for failure of the high-speed planetary section could not be determined due to secondary damage that obscured evidence of the initial failure (Tab J-453).

The left-hand PRGB oil temperature and pressure were normal prior to the loss of controlled flight (Tab J-456). The left-hand PRGB oil temperature remained within normal range throughout the entire flight data set (Tab J-456). The left-hand PRGB oil pressure immediately dropped after the loss of controlled flight (Tab J-456). All other damage associated with the left-hand PRGB is attributed to impact damage, or to damage incurred during or after salvage related activities (Tab J-456).

No damage was found to indicate that right-hand PRGB experienced a functional failure in-flight prior to the impact of the MA (Tab J-458). The absence of a failure indicates that the right-hand PRGB was still capable of transmitting torque to the right-hand proprotor and pylon driveshaft (Tab J-458).

No damage was found to indicate that left-hand TAGB or right-hand TAGB experienced a functional failure in-flight prior to the impact of the MA (Tab J-458). The left-hand TAGB accessory input shaft fracture, seal housing fractures, and case set damage were consistent with impact damage (Tab J-458). The absence of a bevel gear or bevel pinion gear failure indicates that left-hand TAGB and right-hand TAGB were still capable of transmitting torque between the pylon driveshaft and the spindle driveshaft (Tab J-458).

No damage was found to indicate that MWGB experienced a functional failure in-flight prior to the impact of the MA (Tab J-458). The absence of a thru-shaft failure indicates that the MWGB was still capable of transmitting torque between the left-hand and right-hand center wing driveshafts (Tab J-459).

Review of the flight data for the left-hand and right-hand power turbine (Np), torque (Qe), and other engine parameters indicates there were no signs of an engine surge or Hard Clutch Engagement (HCE) event prior to the loss of controlled flight (Tab J-457). The absence of HCE was also confirmed by disassembly and inspection of the left-hand and right-hand input quills, which revealed a lack of damage to the left-hand and right-hand clutch components (Tab J-457).

1) Left-Hand Proprotor Gearbox

MCAS Cherry Point conducted initial teardown of the left-hand PRGB, as seen in figure 20, which was documented by the V-22 FST (Tab J-107). During initial teardown, large metallic fragments were recovered from the gearbox and were examined by MCAS Cherry Point materiel lab personnel (Tab J-107). The materiel was dried under vacuum and then passed through a series of sieves to capture fragments of interest (Tab J-107). The fragments were later analyzed by Air Force Research Laboratory (AFRL) (Tab J-107). No significant pre-existing defects or manufacturing discrepancies in the damaged hardware were identified (Tab J-116). Each of the components satisfied all applicable requirements evaluated, including composition, hardness, and microstructural cleanliness (Tab J-116).

Damage internal to left-hand PRGB compromised its ability to transmit power to the proprotor (Tab J-116). The damage included fracture of one of five high-speed pinion gears, fatigue cracking of the associated pinion gear's bearing cage and shearing of all the bull gear lower drive teeth (Tab J-116). Due to the extent of secondary damage, some aspects could not be evaluated (Tab J-116).

2) Drive System Interface Unit Debris Detection

The FST avionics lab located at FRC-East, MCAS Cherry Point reviewed flight data recovered from the KVADR and VSLED health monitoring system to determine if the gearbox debris sensor system within the DSIU operated correctly (Tab J-328).

The FST avionics lab determined the chip detection system operated as designed in the avionics lab and the results seen in the lab mimicked the data recovered from the MA (Tab J-339). The logic operated the same across multiple different gearbox detectors with multiple methods for simulating chips (Tab J-339). It also operated the same with two different, but equivalent, aircraft software variants (Tab J-339).

3) Left-Hand and Right-Hand Proprotor Gearbox Chip Detectors

AFRL, Wright-Patterson AFB, Ohio carried out an evaluation report of all three left-hand PRGB chip detectors and the right-hand PRGB chip detectors (Tab J-227). AFRL concluded, while in-house testing identified anomalous conditions, all could be attributed to abnormal distress sustained in service (Tab J-224). No definitive pre-existing defects or conditions were identified with the detectors themselves (Tab J-224).

When tested with debris present, as seen in figures 17, 18, and 19 low resistance was measured across the left-hand #1, left-hand #2, and left-hand #3 detector electrodes (Tab J-231). After the debris was removed, nominal resistances were measured (Tab J-231). The change in resistance after the debris was removed confirms that the debris sensors were correctly reporting to the monitoring systems (Tab J-231). Fracture of the right-hand #3 detector housing is consistent with impact damage (Tab J-231). Excess signal leakage current and galvanic voltage noted on the left-hand #2 detector are consistent with intrusion of ionic fluid, such as saltwater (Tab J-231).

Figure 15. MA Left-Hand PRGB Chip Detector #1 (Tab J-240)

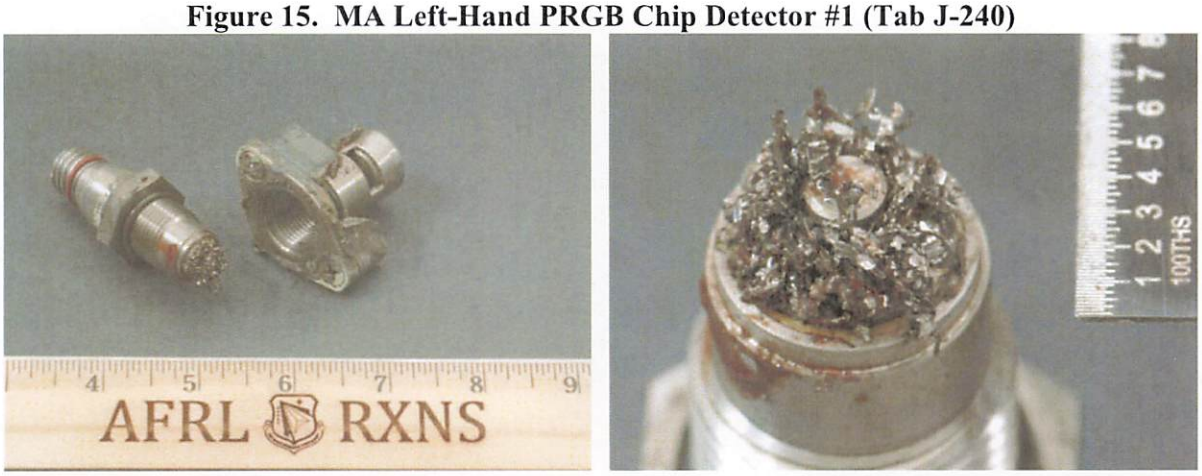


Figure 16. MA Left-Hand PRGB Chip Detector #2 (Tab J-241)

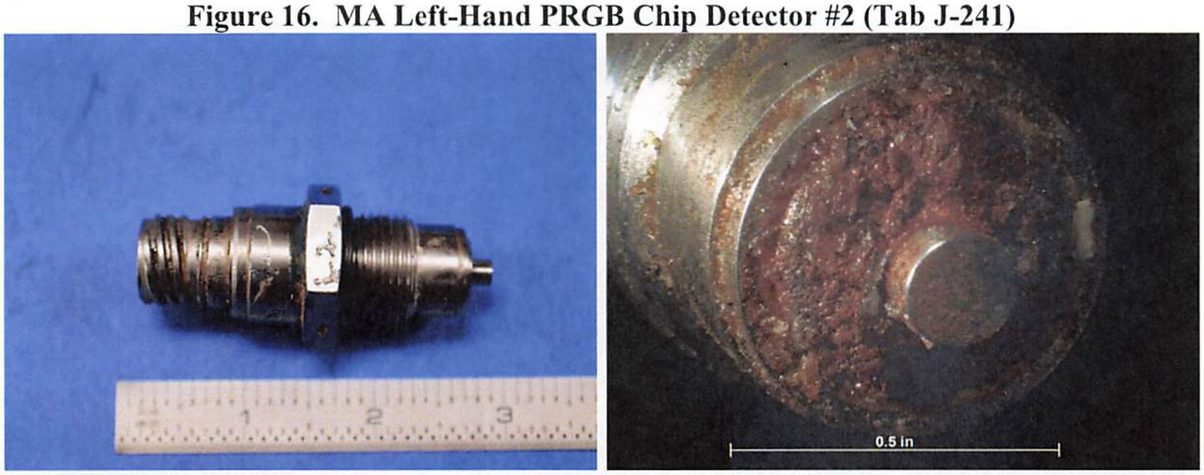
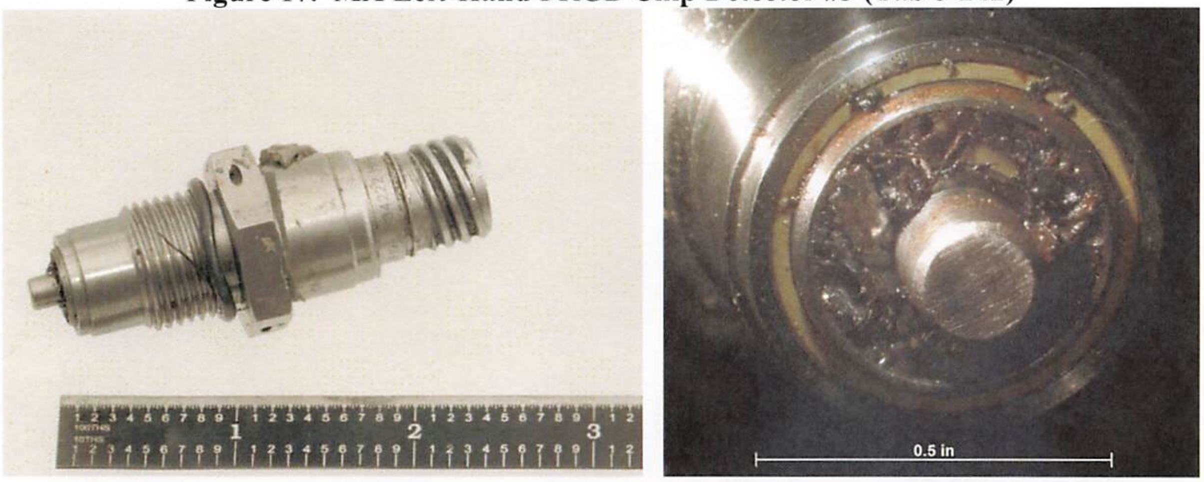


Figure 17. MA Left-Hand PRGB Chip Detector #3 (Tab J-242)



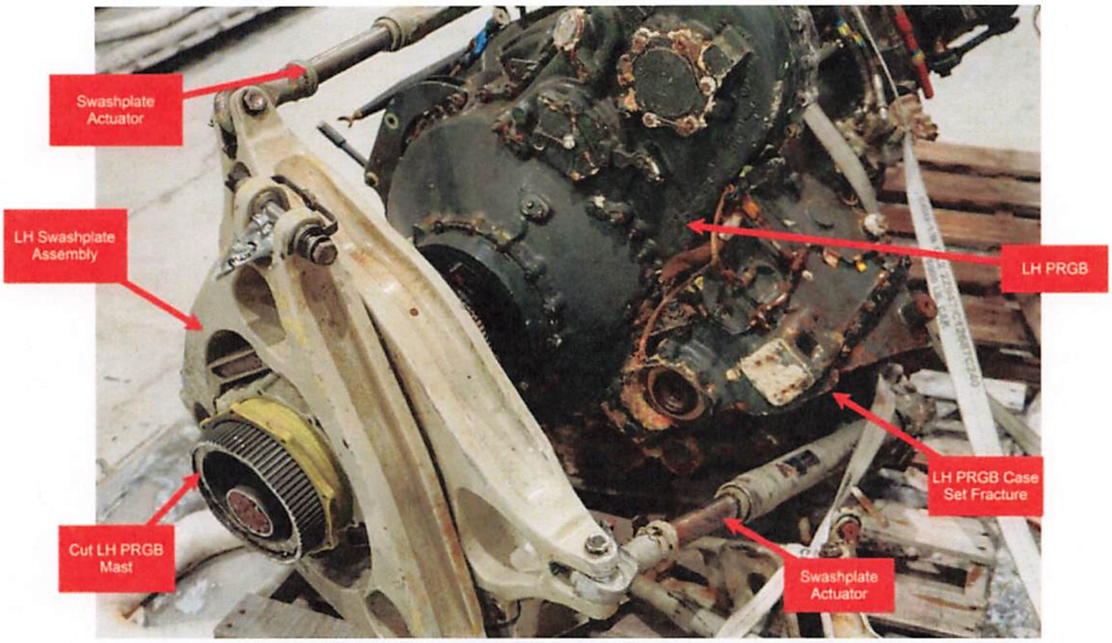
(2) Left-Hand and Right-Hand Proprotor Hub Assemblies

MCAS Cherry Point conducted engineering investigations on the left-hand and right-hand proprotor hub assemblies (Tab J-63). All functional failures and damage within both proprotor hub assemblies and both pendulum assemblies occurred as a result of departure from controlled flight and/or as a result of the impact/recovery sequence (Tab J-95, and J-98). Analysis of the KVADR data showed a last recorded left-hand proprotor speed (NR) of 144 revolutions per minute (RPM) (Tab J-95 to J-96). The left-hand proprotor hub assembly and left-hand pendulum assembly exhibited low rotational energy during the impact sequence (Tab J-96). This is evidenced by the overall condition of the hub assembly, the pendulum assembly, and the flight data, indicating that the left-hand hub was no longer being driven by the PRGB mast (Tab J-96 to J-97). Analysis of the KVADR data showed a last recorded right-hand NR of 416 RPM (Tab J-100). The right-hand hub assembly and right-hand pendulum assembly exhibited high rotational energy during the impact sequence (Tab J-99). This is evidenced by the overall condition of the hub assembly, the pendulum assembly, and the flight data (Tab J-99).

(3) Left-Hand and Right-Hand Swashplate Assemblies

MCAS Cherry Point conducted engineering investigations on the left-hand and right-hand swashplate assemblies, anti-drive assemblies, pitch links, and drive tube assemblies (Tab J-38). The investigations were conducted with AF representatives on-site, including representatives from AFRL (Tab J-38). All failures and damages noted in the swashplate assemblies engineering investigation report can be attributed to the sequence of events that occurred during or after water impact (Tab J-58). This sequence of events consists of water impact, settling on the sea floor, salvage, and transportation (Tab J-58). For most damage, it is impossible to definitively determine where they occurred in the sequence of events (Tab J-58).

Figure 18. MA Left-Hand PRGB Barrel Section As-Received (Tab J-379)



(4) Left-Hand Proprotor Blade Assemblies and Blades

AFRL conducted engineering investigations on all three left-hand blade assemblies (Tab J-465). The investigation concluded all failures identified on the three left-hand proprotor blade assemblies were a result of the impact sequence (Tab J-474). The significant failures in the afterbody of the left-hand red blade were the result of overload likely following impact with the water and sea floor (Tab J-474).

Initial examination of the three blades from the left-hand proprotor of the MA at MCAS Iwakuni revealed that two of the blades experienced only tip damage, whereas the green blade was fractured in two (Tab J-283). All three blades were submitted to AFRL for evaluation. The green blade was the primary focus of this evaluation (Tab J-283).

AFRL evaluated several possible impact candidates that could have caused the damage to the left-hand green proprotor blade but were determined not to be the source of the impact (Tab J-280 and J-283). Physical, thermal, and chemical characterization of the blades were conducted and found in compliance with the drawing specifications, except for the ply layup for the blade skins (Tab J-280). This deviation is deemed to have minimal structural impact (Tab J-280).

(5) Left-Hand Engine and Full Authority Digital Engine Control Assemblies

The left-hand engine, left-hand Full Authority Digital Engine Control (FADEC) "A", left-hand FADEC "B", and left-hand Calibrated Torquemeter Shaft Assembly were recovered from the ocean and shipped to MCAS Cherry Point (Tab J-4). The components were repackaged into wooden crates and shipped to RRC, located in Indianapolis, IN (Tab J-5). The left-hand torquemeter shaft was shipped to the AFRL (Tab J-5). The disassembly and investigation of left-hand engine, left-hand FADEC "A", and left-hand FADEC "B", were performed at RRC (Tab J-5).

Review of MA and engine records identified that engine, S/N CAE130714, was originally built on 16 December 2016 (Tab J-6). The engine was installed in the left-hand position of MA, on 15 October 2019, with 696 hours, time since new (TSN) and 0 hours, time since repair (TSR) (Tab J-6). The left-hand engine accumulated an additional 557 hours and had a total time of 1253 hours TSN on the date of the mishap (Tab J-6). An engine health check, known as a Power Assurance Check (PAC), requires a result with a minimum value of 95% (Tab DD-7). A PAC was performed on 16 November 2023, and had a value of 106.0 percent (Tab J-6).

The investigation concluded that the left-hand FADEC "A" and left-hand FADEC "B" were both recorded in KVADR and VLSED as being capable of engine control, and neither was declared failed (Tab J-16). Based on physical evidence and the KVADR and VSLED flight data, the left-hand engine, left-hand FADEC "A", and left-hand FADEC "B" were operating normally prior to the loss of KVADR and VSLED flight data (Tab J-17). The left-hand engine was providing the requested power and supplying 2,405-foot pounds of torque when VSLED data was lost (Tab J-19). Physical evidence throughout the left-hand engine supports the conclusion that the engine had rotational speed at the time of impact (Tab J-18). All other observed damage to the engine externals and turbine sections are attributed to the distortion, deformation, and fracturing that occurs during an aircraft mishap sequence (Tab J-19).

(6) Right-Hand Engine Assembly and Full Authority Digital Engine Control Assemblies

The right-hand engine, right-hand FADEC "A", right-hand FADEC "B", and the right-hand Calibrated Torquemeter Shaft Assembly, were recovered from the ocean and shipped to MCAS Cherry Point (Tab J-22). The components were repackaged into wooden crates and shipped to RRC (Tab J-23). The right-hand torquemeter shaft was shipped to the AFRL (Tab J-23). The disassembly and investigation of right-hand engine, right-hand FADEC "A", and right-hand FADEC "B" were performed at RRC (Tab J-23).

Review of MA and engine records identified that engine, S/N CAE130359, was originally built on 1 February 2010 (Tab J-24). The engine was installed in the right-hand engine position of MA, on date 10 August 2017, with 1,364 hours TSN and 0 hours TSR (Tab J-24). The right-hand engine accumulated 842 hours and had a total time of 2,206 hours TSN on the date of the mishap (Tab J-24). A PAC was performed on 16 November 2023 and had a value of 100.69 percent (Tab J-24).

The investigation concluded right-hand FADEC "A" and right-hand FADEC "B" were both recorded in KVADR and VLSED as being capable of engine control, and neither was declared failed (Tab J-32). Based on physical evidence and the KVADR and VSLED flight data, the right-hand engine, right-hand FADEC "A", and right-hand FADEC "B" were operating normally prior to the loss of KVADR and VSLED flight data recording (Tab J-33). The right-hand engine was providing the requested power and, supplying 2,155-foot pounds of torque when VSLED data was lost (Tab J-34). Physical evidence throughout the right-hand engine supports the conclusion that the engine had rotational speed at the time of impact (Tab J-34). All other observed damage to the engine externals, inlet guide vanes, and turbine sections are attributed to the distortion, deformation, and fracturing that occurs during an aircraft mishap sequence (Tab J-35).

(7) Left-Hand and Right-Hand Torquemeter and Nacelle Blower Assemblies

AFRL carried out an evaluation report of the left-hand and right-hand torquemeters and nacelle blower quill shafts damage (Tab J-203). The data collected indicated the mishap sequence was not precipitated by failure of the torquemeters or nacelle blower quill shaft shear points (Tab J-206). Both the torque shafts failed due to axial overload (Tab J-206). The nacelle blower quill shaft shear points failed due to torsional overload, with the drive train having rapidly slowed relative to the blower assemblies (Tab J-206).

(8) V-22 Flight Control System

V-22 FST conducted an engineering investigation of the left-hand and right-hand pylon conversion actuators, left-hand and right-hand swashplate actuators, and FCC data at MCAS Cherry Point (Tab J-348). Damage discovered during physical inspection of components occurred during the aircraft mishap sequence (Tab J-350 to J-351).

(9) Flight Control Computer Data Download

BAE System's Endicott, NY facility downloaded NVM from the MA's three flight control computers (FCC) (Tab J-272). The objective of this engineering investigation was to unpackage, clean, and dry the units, bake as necessary to eliminate moisture, then extract all available data stored in NVM and provide to the Air Force (Tab J-272).

V-22 FST analyzed the data from the FCCs (Tab J-341). The NVM for each FCC showed consistent software versions across all processors and identified which position each FCC was located (Tab J-342). Positions stayed consistent between the different pages, indicating the FCCs were not moved between flights (Tab J-342). All three FCCs showed faults on the most recent page (Tab J-342). The NVM only stores the most significant bit of the calibrated airspeed and nacelle angle values at the time of an FCC fault, limiting the information to a range (Tab J-343). The data show the faults all set when the nacelle angle was between 48 and 56 degrees and the calibrated airspeed was between 96 and 128 knots (Tab J-343). There are no timestamps, which means faults cannot be placed into a timeline of events, however KVADR data did not show any FCC faults (Tab J-343). This would indicate the faults set after the event and loss of KVADR (Tab J-343). FCC #1 has a dedicated backup battery and FCC #2 and #3 both receive backup power from the aircraft battery, allowing them to continue to function if the aircraft lost power (Tab J-343).

c. Analysis and Evaluation

(1) Analysis of K-Series Voice and Data Recorder

The KVADR was recovered from the site of the mishap, the flight data was extracted, and then sent to the V-22 FST in two files, "100054_RS6793_2023y_11m_29d_00-01-29_Faults.xlsx" (*fault file*) and "100054_RS6793_2023y_11m_29d_00-01-29.csv" (*raw data file*) (Tab J-361).

For specific chip detector analysis, please refer to applicable reports (Tab J-223 to J-270, and J-327 to J-340). There were no abnormal drive train related faults prior to the last "Weight Off Wheels" timestamp (Tab J-361). The *fault file* contained the following drive system related faults (Tab J-361).

Table 1. Drive System Related Fault Timeline (Tab J-361)

1. 13:09:45L – Weight off Wheels	7. Left-hand PRGB Chip Event 6 – Unsuccessful Burn **(Chip Caution)** 14:21:37L – Left-hand PRGB Chip Caution
2. Left-hand PRGB Chip Event 1 – Successful Burn **(Chip Advisory)** 13:50:50L – Left-hand PRGB CHIP BURN	8. 14:36:39L – **Chip Detector Fail**
3. Left-hand PRGB Chip Event 2 – Successful Burn **(Chip Advisory)** 13:51:13L – Left-hand PRGB CHIP BURN	9. 14:39:49L – Left-hand PRGB Pressure Low Caution
4. Left-hand PRGB Chip Event 3 – Successful Burn **(Chip Advisory)** 14:03:37L – Left-hand PRGB CHIP BURN	10. 14:39:50L – ICDS Fail Warning – Left-hand PRGB Pressure Lost Caution
5. Left-hand PRGB Chip Event 4 – Successful Burn **(Chip Advisory)** 14:09:00L – Left-hand PRGB CHIP BURN	11. 14:39:51L – TCL Overtravel – Left-hand Flapping Critical
6. Left-hand PRGB Chip Event 5 – Successful Burn **(Chip Advisory)** 14:18:43L – Left-hand PRGB CHIP BURN	12. 14:39:52L – Rotor Overtorque – Right-hand Proprotor Overtorque – Left-hand TAGB Pressure Low

The *raw data file* contained the following information: Nacelle Angle, Rotor Torque, Rotor Speed, Engine Power Turbine Speed, Engine Torque, Gearbox Oil Pressure, Gearbox Oil Temperature (Tab J-361 to J-375).

(2) Evaluation of Left-Hand PRGB

Drive line components from the MA, depicted in Figures 19 to 22, were sent to FRC East, at MCAS Cherry Point, North Carolina for disassembly, record review, and engineering investigation (Tab J-354). After the review of technical analysis, due to continued operation, the catastrophic failure of the left-hand PRGB high-speed planetary section was most likely initiated by a crack in one of the high-speed pinion gears and fatigue cracking of the associated pinion gear's bearing cage (Tab J-453 to J-459). Additionally, at least one piece of the failed high-speed planet pinion wedged in the high-speed carrier assembly, grinding against the high-speed sun gear's teeth until finally removed (Tab J-454 to J-455). This mode for removal of the sun gear teeth is consistent with the evidence of grinding and circumferential scuffing on the high-speed sun gear set at the surface where all the teeth were missing (Tab J-455). Finally, the loss of gear meshing removed connection to the high-speed planetary section, causing an asymmetric loss of drive to the left-hand proprotor, which led to loss of controlled flight (Tab J-455).

(3) Evaluation of Vibration Structural Life and Engine Diagnostics

VSLED is an aircraft health monitoring system that records vibration, temperature, and strain monitoring on the aircraft structures, gearboxes, and engine components (Tab DD-7). The VSLED flight data recorder was recovered from the MA and sent to the V-22 FST and extracted by Bell (Tab J-375 to J-378). Vibration data was recovered, but the maintenance summary file was not (Tab J-375 to J-378). File "CV31.vdwi" is the VSLED data file that includes vibrational data in addition to the KVADR data (Tab J-375 to J-378). Five minutes prior to the first left-hand PRGB CHIP BURN, VSLED recorded an increase in vibration in the left pylon drive shaft part of the ICDS (Tab J-376). After the first left-hand PRGB CHIP BURN, VSLED recorded vibrations associated with the left-hand PRGB high-speed planetary pinion bearing (Tab J-378). VSLED data is only available in post-mission maintenance analysis and not available to aircrew during flight or elsewhere within aircraft systems (Tab DD-6).

Figure 19. New Bull Gear vs. Recovered Bull Gear Post Cleaning (Tab J-122, and J-429)

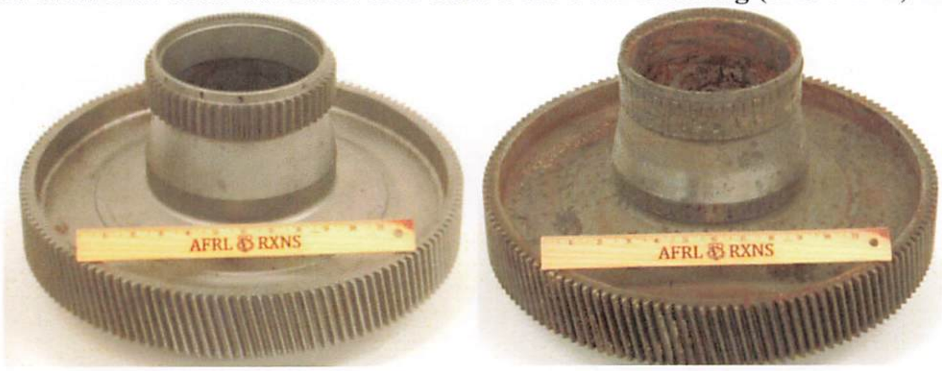


Figure 20. New vs. MA Left-Hand PRGB Bull Gear – HS Sun Gear Teeth Post Cleaning (Tab J-122, and J-430)

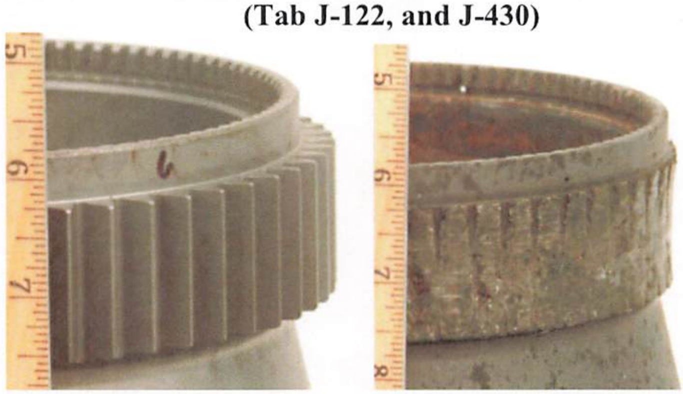


Figure 21. Cleaned HS Planetary Assembly (Tab J-427)

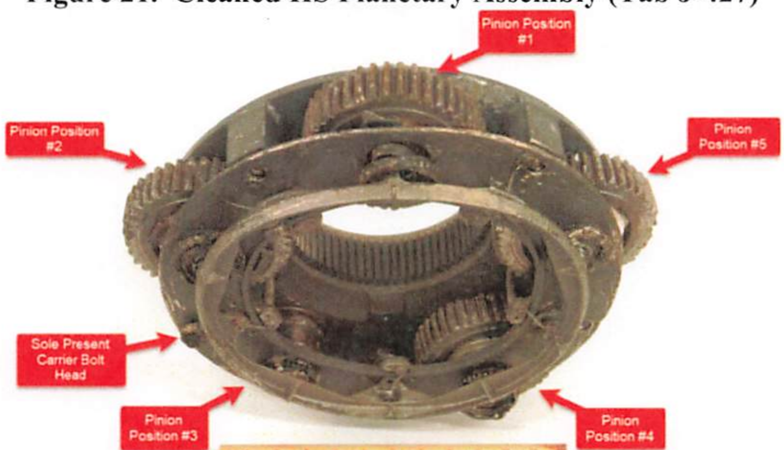
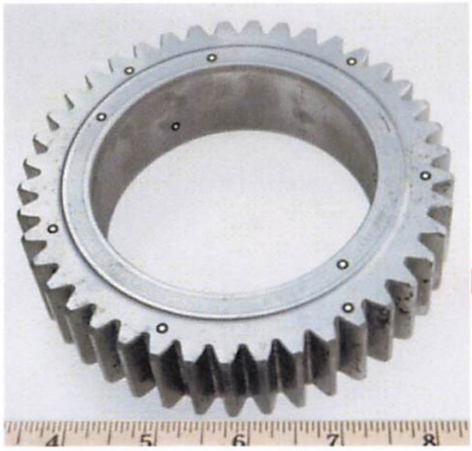
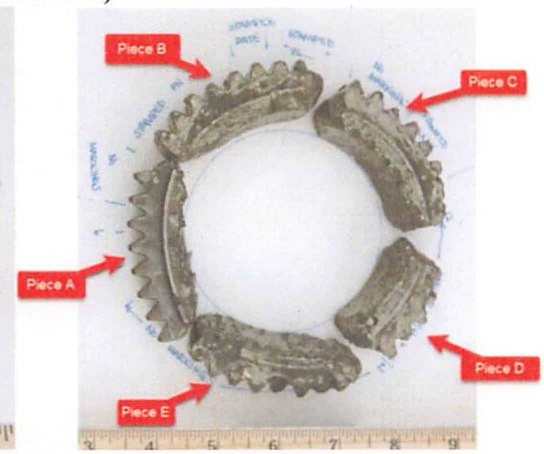


Figure 22. New vs. Five Pieces of Broken High-Speed Planetary Gear Pinion (Tab J-172, and J-421)





7. WEATHER

a. Forecast Weather

The weather forecast obtained by the MC was comprised of six sheets (Tab F-3 to F-8). The weather briefing was an AFSOC-approved weather source in accordance with Air Force guidance (Tab BB-114 to BB-115). The briefing was prepared by the 353 SOW Weather Flight (Tab F-3). The weather forecast was supplemented by the crew's use of ForeFlight, which is AFSOC-provided flight planning software loaded on their EFB to support operations (Tab BB-114). The sky condition along their route of flight was forecasted to be scattered clouds at 4,000 to 7,000 feet above the surface, with no significant weather and visibility of 7 statute miles or greater (Tab F-3). The winds aloft were forecasted to be out of the west, with a headwind/quartering headwind of between 25 to 70 knots along the planned route of flight (Tab F-4).

b. Observed Weather

The weather encountered during flight was consistent with the forecast weather (Tab V-20.4 to V-20.5).

c. Space Environment

Not applicable.

d. Operations

The flight was conducted within operational weather limits (Tab B-37 to B-38).

8. CREW QUALIFICATIONS

a. Mishap Pilot

The MP was an instructor pilot with six years of qualified flying history as well as a senior command pilot aeronautical rating, with 953 CV-22B flight hours and 1,363 total flight hours (Tab G-8 to G-9). His undergraduate pilot training was conducted at Columbus AFB, MS flying the T-6A Texan II and T-1A Jayhawk (Tab T-13). After graduating pilot training, he went on to CV-22B initial qualification at Kirtland AFB, NM graduating on 11 September 2017 (Tab T-1143). MP was upgraded to instructor pilot on 12 May 2021 and graduated the United States Air Force Weapons School on 10 June 2023 (Tab T-1143). His last flight evaluation was conducted on 23 June 2023, and all events were accomplished within standards (Tab G-14 to G-15). The MP was current and qualified for all events planned during the MS (Tab K-3).

Table 2. Recent flight time is as follows (Tab G-4):

CV-22B	Hours	Sorties
Last 30 Days	34.1	12
Last 60 Days	49.1	22
Last 90 Days	57.4	25

b. Mishap Co-Pilot

The MCP had over seven years of qualified flying history as well as a senior command pilot aeronautical rating, with 311 flight hours in the CV-22B, 213 flight hours in the PC-12, and 867 flight hours in the U-28A, totaling 1,837 flight hours (Tab G40, and G-53 to G-54). His undergraduate pilot training was conducted at Laughlin AFB, TX flying the T-6A Texan II and T-1A Jayhawk (Tab T-9). After graduating pilot training he went on to Hurlburt Field, FL for PC-12 qualification, followed by U-28A DRACO initial qualification (Tab T-11). He retrained into the CV-22B at Kirtland AFB, NM, graduating on 17 June 2021 (Tab T-34). According to the unit's pre-mission go/no-go product (dated 28 November 2023) the MCP was erroneously showing as overdue for qualification evaluation; however, the MCP was current and qualified for all events planned during the MS (Tab K-3 to K-4). MCP's flight evaluation folder indicated MCP's last flight evaluation was conducted 21 September 2023, all events were accomplished within standards, and MCP was cleared to fly (Tab G-55).

Table 3. Recent flight time is as follows (Tab G-40):

CV-22B	Hours	Sorties
Last 30 Days	26.8	9
Last 60 Days	42.1	20
Last 90 Days	57.2	26

c. Mishap Special Mission Aviator Flight Engineer

The MSMAFE had almost four years of flying experience; the 21 SOS was his second operational assignment (Tab T-679). He had a (Basic) Airman Aircrew Member aeronautical rating, with a total of 772 flight hours, all in the CV-22B (Tab G-168). In January 2020, he completed Special Mission Aviator training in the CV-22B at Kirtland AFB, NM (Tab T-718). According to the unit's go/no go list (dated 28 November 2023) he was overdue for Mission/Qualification evaluation and was non-current for night water hoist and night vision goggle sorties; however, he was current and qualified for all events planned during the MS (Tab K-3 and K-8 to K-9). MSMAFE's flight evaluation folder indicated an evaluation on 27 September 2023 was completed with all events accomplished within standards (Tab T-703 to T-704).

Table 4. Recent flight time is as follows (Tab G-159):

CV-22B	Hours	Sorties
Last 30 Days	23.2	9
Last 60 Days	51.8	22
Last 90 Days	73.7	29

d. Mishap Special Mission Aviator Tail Scanner

The MSMATS had almost three years of flying experience, the 21 SOS was his second operational assignment (Tab T-471). He had a (Basic) Airman Aircrew Member aeronautical rating with a total of 377 flight hours, all in the CV-22B (Tab G-203). In December 2020, he completed Special Mission Aviator training in the CV-22B at Kirtland AFB, NM (Tab T-500). The MSMATS's last evaluation was 11 October 2022, all events were accomplished within standards (Tab G-212). He was current and qualified for all events planned during the MS except for water hoist, which may have been required if the MC needed to provide medical support to an MFF jumper (Tab DD-52).

Table 5. Recent flight time is as follows (Tab G-201):

CV-22B	Hours	Sorties
Last 30 Days	37.2	14
Last 60 Days	64.2	27
Last 90 Days	99.6	43

e. Mishap Additional Pilot

The MAP was serving his first operational flying tour of duty (Tab T-823 to T-824). He had a pilot aeronautical rating with two years of qualified flying history, 298 CV-22B flight hours, and 721 total flight hours (Tab G-113, and G-122). His undergraduate pilot training was conducted at Columbus AFB, MS flying the T-6A Texan II (Tab T-17). After graduating pilot training in 2019, he went on to CV-22B initial qualification at Kirtland AFB, NM and graduated on 22 December 2021 (Tab T-825). The MAP's last flight evaluation was conducted on 31 March 2023; all events were accomplished within standards (Tab G-127). The MAP was current and qualified for all events planned during the MS (Tab K-3).

Table 6. Recent flight time is as follows (Tab G-113):

CV-22B	Hours	Sorties
Last 30 Days	8.8	4
Last 60 Days	44.9	23
Last 90 Days	75.9	35

f. Mishap Direct Support Operator

The MDSO had a (Basic) Airman Aircrew member aeronautical rating with almost 2.5 years of qualified flying history, including 281 total flight hours (Tab G-262). In April 2021, he completed DSO initial training in the MC-130H at Hurlburt Field, FL (Tab T-228 to T-229). The MDSO's last evaluation was 16 August 2022; all events were accomplished within standards (Tab T-230 to T-281). He was current and qualified for all his duties on the MS (Tab K-3).

Table 7. Recent flight time is as follows (Tab G-259):

CV-22B	Hours	Sorties
Last 30 Days	2.9	2
Last 60 Days	2.9	2
Last 90 Days	3.4	3

g. Mishap Special Operation Forces Medical Element 1

MSOFME1 was a fully qualified, residency-trained flight surgeon on his first tour of duty in AFSOC (Tabs EE-87, and X-7 to X-8). He completed all requisite training for a SOFME, to include Air Commando Indoctrination, Altitude Chamber Training, CASEVAC, Tactical Combat Casualty Care (TCCC), Field Skills, Introduction to Special Operations Medicine, Underwater Egress, Emergency Parachute Water Survival, Advanced SERE (Survive, Evade, Resist, Escape), Trauma Skills Sustainment, and Unit Type Code training (Tab X-7 to X-8). He was current on all initial and sustainment medical training requirements and his medical license, credentialing, and clinical privileges were all in good standing (Tabs T-19 to T-20, X-7 to X-8, and BB-59 to BB-61).

h. Mishap Special Operation Forces Medical Element 2

MSOFME2 was a fully qualified Special Operations Independent Duty Medical Technician (SOIDMT) and certified paramedic on his second AFSOC assignment (Tabs EE-91, and X-8). He completed all the requisite training for a SOFME, to include Air Commando Indoctrination, Altitude Chamber Training, CASEVAC, TCCC, Field Skills, Introduction to Special Operations Medicine, Underwater Egress, Emergency Parachute Water Survival, Advanced SERE, Trauma Skills Sustainment and Unit Type Code training (Tab X-8). He was current on all initial and sustainment medical training requirements as well as national registry paramedic certification (Tabs X-8, and BB-59 to BB-61).

9. MEDICAL

a. Qualifications

All the MC were medically qualified and appropriately certified for flight duty without any restrictions or duty limitations (Tab X-3 to X-9). Annual Preventative Health Assessments, including flight physicals, were current for all individuals and none were on Duties Not Including Flying status (Tab X-3 to X-9).

b. Health

All available medical records were comprehensively reviewed by the AIB medical member, to include the applicable electronic medical systems (Tab X-3). None of the MC were on any duty limitations or restrictions that would preclude their involvement in the mission (Tab X-3 to X-8). Interviews were conducted and reviewed to ascertain the health and personal well-being of each member of the MC, including possible undiagnosed symptoms or conditions that may have not been documented in the health records (Tabs V-1.5 to V-1.6, V-12.2 to V-12.4, V-15.6 to V-15.8, V-18.7 to V-18.8, V-21.6 to V-21.8, V-27.2 to V-27.3, and V-32.12 to V-32.14 and X-3 to X-8). The MC was in good health and had no performance-limiting conditions, diseases, illnesses, medication, requirements, psychological disorders, or injuries prior to the mishap (Tab X-3 to X-9).

c. Pathology

Autopsy reports of the seven recovered MC were reviewed, revealing extensive poly-trauma injuries (Tab X-3 to X-8). It is assessed that all MC sustained non-survivable injuries upon impact (Tab X-3 to X-8).

Post-mortem toxicology specimens of blood and urine were obtained from the recovered MC and mishap maintenance personnel (Tab JJ-5 to JJ-68). The specimens were analyzed for the presence of medications, ethanol (ethyl alcohol), amphetamine, barbiturate, benzodiazepine, cannabinoids, cocaine, opiates, and phencyclidine, as well as cyanides and carboxyhemoglobin (for carbon monoxide) (Tab JJ-3 to JJ-68).

The urine and body cavity blood samples from MP were confirmed to contain diphenhydramine, an antihistamine medication used for allergies and sleep onset, which is unauthorized for aircrew use (Tabs BB-81 to BB-108, JJ-5, and X-4). Consultation with the medical examiner and forensic toxicologist revealed that the medication concentration in circulation at the time of the accident is unable to be determined due to post-mortem redistribution of the drug (Tab X-4). The drug levels in the urine and body cavity are consistent with a therapeutic dose taken 1-2 days prior to death (Tab X-4). It is unknown whether MP was under the influence of the medication's cognitive or sedative effects at the time of the accident (Tab X-4).

The presence of meclizine was detected in the MDSO's body cavity blood sample (Tab JJ-15). Meclizine is an antihistamine medication used for the prevention or treatment of air sickness and unauthorized for aircrew use (Tabs BB-81 to BB-108, and X-7). All other results from MC were negative (Tab JJ-5 to JJ-18).

d. Lifestyle

Interviews with peers and organizational members familiar with the crew did not identify any medical issues, symptoms, medication usage, mental or physical limitations, unhealthy habits, vices or considerable personal stressors (Tab V-1.5 to V-1.6, V-12.2 to V-12.4, V-15.6 to V-15.8, V-18.7 to V-18.8, V-21.6 to V-21.8, V-27.2 to V-27.3, and V-32.12 to V-32.14).

e. Crew Rest and Crew Duty Time

Aircrew members are required to have compulsory "crew rest" prior to performing flight duties (Tab B-30). Normal crew rest is defined as a minimum 12-hour non-duty period before the designated flight duty period begins (Tab B-30). Crew rest is free time and includes time for meals, transportation, and an opportunity for at least eight hours of uninterrupted sleep (Tab B-30).

The squadron's flight schedule and the MC's personal schedules were reviewed for 22 November 2023 through 1 December 2023 (Tab AA-35, AA-45, and AA-47). The daily operations for the seven duty days preceding the mishap involved a maintenance FCF from 0800 until 2000 with crewmembers based off their availability (Tab AA-35). There were no other training or mission flights within the preceding seven days of the mishap (Tab AA-45). There were no crewmembers who were scheduled for duties that would have breached the crew rest rules (Tab AA-47). The MP and MCP were not on the flight schedule the seven days prior to the incident (Tab AA-35).

10. OPERATIONS AND SUPERVISION

a. Operations

The 21 SOS is a small unit with a high operations tempo (Tab V-19.3 and V-22.7). During the months leading up to the mishap, operations tempo was high due to an increased emphasis on flying training directed from AFSOC and several aircraft requiring maintenance phase inspections (Tabs R-9, V-18.5, V-19.3, and V-22.8 to V-22.9). Additionally, there were less SMAs in the unit than pilots, which compelled the 21 SOS Squadron Commander (Sq/CC) to deliberately focus on fatigue management and scheduling practices (Tab R-86).

The planning for the mission on 29 November 2023 started months in advance and key crew members, to include the aircraft commanders and the AMC, were selected weeks in advance (Tab R-82). A mission rehearsal was conducted on 7 November 2023 (Tab V-32.4 to V-32.5). The crews conducted the air mission and crew briefs on 28 November 2023, the day prior to mission execution (Tab V-20.3). On 29 November 2023, the crews showed for the mission, conducted an abbreviated update briefing, and took off as planned (Tab R-28, R-82, and R-132).

b. Supervision

The 21 SOS/CC and DO were both senior aviators with experience in multiple operational CV-22B squadrons, and very familiar with the theater of operations, processes, and procedures in the squadron and wing (Tab V-27.1, and V-35.1). AIB interviews with the Sq/CC and DO revealed they were both familiar with the mission to be conducted 29 November 23 (Tab R-44, and R-82). The unit used a standardized process that requires the Sq/CC or an appointed senior member to review all crew qualifications, currencies, crew complements, and identified risks for all flying missions (Tab DD-51). The DO was the Authorizing Official on the Flight Orders and the ORM form for the MC (Tabs K-3, and AA-5). There were administrative errors with the pre-mission paperwork, but on the day of the mishap, all MC members were qualified to fly the assigned mission (Tab DD-51). For the mission, the MP was also serving as the AMC for all exercise participants (Tab DD-43). While there is no offical guidance that restricts the AMC from occupying a primary crew position, this is a non-standard practice in an AFSOC aircraft (Tab DD-44). Both the Sq/CC and DO discussed the dual roles with the MP prior to mission execution and were comfortable with the crew complement based on the MP's experience, low-risk environmental conditions for the mission, and the addition of the MAP to the crew to alleviate fatigue later in the mission profile (Tabs R-19, R-44, and R-82, V-27.5, and V-35.6).

11. HUMAN FACTORS

Human factors include active failures, which are the last actions or inactions that were the immediate cause of the mishap, and latent failures or conditions, which exist within the chain of command or elsewhere in the organization which affected the tragic sequence of events leading up to the active failure (Tab BB-4). The DoD Human Factors Analysis and Classification System, Version 8.0 (DoD HFACS), was used to assess human factors during the AIB investigation (Tab BB-3).

DoD HFACS are divided into four categories: (1) organizational influences; (2) supervision; (3) preconditions to unsafe acts; and (4) unsafe acts (Tab BB-35).

Seven human factors were identified as relevant to the mishap: (1) Failure to Provide Adequate Information Resources; (2) Purchasing or Providing Poorly Designed or Unsuitable Equipment; (3) Authorized Unnecessary Risk; (4) Instrumentation and Warning Systems Issues; (5) Task/Mission In-Progress Re-Planning; (6) Ineffective Crew Resource Management; and (7) Inadequate Real-Time Risk Management (Tab BB-35).

a. Organizational Influences

Organizational Influences are factors in a mishap if the communications, actions, omissions, or policies of upper-level management directly or indirectly affect supervisory practices, conditions or actions of the operator(s) and result in system failure, human error, or an unsafe situation (Tab BB-26).

(1) Human Factor 1: OR008 – Failure to Provide Adequate Information Resources

Failure to Provide Adequate Information Resources is when weather, intelligence, operational planning material or other information necessary for safe operations planning are too complex, too vague, incorrect, or not available throughout the organization, resulting in hazardous conditions or unsafe acts throughout subordinate units or the field/fleet (Tab BB-30). This also includes knowledge management tools or data collection and analysis tools to support large safety management system programs such as materiel management, systems safety, hazard inspections and assessments, risk management, among other factors (Tab BB-30).

(2) Human Factor 2: OR004 – Providing Poorly Designed or Unsuitable Equipment

Purchasing or Providing Poorly Designed or Unsuitable Equipment is when there are inadequacies in the acquisition and/or fielding of warfighting or commercial materiel, resulting in hazardous conditions or fallible decisions throughout subordinate units, the field, or fleet (Tab BB-29).

b. Supervision

Supervision is a factor in a mishap if the methods, decisions, or policies of those in the chain of command directly affect practices, conditions, or individual actions and result in human error or an unsafe situation (Tab BB-21).

(1) Human Factor 3: SP007 – Authorized Unnecessary Risk

Authorized Unnecessary Risk is when a leader with risk acceptance authority unnecessarily authorizes a mission, activity, or task, which resulted in hazardous conditions, or unsafe acts (Tab BB-25).

c. Preconditions To Unsafe Acts

Preconditions stem from individual lifestyle behaviors, supervisor or leader influences, organizational level influences in training, resource support, policy or standards, or a combination thereof (Tab BB-11). Such conditions include the mishap individual's physical, mental, or cognitive conditions, and his or her interactions with the technological and/or the physical environment (Tab BB-11).

(1) Human Factor 4: PE202 – Instrumentation and Warning System Issues

Instrumentation and Warning System Issues is when workspace or cockpit instrument or warning system elements (design, reliability, lighting or backlighting, audible cues, location, symbology, size, display, etc.) negatively affect performance, which results in a hazardous condition or unsafe act (Tab BB-18).

(2) Human Factor 5: PP111 – Task/Mission In-Progress Re-Planning

Task/Mission In-Progress Re-Planning is when crew or team members fail to adequately reassess changes in their dynamic environment during mission execution and change their mission plan accordingly to ensure adequate management of risk, which results in a hazardous condition or unsafe act (Tab BB-19).

(3) Human Factor 6: PP101 – Ineffective Crew Resource Management

Ineffective Crew Resource Management is when crew or team members fail to actively maintain an accurate and shared understanding of the evolving task, or manage their distribution of tasks, which results in a hazardous condition or unsafe act (Tab BB-19). This includes communication breakdowns, critical information not shared, rank or position intimidation, lack of assertiveness or other teamwork functions (Tab BB-19).

d. Unsafe Acts

Unsafe Acts are those factors that are most closely tied to the mishap and can be described as active failures or actions committed by the operator that result in human error or an unsafe situation (Tab BB-7).

(1) Human Factor 7: AE201 - Inadequate Real-Time Risk Assessment

Inadequate Real-Time Risk Assessment is when the mishap individual, through inexperience, faulty logic, poor judgment, or insufficient information, selected or proceeded with the wrong course of action based on an ineffective real-time risk assessment of immediate hazards during execution of a task, mission, or activity, which result in the near-miss or mishap (Tab BB-9).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publicly Available Directives and Publications Relevant to the Mishap

(1) AFMAN 11-2CV-22V3, *CV-22 Operations Procedures*, 13 September 2021
(2) AFMAN 11-2CV-22V3CL-1, *Flight Crew Checklist*, 7 November 2023
(3) AFMAN 11-202, Volume 3, *Flight Operations*, 10 January 2022
AFMAN 11-202, Volume 3, *Flight Operations*, 4 April 2023, AFSOC Supplement
(4) AFMAN 11-301, Volume 2, *Management and Configuration Requirements for Aircrew Flight Equipment (AFE)*, 1 December 2023
(5) DAFMAN 48-123, *Medical Examination and Standards,* 20 February 2024
(6) AFSOC Command Instruction 48-1010, *Aerospace Medicine, Aeromedical Special Operations,* 23 June 2022
(7) AFMAN 11-290, *Flying Operations, Cockpit/Crew Resource Management and Threat & Error Management Program,* 31 March 2023 *(*AFSOC Supplement)

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

b. Other Directives and Publications Relevant to the Mishap

(1) DoD HFACS 8.0, Human Factors Analysis and Classification System Version 8.0, 25 May 2022
(2) NFM A1-V22AC-AFM-000_1V-22(C)B-1, *CV-22 Tiltrotor*, 15 October 2022
(3) NATOPS Checklist A1-V22AC-AFM-500_IC 33, *USAF Series CV-22 Tiltrotor*, 15 October 2022
(4) Flight Crew Information File, 24-001, 353 SOW/A3V
(5) Military Flight Release WIVE-80
(6) Military Flight Release WIVE-258
(7) CV-22 Standard Operating Procedures 1 September 2016
(8) 753 SOAMXS Operating Instruction 21-01, *Maintenance, Use of Paperless Phase Process,* 30 January 2020
(9) Department of the Air Force Enlisted Classification Directory 30 April 24
(10) Air-2 Lite Maintenance Support Guide Rev 6, 26 April 2022 Draft

(11) NAVAIR 13-1-6.1-1, T.O. 14S3-8-2-1, Technical Manual Aviation Crew Systems, Inflatable Survival Equipment Life rafts, 1 August 2013

(12) Official Air Force Aerospace Medicine Approved Medications, Over the Counter Medications Aircrew Are Allowed to Take Without Flight Surgeon Approval, 21 September 2022

(13) Official Air Force Aerospace Medicine Approved Medications, 6 March 2024

(14) JAPAN Aeronautical Information Publication

(15) CV-22 NATIP NTRP 3-22.4-CV22, 26 December 2023

c. Known or Suspected Deviations from Directives or Publications

(1) Toxicology

Toxicology results from MP and MDSO revealed detectable levels of the medications diphenhydramine and meclizine, respectively (Tab X-4 and X-7). Diphenhydramine and meclizine are not approved in the Aircrew OTC or Aircrew Approved Medication lists, which include medications allowed to be taken without flight surgeon approval, medications that can be approved by a flight surgeon without higher approval authority, and those that require a waiver (Tab BB-81 to BB-108).

(2) Other Deviations

Other than maintenance documentation errors noted in Section 5 and pre-mission documentation errors noted in Section 8, there are no other known or suspected deviations from directives or publications by crew members or others involved in the mishap mission (Tab DD-52). Noted errors did not pose a safety of flight issue and had no bearing on the mishap (Tab DD-52).

30 MAY 2024

MICHAEL E. CONLEY
Brigadier General, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

CV-22B, T/N 10-0054
YAKUSHIMA ISLAND, JAPAN
29 NOVEMBER 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 29 November 2023, at approximately 1440 local time (L), a CV-22B aircraft, tail number 10-0054, impacted the water approximately one-half mile off the coast of Yakushima Island, Japan. The Mishap Aircraft (MA), GUNDAM 22 (G22), was operated by the 21st Special Operations Squadron (21 SOS), 353rd Special Operations Wing (353 SOW), Yokota Air Base (AB), Japan. The MA was destroyed, and all eight crewmembers sustained fatal injuries upon impact. The remains of seven crewmembers were recovered in the subsequent search and recovery. The remains of the eighth crewmember were not recovered, despite wide-ranging search efforts.

The MA departed Yokota AB at 1043L to participate in a joint inter-operability exercise with participants from other United States military units. There were three CV-22B aircraft involved in the mission: GUNDAM 21 (G21), G22, and GUNDAM 23 (G23). G21 and G22 (MA) were a two-ship formation and were the primary aircraft and crews for the exercise. G23 was a flying spare aircraft, dedicated to support any emergent maintenance requirements during the mission.

At 1231L, G22 (MA) landed at Marine Corps Air Station (MCAS) Iwakuni for hot refueling, with G21 landing 10 minutes later. G21 and G22 (MA) departed MCAS Iwakuni at 1309L for the second leg of the mission, for planned tilt-rotor air-to-air refueling with a United States Marine Corps KC-130J, personnel airdrops from G21, and landing at Kadena AB, Japan. After planned ground refueling at Kadena AB, both G21 and G22 (MA) planned to return directly to Yokota AB.

Approximately 40 minutes after takeoff from MCAS Iwakuni, the Mishap Crew (MC) received the first left-hand proprotor gearbox (PRGB) chip burn advisory in the cockpit. This was approximately 49 minutes before the mishap. A second left-hand PRGB CHIP BURN advisory posted in the cockpit approximately 23 seconds later and a third left-hand PRGB CHIP BURN advisory posted approximately 12 minutes after the second advisory. Per Air Force (AF) guidance, a third PRGB CHIP BURN advisory requires the crew to Land as Soon as Practical; however, the guidance also allows the aircraft commander (AC) discretion in continuing the mission, based on circumstances of the mission and operating environment. With sparse discussion amongst the MC, the Mishap Pilot (MP) decided to continue the mission to Kadena AB as planned, an open water flight of almost 300 nautical miles. At the time of the third chip burn advisory, and with Land as Soon as Practical criteria, the MA was still in very close proximity to mainland Japan and approximately 10 miles from the nearest suitable landing airfield. Five minutes later, the MC received a fourth chip burn advisory, followed by a fifth advisory 10 minutes later. The MC continued their planned mission with limited discussion of divert considerations or the changing dynamics of the situation. Of note, G23's role in the mission was to act as a dedicated spare aircraft in case a primary aircraft experienced maintenance issues. The MC never discussed or considered landing to rendezvous with G23. The MC could have swapped to the spare aircraft, allowing the maintenance team to troubleshoot the PRGB issues on the ground.

Approximately 71 minutes after departing MCAS Iwakuni and approximately three minutes after the fifth chip burn advisory, a "L PRGB CHIPS" caution posted in the cockpit. Per AF guidance, a PRGB chips caution directs the crew to Land as Soon as Possible. The MP notified G21 the MC was diverting, due to the caution indication and Land as Soon as Possible criteria. The MP directed the Mishap Co-pilot (MCP) to turn to heading 111 degrees towards Yakushima Airport, which the MCP verbalized being the closest divert location, located approximately 60 miles away.

There was no further discussion or collaboration amongst the MC on other landing options, nor actions by the MC to set the conditions for an immediate landing or ditching (if required), as directed by AF guidance. The MC did not consider any other landing locations, such as islands with helipads, suitable landing terrain on other islands, or runways, such as the one located on Satsuma-IoJima, approximately 36 nautical miles away. Once the MP committed to diverting to Yakushima Airport, the dialogue amongst the MC did not indicate a sense of urgency commensurate with the increasing seriousness of the condition.

While on final approach to Yakushima Airport, at approximately 800 feet above ground level (AGL), the left-hand PRGB catastrophically failed, causing sudden asymmetric lift, and forcing the MA into an immediate left roll, resulting in the aircraft abruptly rolling twice before impacting the water. When the gearbox failure occurred, the aircraft became unrecoverable. At that point no pilot actions could have saved the MA or MC. During the initial roll, the left nacelle caught on fire and an unidentified object separated from the aircraft and fell to the water to the right of the aircraft flight path. The fire occurred after the left-hand PRGB failure and was not a factor in the mishap. The unidentified object was likely an aircraft panel that separated after PRGB failure and was not a factor in the mishap.

I found, by a preponderance of the evidence, the mishap was caused by a catastrophic failure of the left-hand PRGB that created a rapidly cascading failure of the MA's drive system, resulting in an instantaneous asymmetric lift condition that was unrecoverable by the MC, and separately, the MP's decisions were causal, as they prolonged the mishap sequence and removed any consideration of an earlier landing at a different divert location.

In addition, I found, by the preponderance of the evidence, the following factors substantially contributed to the mishap: (1) Inadequate Risk Management; and (2) Ineffective Crew Resource Management. These factors, when considered together, substantially contributed to an insufficient sense of urgency throughout the entire mishap sequence, beginning with the first PRGB cockpit advisory approximately 49 minutes prior to aircraft impact.

2. CAUSES

a. Catastrophic Failure of the Left-hand PRGB

I found, by a preponderance of the evidence, the mishap was caused by a catastrophic failure of the left-hand PRGB and subsequent rapid cascading failures of the MA drive system. Failure of the left-hand PRGB high-speed planetary section was most likely initiated by a crack in one of the high-speed pinion gears and fatigue cracking of the associated pinion gear's bearing cage, which eventually fractured through the high-speed planetary carrier assembly. At least one piece of the failed high-speed planetary pinion wedged in the high-speed carrier assembly, grinding against the high-speed sun gear's teeth until they were completely removed. The removal of the gear teeth prevented torque being applied to the left-hand mast. Removal of the high-speed sun gear teeth is consistent with the evidence of grinding and circumferential scuffing on the high-speed sun gear set at the surface where all the teeth were missing. Once the left-hand PRGB failed, an onset of rapidly cascading malfunctions occurred, to include low/lost left-hand PRGB oil pressure, ICDS failure, and right-hand PRGB over-torque – all occurring less than six seconds after failure.

b. Pilot Decision Making

I also found, by a preponderance of the evidence, decisions made by the MP were causal. These decisions caused a prolonged mishap sequence of events that removed any consideration of an earlier landing at a different landing location. Specifically, the MP's decision to continue with the mission after the third chip burn advisory posted in the cockpit and the situation became Land as Soon as Practical; and MP's decision to land at Yakushima Airport, instead of closer locations, after "L PRGB CHIPS" caution posted in the cockpit and the situation became a Land as Soon as Possible, were causal. The MP and MC did not plan for, deliberate, or even discuss closer suitable landing options after the "L PRGB CHIPS" caution posted.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

I found, by preponderance of evidence, the following factors substantially contributed to this mishap: (1) Inadequate Risk Management and (2) Ineffective Crew Resource Management.

a. Inadequate Risk Management

(1) Program-Level Risk Management

The PRGB is a complex, critically important system, the failure of which can result in the total loss of aircraft and aircrew. Data on the strength and reliability of PRGB internal components is important to V-22 operations, potentially impacting aircraft maintenance requirements, in-flight procedures, and in-flight risk management. Data importance notwithstanding, safety assessments and their findings were given insufficient treatment at the program level and have been inadequately communicated to the military services, creating lack of comprehensive awareness of PRGB risks, and limiting opportunities to impose risk mitigation measures at the service or unit level. I find, by the preponderance of the evidence, that inadequate action at the program level and inadequate coordination between the program office and the services prevented comprehensive awareness of PRGB risks, and substantially contributed to the mishap.

(2) Supervisory Risk Management

While using an Airborne Mission Commander (AMC) as a primary crewmember is permissible, the purpose of dedicating a crewmember to this duty is to allow the AMC to focus on the mission coordination and execution instead of operating the aircraft. Witness interviews during the AIB revealed that having a single person perform both AC and AMC duties was discussed during pre-mission planning. While acknowledged to be a non-standard practice, the MP was permitted to perform AC and AMC functions after determining mission complexity and environmental conditions were within acceptable risk limits (e.g., daylight, good weather). The evidence highlights multiple times during the mishap sequence when the MP prioritized the exercise and coordination with other external participants involved in the exercise over internal coordination with the MC on MA safety of flight issues. I find, by a preponderance of the evidence, the decision to permit the MP to perform both AC and AMC functions substantially contributed to the mishap.

(3) Real-time Risk Management

When the MC received the third PRGB CHIP BURN advisory in the cockpit and had a Land as Soon as Practical condition, the MC was still very close to mainland Japan and several divert airfields. The MP made the decision to continue with the mission with very little discussion amongst the MC, no acknowledgment that there were divert options nearby, and no consideration given to the fact that continuing the mission would place the MA over open water for more than 300 miles before they reached Kadena AB. The MP inadequately prioritized continuing the mission over considerations related to the risk of extended flight without redundancy in the left-hand PRGB.

Departing MCAS Iwakuni, the MC had altered their route of flight by turning westward from their briefed route to facilitate air-to-air refueling timing. This change of plans put the aircraft further to the west and made available different divert options that might not have been practical on the original route of flight. Subsequently, when the MC received the PRGB chips caution in the cockpit and had a Land as Soon as Possible condition, the MP chose a divert option that was not the closest available. The MP did not adequately assess the risk of extended overwater flight with a potentially serious mechanical problem and did not direct anyone in the MC to research other landing options that would get the MA on the ground sooner. Additionally, the MP allowed the MCP to remain flying at 8,000 feet above sea level, rather than descend below the scattered cloud deck in a prudent manner so they might see other divert options. Descending would have also placed the MA in position to affect an immediate landing (or controlled ditching), if secondary indications occurred.

After diverting, the MC only discussed the strong winds aloft and did not re-plan for much calmer surface winds, which would have made a straight-in approach to the airport a consideration, rather than remaining committed to the longer route of flight they chose. Once the MA was in the vicinity of Yakushima Airport, rather than mitigating further risk by declaring an emergency to air traffic control (ATC) and proceeding direct to a straight-in approach to the runway, the MP allowed the MCP to fly a routine box pattern to set up for an approach that added several additional minutes to the flight. Further, the MP directed the MCP to enter a holding pattern to allow a civilian aircraft to takeoff. The MP did eventually notify Yakushima Airport ATC they had an emergency, but not until queried by airfield operations, which was approximately 14 minutes after the PRGB chips caution and less than four minutes before the catastrophic failure of the left-hand PRGB. Until this point, the MP never asserted or assessed that they were in an emergency situation. I find, by the preponderance of the evidence, inadequate real-time risk management by the MP, throughout the entire mishap sequence, substantially contributed to the mishap.

b. Ineffective Crew Resource Management

Crew resource management (CRM) is a foundational operating component for all crewed aircraft. When executed properly, it maximizes crew effectiveness, interoperability, and safety of flight. Each member of a flying crew bears responsibility for active CRM. Professional aviators receive repeated training throughout their careers to arm them with tools to help recognize and counter cognitive traps and unsafe crew actions.

Indications of ineffective CRM amongst the MC started to manifest while on the ground at MCAS Iwakuni and continued through the end of the mishap sequence. The MC (not to include the DSO or SOFME team) failed to execute CRM duties at a level expected of a trained and qualified Air Force aircrew. Most notably, the MP failed to leverage the diverse experience of the MC and seek inputs from the other crewmembers in the aircraft and in the formation. This would have enabled the MC to fully analyze the totality of the situation and discuss response options to the PRGB indications. The MC did not adequately address divert options and the MP did not adequately re-orient the MC as the cockpit advisories and warnings progressed. The MP also failed to direct and/or delegate tasks appropriately as the situation progressed in complexity. Once the MP decided to turn the MA towards Yakushima Airport, the MC did not adequately use the resources available to re-assess their location and explore other options. Other resources included changing ForeFlight settings on the Electronic Flight Bag to more detailed aviation charts or changing chart scale on the Multi-Function Displays in the cockpit to search for other options. The MAP and MSMATS were also available in the cabin to help alleviate cockpit workload and research potential Land as Soon as Possible options, but neither were tasked by the MP to support.

The MCP made multiple passive attempts to prompt the MP to reconsider his response posture to the PRGB CHIP BURN advisories, but never made an assertive statement about his uneasiness with the evolving issues. The MSMAFE and MSMATS remained inappropriately focused on getting the Intelligence Broadcast Receiver operational, instead of backing up the MP with the ongoing emergency procedure.

This dynamic, unplanned sequence of events required the crew to work as a team to prioritize tasks, appropriately delegate the workload, and assertively offer professional opinions, even if the opinions differed from the MP. I find, by the preponderance of the evidence, the MC's ineffective CRM prolonged the sequence of events and significantly contributed to the mishap.

4. CONCLUSION

I find, by a preponderance of the evidence, the mishap was caused by a catastrophic failure of the left-hand PRGB and decisions by the MP that unnecessarily extended the flight after multiple left-hand PRGB advisories and cautions. I also found, by preponderance of the evidence, inadequate risk management and ineffective crew resource management substantially contributed to the mishap.

30 MAY 2024

MICHAEL E. CONLEY
Brigadier General, USAF
President, Accident Investigation Board

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