UNITED STATES AIR FORCE ABBREVIATED AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

MQ-1B, T/N 09-3260

18TH RECONNAISSANCE SQUADRON
432D WING
CREECH AIR FORCE BASE, NEVADA

LOCATION: MEDITERRANEAN SEA

DATE OF ACCIDENT: 17 JANUARY 2014

BOARD PRESIDENT: COLONEL BRADLEY M. CRITES

ABBREVIATED ACCIDENT INVESTIGATION, CONDUCTED PURSUANT TO CHAPTER 11 OF AIR FORCE INSTRUCTION 51-503

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR COMBAT COMMAND
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JUL 3 2014

ACTION OF THE CONVENING AUTHORITY

The Report of the Abbreviated Accident Investigation Board, conducted under the provisions of AFI 51-503, that investigated the 17 January 2014, mishap over the Mediterranean Sea, involving MQ-1B, T/N 09-3260, assigned to the 18th Reconnaissance Squadron, 432d Wing, Creech Air Force Base, Nevada, complies with applicable regulatory and statutory guidance; on that basis it is approved.

LORI J. ROBINSON
Lieutenant General, USAF
Vice Commander

Agile Combat Power

EXECUTIVE SUMMARY
ABBREVIATED AIRCRAFT ACCIDENT INVESTIGATION

MQ-1B, T/N 09-3260
MEDITERRANEAN SEA
17 JANUARY 2014

On 17 January 2014, at approximately 1132 Zulu (Z) time, the mishap remotely piloted aircraft (MRPA), a MQ-1B Predator, tail number (T/N) 09-3260, operated by the 18th Reconnaissance Squadron (18 RS), 432d Wing (432 WG), Creech Air Force Base (AFB), made a forced landing in the Mediterranean Sea. There were no reported injuries/deaths or reported non-governmental property damage. The loss to the United States is $4,591,058.55, and includes the MRPA, special mission equipment and associated internal components.

During preflight checks while accomplishing a full power engine run, the launch and recovery element (LRE) crew noticed fluid draining at the rear of the aircraft. The crew chief conducted a close-up inspection and determined the liquid to be water that collected under the engine intake. The LRE and crew chief discussed the issue and determined there were no engine abnormalities precluding departure. Therefore, the LRE taxied and launched the MRPA from the forward operating location, taking off at 2358Z on 16 January 2014. The mission was uneventful for over 10 hours and three crew changes, with the mishap crew (MC) taking control of the MRPA at 0800Z on 17 January 2014. Thereafter, at 1040Z, with the MRPA at an altitude of 14,000 feet mean sea level, the MC noticed sudden abnormal engine temperatures indicative of a coolant failure, accompanied by a significant loss of thrust and an uncommanded descent. The MC began an immediate emergency divert to the closest suitable airfield approximately 400 miles away and began troubleshooting. The MC noticed the MRPA's aircraft digital control system (ADCS) had initiated an increase in fuel flow, in accordance with the engine cold enrichment software. The ADSC incorrectly interpreted the abnormal engine temperature as a ground cold-start situation, and the enriched fuel-to-air mixture reduced thrust enough to prevent sustained flight. After running the applicable emergency checklists multiple times and consulting with the on-duty instructor pilot in the ground control station, the MC realized the MRPA could not make it to the divert airfield within the existing altitude and distant constraints, and prepared the MRPA for a forced landing in the water, which occurred at 1132Z.

The Abbreviated Accident Investigation Board President found, by clear and convincing evidence, the cause of the mishap was a loss of coolant due to an indeterminate failure in the coolant system. The Board President also found by a preponderance of the evidence, that a substantially contributing factor was the MRPA's ADCS incorrectly enriching the fuel-to-air mixture, negating the MC's attempts to reduce fuel flow and improve engine performance. The Board President developed his opinion by analyzing factual data from the flight data logs, reviewing engineering analysis from the General Atomics report, MRPA maintenance records, Air Force Technical Orders, witness testimonies, consultation with maintenance and other subject matter experts, and physical examination of MQ-1B engines and aircraft systems.

SUMMARY OF FACTS AND STATEMENT OF OPINION
MQ-1B, T/N 09-3260
17 JANUARY 2014

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ACRONYMS AND ABBREVIATIONS

12 AF	Twelfth Air Force
11 RS	11th Reconnaissance Squadron
18 RS	18th Reconnaissance Squadron
432 WG	432d Wing
A1C	Airman First Class
AAIB	Abbreviated Accident Investigation Board
ACC	Air Combat Command
ADCS	Aircraft Digital Control System
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AFE	Aircrew Flight Equipment
AFTO	Air Force Technical Order
AMXS	Aircraft Maintenance Squadron
ANG	Air National Guard
ATO	Air Tasking Order
AZ	Arizona
Capt	Captain
CHT	Cylinder Head Temperature
Col	Colonel
DO	Director of Operations
ECT	Engine Coolant Temperature
EGT	Exhaust Gas Temperature
EP	Emergency Procedure
FDP	Flight Duty Period
FPM	Feet Per Minute
FOD	Foreign Object Damage
GA	General Atomics
GCS	Ground Control System
IP	Instructor Pilot
IR	Infrared
ISR	Intelligence, Surveillance, Reconnaissance
KIAS	Knots Indicated Airspeed
LRE	Launch Recovery Element
Maj	Major
MAJCOM	Major Command
MAP	Manifold Air Pressure
MC	Mission Crew
MCE	Mission Component Element
MIC	Mission Intelligence Coordinator
MIP	Mishap Instructor Pilot
MP	Mishap Pilot
MRPA	Mishap Remotely Piloted Aircraft
MS	Mishap Sortie
MSgt	Master Sergeant
MSL	Mean Sea Level
MSO	Mishap Sensor Operator
MTS	Multispectral Targeting System
NOTAM	Notice to Airmen
NV	Nevada
OAT	Outside Air Temperature
Ops Sup	Operations Supervisor
RPA	Remotely Piloted Aircraft
RPM	Revolutions Per Minute
SAR	Search and Rescue
SCAR	Strike, Coordination, and Reconnaissance
SrA	Senior Airman
SSgt	Staff Sergeant
SO	Sensor Operator
T/N	Tail Number
TCTO	Time Compliance Technical Order
TO	Technical Order
TX	Texas
TSgt	Technical Sergeant
UAV	Unmanned Aerial Vehicle
VA	Virginia
VIT	Variable Information Table
VPP	Variable Pitch Propeller
Z	Zulu

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

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 3 April 2014, Lieutenant General Lori J. Robinson, Vice Commander, Air Combat Command (ACC), appointed Colonel Bradley M. Crites to conduct an abbreviated aircraft accident investigation of a mishap that occurred on 17 January 2014 over the Mediterranean Sea involving an MQ-1B Predator, tail number (T/N) 09-3260, hereinafter referred to as the mishap remotely piloted aircraft (MRPA), (Tab Y-3). The abbreviated aircraft accident investigation board (AAIB) was conducted in accordance with Air Force Instruction AFI 51-503, *Aerospace Accident Investigations*, Chapter 11, at Nellis Air Force Base (AFB), Nevada (NV), from 29 April 2014 through 19 May 2014 (Tab Y-3). Board members were Board President (Colonel), Legal Advisor (Colonel), Foreign Military Representative (Lieutenant Colonel), and Recorder (Airman First Class) (Tab Y-3).

b. Purpose

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

2. ACCIDENT SUMMARY

On 17 January 2014, the MRPA, an MQ-1B Predator, Tail Number (T/N) 09-3260, made a forced landing in the Mediterranean Sea (Tab L-2 to 7). No injuries/deaths were reported and no other government or private property was damaged (Tab P-2). The aircraft was valued at $4,591,058.55, including special mission equipment and associated internal components (Tab P-2). At the time of the mishap, the Mishap Crew (MC) operated the MRPA; the MC consisted of the Mishap Pilot (MP), the Mishap Sensor Operator (MSO), and the Mishap Instructor Pilot (MIP) (Tab K-9).

3. BACKGROUND

The MPRA was an asset of the 18th Reconnaissance Squadron (18 RS), which is a component of the 432d Wing (432 WG) (Tab CC-16), based at Creech AFB, NV. The 432 WG is a component of 12th Air Force (12 AF) (Tab CC-7), headquartered at Davis-Monthan AFB, Arizona (AZ). The 12 AF is a component of ACC (Tab CC-3), headquartered at Langley AFB, Virginia (VA).

The MRPA was launched from a forward operating location by the Launch and Recovery Element (LRE) crew, consisting of a Pilot and Sensor Operator (SO) (Tab K-9), assigned to the 11th Reconnaissance Squadron (11 RS). The 11 RS is a component of the 432 WG, but were forward deployed as a component of the 147d Reconnaissance Wing (147 RW) (Tab CC-12), headquartered at Ellington Joint Reserve Base, Texas (TX).

The LRE crew handed off control of the MPRA to crew #2 (Tab K-9, R-21, 24 to 25), and crew #2 handed the MRPA off to crew #3 (Tab K-9, R-21, 24 to 25), who ultimately handed the MRPA off to the MC (Tab K-9, R-4 to 19). At the time of the mishap, the MRPA was operated by the MC, who were assigned and operating out of the 18 RS, 432d WG, Creech AFB, NV (Tab K-9, R-4 to 19).

a. Air Combat Command (ACC)

ACC is the primary force provider of combat airpower to America's warfighting commands (Tab CC-3). To support the global implementation of national security strategy, ACC operates fighter, bomber, reconnaissance, battle-management, and electronic-combat aircraft (Tab CC-3), and also provides command, control, communications and intelligence systems, and conducts global information operations (Tab CC-3).

b. Twelfth Air Force (12 AF)

12 AF is responsible for the readiness of 10 active duty wings and one direct reporting unit (Tab CC-7). These subordinate commands operate more than 800 aircraft with more than 65,000 uniformed and civilian Airmen (Tab CC-7). The command is also responsible for the operational readiness of 17 12 AF-gained wings and other units of the Air Force Reserve and Air National Guard (Tab CC-7).

c. 432d Wing (432 WG)

The 432 WG "Hunters" consists of combat-ready Airmen who fly RPAs in direct support of the joint warfighter (Tab CC-10). The Hunters conduct RPA training for aircrew, intelligence, weather, and maintenance personnel (Tab CC-10). The 432 WG flies and maintains the MQ-1B Predator and MQ-9 Reaper RPAs to support the United States and coalition war-fighters (Tab CC-10).

d. 147d Reconnaissance Wing (147 RW)

The 147d RW is an Air National Guard (ANG) wing that flies MQ-1B combat support sorties, providing theater and national-level leadership with critical real-time intelligence, surveillance and reconnaissance and air-to-ground munitions precision strike capability (Tab CC-12). The Wing also provides terminal control for weapons employment in close air support scenarios integrating combat air and ground operations (Tab CC-12).

e. 18th Reconnaissance Squadron (18 RS)

The 18 RS conducts intelligence, surveillance, and reconnaissance (ISR) missions with the MQ-1 (Tab CC-16). The 18 RS provides real-time intelligence, strike, interdiction, close air support, and special missions to deployed war fighters (Tab CC-16); it is headquartered at Creech AFB, NV.

f. 11th Reconnaissance Squadron (11 RS)

Following inactivation in 1994, the 11 RS re-activated in July 1995, and was re-designated as the first RPA squadron in the Air Force (Tab CC-18). From 1996 through 2002, the Squadron provided deployable, long-endurance, serial reconnaissance and surveillance (Tab CC-19). Since 2003, the squadron has conducted flight training on the MQ-1B Predator remotely piloted aircraft, headquartered at Creech AFB, NV (Tab CC-19).

g. MQ-1B – Predator

The MQ-1B Predator is an armed, multi-mission, medium-altitude, long-endurance remotely piloted aircraft that is employed primarily as an intelligence-collection asset and secondarily against dynamic execution targets (Tab CC-21). Given its significant loiter time, wide-range sensors, multi-mode communications suite, and precision weapons, the Predator provides a unique capability to perform strike, coordination and reconnaissance (SCAR) missions against high-value, fleeting, and time-sensitive targets (Tab CC-21). Predators can also perform the following missions and tasks: intelligence, surveillance, reconnaissance, close air support, combat search and rescue, precision strike, buddy-lase, convoy/raid overwatch, route clearance, target development, and terminal air guidance (Tab CC-21). The MQ-1's capabilities make it uniquely qualified to conduct irregular warfare operations in support of combatant commander objectives (Tab CC-21).

4. SEQUENCE OF EVENTS

a. Mission

The mishap sortie was an Intelligence, Surveillance and Reconnaissance (ISR) mission authorized by a routine Air Tasking Order (ATO). The LRE crew consisted of a Pilot and SO assigned to the 11 RS, operating the MRPA at a forward deployed location with a unit of the 147d RW (Tab K-9). During the course of the mission, the MRPA was handed off to three separate mission control element (MCE) crews. All MCE crewmembers who flew the MRPA were assigned to the 18 RS from Creech AFB (Tab K-9, Tab CC-16). The MRPA departed at 2358Z on 16 January 2014, being flown by the LRE crew; it was then handed off uneventfully to crew #2 at 0017Z, now 17 January 2014 (Tab K-9, R-26 to 27). Crew #2 subsequently accomplished a crew change with crew #3 at approximately 0400Z (Tab K-9, R-21, R-24 to 25), and crew #3 accomplished a final crew change with MC at approximately 0800Z (K-9, R- 4 to 19, R-21, R-24 to 25).

b. Planning

On 16 January 2014, the LRE crew arrived prior to the scheduled shift start time to go through all the standard preflight briefings (Tab R-27). On 17 January 2014, the MC attended the mass aircrew briefing that was given by the Operations Supervisor (Ops Sup) and was conducted in accordance with Air Force Instructions (AFI); the briefing covered weather, area review, notice to airmen (NOTAM), threats (none noted), and standards (Tab R-10, V-3, V-7). The MC also conducted a crew change brief with crew #3 (Tab R-4 to 19, V-6 to 8). There is no evidence to suggest mission planning was a factor in this mishap.

c. Preflight

Preflight of the MPRA was performed by the LRE and the maintenance crew consisting of Maintainer #1 and Maintainer #2 (Tab L-4, R-26 to 27, R-34 to 35, R-44 to 45). NOTAMs, weather, route of flight and aircraft configuration were reviewed prior to engine start (Tab L-4, R-26 to 27).

During preflight checks, while accomplishing a full power engine run, the LRE crew noticed a small amount of liquid draining at the rear of the aircraft while using the infrared (IR) camera in the multispectral targeting system (MTS) (Tab L-4, R-26 to 27, R-34 to 35, R-44 to 45). The maintenance crew conducted a close-up inspection and determined the liquid was water; the maintenance crew believed the water was either sucked up from a depression on the ground by propeller suction, or was rainfall that had collected under the engine intake (Tab V-4 to 5). Maintenance subject matter experts and General Atomics (GA) experts also stated it was normal during engine runs for coolant to absorb heat, expand, and exit the coolant system via an overpressure valve and tube at the rear of the aircraft (Tab DD-9).

Also during the pre-flight engine run-up, two small objects appear to have fallen from the rear area of the aircraft, landing behind the left wing and bouncing out of view (Tab L-4, DD-6). This was not noticed until the IR camera video was reviewed during the mishap investigation (Tab L-4). However, the objects could not be positively identified, nor were any foreign object damage (FOD) fragments found on the ramp (Tab L-4, DD-9).

After a discussion between the LRE crew and maintenance crew, no engine abnormalities were noted and the MRPA was cleared to depart on the mission (Tab L-4, V-3 to 5). The MRPA taxied and departed from the forward operating location at 2358Z, on 16 January 2014 (Tab L-4, K-9).

There is no evidence to suggest any of these preflight actions were a factor in the mishap.

d. Summary of Accident

From takeoff to the hand-off to the MC at approximately 0800Z, no aircraft or engine abnormalities were detected or reported (Tab R-9-19, R-21, R-24 to 25). However, at 1040Z, with the MRPA at 14,000 feet mean sea level (MSL), the MC noticed a significant temperature split between cylinder head temperature (CHT) and engine coolant temperature (ECT) (Tab L-4, R-9 to 19, V-6 to 7). The MC immediately turned the aircraft to the closest recovery airfield approximately 400 nautical miles away and began accomplishing the emergency checklist for engine overheat (Tab L-4, R-9 to 19, V-6 to 7). The MC determined from the high CHT and low ECT the aircraft was most likely experiencing an engine overheat due to a coolant leak, and that engine failure was possible (Tab L-4, R-9 to 19, V-6 to 7). The MP and MSO worked together to verbalize and accomplish all appropriate steps of the engine overheat and engine failure checklists, and notified all appropriate agencies of the MC's emergency situation (Tab L-4, R-9 to 19, V-6 to 7). The MC analyzed the situation further by swiveling the IR camera in the MTS rearward to examine the aft underside of the MRPA; the MC saw a significant amount of warm fluid flowing from the underside of the engine intake (Tab L-4, R-9 to 19, V-6 to 7).

Simultaneously with the loss of coolant, the MC recognized the MRPA could not maintain altitude and it began descending at approximately 280 feet per minute (Tab L-4, R-9 to 19, V- 6 to 7). Several minutes later the MIP entered the ground control station and began to assist the MP and MSO to further troubleshoot the malfunction (Tab L-4, R-4 to 19, V-6 to 8). The MC realized early on that if the engine failed or they could not restore more thrust to the aircraft, a forced landing in the water was inevitable based on the altitude and distance constraints; therefore, the MC elected to run the forced landing checklist (Tab L-4, R-4 to 19, V-6 to 8). Over the next 30 minutes, the MC attempted two techniques in an attempt to restore more thrust to MRPA (Tab L-4, R-4 to 19, V-6 to 8). One technique the MC attempted was to adjust pitch angle of the propeller through the variable pitch propeller (VPP) control, hoping to drive the blade angle higher to produce more thrust (Tab L-4, R-4 to 19, V- 6 to 8). The MC also recognized the MRPA was in an enriched fuel state, and applied the prescribed technique for cold enrichment, attempting to counter the overly enriched fuel-to-air mixture by pulling the throttle back to 50 percent, hoping to reduce fuel flow enough to improve engine thrust (Tab L-4, V-6 to 8). However, neither of these attempts were successful and the MP returned both propeller and throttle to their normal present positions (Tab L-4, V-6 to 8).

At 1112Z the 18 RS Director of Operations (DO) instructed the MIP to take over the pilot seat so that a more experienced pilot could troubleshoot and fly the MRPA (Tab L-4, R-4 to 19, V-6 to 8). The MIP again accomplished all steps of the engine overheat and pertinent steps of the engine failure checklists (Tab L-4, R-4 to 19, V-6 to 8), to no avail. Thereafter, at 1115Z, the DO instructed the MP to resume control of the MRPA (Tab L-4, R-4 to 19, V-6 to 8). Over the next 17 minutes, the MC finished the forced landing checklist, discussed forced landing procedures and techniques, and coordinated with control agencies and other airborne aircraft (Tab L-4, R-4 to 19, V-6 to 8). As briefed by the MC during the descent, the MP kept the landing gear up, and at 500 feet above the water, the MP shut down the MRPA's engine, hoping to reduce impact damage to the MRPA when it hit the water (Tab L-4, R-4 to 19, V-6 to 8). The MP guided the MRPA into its forced water landing at 1132Z (Tab L-4, R-4 to 19, V-6 to 8).

e. Impact

At 1132Z the MRPA impacted the water of the Mediterranean Sea. The MRPA was carrying special mission equipment and associated internal components. Prior to impact, the MRPA's gear was up, its engine was shutdown, the propeller blade angle was adjusted to reduce wind resistance, and its airspeed was 61 knots indicated airspeed (KIAS). The MRPA's pitch angle was 5.4 degrees nose up, a descent rate of 280 feet per minute (FPM), and a north westerly heading (Tab L-2 to 7).

f. Egress and Aircrew Flight Equipment (AFE)

Not Applicable.

g. Search and Rescue (SAR)

Not Applicable.

h. Recovery of Remains

Not Applicable.

5. MAINTENANCE

a. Forms Documentation

The Air Force Technical Order (AFTO) 781 series forms for the MRPA were documented IAW applicable maintenance guidance (Tab D-3 to 40). The forms had no entries that would have prevented the MRPA from flying (Tab D-3 to 40).

b. Inspections

The aircraft inspections were documented and up to date (Tab D-2 to D-40). The last major aircraft inspections performed on the MRPA were a 60-hour and 150-hour inspections, both on 14 January 2014 (Tab D-19). There is no evidence suggesting the 60-hour and 150-hour inspections were a factor in the mishap.

c. Maintenance Procedures

Through review of aircraft maintenance documents, witness interviews, and consultation with maintenance subject matter experts, it was determined all maintenance procedures were completed in accordance with applicable Technical Orders (TOs) and Air Force Instructions (AFIs) (Tab D-1 to 42, R-34 to 35, R-44 to 45). There is no evidence suggesting maintenance procedures were a factor in the mishap.

d. Maintenance Personnel and Supervision

Maintenance records show the maintenance crew conducted the last 60-hour and 150-hour inspections, in addition to the preflight and launch duties on the MRPA prior to the mishap (Tab D-19, R-34 to 35, R-44 to 45). All pre-flight servicing and maintenance was correctly documented and conducted by properly trained, qualified, and supervised maintenance personnel (Tab D-2 to 40).

e. Fuel, Hydraulic, and Oil Inspection Analyses

Fuel samples were taken from the two fuel carts used to refuel the MRPA; the results were negative for anything that could have contaminated the fuel and caused the mishap (Tab J-2 to 3).

f. Unscheduled Maintenance

A review of the unscheduled maintenance actions revealed the following write-ups and corrective actions:

1. 14 January 2014 at the forward operating location – Manifold Air Pressure (MAP) sensor failure (Tab D-18); Turbocharger seized requires replacement (Tab D-20); Turbocharger removed and replaced (Tab D-20).

2. 16 Jan 2014 at the forward operating location – Special systems pod inoperative (Tab D-30); removed and replaced pod (Tab D-30).

Maintenance personnel removed and replaced the turbocharger to clear up the erroneously diagnosed MAP sensor failure write-up (Tab D-2 to 40). The turbo charger is not a part of the coolant system; thus, the turbocharger was not a factor in this mishap (Tab D-2 to 40). There is no evidence suggesting these unscheduled maintenance tasks were a factor in the mishap.

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

The MRPA made a forced landing in the sea and was not recovered; therefore, no structural or systems evaluation could be accomplished (Tab L-4, R-8, R-13 to 14, R-18).

b. Evaluation and Analysis

Based on data log file (the historical record of the flight and engine parameters) analysis, the MRPA was flying at 14,000 feet mean sea level (MSL) at 72 knots indicated airspeed (KIAS), when engine coolant parameters suddenly deviated from normal values (Tab L-4).

General Atomics (GA) stated that decreasing coolant temperature, a significant increase in fuel flow rate, and increasing cylinder head temperature are signature characteristics of a loss of coolant (Tab DD-8). GA also stated no erratic engine vibration was present prior to the leak, so a catastrophic mechanical failure did not likely occur (Tab DD-8).

The coolant temperature sensor is located at the coolant system's highest point (Tab DD-8). Once coolant drops by a given amount from a leaking system, the coolant temperature sensor will no longer be in contact with coolant (Tab DD-8). In this situation, the sensor reports the temperature of the ambient air in the radiator housing (Tab DD-8). GA noted that during the mishap the indicated coolant temperature decreased almost to the outside air temperature (OAT), which was significantly cooler than immediately prior to the loss of fluid (Tab DD-8). GA indicated the low coolant temperature was consistent with a loss of coolant in the coolant radiator and low OAT (Tab DD-8).

Erroneously low coolant temperature resulted in the aircraft digital control system (ADCS) injecting additional fuel in accordance with engine cold-start enrichment software programming (Tab DD-4, L-4). This engine cold-start enrichment software is intended to only add more fuel when the aircraft is on the ground during cold air temperatures (Tab DD-4, L-4). Subject matter experts noted from the data logs that the additional fuel injection resulted in incomplete combustion and erratic engine performance, as seen in the variation of exhaust gas temperature (EGT) values (Tab DD-4, L-4). The additional fuel injection led to a rich mixture, lower EGT and cylinder head temperature (CHT) values, which reduced engine thrust, prevented sustained flight, and induced an uncommanded descent rate of approximately 280 feet per minute (Tab DD-4, L-4).

GA indicated propeller pitch was automatically adjusted by the ADCS to the minimum allowable pitch angle during the descent because the engine was unable to make full power and was attempting to reduce the engine load (Tab DD-9).

Data logs also clearly show that several minutes after the loss of coolant, alternator #1 dropped offline without command from the pilot; further analysis of the data logs could not isolate a cause (Tab L-4).

A review of the data logs, IR video, and all other available evidence could not isolate the location of the coolant leak. However, GA and maintenance subject matter experts stated that historical causes of coolant systems include failed coolant pump seals, chafing between coolant hoses and oil hoses, and failure of coolant line feed elbows at each cylinder head (Tab L-4, DD-4, 10, V-9).

7. WEATHER

a. Forecast Weather

Forecasted weather conditions at the time of the mishap was scattered clouds at 2,000 feet above ground level, with visibility greater than seven miles and winds calm (Tab W-3).

b. Observed Weather

The MC stated they observed weather over the operating area had scattered clouds at approximately 2,000 feet and visibility was good (Tab L-4, R-9 to 19, V-6 to 8). Just prior to the mishap, weather did hamper line-of-site viewing of the objective area, but was not a factor at the MRPA's altitude or throughout the descent (Tab L-4, R-9 to 19, V-6 to 8).

c. Space Environment

Not Applicable.

d. Operations

There is no evidence to suggest any system was being operated outside of its prescribed operational weather limits.

8. CREW QUALIFICATIONS

a. Mishap Pilot - MCE

The MP was a current and qualified MQ-1B Pilot – the MP has been qualified in the MQ-1B since 22 July 2013 (Tab G-71). The MP had 64.0 hours of total time in the MQ-1B and 1770.7 hours of grand total time (Tab G-6).

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

	Hours	Sorties
Last 30 Days	11.4	4
Last 60 Days	11.4	4
Last 90 Days	18.6	8

There is no evidence to suggest the MP's qualifications were a factor in this mishap.

b. Mishap Sensor Operator - MCE

The MSO was a current and qualified MQ-1B Sensor Operator – the MSO has been qualified in the MQ-1B since 13 June 2011, and was Launch and Recovery Sensor Operator qualified on 2 May 2012, with a most recent Instructor Sensor Operator evaluation of 14 May 2013 (Tab G-99). The MSO had 980.6 hours of total time in the MQ-1B and 980.6 hours of grand total time (Tab G-38).

The MSO's recent flight time is as follows (Tab G-39):

	Hours	Sorties
Last 30 Days	30.4	8
Last 60 Days	58.6	18
Last 90 Days	83.3	28

There is no evidence to suggest the MSO's qualifications were a factor in this mishap.

c. Mishap Instructor Pilot - MCE

The MIP was a current and qualified MQ-1B Instructor Pilot – he has been qualified in the MQ-1B since 4 March 2011, and was Launch and Recovery Pilot qualified on 22 March 2012, with a most recent Initial Instructor Pilot evaluation of 12 July 2013 (Tab G-86). The MIP had 1127.9 hours of total time in the MQ-1B and 1378.8 hours of grand total time (Tab G-13).

The MIP's recent flight time is as follows (Tab G-14):

	Hours	Sorties
Last 30 Days	30.4	8
Last 60 Days	58.6	18
Last 90 Days	83.3	28

There is no evidence to suggest the MIP's qualifications were a factor in this mishap.

9. MEDICAL

a. Qualifications

At the time of the mishap, the LRE crew and the MC were fully medically qualified for flight duty (Tab K-2, EE-3).

b. Health

There is no evidence to suggest the health of the LRE crew and MC contributed to the mishap (Tab EE-3).

c. Toxicology

Immediately following the mishap, local commanders directed toxicology testing for the LRE, MC, and the maintenance crews. All toxicology testing was negative and not a factor in the aircraft mishap (Tab EE-3).

d. Lifestyle

All operation risk management (ORM) scores for the LRE crew and the MC were in the low category for this mission (Tab K-4 to 5). There is no evidence that unusual lifestyle habits, behavior, or stress on the part of the LRE crew or the MC contributed to the aircraft mishap.

e. Crew Rest and Crew Duty Time

Air Force Instruction require aircrew members to have proper "crew rest," as defined in AFI 11-202, Volume 3, *General Flight Rules*, 22 October 2010, prior to performing in-flight duties. AFI 11-202 defines normal crew rest as a minimum 12-hour non-duty period before the designated flight duty period (FDP) begins. During this time, any aircrew member may participate in meals, transportation or rest as long as he or she has the opportunity for at least eight hours of uninterrupted sleep.

ORM sheets indicate the LRE crew and the MC met the AFI requirements for crew rest and crew duty time for the flight (Tab K-4 to 5).

As such, there is no evidence to suggest crew rest and crew duty time were a factor in this mishap.

10. OPERATIONS AND SUPERVISION

a. Operations

The MC stated the operations tempo was normal, easily manageable, and no stressors were indicated (Tab K-2 to 7, R-10, V-3, V-7). There is no evidence to suggest operations tempo was a factor in this aircraft mishap.

b. Supervision

The 18 RS Ops Sup provided a mass briefing to all aircrews on shift, which covered weather, area review, notice to airmen (NOTAM), threats (none noted), and standards (Tab K-2 to 7, R-10, V-3, V-7). The Ops Sup reviewed the MC's ORM sheet, qualification and currencies (Tab K-2 to 7, R-10, V-3, 7). There is no evidence to suggest supervision was a factor in this aircraft mishap.

11. HUMAN FACTORS

There is no evidence to suggest human factors were a factor in this mishap.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 11-2MQ-1, Volume 1, *MQ-1 Aircrew Training*, 21 January 2010
(2) AFI 11-2MQ-1, Volume 2, MQ-1 *Crew Evaluation Criteria*, 28 November 2008
(3) AFI 11-2MQ-1, Volume 3, *MQ-1&9 Operations Procedures*, 1 November 2012
(4) AFI 11-202, Volume 3, *General Flight Rules*, 22 October 2010
(5) AFI 11-401, *Aviation Management*, 10 December 2010
(6) AFI 11-418, *Operations Supervision*, 15 September 2011, incorporating Change 1, 1 March 2013
(7) AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010, ACC Supplement dated 5 September 2013
(8) AFI 21-101, *Aircraft and Equipment Maintenance Management*, 26 July 2010

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

b. Other Directives and Publications Relevant to the Mishap

(1) T.O. 1Q-1(M)B-1, *Flight Manual, USAF Series MQ-1B System*, 13 December 2010, Change 5 - 7 May 2013, S-71 - 25 Nov 2013

(2) T.O. 1Q-1(M)B-1CL-1, *Flight Crew Checklist – All, USAF Series MQ-1B System*, 13 December 2010, Change 5 - 7 May 2013, S-70 - 5 August 2013
(3) T.O. 1Q-1(M)B-2-72GS-00-1, *General Systems Maintenance, General System Engine Reciprocating, USAF Series MQ-1B Remotely Piloted Aircraft*, 8 June 2010, Change 4 - 9 October 2013
(4) T.O. 1Q-1(M)B-2-72JG-50-1, *Job Guide, Engine, Reciprocating, Cooling & Lubrication, USAF Series MQ-1B Remotely Piloted Aircraft*, 8 June 2010, Change 7 - 9 October 2013

c. Known or Suspected Deviations from Directives or Publications

There are no known or suspected deviations from directives or publications by crew members or others involved in the mishap mission.

13. ADDITIONAL AREAS OF CONCERN

Not Applicable.

19 MAY 2014

BRADLEY M. CRITES, COLONEL, USAF
President, Abbreviated Accident Investigation Board

STATEMENT OF OPINION

MQ-1B, T/N 09-3260
MEDITERRANEAN SEA
17 JANUARY 2014

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

1. OPINION SUMMARY

I find by clear and convincing evidence the cause of the mishap was a loss of engine coolant due to an indeterminate failure in the coolant system. Loss of engine coolant exposed the coolant temperature sensor, which caused the MRPA's aircraft digital control system (ADCS) to inappropriately activate its engine cold enrichment software programming, enriching the fuel-to-air mixture to the point engine power output was reduced sufficiently to prevent sustained flight. In addition, I find by a preponderance of evidence a substantially contributing factor in the mishap was the inappropriately activated engine cold enrichment software programming by the MRPA's ADCS. The software program overrode the MC's attempts to reduce fuel flow and improve engine performance; this enriched fuel-to-air mixture reduced engine power enough to prevent sustained flight by the MRPA.

I analyzed factual data from the flight data loggers, reviewed engineering analysis from the General Atomics Contractor Report, Air Force Technical Orders, and other guidance, MRPA maintenance records, took witness testimony, consulted with maintenance and other subject matter experts, and physically examined MQ-1B engines and aircraft systems.

2. CAUSE

At 1040Z, with the MRPA at 14,000 feet mean sea level, the MC noted a significant temperature difference between cylinder head temperature (CHT) and engine coolant temperature (ECT), which is a significant characteristic of a coolant leak. Using the infrared camera on the MRPA, the mishap sensor operator observed a large amount of coolant leaking from the bottom of the MRPA's engine intake. The observation of a coolant leak was also evident from data contained in the engine data logs. The coolant leak resulted in an abnormally high CHT with a correspondingly low ECT, due to the exposure of the coolant temperature sensor to ambient air. The low ECT inappropriately activated the engine cold enrichment software program, which overly enriched the fuel-to-air mixture, reducing engine power output and preventing sustained flight. However, because the MRPA was not recovered, a specific root cause of the coolant leak could not be determined.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

From an examination of the MRPA's engine data logs and the MC's testimony, it is apparent that inappropriately initiated engine cold enrichment software programming by the MRPA's ADCS reduced engine thrust, which prevented sustained flight and induced an uncommanded descent rate of approximately 280 feet per minute. The enrichment program also negated the MC's attempts to reduce fuel flow and restore engine performance. The evidence clearly shows the MC recognized the MRPA's engine was in an overly enriched fuel state and tried to counter this condition by pulling the throttle back 50 percent to reduce fuel flow, which should have improved engine performance. The engine data logs show this action did partially arrest the descent, but the ADCS then scheduled near maximum fuel flow again, even with the throttle still set at 50 percent, and the MRPA resumed its previous descent rate. The MP realized the prescribed cold enrichment technique did not improve engine performance, and elected to return the throttle to maximum. Upon noticing the coolant leak, the MC had immediately initiated a turn to the nearest divert airfield approximately 400 miles away, but after finishing all appropriate checklists and exhausting all trouble shooting procedures to regain sufficient engine power without success, the MC realized the MRPA could not make it to any airfield. Therefore, the MC guided the MRPA through a forced landing into the Mediterranean Sea, approximately 52 minutes after the loss of engine coolant was observed.

4. CONCLUSION

There is clear and convincing evidence the cause of the mishap was a loss of engine coolant due to an indeterminate failure in the coolant system; this loss of coolant led to a rich fuel-to-air mixture and a subsequent loss of thrust. In addition, there is a preponderance of evidence a substantially contributing factor in the mishap was the inappropriately activated engine cold enrichment start software program by the MRPA's ADCS. Consequently, the engine cold enrichment start program overrode the MC's attempts to restore engine power, preventing sustained flight, forcing the MRPA into an uncommanded descent and a forced landing into the sea.

19 MAY 2014

BRADLEY M. CRITES, COLONEL, USAF
President, Abbreviated Accident Investigation Board

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