UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

MQ-1B T/N 06-3173
432D WING
CREECH AIR FORCE BASE, NEVADA

LOCATION: REPUBLIC OF DJIBOUTI

DATE OF ACCIDENT: 7 MAY 2011

BOARD PRESIDENT: LIEUTENANT COLONEL HENRY T ROGERS III

Conducted IAW Air Force Instruction 51-503

Abbreviate Accident Investigation pursuant to Chapter 11

EXECUTIVE SUMMARY

ABBREVIATED AIRCRAFT ACCIDENT INVESTIGATION
MQ-1B T/N 06-3173, Republic of Djibouti
7 MAY 2011

On 7 May 2011, at 0355 Zulu (Z) time, the mishap remotely piloted aircraft (MRPA), an MQ-1B Predator, tail number (T/N) 06-3173, crashed in the Gulf of Aden while returning to an undisclosed base approximately one and a half hours after takeoff. Destruction of the MRPA with one missile was assessed to be a financial loss of $4,400,000. No injuries, damage to other government property, or damage to private property occurred as a result of the mishap.

The aircraft belonged to the 432d Wing at Creech Air Force Base (AFB), Nevada, but was deployed at the time in support of Operation HORN OF AFRICA. The crew flying the aircraft at the time of the mishap was from the 3d Special Operations Squadron, at Cannon Air Force Base (AFB). The 60th Expeditionary Reconnaissance Squadron, in conjunction with the 849th Aircraft Maintenance Squadron, Holloman AFB, provided the maintenance support.

Following normal pre-flight checks, the MRPA taxied and departed a Forward Operating Base (FOB) at 0215Z. The Launch and Recovery Element (LRE) handed off the MRPA to the Mission Control Element (MCE) uneventfully at 0230Z. Forty-two minutes later, the MRPA experienced a Right Wing Control Module (RWCM) failure. The MCE crew accomplished all the correct critical action steps in the checklist as they turned the aircraft back towards the FOB. The MCE successfully handed off the MRPA back to the LRE at 0324Z. The AAIB President found by a preponderance of the evidence a substantially contributory factor in this mishap was the extended flight time due to the excess altitude at the handoff. At 0355:15Z, on approach to the landing runway, the MQ-1B initiated an uncommanded right roll. The LRE pilot recovered the aircraft to level flight, but then the MRPA began an uncommanded left roll that could not be countered by pilot input. The MRPA impacted the water at 0355:42Z. The MRPA was a total loss with some portions recovered.

The AAIB President determined by clear and convincing evidence that the cause of the mishap was component failure. Specifically, the MRPA experienced a transistor short in the right aileron servo, resulting in both a power supply voltage drop and an excessive current draw. This in turn failed the RWCM and caused the right aileron to move to a trailing edge up position. The servo had enough power to maintain the aileron's position, but was not communicating with the failed RWCM and could not respond to pilot commands. Eventually, the excessive current draw blew two fuses, removing all power from the right aileron servo. With no power to hold the aileron in place, the right aileron dropped due to gravity and aerodynamic forces, resulting in an uncommanded and uncorrectable left roll until it crashed into the water, while on final approach to the runway.

Under 10 U.S.C. 2254(d), the opinion of the accident investigators 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.

SUMMARY OF FACTS AND STATEMENT OF OPINION
MQ-1B T/N 06-3173
7 May 2011

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COMMONLY USED ACRONYMS & ABBREVIATION

ACC	Air Combat Command
AEW	Air Expeditionary Wing
AIB	Accident Investigation Board
AAIB	Abbreviated Accident Investigation Board
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AFTO	Air Force Technical Order
AFSOC	Air Force Special Operations Command
AGM	Air-Ground Missile
ATC	Air Traffic Control
EGT	Exhaust Gas Temperature
FOB	Forward Operating Base
GA	General Atomics
GCS	Ground Control Station
HUD	Head-up Display
IMDS	Integrated Maintenance Data System
IAW	In Accordance With
IC	Incorporating Change
ISR	Intelligence, Surveillance and Reconnaissance
KIAS	Knots Indicated Airspeed
L	Local Time
LOS	Line of Sight
LRE	Launch and Recovery Element
MAP	Manifold Air Pressure
MC	Mishap Crew
MCE	Mission Crew Element
ME	Mishap Engine
MIS	Maintenance Information System
MP	Mishap Pilot
MRPA	Mishap Remotely Piloted Aircraft
MS	Mishap Sortie
MSL	Mean Sea Level
MSO	Mishap Sensor Operator
OG	Operations Group
PPSL	Predator Primary Satellite Link
RPA	Remotely Piloted Aircraft
RPM	Revolutions Per Minute
RS	Reconnaissance Squadron
RW	Reconnaissance Wing
RX	Receiving
S/N	Serial Number
SOF	Special Operations Forces
SOS	Special Operations Squadron
SATCOM	Satellite Communications
TCTO	Time Compliance Technical Order
TO	Technical Order
TV	Television
TX	Transmitting
USAF	United States Air Force
USAFCENT	United States Air Forces Central
USCENTCOM	United States Central Command
Z	Zulu or Greenwich Meridian Time (GMT)

The above list was compiled from the Summary of Facts, the Statement of Opinion, the Index of Tabs, and witness testimony (Tab R & Tab V).

SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority.

On 24 June 2011, Lieutenant General William J. Rew, Vice Commander Air Combat Command, appointed Lieutenant Colonel Henry T. Rogers as the Abbreviated Accident Investigation Board (AAIB) President to investigate the 7 May 2011 crash of an MQ-1B Predator aircraft, tail number T/N 06-3173. An abbreviated AIB was conducted at Nellis Air Force Base (AFB), Nevada, from 6 July 2011 to 28 July 2011, pursuant to Chapter 11 of Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*. A Legal Advisor and Recorder were also appointed to the AAIB. A maintenance non-commissioned officer served as a Functional Area Expert. (Tab Y-4)

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

The mishap remotely piloted aircraft (MRPA) taxied and departed from a Forward Operating Base (FOB) in the Republic of Djibouti at 0215Z. Approximately one hour into the flight, the MRPA experienced a component failure causing the aircraft to initiate uncommanded right aileron positions. Enroute to the FOB, an uncommanded right aileron movement caused an unrecoverable left roll, resulting in the MRPA impacting the water while on its final approach to the runway. The MRPA crashed approximately a half mile off the coast of the Republic of Djibouti in the Gulf of Aden. The aircraft was totally destroyed upon impact with the loss valued at $4,400,000. (Tab P-2) There were no injuries or damage to personal property. (Tab P-2)

3. BACKGROUND

a. Units and Organization

(1) Air Combat Command (ACC)

Air Combat Command is a major command of the United States Air Force and primary force provider of combat airpower to America's warfighting commands. Its mission is to organize, train, equip, and maintain combat-ready forces for rapid deployment and employment while ensuring strategic air defense forces are ready to meet the challenges of peacetime air sovereignty and wartime air defense. ACC operates fighter, bomber, reconnaissance, battle-management, and electronic-control aircraft and provides command, control, communications, and intelligence systems and conducts global information operations. Over 67,000 active duty members, 13,500 civilians, and when mobilized, 50,000 Air National Guard and Reserve members compose ACC, and its units operate 1,800 aircraft. (Tabs X-2, X-3, X-4)

(2) Air Force Special Operations Command (AFSOC)

AFSOC is headquartered at Hurlburt Field, FL, and is one of ten major Air Force commands. AFSOC provides Air Force special operations forces for worldwide deployment and assignment to regional unified commands. The command's Special Operations Forces (SOF) are composed of highly trained, rapidly deployable Airmen conducting global special operations missions ranging from precision application of firepower, to infiltration, ex-filtration, resupply and refueling of SOF operational elements. (Tabs X-5, X-6, X-7)

(3) 12th Air Force (12 AF)

12th Air Force controls ACC's conventional forces in the western United States and has the warfighting responsibility for U.S. Southern Command as well as the U.S. Southern Air Forces. It manages all Air Force assets and personnel in the AFSOUTH AOR, which includes Central and South America. 12th Air Force has worked closely with nations in the Caribbean, Central and South America in the Global War on Terrorism by providing forces to OEF, OIF, and Operation NOBLE EAGLE, and it also has supported efforts to stem the flow of illegal drugs into the U.S. and neighboring countries. 12th Air Force directs 10 active duty wings and one direct reporting unit as well as 13 gained wings and other units of the Air National Guard and Reserve. (Tabs X-8, X-9)

(4) 432d Wing (432 WG)

The 432d Wing (432 WG), stationed at Creech AFB, Nevada, flies the MQ-1B Predator and MQ-9 Reaper remotely piloted aircraft (RPA) systems to provide real-time reconnaissance, surveillance, and precision attack against fixed and time-critical targets to support American and coalition forces worldwide. The 432 WG also conducts initial qualification training for aircrew, intelligence, weather, and maintenance personnel who will fly and support RPA systems. The wing's organization includes two groups, six RPA flying squadrons, an operational support squadron, and a maintenance squadron. The wing and its subordinate units are components of the Air Force's ACC and 12 AF. (Tabs X-10, X-11, X-12, X-13)

(5) 432d Operations Group (432 OG)

The 432d Operations Group employs RPA in 24-hour Combat Air Patrols in support of combatant commander needs, and deploys combat support forces worldwide. This includes combat command and control, tactics development, intelligence support, weather support, and standardization and evaluation oversight for ACC, USAFCENT, Air Force Material Command, Air National Guard, the United Kingdom Royal Air Force, seven geographic combatant commanders, and Air Reserve Command RPA units. The Group is also responsible for all air traffic control, airfield management, and weather services for RPA operations at Creech AFB, NV. (Tab X-11)

(6) 3d Special Operations Squadron (3 SOS)

The 3d SOS accomplishes global special operations tasking as a member of the Air Force component of United States Special Operations Command. It directly supports theater commanders by providing precision weapons employment and persistent intelligence, surveillance, and reconnaissance. It also plans, prepares, and executes MQ-1B Predator missions supporting special operations forces. (Tabs X-14, X-15)

b. Aircraft: MQ-1B Predator

The MQ-1B Predator is a medium-altitude, long-endurance, unmanned aircraft system with primary missions of close air support, air interdiction, and ISR. It acts as a Joint Forces Air Component Commander-owned theater asset for reconnaissance, surveillance and target acquisition in support of the Joint Forces Commander. The MQ-1B is actually a system, not just an aircraft, which consists of four aircraft (with sensors and weapons), a Ground Control Station (GCS), a Predator Primary Satellite Link (PPSL), and spare equipment along with operations and maintenance crews for deployed 24-hour operations. The entire system is deployable worldwide for operations and can be transported on almost any Air Force cargo aircraft. (Tabs X-16, X-17)

Figure 1. Fully Armed MQ-1B Predator Taxiing (Report Cover Page)

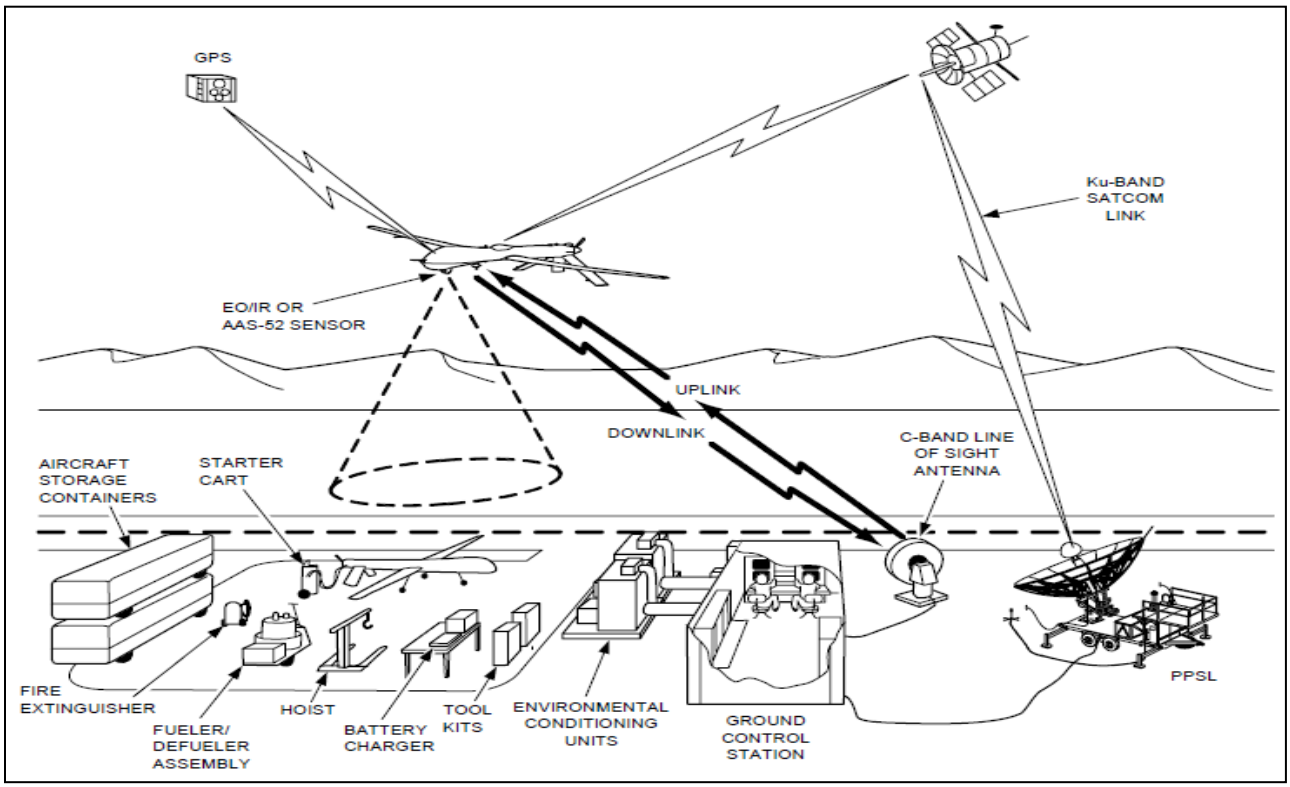

Figure 2. Typical Components of the MQ-1B System

Figure 3. Inside View of Ground Control Station

The basic crew for the Predator consists of a pilot to control the aircraft and command the mission and an enlisted aircrew member to operate sensors and weapons plus a mission coordinator, when required. The crew employs the aircraft from inside a GCS via a line-of-sight data link or a satellite data link for beyond line-of-sight operations. The MQ-1B carries the Multi-spectral Targeting System, or MTS-A, which integrates an infrared sensor, a color/monochrome daylight television (TV) camera, an image-intensified TV camera, a laser designator and a laser illuminator into a single package. The full motion video from each of the imaging sensors can be viewed as separate video streams or fused together. The aircraft can employ two laser-guided AGM-114 Hellfire missiles which possess a highly accurate, low collateral damage, and anti-armor and anti-personnel engagement capability. The aircraft has a wingspan of 55 feet, a maximum takeoff weight of 2,250 pounds, and cruises at 84 miles per hour. (Tabs X-16, X-17)

The aircraft is initially controlled by a LRE, which consists of a crew in a GCS at the same airfield as the aircraft, using line-of-sight data link connections between the aircraft and ground data terminal, which is a radio antenna at the same airfield. The LRE is typically deployed in a theater of operations, where it will launch the aircraft, get it to a specified altitude, accomplish a systems check, and via either multi-user internet relay chat or a phone call, hand the aircraft off to a stateside GCS in what is called remote split operations. The stateside GCS crew will control the aircraft via Ku-band satellite data link and performs the designated mission until the aircraft is ready to land at which time control is returned to the LRE. Some missions, however, such as local base defense missions, are performed entirely by the LRE using the line-of-sight data link with the aircraft. (Tabs X-16, X-17)

4. SEQUENCE OF EVENTS

a. Summary of Previous Missions.

The Right Wing Control Module (RWCM) maintenance troubleshooting steps include evaluating both the Primary Control Module (PCM) and Secondary Control Module (SCM) so this report includes when maintenance personnel worked on these components. On 08 March 2011, the MRPA, aircraft tail number (T/N) 06-3173, experienced a problem of aircraft power not turning off when the battery off button was held. Upon troubleshooting of the MRPA per the technical order, maintenance replaced the SCM. On 12 March 2011, maintenance removed and reinstalled the PCM. The MRPA flew an uneventful sortie on 15 March 2011 for 22.0 hours. On 16 March 2011, while under the control of the Mission Control Element (MCE), the MRPA experienced a problem of all four Exhaust Gas Temperature (EGT) sensors reading 550-600 Fahrenheit and lost 500 feet of altitude. The aircraft returned to base and maintenance replaced both the RWCM and the SCM.

The MRPA subsequently flew two sorties with no issues related to the RWCM: 18 March 2011 for 17.6 hours and 21 March 2011 for 22.0 hours. On 23 March 2011, the MRPA experienced an engine Manifold Air Pressure (MAP) sensors out of limits event, and air aborted its 30 March 2011 flight for a total of only 2.3 hours due to further engine problems. Maintenance replaced the MAP sensors and the SCM. The MRPA air aborted its next flight on 8 April 2011 for erratic MAP indications and a Flight Services Unit failure, resulting in remove/replacing the MAP sensors and the SCM. This was the fourth SCM replacement since 12 March 2011.

On 9 April 2011, the MRPA experienced more engine trouble, a forward fuel leak warning, and a RWCM receiving (RX) and transmitting (TX) failure reported for about five seconds. A Form 107 was sent out to General Atomics (GA) to request assistance with troubleshooting since this was the third occurrence with similar engine problems. GA replied with recommendations for troubleshooting the engine and RWCM. All maintenance requested per the Form 107 reply was accomplished including replacement of the engine, SCM, and a thorough check of the RWCM. The MRPA returned to service on 20 April 2011 and flew uneventfully on a 17.2 hours mission.

The MRPA air aborted on 24 April 2011 for a weapons malfunction and returned to base, was fixed and relaunched. It then air aborted a second time for a RWCM RX Fail with the MCE at the controls. Maintenance removed and replaced the PCM, SCM, and W036 wiring harness connector. All operations checks passed with no discrepancies and the MRPA returned to service on 7 May 2011.

The mishap sortie launched at 0215Z on 7 May 2011. (Tab AA-12)

b. Planning.

The MRPA launched from the Republic of Djibouti at 0215Z by the Launch and Recovery Element LRE using line of sight (LOS) C-Band transmitters, then handed off at 0230Z to the MCE crew via Ku Band satellite transmissions. (Tab AA-12, Tab V-2.5)

The launching LRE accomplished all preflight mission requirements and briefed in accordance with standard operating procedures. (Tab V-2.5) This was their first sortie of the day.

The mishap crew (MC), functioning as the recovering LRE, was assigned to the 60 ERS, Creech AFB, and the MRPA was assigned to the 432d Wing at Creech AFB. (Tab T-2, T-7)

c. Preflight.

The launching LRE conducted a standard preflight, launch, and handoff. Of note, the Multispectral Targeting System (MTS) ball powered on inadvertently with application of power to the Identify Friend/Foe (IFF) system during ground operations. The pilot and maintenance crew discussed the anomaly, verified that everything was working normally, and elected to continue the mission. The MTS ball and its associated electrical wiring does not affect the RWCM. (Tab V-2.4, Tab V-2.5)

d. Summary of Accident.

Prior to handing off the MRPA to the MCE crew, the LRE did not observe any anomalies with the MRPA. (Tab 2.5) The MCE gained control at 0230Z. (Tab AA-12) At 0312:30Z the MRPA reported a RWCM (RX) fail, Angle of Attack Stall, and Airspeeds differ by > 5 kts warnings. After applying the appropriate Critical Action Procedures for all warnings, the problems persisted. GA engineering analysis indicates that the MRPA experienced a transistor short in the right aileron servo, which resulted in a drop in power supply voltage and an excessive current draw. This in turn failed the RWCM and caused the right aileron to move to a trailing edge up position. The servo had enough power to maintain the right aileron position, but was not communicating with the failed RWCM and thus would not respond to pilot commands. The left aileron continued to work properly and could compensate for the right aileron stuck in a trailing edge up position.

The MCE crew immediately turned the MQ-1B around towards the LRE base at 0314Z, less than two minutes after the failures occurred. At 0317:52Z, the MCE pilot selected Secondary Airspeed in accordance with the checklist. An MQ-1B receives two airspeed inputs: Primary Airspeed from the RWCM and Secondary Airspeed from the Left Wing Control Module. The RWCM provided the incorrect airspeed value to the PCM when it reported its warnings. The PCM is the brains of the MQ-1B and uses airspeed to adjust the flight controls and engine to accomplish the pilot's inputs. Selecting Secondary Airspeed in this case gave the PCM the proper airspeed and angle of attack inputs and also displayed the correct flight conditions to the pilot in the GCS. (Tab V-2.5, Tab AA-12)

The MCE coordinated with the MC, explained the situation, checklists used, verified switch positions, and then handed off the MRPA to the LRE at 0324Z. The handoff occurred at 16,000 feet, 9,500 feet higher compared to the normal recovery profile. At 0343Z, the MP performs two 360 degree right hand spirals to descend to the proper approach altitude, adding approximately four and one half minutes to the flight. (Tab AA-12)

At 0355:15Z, when on short final to the intended runway, the MRPA began an uncommanded right roll. The MP recovered with left roll input. GA data logger analysis states the right aileron most likely moved to a higher trailing edge up position, which initiated the right roll. Left roll input (left aileron trailing edge up) counteracted the right aileron and the MP regained control of the MRPA. (Tab V-2.5, Tab AA-12)

At 0355:39Z, the MRPA began an uncommanded left roll. GA analysis states the right aileron servo lost power due to two blown fuses from the excessive current draw, which allowed the right aileron to move, uncommanded, to a trailing edge down position which caused the left roll. (Tab Z-3, Tab Z-16) The MP attempted to correct with a right roll input, but MQ-1B ailerons cannot be commanded to a trailing edge down position, so the left aileron could not counteract the left roll. (Tab V-2.5, Tab AA-12)

The MP could not influence the position of the right aileron due to a possible failed right wing aileron servo and RWCM. (Tab Z-16) Further, an MQ-1B pilot can request a maneuver but the PCM determines how the control surfaces move to meet that request. The MQ-1B software will only position an aileron between level and trailing edge up based on a pilot's input. For example, a right roll input would result in a left aileron level and right aileron up configuration. On 7 May 2011, the right aileron moved, uncommanded, to a trailing edge down position which initiated the left roll. (Tab Z-3, Tab Z-16) The pilot declared an in-flight emergency and, according to MP testimony and verified with the data logger, attempted to counter with a maximum right roll input. With no ability to move the right aileron due to the failed servo and RWCM, and because the MQ-1B's software prohibits the left aileron from moving to a position below level, the MRPA's left aileron did not and could not symmetrically match the right aileron's position which could have recovered the MRPA. Thus the MRPA continued its left roll until impact. (Tab V-2.5, Tab AA-12)

At 0355:42Z, the MRPA continued to roll inverted and impacted the water. (Tab AA-12)

e. Impact

The MRPA impacted the water approximately 1.5 miles off shore. (Tab W-2) The MRPA wreckage, including the attached AGM-114 Hellfire missile, was recovered. (Tab AA-13) The total estimated cost for the MRPA and equipment is $4,400,000.00. (Tab P-2)

f. Egress and Aircrew Flight Equipment.

This section is not applicable for mishaps involving RPA.

g. Search and Rescue.

This section is not applicable for mishaps involving RPA.

h. Recovery of Remains.

This section is not applicable for mishaps involving RPA.

5. MAINTENANCE

a. Forms Documentation.

The active 781-series forms for the MRPA were documented in accordance with applicable maintenance guidance for the MQ-1B, and the forms indicated that the MRPA had no outstanding maintenance issues that would prevent it from flying. The Air Force Technical Order (AFTO) Form 781A for the MRPA had no outstanding issues. The AFTO Form 781K had delayed discrepancies and the production superintendent, the maintainer who ultimately approves the aircraft for flight, approved the aircraft for flight after reviewing all forms. The production superintendent certified the aircraft for flight. (Tab D-134, Tab D-136)

A 60-day pre-mishap history check in Integrated Maintenance Data System (IMDS) and AFTO 781-series forms revealed numerous maintenance issues leading up to the mishap. On 10 March 2011, the MRPA experienced a problem of aircraft power not turning off when the Battery Off button was held. Upon troubleshooting of the MRPA per the technical order, maintenance replaced the Secondary Control Module (SCM). (Tab U-176) On 12 March 2011, the MRPA PCM was removed and reinstalled for software upgrades per a Time Compliance Technical Order (TCTO). (Tab U-164 through Tab U-174) On 16 March 2011, while under MCE control, the MRPA experienced a problem of all four Exhaust Gas Temperature (EGT) sensors reading 550-600 degrees Fahrenheit and lost 500 feet in altitude due to lost thrust. After landing, maintenance replaced the RWCM and the SCM. (Tab U-81 through Tab U-83, Tab U-163 through Tab U-174, and Tab U-180 through Tab U-184))

On 23 March 2011, the MRPA experienced a Manifold Air Pressure (MAP) Sensor 1 out of limits. After landing, maintenance replaced MAP sensors 1 and 2. On 30 March 2011, the MRPA experienced engine problems with all four EGT sensors in the red, resulting in a loss of 1500 feet due to insufficient thrust. MAP sensor 1's readings were erratic and did not match MAP sensor 2. Maintenance replaced the MAP sensors and the SCM. (Tab D-17, D-18)

On 8 April 2011, the MRPA experienced another erratic MAP sensor 1. Upon troubleshooting the aircraft, maintenance replaced the MAP sensors and the SCM. (Tab U-92) On 9 April 2011, the MRPA experienced a loss of engine speed and a MAP failure. Manifold Charge Temperature climbed into the red, EGT dropped into the red momentarily, and a forward fuel leak warning occurred. Additionally, a RWCM RX and TX failure warning occurred for

about five seconds. A Form 107 Depot Assistance Request was sent to GA to request assistance with troubleshooting the MRPA since this was the third occurrence with MAP associated failures. The MAP sensors and SCM were replaced on the previous two failures. GA replied with recommended troubleshooting steps. All maintenance actions requested per the 107 response were accomplished and the MRPA returned to service. (Tab U-92 through Tab U-100)

On 24 April 2011, the MRPA experienced Angle of Attack (AoA) and RWCM RX failures. Upon troubleshooting of the aircraft, maintenance replaced the AoA sensor (Tab D-87) and removed/replaced the PCM, SCM, and the W036 harness. (Tab D-93 through Tab D-99)

On 7 May 2011, maintenance performed standard pre-flight inspections, serviced fuel, loaded a single AGM-114 Hellfire missile, and launched the aircraft on the mishap sortie. (Tab D-134, Tab D-136, Tab D-137, Tab D-138, Tab D-140, Tab D-141)

b. Inspections.

All required inspections were accomplished on the MRPA, and there were no overdue aircraft TCTOs directing hardware, software, or inspection criteria modifications. The MRPA's next scheduled inspection was a 30-Day Records Review due 16 May 2011, a 28-day Battery Reconditioning due 3 June 2011, and a 60-hour engine inspection due in 30 flying hours. (Tab D-140 through Tab D-141)

c. Maintenance Procedures.

Review of maintenance procedures noted the following discrepancies.

1. The updated serial numbers of the PCM, SCM, and RWCM were not properly documented in the aircraft forms on the AFTO Form 781C, Avionics Configuration and Load Status. (Tab U-1.1)

2. The type and serial number of the missile that was loaded on the 7 May 2011 was not properly documented on the AFTO 781A Informational Note page. (Tab D-128)

d. Maintenance Personnel and Supervision:

Aircraft maintenance records and statements provided by maintenance personnel indicated all preflight maintenance and supervisory activities were normal. The AAIB accomplished a thorough review of the training records provided and special certification rosters of those who performed maintenance on the MRPA. All individual training records indicate they were trained and qualified. Maintenance personnel qualification and proficiencies were not a factor in this mishap.

e. Fuel, Hydraulic and Oil Inspection Analysis.

Maintenance personnel properly serviced fuel tanks and oil reservoirs in accordance with technical data. The servicing certification on the AFTO Form 781H reflected full oil levels and

adequate fuel levels. (Tab D-137) The "Info Note" page correctly reflected the 3:2 ratio in the forward and aft fuel tanks per the applicable technical order. (Tab D-128)

f. Unscheduled Maintenance.

All necessary repairs or replacements were properly made when required independent of maintenance schedules and were not a factor to the mishap.

6. AIRCRAFT AND AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems.

The MRPA impacted the water and the majority of the MRPA and its missile were recovered. (Tab AA-13) The LRE and MCE GCSs were immediately sequestered for test and evaluation and determined to not be a factor in the mishap. (Tab Z-#)

b. Engineering Evaluations and Analyses.

GA and the AAIB analyzed the data logger files from the GCS. The GA report asserts that the RWCM failed resulting in uncommanded positioning of the right aileron. The AAIB's analysis of the data logger files confirm that the RWCM failed and the right aileron did not respond to the MP's inputs. (Tab V- 2.5)

7. WEATHER

a. Forecast Weather.

A printed weather forecast was not available. (Tab F-2)

b. Observed Weather.

The MP and MSO both reported in interview testimony that the weather was VFR and that the winds were not a factor. The AAIB confirmed the VFR flight conditions from the MRPA HUD tape. (Tab F-2)

c. Operations.

There was no significant weather in the forecast that would affect the ability for the MQ-1B to effectively operate. No evidence suggests weather was a factor in the mishap. (Tab F-2)

8. CREW QUALIFICATIONS

a. MCE Crew Pilot

(1) **Training**

The MCE pilot was qualified in the MQ-1B since 10 November 1997.

(2) **Experience**

The MCE crew pilot has a total of 3866.2 non-UAV pilot hours and a total of 2337.3 UAV hours in the MQ-1B. The MQ-1B is the MCE crew pilot's second assigned aircraft after the C-5. The MCE crew pilot was designated as an "Experienced" crewmember in the MQ-1B (had more than 500 hours flying the aircraft). The MCE crew pilot's flight time during the 90 days before the mishap was as follows:

	Hours	Sorties
30 days	46.1	18
60 days	113.9	33
90 days	166.5	67

(Tabs G-24 through G-33)

b. MCE Sensor Operator (SO)

(1) **Training**

The MCE SO was qualified in the MQ-1B since 28 October 2010.

(2) **Experience**

The MCE SO had a total flight time of 260.1 hours, all in the MQ-1B. The MQ-1B was the MCE SO's first flight operations assignment. Prior to becoming a MQ-1 B sensor operator, the MCE SO was in a non-aviation career field. The MCE SO is not designated as an "Experienced" crewmember in the MQ-1B. The MCE SO's flight time during the 90 days before the mishap was as follows:

	Hours	Sorties
30 days	82.9	20
60 days	173.3	35
90 days	230.7	48

(Tab T-24)

c. Mishap Pilot

(1) **Training**

The Mishap Pilot was qualified in the MQ-1B since 20 March 2009.

(2) **Experience**

MP had a total flight time of 1099.4 hours, all in the MQ-1B. The MQ-1B was MP's first flight operation's assignment. MP was designated as an "Experienced" crewmember in the MQ-1B.
The MP's flight time during the 90 days before the mishap was as follows:

	Hours	Sorties
30 days	22.9	25
60 days	39.4	50
90 days	51.4	69

(Tabs T-18 through T-23 and G-11)

d. Mishap Sensor Operator

(1) **Training**

The MSO is a qualified MQ-1B sensor operator.

(2) **Experience**

MSO had a total flight time of 695.7 hours, all in the MQ-1B. The MQ-1B was MSO's first flight operations assignment. Prior to becoming a MQ-1 B sensor operator, the MSO was in a non-aviation career field. MSO was designated as an "Experienced" crewmember in the MQ-1B. The MSO's flight time during the 90 days before the mishap was as follows:

	Hours	Sorties
30 days	23.3	26
60 days	48.0	38
90 days	69.9	49

(Tab T-9)

9. MEDICAL

a. Qualifications.

At the time of the mishap flight, both crew members had current flight physicals, no known illnesses or injuries, and were medically qualified to perform flying duties.

b. Health.

No health issues for the mishap crew members were relevant to the cause of the mishap.

c. Pathology.

Pathology was not applicable to this mishap.

d. Lifestyle.

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

e. Crew Rest and Crew Duty Time.

Aircrew members are required to have 12 hours of crew rest, eight of which must be uninterrupted, and both mishap crew members reported having the required amount of sleep prior to the mishap.

10. OPERATIONS AND SUPERVISION

a. Operations.

Operations tempo was thoroughly investigated and found not a factor in this mishap flight.

b. Supervision.

Operations supervision was thoroughly investigated and found not a factor in this mishap flight.

11. HUMAN FACTORS ANALYSIS

A human factor is any environmental or individual physical or psychological factor a human being experiences that contributes to or influences his performance during a task. There is no evidence to suggest that any human factors contributed to this mishap.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications.

(1) T.O. 1Q-1(M)B-1, Flight Manual USAF Series MQ-1B and RQ-1B Systems, 13 December 2010
(2) T.O. 1Q-1(M)B-1CL-1, Flight Crew Checklist All USAF Series MQ-1B System, 13 December 2010
(3) AFI 11-2MQ-1, Volume 1, MQ-1 Aircrew Training, 21 January 2010
(4) AFI 11-2MQ-1, Volume 2, MQ-1 Crew Evaluation Criteria, 28 November 2008
(5) AFI 11-2MQ-1, Volume 3, MQ-1 Operations Procedures, 29 November 2007
(6) AFI 11-418, Operations Supervision, 21 October 2005, IC 1, 20 March 2007
(7) AFI 11-401, Aviation Management, 7 March 2007, IC 2, 18 May 2009
(8) AFI 11-202, Volume 3, General Flight Rules, 22 October 2010

b. Maintenance Directives and Publications.

(1) T.O. 1Q-1(M)B-2-93GS-00-1, General System Surveillance, 8 February 2010
(2) T.O. 1Q-1(M)B-5-1, Basic Weight Checklists, USAF Series, MQ-1B Remotely Piloted Aircraft, 26 March 2010
(3) T.O. 00-20-1, Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures, 1 September 2010
(4) T.O. 1Q-1(M)B-2-48JG-00-1, Job Guide, Communication/Navigation/Identification, General, USAF Series, MQ-1B Remotely Piloted Aircraft, 09 October 2009
(5) T.O 1Q-1(M)B-2-42FI-00-1, Fault Isolation Integrated Avionics, USAF Series, MQ-1B Remotely Piloted Aircraft, 11 March 2010
(6) T.O. 1Q-1(M)B-2-42JG-00-1, Job Guide, Integrated Avionics General, USAF Series, MQ-1B Remotely Piloted Aircraft, 11 March 2010
(7) T.O 1Q-1(M)B-2-42JG-20-1, Job Guide, Aircraft Digital Control System, USAF Series, MQ-1B Remotely Piloted Aircraft, 11 March 2010
(8) T.O. 1Q-1(M)B-2-05JG-10-1, Ground Handling USAF Series, MQ-1B Remotely Piloted Aircraft, 9 Jun 2009, thru change 5 21 July 2010
(9) T.O. 1Q-1(M)B-6WC-1, Preflight, Thruflight, Basic Postflight, Combined Basic Postflight/Preflight inspection requirements, ASAF Series, MQ-1B Remotely Piloted Aircraft, 21 January 2010
(10) T.O. 1Q-1(M)B-6WC-2, Aircraft Periodic Inspections and Maintenance Requirements, USAF Series, MQ-1B Remotely Piloted Aircraft, 21 January 2010
(11) T.O. 1Q-1(M)B-2-72FI-00-1, Fault Isolation Engine Reciprocating, USAF Series MQ-1B Remotely Piloted Aircraft, 8 June 2010
(12) T.O. 1Q-1(M)B-2-72JG-00-2, Job Guide Engine Reciprocating General Volume II, USAF Series MQ-1B and RQ-1B Remotely Piloted Aircraft, 08 June 2010
(13) T.O. 1Q-1(M)B-6, Aircraft Scheduled Inspection and Maintenance Requirements, USAF Series MQ-1B Remotely Piloted Aircraft, 21 January 2010
(14) AFI 21-101, Aircraft and Equipment Maintenance Management, 26 July 2010

(15) AFI 21-101, Holloman AFB Supplement 1, Aircraft and Equipment Maintenance Management, 6 October 2010
(16) 380 AEWI 21-101, Aircraft and Equipment Maintenance Management, 28 September 2009

The AFIs can be found via the internet on the Air Force electronic publications website (http://www.e-publishing.af.mil/).

c. Known or Suspected Deviations from Directives or Publications.

There are deviations noted in section 5, Maintenance. Please see above. These deviations were found not to be causal or contributory.

13. ADDITIONAL AREA OF CONCERN

Flight time: The MP added four and one half minutes to the flight by flying two spirals to descend to the proper approach altitude. The MRPA's servo failure occurred approximately two minutes prior to expected touchdown. The checklist procedures for a failed RWCM inform the pilot to land as soon as possible. The MCE did turn the MRPA towards the FOB immediately, but did not descend the MRPA in order to be in a position to land without having to maneuver to get rid of excessive altitude. (Tab V-2.5)

28 July 2011

HENRY T. ROGERS III, Lt Col, USAF
President, Accident Investigation Board

STATEMENT OF OPINION
MQ-1B T/N 06-3173 ACCIDENT
7 MAY 2011

Under 10 U.S.C. 2254(d), the opinion of the accident investigators 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:

Based on aircraft records, mission data logs, maintenance records, interviews with the individuals involved in the aircraft maintenance, interviews with the Mission Crew Element (MCE) and Mishap Crew (MC), General Atomics (GA) reports, and information provided by the functional area expert, I find by clear and convincing evidence that the cause of the mishap was component failure. Specifically, the total and catastrophic failure of the Right Wing Control Module (RWCM) resulted in an uncommanded and uncorrectable left roll while on final approach to the runway.

2. DISCUSSION OF OPINION:

On 7 May 2011, an MQ-1B (T/N 06-3173) suffered an uncommanded and unrecoverable left roll while on short final to the landing runway due to a failed RWCM, impacting the water 1.5 miles from the runway. The mishap remotely piloted aircraft's (MRPA) RWCM failed after being airborne for 57 minutes. The MRPA's RWCM was replaced on 16 March 2011 and flew nine times and 87.8 hours prior to the mishap flight. Two previous flights returned with RWCM failures: 09 April 2011 for five seconds of reported RWCM Receiving (RX) and Transmitting (TX) failure, and again on the flight prior to the mishap sortie, 24 April 2011, for a RWCM RX that did not clear out. Maintenance correctly followed the fault analysis guidance and performed the required operational checks prior to the mishap flight.

During the mishap flight, the MRPA reported three warnings indicating a complete failure of the RWCM: Angle of Attack Stall, Airspeed Difference Greater Than Five Knots, and RWCM RX Fail. The GA analysis stated the RWCM failed and the right aileron most likely was in an uncommanded 5-10 degree trailing edge up configuration, which was most likely matched by trimming the left aileron to a similar configuration. In the seconds prior to the crash, GA stated the right aileron most likely moved further up, which was correctable, and then reversed to a trailing edge down configuration which was not correctable. An MQ-1B pilot cannot command an aileron trailing edge down position, and therefore was unable to counteract the left roll with a required left aileron down configuration. The mishap pilot (MP) could not recover the MRPA, and the MRPA continued its left roll until impacting the water at 0355:42Z, one hour and forty minutes after takeoff.

Prior to handing off the MRPA to the Mission Control Element (MCE) crew, the Launch and Recovery Element (LRE) did not observe any airborne anomalies with the MRPA. The MCE gained control at 0230Z. At 0312:30Z the MRPA reported its three warnings consistent with a failed RWCM. The MCE crew immediately and correctly applied the appropriate Critical Action Procedures for all failure warnings, yet the problems persisted. The MCE crew immediately turned the MQ-1B around towards the LRE base at 0314Z, less than two minutes after the failures. At 0317:52Z, the MCE pilot selected Secondary Airspeed in accordance with the checklist.

The MCE coordinated with the landing LRE, explained the situation, checklists used, verified switch positions, and then handed off the MRPA to the LRE at 0324Z. I determined the MCE crew performed all actions in accordance with the checklists and did nothing causal regarding the mishap. I find by a preponderance of the evidence that a substantially contributory factor in this mishap was the extended flight time due to the excess altitude at the handoff. The fact that the handoff occurred 9,500 ft higher than normal meant the MRPA required additional time to reach a proper approach altitude. The MCE pilot had to weigh the advantages of handing off the MRPA with extra altitude for the contingency of recovering the aircraft if it went out of control against the time saved by being at the correct altitude. No pilot could have predicted the impending servo failure and it is standard protocol to have excess altitude since the LRE pilot would perform a controllability check prior to landing.

The LRE crew properly coordinated with the MCE and took control of the MRPA. The MP did a proper controllability check and expeditiously attempted to return the MRPA back to base. When the MRPA began an uncommanded right roll on short final, the MP immediately recovered the aircraft, declared an emergency, and began correcting his approach. The MP used correct stick inputs to counter the uncommanded left roll, but was unable to recover the aircraft due to system limitations. The MCE and MP actions were confirmed via Heads Up Display video and Ground Control Station data logger files.

This AAIB thoroughly reviewed the maintenance history and forms, and made follow-up interviews with those who worked on the MRPA and their supervisors prior to its last flight. All maintenance tasks were in accordance with technical order procedures. Our only noted discrepancy was with parts' serial number documentation on the Form 781C. Since maintenance performed all tasks correctly and completed all required operational checks prior to the mishap flight, I do not find any maintenance procedures, supervision, or actions of any individual as causal or contributory to this mishap.

My review of the facts presented determined that the mishap was not caused by maintenance actions or operator error, and I find by clear and convincing evidence the cause of the mishap was a component failure. Specifically, the MRPA experienced a transistor short in the right aileron servo, resulting in both a power supply voltage drop and an excessive current draw. This in turn failed the RWCM and caused the right aileron to move to a trailing edge up position. The servo had enough power to maintain the aileron's position, but was not communicating with the failed RWCM so could not respond to pilot commands. Eventually, the excessive current draw blew two fuses, removing all power from the right aileron servo. With no power to hold the aileron in place, the right aileron dropped due to gravity and aerodynamic

forces, resulting in an uncommanded and uncorrectable left roll while on final approach to the runway. The MRPA continued its left roll until it crashed into the water.

28 July 2011

HENRY T. ROGERS III, Lt Col, USAF
President, Accident Investigation Board

Under 10 U.S.C. 2254(d), the opinion of the accident investigators 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.