UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

MQ-9A, T/N 06-4105

645TH AERONAUTICAL SYSTEMS GROUP
AERONAUTICAL SYSTEMS CENTER
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

LOCATION: VICTORIA, REPUBLIC OF SEYCHELLES

DATE OF ACCIDENT: 13 DECEMBER 2011

BOARD PRESIDENT: COLONEL DOUGLAS W. JAQUISH

Conducted IAW Air Force Instruction 51-503

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION
MQ-9A, T/N 06-4105
VICTORIA, REPUBLIC OF SEYCHELLES
13 DECEMBER 2011

On 13 December 2011, at 0620 Zulu time (Z), an MQ-9A Reaper Remotely Piloted Aircraft (RPA), tail number (T/N) 06-4105, crashed following an uncommanded engine shutdown and attempted forced landing that occurred shortly after takeoff from Seychelles International Airport in Victoria, Republic of Seychelles. The RPA, its Multi-Spectral Targeting System, Multi-Spectral Targeting System Electronics Unit, and Beyond Line-of-Sight pod were destroyed, a loss valued at $9,643,000. There were no fatalities, injuries, or damage to other property.

The Mishap Remotely Piloted Aircraft (MRPA) was an asset of the 645th Aeronautical Systems Group, Wright-Patterson Air Force Base, Ohio. The MRPA was forward-operated by the 409th Air Expeditionary Group Detachment 1 at Seychelles International Airport, Victoria, Republic of Seychelles. The Mishap Crew consisted of a contractor-furnished pilot and sensor operator.

The accident investigation board (AIB) president found, by clear and convincing evidence, the cause of the mishap was an electrical short in the MRPA engine control cable assembly. Additionally, the AIB president found, by a preponderance of evidence, continued operation of the MRPA without accomplishing Time Compliance Technical Orders (TCTO) 1Q-9A-554 and -587, and the Mishap Pilot's improperly executed forced landing, substantially contributed to the mishap.

SUMMARY OF FACTS AND STATEMENT OF OPINION

AIRCRAFT ACCIDENT INVESTIGATION
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COMMONLY USED ACRONYMS AND ABBREVIATIONS

ACC	Air Combat Command
ACC/A8Q	ACC/RPA Requirements Directorate
AEG	Air Expeditionary Group
AESG	Aeronautical Systems Group
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AFMC	Air Force Materiel Command
AFRICOM	U.S. Africa Command
AFSAS	Air Force Safety Automated System
AFTO	Air Force Technical Order
AGL	Above Ground Level
AIB	Aircraft Investigation Board
AoA	Angle of Attack
AOR	Area of Responsibility
ASC	Aeronautical Systems Center
ASC/WI	ASC/PEO ISR/SOF
ASC/WII Det 3	ASC/PEO MQ-1/9 Det 3
AT	Avionics Technician
ATC	Air Traffic Control
ATIS	Automated Terminal Information System
ATP	Airline Transport Pilot
BLOS	Beyond Line-of-Sight
C	Celsius
CAP	Critical Action Procedures
CC	Commander
C2	Command and Control
Capt	Captain
Col	Colonel
CONOPS	Concept of Operations
CRM	Crew Resource Management
DEEC	Digital Engine Electronic Controller
deg, °	degree(s)
Det, DET	Detachment
DET 1 CC/GFR	Detachment 1 CC/GFR
DL	downlink/datalink
DNIF	Duty Not Including Flying
DoD	Department of Defense
DoD-HFACS	DoD Human Factors Analysis and Classification System
DVR	Digital Video Recorder
EP	Emergency Procedure
EQUIP SPEC1	Equipment Specialist 1
EQUIP SPEC2	Equipment Specialist 2
ESM	Engine Start Module
FAA	Federal Aviation Administration
FAE	Functional Area Expert
F	Fahrenheit
fpm, ft/min	feet per minute
FSR	Field Service Representative
FSIA	Seychelles International Airport (ICAO)
FSOV	Fuel Shutoff Valve
ft.	feet, foot
FUEL1	Fuels Technician 1
FUEL2	Fuels Technician 2
GA-ASI	General Atomics Aeronautical Systems, Inc.
GCS	Ground Control Station
GDT	Ground Data Terminal
GFR	Government Flight Representative
GGR	Government Ground Representative
GLS	GPS Landing System
GOCO	Government Owned, Contractor Operated
GPS	Global Positioning System
HDD	Heads-Down Display
HQ	Headquarters
HUD	Heads-Up Display
IAW	in accordance with
ICAO	International Civil Aviation Organization
IETMS	Interactive Electronic Technical Manual System
in	inch(es)
in Hg	inches Mercury
IMDS	Integrated Maintenance Data System
IP	Instructor Pilot
ISB	Interim Safety Board
ISB IO	Interim Safety Board Investigating Officer
ISO	Instructor Sensor Operator
ISR	Intelligence, Surveillance, and Reconnaissance
KIAS	knots indicated airspeed
kts	nautical miles per hour
L	Local time
LA	Legal Advisor
LCA	Lead Command Approver
LCV	Lead Command Validator
LP	Lead Pilot
LR	Launch and Recovery
LRE	Launch and Recovery Element
LRT	Launch and Recovery Training
Lt Col	Lieutenant Colonel
LSO	Lead Sensor Operator
Maj	Major
MAJCOM	Major Command
MC	Mishap Crew (MP and MSO)
MCE	Mission Control Element
MDS	Mission Design Series
m	meter(s)
MP	Mishap Pilot
MRI	Merlin RAMCo Inc.
MRPA	Mishap Remotely Piloted Aircraft
MSL	above Mean Sea Level
MSO	Mishap Sensor Operator
MTS	Multi-Spectral Targeting System

MX	Maintenance
MX1	Maintenance Technician 1
MX2	Maintenance Technician 2
MX3	Maintenance Technician 3
MX SUP	Maintenance Superintendent
NATOPS	Naval Air Training and Operating Procedures Standardization
nm	nautical mile(s)
NOTAMS	Notices to Airmen
OCO	Overseas Contingency Operations
ORM	Operational Risk Management
OT&E	Operational Test and Evaluation
PEO	Program Executive Office(r)
PHA	Physical Health Assessment
PMATS	Predator Mission Aircrew Training Simulator
POL	Petroleum, Oil, & Lubricants
PPSL	Predator Primary Satellite Link
RCM	Redundant Control Module
RPA	Remotely Piloted Aircraft
RPM	Revolutions per Minute
RTB	Return to Base
RWY	Runway
SCAA	Seychelles Civil Aviation Authority
SIB	Safety Investigation Board
SMA	Single Manager
S/N	Serial Number
SO	Sensor Operator
SOCOM	U.S. Special Operations Command
SOF	Special Operations Forces
SFO	Simulated Flame Out
SSgt	Staff Sergeant
TCTO	Time Compliance Technical Order
T/N	Tail Number
T.O./TO	Technical Order
TOD	Technical Order Data
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
U.S./US	United States
USAF	United States Air Force
VVI	Vertical Velocity Indicated
Z	Zulu time/Greenwich Mean Time

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

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 17 January 2012, Lieutenant General C.D. Moore II, Vice Commander, Air Force Materiel Command (AFMC), appointed Colonel Douglas W. Jaquish to conduct an RPA accident investigation of the 13 December 2011 crash of an MQ-9A Reaper Remotely Piloted Aircraft (RPA), tail number (T/N) 06-4105, in Victoria, Republic of Seychelles. The investigation occurred at Kirtland Air Force Base (AFB), New Mexico from 6 June 2012 through 28 June 2012. The following board members were also appointed: Pilot Member, Legal Advisor, Maintenance Member, and Recorder (Tabs Y-3 to Y-9).

b. Purpose

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

2. ACCIDENT SUMMARY

On 13 December 2011, at 0620 Zulu time (Z), an MQ-9A Reaper RPA, T/N 06-4105, crashed following an uncommanded engine shutdown and attempted forced landing that occurred shortly after takeoff from Seychelles International Airport (FSIA) in Victoria, Republic of Seychelles (Tabs B-3, C-3, DD-4). The RPA, its Multi-Spectral Targeting System, Multi-Spectral Targeting System Electronics Unit, and Beyond Line-of-Sight (BLOS) pod were destroyed, a loss valued at $9,643,000 (Tab P-3). There were no fatalities, injuries or damage to other property.

3. BACKGROUND

The Mishap Remotely Piloted Aircraft (MRPA) was assigned to the 645th Aeronautical Systems Group (645 AESG), Wright-Patterson AFB, Ohio (Tab B-3). At the time of the mishap, 409th Air Expeditionary Group (409 AEG)/Detachment 1 (Det 1) forward-operated the MRPA from FSIA. The site was supported by contractor-furnished operations and maintenance personnel qualified in the MQ-9A Unmanned Aircraft System (UAS), managed under a 645 AESG contract with Merlin RAMCo Inc. (MRI) (Tab V-6.6).

a. Air Force Materiel Command (AFMC)

AFMC delivers war-winning expeditionary capabilities to the warfighter through development and transition of technology, professional acquisition management, exacting test and evaluation, and world-class sustainment of all United States Air Force (USAF) weapon systems. AFMC provides the work force and infrastructure necessary to ensure the United States (U.S.) remains the world's most respected air and space force. AFMC fulfills its mission of equipping the USAF with the best weapon systems

through the Air Force Research Laboratory and several unique centers, which are responsible for the total oversight for aircraft, electronic systems, and missiles and munitions (Tab CC-3).

b. Aeronautical Systems Center (ASC)

ASC is the largest of three USAF product centers within AFMC. The center designs, develops, and delivers dominant aerospace weapon systems and capabilities for U.S. military and coalition warfighters. ASC focuses on speed and innovation in acquisition management, and rapid transition of technology into aerospace systems (Tab CC-7).

c. 645th Aeronautical Systems Group (645 AESG)

645 AESG, commonly referred to as Big Safari, is a USAF program office that provides management, direction, and control of acquisition, modification, and logistics for special purpose weapons systems. It oversees the testing and fielding of new weapons systems, sensors, and platforms. 645 AESG reports to ASC/WI, the Program Executive Office for Intelligence, Surveillance, and Reconnaissance (ISR) and Special Operations Forces (Tab CC-9).

d. 409th Air Expeditionary Group (409 AEG)

409 AEG supports the USAF ISR mission across the entire U.S. Africa Command (AFRICOM) area of responsibility from multiple locations. The objective is to promote regional security and stability, dissuade conflict, and protect U.S. and coalition interests. 409 AEG was activated 1 January 2011 in support of Overseas Contingency Operations (OCO) in AFRICOM (Tab CC-10). 409 AEG/Det 1 was forward-deployed to FSIA.

e. Merlin RAMCo Inc. (MRI)

Merlin RAMCo Inc. (MRI) employs qualified personnel to aid the Armed Forces in meeting their challenging demands. Their ISR professionals support a variety of manned and unmanned platforms across many disciplines. MRI employees are deployed across the globe performing engineering services, operational training, flight operations, ISR maintenance, security support, technical manual services, and logistics support. MRI has more than 80 employees at 14 locations across the U.S. and in five other countries, and services multiple customer support sites around the world (Tab CC-11).

f. MQ-9A Reaper Remotely Piloted Aircraft (RPA)

The MQ-9A Reaper is a medium-to-high altitude, long endurance RPA system employed primarily in a hunter/killer role against dynamic execution targets and secondarily as an ISR asset. The MQ-9A is manufactured by General Atomics Aeronautical Systems, Inc. (GA-ASI) in Poway, California. A fully operational MQ-9A UAS consists of several sensor/weapon-equipped RPAs, a Ground Control Station (GCS), a Predator Primary Satellite Link and spare equipment, along with operations and maintenance crews for deployed 24-hour operations (Tab CC-12).

The basic crew consists of a rated pilot to control the RPA and command the mission, a sensor operator (SO) to operate the payloads, and a Mission Coordinator, when required. To meet combatant commander requirements, the MQ-9A delivers tailored capabilities using mission kits containing various weapons and sensor payload combinations (Tab CC-12).

The MQ-9A baseline system carries a Multi-spectral Targeting System (MTS), which has a robust suite of sensors for targeting. The MTS integrates an infrared sensor, a color/monochrome daylight TV camera, an image-intensified TV camera, a laser designator and a laser illuminator into a single package (Tab CC-12).

The USAF proposed the MQ-9A UAS in response to Department of Defense (DoD) direction to support OCO. It is larger and more powerful than the MQ-1B Predator UAS and is designed to destroy or disable time-sensitive targets with persistence and precision. "MQ-9A" is the DoD designation for its multi-role (“M”) RPA series (“Q”), ninth model, version A (“-9A”) aircraft (Tab CC-13).

4. SEQUENCE OF EVENTS

a. Mission

The MRPA was supporting a classified ISR mission (Tab V-6.26).

b. Planning and Preflight

On 13 December 2011, at approximately 0430Z, two hours prior to the scheduled takeoff, the Mishap Crew (MC), comprised of the Mishap Pilot (MP) and Mishap Sensor Operator (MSO), arrived at the 409 AEG/Det 1 facility at FSIA (Tabs V-12.10, V-13.8). They attended a mission briefing which covered RPA maintenance, operational risk management (ORM) analysis, Notices to Airmen (NOTAMS), weather, and safety considerations (Tabs V-6.26, V-8.5, V-12.12, V-12.13). The briefing was conducted by the MP in accordance with (IAW) unit mission briefing guides (Tabs V-6.26, V-27, V-12.12). The MC, 409 AEG/Det 1 Commander, MRI Maintenance Supervisor, MRI Site Lead, and a weather briefer attended the mission briefing (Tabs V-8.5, V-12.11, V-12.12).

When the mission briefing was completed, the MC prepared the GCS to gain control of the MRPA (Tab V-12.13). The MP then conducted a preflight walk-around inspection of the MRPA (Tab V-12.14). Upon completion, the MP returned to the GCS to continue preparing for the mission (Tab V-12.15). All preflight preparations were accomplished IAW published guidance (Tabs V-3.6, V-12.15, V-13.16). The MRPA engine start and taxi to Runway (RWY) 31 were uneventful (Tabs V-12.19, V-13.16, V-13.17).

c. Summary of Accident

The MP lined up on RWY 31 and performed a normal takeoff at 0614Z (Tabs V-12.19, EE-11). Approximately two minutes after takeoff, the MRPA was on a heading of 330 degrees (°) at 2,780 feet (ft) above Mean Sea Level (MSL) at 111 knots indicated airspeed (KIAS) and was 4.12 nautical miles (nm) from the Ground Data Terminal (GDT) when the MRPA engine torque

rapidly fell to zero percent (Tab EE-11). This event was immediately followed by an "Engine out detected" warning on the MC Heads-Down Displays (Tab V-12.19). The MP initiated a right turn within fifteen seconds, declared to FSIA Air Traffic Control (ATC) his intent to "come back around for a 'one three' emergency landing," opposite the direction of takeoff, and rolled out to a heading of 172° pointing the MRPA toward FSIA (Tab EE-11). The MC began to execute the Critical Action Procedures (CAP) of the Engine Failure checklist (Tabs N-5, V-12.23, V-13.18).

The MP turned further right to a heading of 185° (Tab EE-11). Automatic engine restarts were unsuccessful, leading to the MRPA steadily losing altitude (Tabs V-12.22, EE-11, EE-12). Less than two minutes prior to landing, FSIA ATC queried the MP on his expected landing time, to which the MP responded, "About five minutes" (Tabs N-6, DD-11, EE-12). The MC continued with the Engine Failure checklist, in which the MP set the GCS Condition Lever aft, feathering the MRPA propeller, which aligned the propeller with the slipstream to reduce drag, and told the MSO, "We'll go cold" with GCS Ignition (Tabs N-7, V-12, DD-11). The MP announced, "Field's made. Gear's coming down" and lowered the landing gear approaching the runway (Tabs N-7, EE-12). The MP announced to FSIA ATC, "Short final at this time," initiated a final turn to the left to align with RWY 13 and remarked, "It's still kinda high" (Tabs N-8, DD-11, EE-12). The MP further remarked, "Speed's fast," at 490 ft MSL and 144 KIAS while in the final turn (Tabs N-8, DD-11, EE-12).

The MP achieved wings level at 310 ft MSL and 147 KIAS, more than 300 ft above the threshold, over the RWY 13 number markings (Tab EE-12). The MP lowered the nose, increased airspeed to 150 KIAS, flared the MRPA at approximately 1,500 ft down RWY 13 to arrest the sink rate, and flew the MRPA just above the runway until the landing (Tabs EE-12, EE-19).

d. Impact

The MRPA landed at 0619Z approximately 3,800 ft down RWY 13 at 132 KIAS (Tabs EE-12, EE-19). The MP applied full brakes, slowing the MRPA to 66 KIAS in the 5,000 ft of runway remaining (Tabs DD-7, DD-17, EE-19). The MRPA crossed the RWY 13 departure end at approximately 66 KIAS, bounced over the airport perimeter road, struck a rock breakwater, and came to rest in the ocean at 0620Z (Tabs B-3, V-8.13, V-8.14, EE-12). The MRPA, its MTS, MTS Electronics Unit, and BLOS pod were destroyed, a loss estimated at $9,643,000 (Tab P-3). There were no fatalities, injuries, or damage to other property.

e. Egress and Aircrew Flight Equipment

Not applicable.

f. Search and Rescue

Not applicable.

g. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

A thorough review of the Air Force Technical Order (AFTO) 781-series forms for the MRPA revealed one discrepancy. The AFTO Form 781K identified a Time Compliance Technical Order (TCTO) due for the MRPA at the time of the mishap (Tab D-24). However, further review revealed the TCTO was, in fact, accomplished on 23 October 2011, but had not been properly documented as completed (Tab U-5). Absent that discrepancy, the AFTO 781 forms were documented IAW applicable maintenance guidance and there were no outstanding maintenance issues preventing the MRPA from flying on 13 December 2011 (Tabs D-10 to D-16, D-24).

Further, per AFTO Form 781K, there were no delayed discrepancies that would have required the MRPA to be grounded on 13 December 2011 (Tab D-24). Automated AFTO Forms 781A, 781J and 781K were not being used as required by Technical Order (T.O.) 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*, para 3.3, 15 June 2011, but this was not found to be a factor in the mishap (Tabs V-10.7, V-10.8, BB-6).

On 13 December 2011, the MRI maintenance superintendent (MX SUP) reviewed all applicable maintenance forms and data for the MRPA, and signed the AFTO Form 781H, approving the MRPA for flight (Tabs D-10, V-8.6, V-8.8).

b. TCTOs 1Q-9A-554 and -587

A TCTO provides instructions to modify military systems or commodities within specified time limits, initiate special "one time" inspections, or impose temporary restrictions and track configurations on systems or equipment (Tab BB-4).

At the time of the mishap, the MRPA had no overdue TCTOs. However, TCTOs 1Q-9A-554 and -587 were issued 2 June 2009 and 31 January 2011, respectively, to add redundancy to the engine control cable assembly and upgrade the Engine Start Module in specified MQ-9A RPAs (Tabs BB-7, BB-8, EE-15). The TCTOs eliminated a known vulnerability to a single-point open circuit failure, such as an electrical short, that could result in the engine Fuel Shutoff Valve (FSOV) closing in flight and preventing fuel flow to the engine (Tabs DD-25, BB-7, BB-8).

At the time the TCTOs were issued, the MRPA was owned and operated by the U.S. Navy. However, the USAF TCTOs were not applicable to U.S. Navy MQ-9As (Tabs D-53, U-3, EE-15, EE-16). On 19 March 2011, MRPA ownership transferred in place to the USAF (Tab EE-15).

On 8 August 2011, 645 AESG initiated an AF Form 1067, *Modification Proposal*, to authorize continued use of the MRPA until the TCTOs were accomplished (Tabs D-54, U-3). The AF Form 1067 did not specify a due date for the TCTOs' accomplishment. On 9 August 2011, the AF Form 1067 was approved by "ASC/WII Det 3," the MQ-9A Single Manager representative. On 10 August 2011, the AF Form 1067 was approved by "ACC/A8Q," the MQ-9A Lead Command representative (Tabs D-54, U-3). At the time of the mishap, TCTOs 1Q-9A-554 and -587 had not been accomplished on the MRPA (Tab DD-4).

c. Inspections

All MRPA maintenance inspections and procedures were completed and documented IAW applicable maintenance guidance. At the time of the mishap, the MRPA airframe had a total of 2,862.5 flight hours (Tab D-3). On 30 November 2011, 13 days prior to the mishap, the MRPA underwent 100-hour airframe, power plant and propeller periodic inspections IAW the maintenance guidance (Tabs D-22, U-8). At the time of the mishap, the MRPA was current on all periodic inspections and had flown 51.4 hours since completion of the 100-hour airframe, power plant and propeller periodic inspections (Tab D-3).

On 12 December 2011, one day prior to the mishap, a combined Basic Post Flight/Preflight inspection was performed IAW applicable maintenance guidance with no discrepancies noted (Tab D-10).

d. Maintenance Procedures

The MRPA was maintained by MRI maintenance personnel. MRI was contracted by 645 AESG to provide deployed maintenance support on the MQ-9A weapon system at FSIA (Tabs V-6.6, V-9.4). The MRI personnel deployed to FSIA at the time of the mishap were qualified and performed maintenance procedures IAW applicable maintenance guidance and T.O.s (Tabs V-10.18, EE-16).

e. Maintenance Personnel and Supervision

Training records were reviewed for the MRI maintenance personnel who performed relevant maintenance on the MRPA in the 90 days prior to the mishap (Tab EE-16). All MRI personnel involved in maintenance on the MRPA prior to the mishap were qualified and adequately supervised for the tasks they performed (Tabs V-10.18, EE-16).

f. Fuel and Oil Inspection Analyses

After the mishap, a fuel sample was collected directly from the portable fuel tank, or "bowser," used to fuel the MRPA on 13 December 2011 (Tab V-1.18). The sample was sent for analysis to the Air Force Petroleum Laboratory, Wright-Patterson AFB, Ohio. The fuel sample analysis showed no contamination or anomalies (Tab J-3).

During the post-mishap engine teardown inspection by the manufacturer, oil samples were taken and analyzed. The results did not indicate component failure (Tabs J-18 to J-25).

g. Unscheduled Maintenance

From 30 November 2011 to 6 December 2011, in conjunction with the 100-hour airframe, power plant and propeller periodic inspections, MRI and other contractor personnel performed modifications to the MRPA (Tabs U-7 to U-14, V-2.18). Both wings were removed to facilitate the modifications and were reinstalled on 2 December 2011 (Tab U-12). The modifications and wing reinstallation performed by MRI and other contractor personnel were accomplished IAW contractor technical data and published maintenance guidance and T.O.s (Tabs U-13, U-14).

The MRPA Redundant Control Module (RCM) was removed on 30 November 11 for temporary use on another MQ-9A and reinstalled on the MRPA on 6 December 2011 (Tab U-7). The maintenance was performed by qualified MRI maintenance personnel IAW published maintenance guidance and T.O.s (Tabs U-7, EE-16).

6. AIRFRAME

a. Structures and Systems Analysis

(1) Ground Control Station (GCS)

After the mishap, in an effort to determine if the GCS was a factor in the mishap, GA-ASI engineers reviewed the data logs from the mishap sortie. The datalink was normal and the MRPA responded to all pilot commands, and GCS commands appeared normal (Tab E-8). GA-ASI engineers determined the MRPA GCS was not a factor in the mishap (Tab EE-8).

(2) MRPA Brakes

Using information obtained from data logs, GA-ASI engineers conducted an analysis of MRPA braking efficiency. They determined the MRPA brakes functioned normally and provided expected deceleration (Tabs DD-7, DD-17, DD-20, DD-24).

(3) MRPA Engine

GA-ASI engineers analyzed data logs in an effort to determine if the MRPA engine was a factor in the mishap. They determined the engine was performing normally until the uncommanded shutdown (Tabs DD-4, DD-5, DD-19, DD-20). There were no Digital Engine Electronic Controller faults indicating an engine malfunction (Tabs DD-6, DD-19).

The MRPA engine was returned to the manufacturer, Honeywell Product Integrity Laboratory in Phoenix, Arizona, for a teardown inspection (Tab DD-14). Teardown analysis determined there was no evidence of an engine malfunction that would have prevented operation or interrupted combustion (Tabs D-23, DD-24).

GA-ASI engineering analysis concluded the most likely cause of the engine shutdown was a loss of fuel to the engine (Tab DD-20).

(4) MRPA Components

GA-ASI engineers analyzed relevant MRPA components (Tab DD-18). The analysis determined an intermittent electrical short occurred in the engine control cable assembly between two wires, approximately 8 ft 3 in from the connector end (Tabs DD-19, DD-27). The electrical short produced extra current, burned open the corresponding electrical circuit in the RCM, closing the FSOV and preventing fuel flow to the engine (Tabs DD-4, DD-28).

The engine control cable assembly runs nearly the full length of the RPA fuselage and is surrounded by a protective conduit, with the exception of a small area near the left aft wing pin

inner access panel, where it exits the protective conduit (Tab DD-22). The electrical short in the MRPA engine control assembly occurred in close proximity to this exposed area (Tabs DD-22).

GA-ASI concluded the electrical short occurred due to damage that "possibly occurred during recent maintenance" (Tab D-25). The AIB President could not determine, by clear and convincing evidence, the cause of the electrical short in the MRPA engine control cable assembly.

7. WEATHER

a. Forecast Weather

The forecasted weather at FSIA for 13 December 2011 at 0200Z to 14 December 2011 at 0200Z was: wind variable at 5 knots (kts), visibility 10,000 meters (m) or more, clouds scattered at 1,500 ft above ground level (AGL) and broken at 15,000 ft AGL, altimeter 29.80 inches Hg (in Hg); becoming from 0600Z to 0700Z, wind variable at 5 kts, visibility 5,000 m, light rain showers, clouds broken at 1,000 ft AGL and 25,000 ft AGL, altimeter 29.78 in Hg; becoming from 1100Z to 1200Z, wind variable at 5 kts, visibility 10,000 m or more, clouds scattered at 1,500 ft AGL and broken at 15,000 ft AGL, altimeter 29.78 in Hg (Tab F-3).

b. Observed Weather

Observed weather at FSIA on 13 December 2011 at 0555Z, approximately 25 minutes before the mishap, was: wind 090° at 3 kts, temperature 30°Celsius (C), dew point 23°C, visibility 10,000 m or more, clouds few at 2,200 ft AGL and broken at 25,000 ft AGL, altimeter 29.87 in Hg (Tab F-11).

Observed weather for FSIA on 13 December 2011 at 0626Z, approximately six minutes after the mishap, was: wind 070° at 5 kts, temperature 29°C, dew point 23°C, visibility 10,000 m or more, clouds scattered at 2,000 ft AGL and broken at 3,200 ft AGL and 25,000 ft AGL, altimeter 29.87 in Hg (Tab F-11).

c. Space Environment

Not applicable.

d. Operations

Weather at the time of the mishap was within MQ-9A operational limits (Tabs F-3, F-11).

8. CREW QUALIFICATIONS

a. Mishap Pilot (MP)

(1) Training

The MP was initially qualified as a U.S. Navy MQ-9A Mission Control Element (MCE) pilot on 11 May 2010 (Tab T-3). The MP was initially qualified in the MQ-9A as an MRI MCE/Launch and Recovery Element (LRE) Pilot on 23 August 2011 (Tab G-3).

(2) Experience

At the time of the mishap, the MP had over 4,000 hours total flight time (Tabs G-5, G-8, G-9, V-12.35). The MP had 824 hours in the MQ-9A as both a U.S. Navy MCE Instructor Pilot (IP) and an MRI MCE/LRE Pilot (Tabs G-5, G-8, G-9). Additionally, the MP had 1,482 hours in the P-3 and approximately 1,000 hours in the T-34 as a U.S. Navy Pilot (Tabs G-5, V-12.35). The MP had 100 hours as an MCE IP and flew the majority of his T-34 hours as an IP (Tabs G-5, V-12.36). The MP also held a Federal Aviation Administration Airline Transport Pilot Certificate for Airplane Multi-engine Land with Commercial privileges in Airplane Single Engine Land (Tab T-4). The MP's flight time for the 30, 60, and 90 days prior to the mishap was as follows (Tabs G-8, G-9):

MP	Hours	Sorties	Landings
Last 30 Days	103.0	24	3
Last 60 Days	221.8	50	6
Last 90 Days	301.9	72	15

b. Mishap Sensor Operator (MSO)

(1) Training

The MSO was initially qualified as a USAF MQ-9A MCE SO in the USAF in May 2006 (Tabs G-36). The MSO was initially qualified in the MQ-9A as an MRI MCE/LRE SO on 23 November 2011 (Tab G-25).

(2) Experience

At the time of the mishap, the MSO had a total flight time of 293.3 hours in the MQ-9A (Tabs G-26, G-35, G-36). The MSO also had 1,149.8 hours in the MQ-1B, of which 242.5 hours was Instructor SO time (Tabs G-35, G-36). The MSO's flight time for the 30, 60, and 90 days prior to the mishap was as follows (Tab G-26):

MSO	Hours	Sorties
Last 30 Days	42.4	16
Last 60 Days	42.4	16
Last 90 Days	42.4	16

9. MEDICAL

a. Qualifications

At the time of the mishap, the MP and MSO were medically qualified for flight duty without restrictions (Tab EE-13).

b. Health

The AIB reviewed the written histories documenting MP and MSO nutrition, medication, hydration, sleep patterns, fatigue, and exertion for the 72-hour and 14-day time periods prior to the mishap. There is no evidence any prescription or over-the-counter medication was a factor in the mishap. There is no evidence the health of the MP and MSO contributed to the mishap (Tabs EE-13, EE-14).

c. Toxicology

Immediately after the mishap, a USAF medical provider collected blood and urine samples from the MP and MSO. The samples were sent to the Armed Forced Medical Examiner System for analysis. The blood samples were tested for the presence of ethanol (alcohol). The urine samples were tested for the presence of drugs of abuse (amphetamine, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates, and phencyclidine). The MP and MSO toxicology testing resulted in negative findings for the presence of ethanol or drugs of abuse (Tab EE-13).

d. Lifestyle

No lifestyle factors were found to be relevant to the mishap.

e. Crew Rest and Crew Duty Time

Aircrew are required to have proper crew rest prior to performing in-flight duties and adhere to proper duty time requirements as defined in AFI 11-202, Volume-3, *Flying Operations-General Flight Rules,* Chapter 9, 22 October 2010. No crew rest or crew duty time requirements were violated or found to be a factor in the mishap. There was no evidence that fatigue was a factor in the mishap (Tab EE-14).

10. OPERATIONS AND SUPERVISION

a. Operations

409 AEG/Det 1 operations tempo was normal at the time of the mishap (Tab V-6.25).

b. Supervision

There is no evidence 409 AEG/Det 1 or MRI supervision contributed to the mishap.

11. HUMAN FACTORS

a. Overview

A DoD taxonomy was developed to identify hazards and risks, called DoD Human Factors Analysis and Classification System (DoD-HFACS), referenced in Attachment 5 of AFI 91-204, *Safety Investigations and Reports*, 24 September 2008. All human factors enumerated in AFI 91-204 Attachment 5, including channelized attention, task saturation, complacency, and distraction were carefully analyzed for possible contribution to the mishap sequence. The relevant human factors are discussed below. The DoD-HFACS taxonomy nanocodes are also included for reference (AFI 91-204, Attachment 5).

b. Causal

(1) AE 103 Procedural Error

Procedural error is a factor when a procedure is accomplished in the wrong sequence or using the wrong technique or when the wrong control or switch is used. This also captures errors in navigation, calculation or operation of automated systems (AFI 91-204, Attachment 5).

During the forced landing, the MP did not establish the MRPA on a proper profile for the intended landing point IAW published guidance for the engine out approach (Tabs DD-8, EE-12). The MP also gained excessive airspeed during the final portion of the landing (Tabs DD-11, DD-12, EE-12). As a result, the MRPA landed beyond the normal runway landing zone, well above normal landing speed, and the MP was unable to stop the MRPA on the runway remaining (Tabs DD-11, DD-12, EE-12).

c. Contributory

(1) PP 102 Cross-Monitoring Performance

Cross-Monitoring Performance is a factor when crew or team members failed to monitor, assist or back-up each other's actions and decisions (AFI 91-204, Attachment 5).

Shortly after the uncommanded engine shutdown, the MP called for the Engine Failure checklist (Tabs N-5, V-13.18, DD-11). The MSO complied, but improperly executed the Engine Failure CAP by calling for the landing gear extension instead of the proper step in the CAP (Tab N-5). Additionally, the MSO stated, "I'll just watch your altitudes," but did not audibly communicate either altitude or airspeed information to the MP for the remainder of attempted forced landing (Tabs N-7 to N-9).

(2) PE 205 Automation

Automation is a factor when the design, function, reliability, use guidance, symbology, logic or other aspect of automated systems creates an unsafe situation (AFI 91-204, Attachment 5).

During the mishap sortie, the MP and MSO Heads-Up Display (HUD) Global Positioning System (GPS) Landing System (GLS) were set for RWY 31. The HUD GLS displays may have

provided the MC useful glide slope indicator graphics for the MP's attempted forced landing had the MC set their GLS for RWY 13 (Tabs V-12.25, EE-19).

d. Non-Contributory

All human factors listed in AFI 91-204, Attachment 5 were considered for their possible contribution to the mishap sequence. No non-contributory human factors worthy of discussion were identified.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Flight Directives and Publications

(1) AFI 11-202, Volume 1, *Flying Operations-Aircrew Training*, 22 November 2010*
(2) AFI 11-202, Volume 3, *Flying Operations-General Flight Rules*, 22 October 2010* 16 November 2011*
(3) AFI 11-2FT, Volume 1, *Flight Test Aircrew Training*, 20 September 2011*
(4) AFI 11-2FT, Volume 3, *Flying Operations-Flight Test Operations Procedures*,
(5) AFI 11-2MQ-9, Volume 1, *Flying Operations-MQ-9 Crew Training*, 3 June 2001 (certified current, 23 June 2010)*
(6) AFI 11-2MQ-9, Volume 3, *Flying Operations-MQ-9 Operations Procedures*, 28 November 2008 (Change 1 – 3 September 2010)*
(7) TO 1Q-9(M)A-1, *MQ-9A Flight Manual*, Change 4 – 20 July 2011
(8) TO 1Q-9(M)A-1CL-1, *MQ-9A Flight Crew Checklist*, Change 4 – 20 July 2011

b. Maintenance Directives and Publications

(1) TO 00-5-15, *Air Force Time Compliance Technical Order Process*, 1 January 2010
(2) TO 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*, 15 June 2011

c. Other

(1) AFI 10-220(I), *Contractor's Flight and Ground Operations*, 1 March 2007 (Certified current – 21 March 2011)*
(2) AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010*
(3) AFI 91-204, *Safety Investigations and Reports*, 24 September 2008*
(4) Merlin RAMCo Inc., *Contractor's Procedures for GOCO Operations*, Contract Number: FA8620-11-C-4043, 15 November 2011

* Available digitally at: http://www.e-publishing.af.mil.

d. Known or Suspected Deviations from Directives or Publications

MQ-9A pilots must conduct a nose camera landing every 60 days and a Simulated Flame Out (SFO) every 120 days, as defined in AFI 11-2FT, Volume 1, *Flight Test Aircrew Training*, Table A-27.1, 20 September 2011. Based on the MRI-generated aircrew currency spreadsheet, dated 5 December 2011, the MP's last performed nose camera landing was 31 August 2011 and last performed SFO was indeterminate (Tab EE-20). Based on the MRI-generated aircrew currency spreadsheet dated 13 December 2011, the MP's last performed SFO was 21 August 2011, which coincided with his initial MCE/LRE qualification (Tabs G-3, G-4, EE-21). The MP performed the mishap landing on 13 December 2011 using the MRPA nose camera, for which the MP was not current, and was due within seven days for SFO (Tabs EE-20, EE-21).

13. ADDITIONAL AREAS OF CONCERN

None.

28 June 2012

DOUGLAS W. JAQUISH, Colonel, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

AIRCRAFT ACCIDENT INVESTIGATION
MQ-9A, T/N 06-4105
VICTORIA, REPUBLIC OF SEYCHELLES
13 DECEMBER 2011

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 13 December 2011, at 0620 Zulu time (Z), an MQ-9A Reaper Remotely Piloted Aircraft, tail number (T/N) 06-4105, crashed following an uncommanded engine shutdown and attempted forced landing that occurred shortly after takeoff from Seychelles International Airport (FSIA) in Victoria, Republic of Seychelles. The RPA, its Multi-Spectral Targeting System, Multi-Spectral Targeting System Electronics Unit, and Beyond Line-of-Sight pod were destroyed, a loss valued at $9,643,000. There were no fatalities, injuries, or damage to other property.

I find, by clear and convincing evidence, the cause of the mishap was an electrical short in the Mishap Remotely Piloted Aircraft (MRPA) engine control cable assembly. Additionally, I find by a preponderance of evidence, continued operation of the MRPA without accomplishing Time Compliance Technical Orders (TCTO) 1Q-9A-554 and -587, and the Mishap Pilot's (MP) improperly executed forced landing, substantially contributed to the mishap.

2. DISCUSSION OF OPINION

a. Cause: Electrical short in the MRPA engine control cable assembly

The MP lined up on Runway (RWY) 31 and performed a normal takeoff at 0614Z. Approximately two minutes after takeoff, an electrical short occurred in the MRPA engine control cable assembly. This electrical short produced excess current that burned open the corresponding electrical circuit in the MRPA Redundant Control Module. This chain of events irreversibly closed the MRPA Fuel Shutoff Valve (FSOV), preventing fuel flow to the engine, which led to the engine shutdown. Automatic engine restarts were unsuccessful, leading to the MRPA steadily losing altitude and the MP's attempted forced landing.

I was unable to determine, by clear and convincing evidence, the cause of the electrical short in the MRPA engine control cable assembly.

b. Substantially Contributing Factor: Unaccomplished TCTOs 1Q-9A-554 and -587

TCTOs 1Q-9A-554 and -587 were issued to add redundancy to the RPA engine control cable assembly and upgrade its Engine Start Module. The TCTOs eliminated a known vulnerability to a single-point open circuit failure, such as an electrical short, that could result in the engine

FSOV closing in flight and preventing fuel flow to the engine. At the time of the mishap, the MRPA was approved for operation without the TCTOs accomplished. Accomplishing the TCTOs may have prevented the FSOV closing due to the electrical short in the engine control cable assembly, breaking the chain of events that led to the uncommanded engine shutdown.

c. Substantially Contributing Factor: Improperly executed forced landing

Shortly after the uncommanded engine shutdown, the MP initiated a right turn and declared to FSIA Air Traffic Control his intent to land on RWY 13, opposite the direction of takeoff. The Mishap Crew (MC) began executing the Critical Action Procedures of the Engine Failure checklist and prepared for the forced landing.

The MP feathered the propeller, lowered the landing gear, and initiated the final turn to align with RWY 13. The MP achieved wings level more than 300 feet (ft) above the RWY 13 threshold at 147 knots indicated airspeed (KIAS). The MP lowered the nose and flared for landing approximately 1,500 ft down the runway. The MRPA landed at 0619Z approximately 3,800 ft down the runway at 132 KIAS. The MP slowed the MRPA, with full brakes applied, in the 5,000 ft of runway remaining. The MRPA crossed the departure end of the runway at 66 KIAS, bounced over a perimeter road, struck a rock breakwater, and came to rest in the ocean at 0620Z.

During the recovery, the MP did not establish the MRPA on a proper profile for the engine out approach. The MP also gained excessive airspeed during the final portion of the landing. As a result, the MRPA landed beyond the normal landing zone, well above normal landing speed, and the MP was unable to stop the MRPA on the runway remaining.

3. CONCLUSION

I developed my opinion by examining witness testimony and engineering analysis, consulting subject matter experts in MQ-9A operations, maintenance, engineering and program management, reviewing digital images of the MRPA wreckage, and crash site, physically inspecting the MRPA engine control cable assembly, and reviewing applicable directives and guidance. I further developed my opinion by extensively reviewing digital images and audio/video recordings of the MC Heads-Up and Heads-Down Displays, and observing multiple landing scenarios performed in a Predator Mission Aircrew Training Simulator by a highly qualified MQ-9A Launch and Recovery Instructor Pilot.

I find, by clear and convincing evidence, the cause of the mishap was an electrical short in the MRPA engine control cable assembly. Additionally, I find by a preponderance of evidence, continued operation of the MRPA without accomplishing TCTOs 1Q-9A-554 and -587, and the MP's improperly executed forced landing, substantially contributed to the mishap.

28 June 2012

DOUGLAS W. JAQUISH, Colonel, USAF
President, Accident Investigation Board