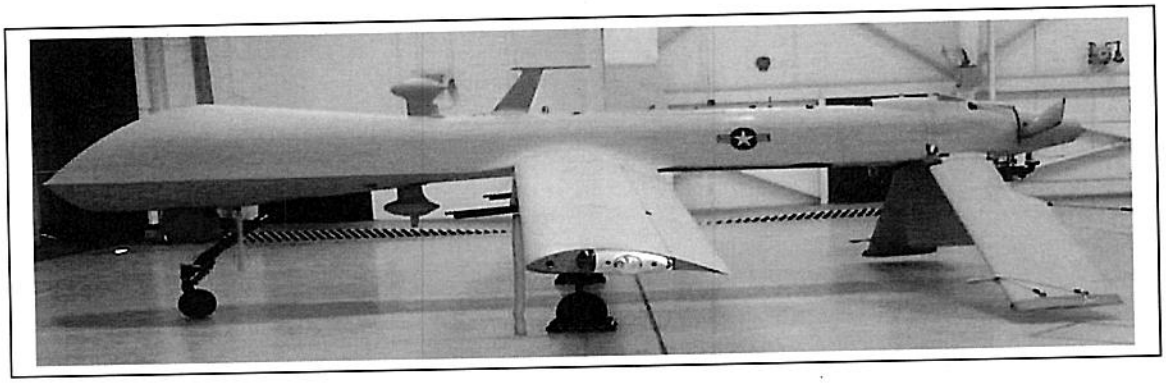
UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

MQ-1B, T/N 04-3133

3d Special Operations Squadron
27th Special Operations Wing
Cannon Air Force Base, New Mexico



LOCATION: Near Kandahar Air Field, Afghanistan

DATE OF ACCIDENT: 2 March 2013

BOARD PRESIDENT: Lt Col Justin R. Wymore

CONDUCTED IAW AIR FORCE INSTRUCTION 51-503

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION
MQ-1B PREDATOR, T/N 04-3133
NEAR KANDAHAR AIRFIELD, AFGHANISTAN
2 MARCH 2013

On 2 March 2013, at approximately 0213 hours Zulu time (Z), an MQ-1B, tail number 04-3133 assigned to the 3d Special Operations Squadron (SOS), 27th Special Operations Wing (SOW), being flown by a Launch and Recovery Element (LRE) assigned to the 62d Expeditionary Reconnaissance Squadron (ERS), 451st Air Expeditionary Wing (AEW), Kandahar Air Field Afghanistan, experienced a Secondary Control Module (SCM) malfunction causing abnormal flight control outputs to the aircraft's left tail board (ruddervator), entered into an unrecoverable spin, and impacted the ground approximately 7 nautical miles (nm) southwest of Kandahar Air Base. There were no injuries or fatalities nor damage to private property. The Mishap Remotely Piloted Aircraft (MRPA) was destroyed upon impact with a loss valued at $4,688,557.

On 1 March 2013 at 0422Z, the Mishap Crew (MC) composed of the Mishap Pilot (MP) and Mishap Sensor Operator (MSO) launched the MRPA from Kandahar Air Field. At 0436Z, 14 minutes after take-off, the MC handed the MRPA over to the Mission Control Element (MCE), whose crews accomplished the mission phase of the sortie over the next 21.4 hours.

At 0159Z, 2 March 2013, the MCE relinquished control to the MC at Kandahar Air Field for landing. Eight minutes after the MC took control and while in a shallow descent, the MRPA displayed a loss of telemetry on the MP's flight graphics. The MP opted to send the aircraft lost link and execute its preprogrammed emergency mission. At 0210Z, the MP regained downlink of the aircraft and was able to see the aircraft executing its preprogrammed emergency mission. The MC noticed a warning message on the Heads Down Display (HDD), "Tail Computer Left - ROM Failed". The MP took control of the MRPA and noted that the flight control outputs were not matching commanded inputs. One minute and 30 seconds after taking aircraft control, the MRPA dropped to an extremely low nose down attitude and began to spin. The MP and MSO killed the uplinks to the MRPA in order to get the MRPA to fly its preprogrammed emergency mission. When the MC tried to reestablish link a few moments later, they saw nothing but static. The Tower Controller verified that he saw a cloud of smoke on the ground at or near the MRPA's last known position.

The Accident Investigation Board (AIB) President found, by clear and convincing evidence, that the cause of the mishap was the failure of an Erasable Programmable Read-Only Memory (EPROM) chip on the circuit board within the SCM that controls the ruddervator. Failure of the EPROM chip led to uncommanded movements of the left ruddervator, eventually resulting in a trailing-edge down position beyond 10 degrees, departure from controlled flight, and impact with the terrain.

SUMMARY OF FACTS AND STATEMENT OF OPINION
MQ-1B, T/N 04-3133
2 March 2013

TABLE OF CONTENTS

COMMONLY USED ACRONYMS AND ABBREVIATIONS

AB	Air Base
ACC	Air Combat Command
AEW	Air Expeditionary Wing
AF	Air Force
AFSOC	Air Force Special Operations Command
AFB	Air Force Base
AFI	Air Force Instruction
AFTO	Air Force Technical Order
AGM	Air to Ground Missile
AIB	Accident Investigation Board
AMXS	Aircraft Maintenance Squadron
AOA	Angle of Attack
AOR	Area of Responsibility
ARMS	Aviation Resource Management System
ATO	Air Tasking Order
CPU	Central Processor Unit
DoD	Department of Defense
EOD	Explosive Ordinance Disposal
EPROM	Erasable Programmable Read Only Memory
ERS	Expeditionary Reconnaissance Squadron
FAE	Functional Area Expert
FL	Florida
GA-ASI	General Atomics Aeronautical Systems, Inc.
GCS	Ground Control Station
GDT	Ground Data Terminal
HFACS	Human Factors Analysis and Classification System
HDD	Heads-Down Display
HUD	Heads-Up Display
IMDS	Integrated Maintenance Data System
IR	Infrared
ISR	Intelligence, Surveillance, and Reconnaissance
KAF	Kandahar Airfield
KIAS	Knots Indicated Airspeed
LL	Lost Link
LOS	Line of Sight
LRE	Launch and Recovery Element
LREOS	LRE Operations Supervisor
LREGCS	LRE Ground Control Station
MC	Mishap Crew
MCE	Mission Control Element
MP	Mishap Pilot
MRPA	Mishap Remotely Piloted Aircraft
MSL	Mean Sea Level
MSO	Mishap Sensor Operator
MT	Maintenance Technician
MTS	Multi-Spectral Targeting System
MXG	Maintenance Group
NICAD	Nickle Cadium Battery
NM	New Mexico
OEF	Operation ENDURING FREEDOM
OG	Operations Group
PCM	Primary Control Module
PPSL	Predator Primary Satellite Link
RPA	Remotely Piloted Aircraft
ROM	Read Only Memory
RS	Reconnaissance Squadron
RW	Reconnaissance Wing
SCM	Secondary Control Module
SO	Sensor Operator
SOF	Special Operations Forces
SOS	Special Operations Squadron
SOW	Special Operations Wing
S/N	Serial number
TCTO	Time Compliance Technical Order
T/N	Tail Number
TO	Technical Order
USAF	United States Air Force
USAFCENT	United States Air Force Central
USCENTCOM	United States Central Command
WG	Wing
Z	Zulu Time

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 17 April 2013, General Williams, Vice Commander, Air Force Special Operations Command (AFSOC), appointed Lt Col Justin R. Wymore to conduct an aircraft accident investigation of the 2 March 2013 mishap of an MQ-1 Predator, (T/N 04-3133) near Kandahar, Afghanistan. The aircraft accident investigation was conducted in accordance with Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*, [Chapter 11,] at Hurlburt Field, Florida, from 27 April 2013 through 29 May 2013. The following board members were also appointed:

Lieutenant Colonel Justin R. Wymore	President
Lieutenant Colonel (Redacted)	Legal Advisor
Major (Redacted)	Functional Area Expert (FAE)
Major (Redacted)	Functional Area Expert (FAE)
MSgt (Redacted)	Maintenance Member
SSgt (Redacted)	Recorder

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. This report is available for public dissemination under the Freedom of Information Act, Title 5, United States Code, Section 552.

c. Circumstances

The AIB was convened to investigate the 2 March 2013 aircraft mishap involving an MQ-1B Predator Aircraft, T/N 04-3133, hereinafter referred to as the Mishap Remotely Piloted Aircraft (MRPA), assigned to the 3d SOS, 27th SOW, Cannon AFB, New Mexico (NM).

2. ACCIDENT SUMMARY

On 2 March 2013, at approximately 0213Z, the MRPA, an MQ-1B, tail number 04-3133, an asset of the 3rd SOS, 27th SOW, being flown by a LRE assigned to the 62nd ERS, 451st AEW, Kandahar Air Field Afghanistan, experienced an SCM malfunction causing abnormal flight control outputs to the aircraft's left ruddervator. The aircraft entered into an unrecoverable spin and impacted the ground approximately 7 nm southwest of Kandahar Air Field (TAB M-6). The aircraft was destroyed upon impact with the loss valued at $4,688,557 (TAB P-3). Other than the aircraft, there were no damages to government or civilian property. There were no civilian casualties and no media reports from this incident.

On 1 March 2013 at 0422Z, the MRPA took off from Kandahar Air Field uneventfully, eight minutes before its scheduled take off time of 0430Z. At 14 minutes after take-off at 0436Z, the LRE handed the MRPA over to the MCE where they proceeded to accomplish the mission phase of the sortie. The MCE consisted of seven Pilots and eight Sensor Operators out of the 196th Reconnaissance Squadron (RS), 163rd Reconnaissance Wing (RW), March Air Reserve Base California, who flew the MRPA for the next 21.4 hours. All members of the MCE reported no indication of abnormal flight control movements or SCM malfunctions while they were in control of the MRPA. (TAB V-21)

At 0159Z, 2 March 2013, the MCE relinquished control back to the LRE at Kandahar Air Field for the landing. The hand back was uneventful. Eight minutes after the LRE took control and while in a shallow descent, the MRPA displayed a loss of telemetry on the Mishap Pilot's (MP) flight graphics. The MP could still see video but was unable to determine the exact position of the aircraft due to the telemetry loss. At this point the MP opted to send the aircraft lost link and execute its preprogrammed emergency mission. (TAB EE-5 and TAB N-7)

At 0210Z, the MP regained downlink of the aircraft and was able to see the aircraft executing it's preprogrammed emergency mission. Both crew members noticed a warning message on the HDD, "Tail Computer Left - ROM Failed." After closing out the lost link checklist, the MP took control of the MRPA and noticed that the flight control outputs were not matching his commanded inputs. One minute and 30 seconds after taking aircraft control, the MRPA dropped to an extreme nose down attitude and began to spin. The MC killed the uplinks to the MRPA in order to command the MRPA to fly its preprogrammed emergency mission. When the crew tried to reestablish link a few moments later, they saw nothing but static. The Tower Controller verified that they could see a cloud of smoke on the ground at the aircraft's last known position. (TAB EE-9 and TAB N-10)

3. BACKGROUND

The MRPA was an asset of the 3 SOS, 27 SOW, Cannon AFB, NM. The 27 SOW belongs to Air Force Special Operations Command (AFSOC) headquartered at Hurlburt Field, Florida (FL). At the time of the mishap, the MRPA was controlled by the LRE crew operating out of Kandahar AB, Afghanistan, and assigned to the 62 ERS. The 62 ERS is a unit within the 451 AEW. The 451 AEW is operationally assigned to the US Air Forces Central (USAFCENT). The MP's home unit is the 15 RS, 432 WG, Creech AFB, NV. The MSO's home unit is the 20 RS, 432 WG, Whiteman AFB, MO.

Note: Because AFSOC remotely piloted aircraft operate from a deployed location, employment of AFSOC deployed MQ-1B aircraft by mixed crews (AFSOC & ACC) occurs regularly.

a. Air Force Special Operations Command

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 Operation 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 (Tab CC-1).

b. Air Combat Command

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

c. United States Air Forces Central

USAFCENT is the air component of United States Central Command (USCENTCOM), a regional unified command. USAFCENT is responsible for air operations (either unilaterally or in concert with coalition partners) and developing contingency plans in support of national objectives for USCENTCOM's 20-nation area of responsibility in Southwest Asia. Additionally, USAFCENT manages an extensive supply and equipment prepositioning program at several Area of Responsibility (AOR) sites (Tab CC-6).

d. 432d Wing

The 432 WG flies and maintains the MQ-1B Predator and MQ-9 Reaper aircraft to support United States and Coalition war-fighters. The 432 WG conducts RPA initial qualification training for aircrew, intelligence, weather, and maintenance personnel. The 432 WG overseas operations include the 432d Operations Group (432 OG), 432 MXG, 11th RS, 15th RS, 17th RS, 30th RS, 18th RS, 20th RS, 42d Attack Squadron, 432 AMXS, 432d MXT Squadron, and the 432d Operations Support Squadron (Tab CC-9).

e. 15th Reconnaissance Squadron

The 15 RS is one of the first armed Remotely Piloted Aircraft (RPA) squadrons. The squadron provides combatant commanders with persistent ISR, full-motion video, and precision weapons employment. Global operations architecture supports continuous MQ-1B Predator employment, providing real-time actionable intelligence, strike, interdiction, close air support, and special missions to deployed war fighters. (Tab CC-12).

f. 20th Reconnaissance Squadron

The 20 RS is one of the newest armed Remotely Piloted Aircraft (RPA) squadrons. The squadron provides combatant commanders with persistent ISR, full-motion video, and precision weapons employment. Global operations architecture supports continuous MQ-1B Predator employment, providing real-time actionable intelligence, strike, interdiction, close air support, and special missions to deployed war fighters. (Tab CC-15).

g. Kandahar Airfield, Afghanistan

Kandahar Air Field (KAF) is home to both the 62 ERS, and the larger host-wing, the 451 AEW. It is located outside of Kandahar, Afghanistan.

(1) 451st Air Expeditionary Wing, ACC

The 451 AEW provides a persistent and powerful airpower presence in the Afghanistan area of operations. 451st AEW Airmen provide world-class Tactical Airlift, Close Air Support, ISR, Command and Control, Airborne Datalink, Combat Search and Rescue, Casualty Evacuation and Aeromedical Evacuation capabilities whenever and wherever needed (Tab CC-17).

(2) 62nd Expeditionary Reconnaissance Squadron, ACC

The 62 ERS is a Remote Piloted Aircraft (RPA) squadron that provides combatant commanders with persistent ISR, full-motion video, and precision weapons employment. Global operations architecture supports continuous MQ-1B Predator and MQ-9 Reaper employment providing real-time actionable intelligence, strike, interdiction, close air support, and special missions to deployed war fighters (Tab CC-19).

h. Predator System

The MQ-1B Predator aircraft is a medium-altitude, long endurance RPA. Its primary mission is conducting armed reconnaissance and interdiction against critical perishable targets. When the MQ-1B is not actively pursuing its primary mission, it augments the MQ-9 Reaper as a Joint Forces Air Component Commander-owned theater asset for reconnaissance, surveillance and target acquisition in support of the Joint Forces Commander (Tab CC-21).

The MQ-1B Predator is a system, not just an aircraft (See diagram below). A fully operational system consists of four aircraft (with sensors), a Ground Control Station (GCS), a Predator Primary Satellite Link (PPSL), along with operations and maintenance crews for a sustained 24-hour combat orbit (Tab CC-21).

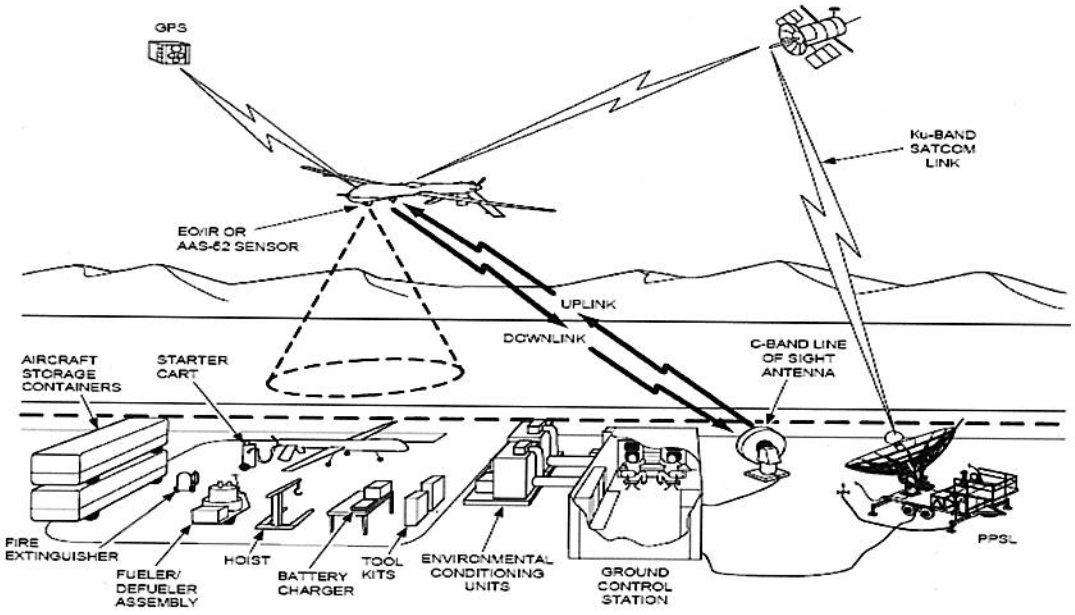


Diagram displaying typical system components of MQ-1B Predator

The basic crew for the Predator is a pilot and Sensor Operator. They fly the aircraft from inside the GCS via a line-of-sight (LOS) data link or a satellite data link for beyond LOS flight. The aircraft is equipped with a color nose camera (generally used by the pilot for flight control), a day variable-aperture TV camera, a variable-aperture infrared (IR) camera (for low light/Night), and other sensors as the mission requires. The cameras produce full-motion video. (Tab CC-21)

The MQ-1B Predator carries the Multi-Spectral Targeting System (MTS) which integrates electro-optical, infrared, laser designator and laser illuminator into a single sensor package. The aircraft can employ two laser-guided AGM-114 Hellfire missiles. (Tab CC-21)

The system is composed of four major components, which can be deployed for worldwide operations. The Predator aircraft can be disassembled and loaded into a single container for transport. The GCS is transportable in a C-130 Hercules (or larger) transport aircraft or installed in a fixed facility. The Predator can operate on a 5,000 by 75 feet (1,524 meters by 23 meters) hard surface runway with clear LOS. The ground data terminal antenna provides LOS communications for takeoff and landing. The PPSL provides over-the-horizon communications for the aircraft (Tab CC-21).

An alternate method of employment, Remote Split Operations, employs a smaller version of the GCS called the LRE GCS. This system conducts takeoff and landing operations at the forward deployed location while the Contiguous United States-based GCS conducts the mission via extended satellite communication links (Tab CC-21).

4. SEQUENCE OF EVENTS

a. Mission

The mishap sortie was an armed Intelligence, Surveillance and Reconnaissance (ISR) mission flown in support of Operation ENDURING FREEDOM (OEF) and was authorized by a classified Air Tasking Order (ATO).

The MC responsibilities for operating the MRPA were limited to LRE only. Once the aircraft completed the mission phase of flight, controlled by the MCE, it returned to base where control was transferred to the LRE for the landing.

b. Planning

The Pilot and Sensor Operator performed mission planning within their responsibilities as the LRE. Specific mission planning for LRE was limited to aircraft preflight, taxi, takeoff, handover to the MCE, recovery from the MCE and landing. (TAB G-24 thru 26 and G-28 thru 30).

c. Preflight

Although the mishap on this sortie occurred during the landing phase, due to the long nature of RPA sorties, the MC also conducted preflight procedures and the takeoff of the MRPA on 1 March 2013.

The MC showed for duty at approximately 2215Z on 28 February 2013. They received a weather brief and turnover brief from the departing crew. The Pilot executed the exterior inspection checking the Exceptional Release, the 781 forms and the visual condition of the

MRPA. There were no discrepancies noted in the forms or during the Pilot walk around. The MC accomplished all required checklists for takeoff and hand over of the MRPA to the MCE. At approximately 0930Z on 1 March 2013 the MC entered crew rest. (TAB V-3)
The MC once again showed for duty at approximately 2215Z on 1 March 2013. They received a weather brief and turnover brief from the departing crew. (TAB F-3 thru 7). The MC stepped out to the GCS and accomplished all required checklists in preparation for gaining control from the MCE. (TAB V-3)

d. Summary of Accident

At 0159Z on 2 March 2013, 21.4 hours into the sortie, the MCE handed the MRPA over to the MC for the landing phase of the mission. The MRPA was at an altitude of 10,000 feet Mean Sea Level (MSL) and flying at 75 Knots Indicated Air Speed (KIAS). All checklists were complete and the MC was able to gain control of the MRPA without incident. There was a warning on the HDD stating "Fuel - Forward Fuel Leak Detected". This is a known anomaly with the 104.2 software on the MQ-1B and is produced any time there is greater than a 20 pound difference between the aircraft fuel levels being read by the GCS and the actual fuel probe levels in the fuel tanks. Due to an error in a conversion equation, the detection system may cause a fuel leak warning to appear when no leak is present. (TAB AA-1).

Once control of the MRPA was verified by the MP, he commanded the MRPA into a shallow descent and began steering the MRPA toward the airfield in preparation for landing. The MP did not report any discrepancies or any anomalies with the MRPA during this descent and all required checklists were accomplished. (TAB V-3; TAB EE-1 thru 5; and TAB N-3 thru 7)

At 0208Z, while executing a left 360 degree turn for the descent, the MC noticed that the telemetry of their flight graphics on the Heads Up Display (HUD) was frozen. While the MC could still see the MRPA video, they could no longer determine the airspeed or altitude of the MRPA. The MC opted to shut down the LOS uplink to the MRPA, sending the aircraft to its preprogrammed emergency mission in accordance with the lost link checklist. At the point of lost link, the MRPA was at 6,260 feet MSL and flying at 82 KIAS. (TAB EE-5 and TAB N-7)
At 0210 Z, having completed the lost link checklist, the MC turned on the Ground Data Terminal (GDT) in an attempt to visually acquire the MRPA. The MC was able to recapture the downlink signal and once again see the telemetry. The MC noticed the warning message "Tail Computer Left - ROM Failed" on the HDD and the MP directed the MSO to reference the Dash 1 regarding the warning message. At this point the MRPA was still flying its preprogrammed emergency mission and was at 6,370 feet MSL and 70 KIAS in the climb to the emergency mission altitude of approximately 13,500 feet MSL with a "Speed Priority In Effect" caution on the HUD. "Speed Priority In Effect" is a safety feature of the autopilot which commands the aircraft to stall speed plus 13 knots. During this phase of flight the MP noted that the aircraft appeared to be in a slight left hand turn by looking at the horizon indicator on the HUD when in fact the aircraft was tracking directly towards the entry waypoint of the emergency mission. (TAB V-4; TAB EE-6 and TAB N-7)

At 0211Z, the MC closed out the lost link checklist and enabled the uplink transmitters, taking control of the MRPA. The MRPA was at 6,540 feet MSL and 70 KIAS. Upon gaining control, the MRPA dropped to a nose low attitude of -10 degrees. The MP immediately corrected the nose low attitude and positioned the aircraft into level flight. The MP began to coordinate for airspace with tower control so they could troubleshoot the warning message "Tail Computer Left - ROM Failed" which displayed constant on the HDDs for the remainder of the sortie (TAB V-7). The tower controller issued the crew a vector to turn 20 degrees left, maintain 7,000 feet MSL and contact departure control. The MP acknowledged the clearance and verbally noted that his pitch stick markers were not matching the commands that he was applying to the MRPA. The MP then stated "what's going on!" (TAB EE-7; TAB V-6 and TAB N-8)

At 0212Z, approximately 1 min and 30 seconds after taking aircraft control, at 6,560 feet MSL and flying at 71 KIAS, the MC tried to roll wings level on his assigned heading and experienced a violent nose down pitch angle of greater than 60 degrees. Various warnings appeared on the HUD including Aileron Tip Stall Override and G force limit exceeded and another warning on the HDD that they were unable to determine. The MRPA nose fell below 90 degrees and entered an inverted spin with airspeed reading zero. The MP immediately directed the MSO to kill the uplinks and send the MRPA into its preprogrammed emergency mission. Last known altitude was 5,340 feet MSL and descending at a rate greater than 3000 feet per minute which is the maximum vertical velocity reading on the MQ-1B. (TAB EE-8 and TAB N-9)

At approximately 0214Z the MC turned on the GDT in an effort to reestablish contact with the MRPA but saw only static. Tower control confirmed that they saw smoke on the ground at or near the MRPA's last known location. (TAB EE-9 and TAB N-10)

e. Impact

The MRPA impacted the terrain approximately 7 nm southwest of KAF. The MRPA was carrying one AGM-114 Hellfire missile. The MRPA and the AGM-114 were severely damaged and beyond repair. An Explosive Ordinance Disposal (EOD) team were airlifted to the crash site and destroyed the remaining wreckage and the AGM-114.

f. Life Support Equipment, Egress and Survival

Not Applicable.

g. Search and Rescue

Not Applicable.

h. Recovery of Remains

Not Applicable.

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 on the date of the mishap. 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 U-9)

A 60-day pre-mishap history check in Integrated Maintenance Data System (IMDS) and AFTO 781-series forms revealed that, on 22 January 2013, the MRPA experienced nose wheel steering servo pot fail. Upon troubleshooting of the MRPA per the technical order, the maintenance technician (MT) replaced the nose wheel steering servo. (TAB U-2) On 25 January 2013, the MRPA experienced high idle RPM. The MT adjusted idle. (TAB U-3) On 26 January 2013, the MRPA Pod pylon bolt was documented as worn beyond limits. The MT removed and replaced the worn bolt. (TAB U-4)

On 29 January 2013, the MRPA experienced an intermittent cowl flap servo warning light. The MT found the UUO cable to be defective and replaced the cable. (TAB U-5) On 28 January 2013, while preforming the 150 hour inspection, the MT found a flap servo arm bearing requiring replacement. The MT installed a new flap servo arm. (TAB U-6) On 23 February 2013, the forms indicated that the MRPA required turbulator tape on the right wing forward of the flap. The MT re-applied tape to the right wing forward of the flap. (TAB U-7) On 27 February 2013, the forms indicated that the lower directional fairing was loose and the screen was broken/removed. The MT replaced the screen and reinstalled the antenna fairing. (TAB U-8)

On 27 February 2013, maintenance performed standard Basic Post flight/Pre-flight inspections. On 1 March 2013, the MT serviced fuel, loaded a single AGM-114 Hellfire missile on station 2 and launched the aircraft on the mishap sortie. (TAB U-11)

b. Inspections

All required inspections were accomplished on the MRPA, and there were no overdue Aircraft Time Compliance Technical Orders (TCTO) directing hardware, software, or inspection criteria modifications. The MRPA's next scheduled inspection was a 28 Day Dry-Cell NICAD battery reconditioning due 12 March 2013, a 30-Day Records Review due 27 March 2013, a 60-Day Weapons 101 check due 24 April 2013, a 60hr Engine inspection due in 30 hours, and a 180 Day aircraft wash due 26 Apr 2013. (TAB U-12) Inspections were not a factor in this mishap.

c. Maintenance Procedures

Review of maintenance procedures noted two discrepancies: The serial numbers of the PCM and SCM were not properly documented on the AFTO Form 781C, Avionics Configuration and load status; and the updated serial numbers of the Vertical Tail-Air Handler or GMESH, Air Handler unit and GMESH Unit were not properly documented on the AFTO Form 781C, Avionics Configuration and load status (TAB U-13). Maintenance Procedures were not a factor in this mishap.

d. Maintenance Personnel and Supervision

Aircraft maintenance records provided by Battle Space Flight Services indicated all preflight maintenance and supervisory activities were normal. The AIB 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 that they were trained and qualified. Maintenance personnel qualification and proficiencies were not a factor in this mishap.

e. Fuel, Hydraulic and Oil Inspection Analyses

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 U-10) The "Info Note" page correctly reflected the 3:2 ratio in the forward and aft fuel tanks per the applicable technical order. (TAB U-11) The Fuel, Hydraulic and Oil Analyses were not a factor in this mishap.

f. Unscheduled Maintenance

There were no unscheduled maintenance inspections since the last inspection. All necessary repairs or replacements were properly made when required, independent of maintenance schedules, and were not a factor in this mishap.

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS.

a. Structures and Systems

The MRPA impacted the terrain approximately 7 nm Southwest of KAF. The MRPA was carrying one AGM-114 Hellfire missile. The MRPA and the AGM-114 were severely damaged upon impact. The MRPA Primary Control Module, Secondary Control Module and left tail servo, were recovered and sent to General Atomics (GA) for evaluation. EOD destroyed the wreckage with explosives. The MCE GCS was immediately sequestered for test and evaluation and determined to not be a factor in the mishap. (TAB D-5) The LRE GCS was immediately sequestered for test and evaluation and determined to not be a factor in the mishap (TAB GG-1).

b. Evaluation and Analysis

GA and the Accident Investigation Board (AIB) analyzed the data logger files from the GCS. The loss of control and crash of aircraft 04-3133 was likely due to a failed left tail servo control board (ruddervator). The left ruddervator failed during an unrelated lost-link event and reported a failed ROM. All subsequent telemetry was static. The tail servo initially maintained a slightly trailing edge up position, and the aircraft was able to maintain flight control. Eventually, the left ruddervator moved to an extreme trailing-edge down position, which caused a loss of control and crash.

(1) Analysis 1

The received left ruddervator was damaged to such a degree that it was not useful in determining the cause of the failure.

(2) Analysis 2

Eight erasable programmable read only memory (EPROM) are used in MQ-1 aircraft: These are the Payload Power Distribution Module, Servo Board, Data link Board, Interface Board, two aileron servo control boards, and two tail servo control boards. MQ-1 aircraft have flown approximately 1.5 million flight hours, for a total of 12 million flight hours on the EPROM chips. This was the first known ROM failure. The EPROM was manufactured by Micross.

7. WEATHER

a. Forecast Weather

On 2 March 2013, the forecasted weather for Kandahar issued on 1 March 2103 at 2230z (valid for the 24 hr zulu period of 2 March 2013) was winds from 050 degrees at 10 knots gusting to 15 knots; unrestricted visibility; sky conditions clear; maximum temperature of 23C on 2 March 2013 at 1100z and a minimum temperature of 7C on 2 March 2013 at 0300z.

There was no evidence to suggest weather was a factor in the mishap.

b. Observed Weather

The observed weather taken 15 minutes prior to the mishap shows that the winds were out of the northeast at 14 knots, there were a few clouds at 23,000 feet and the visibility was unrestricted. Operations were conducted within the weather conditions.

8. CREW QUALIFICATIONS

a. Mishap Pilot (MP)

(1) Training

The MP has been a qualified MQ-1B pilot since 27 September 2011. Additionally, the MP qualified as a LRE pilot on 12 December 2012. (TAB G-6, TAB G-16).

(2) Experience

The MP's total flight time is 739.4 hours, all of which were accomplished in the MQ-1B. The MP has no previous airframe experience. (TAB G-7). The MP was fully current and qualified at the time of the mishap. The MP's flight time during the 90 days before the mishap is as follows: (TAB G-4)

MP	Hours	Sorties*
Last 30 Days	14.6	15
Last 60 Days	22.2	24
Last 90 Days	28.5	28

b. Mishap Sensor Operator (MSO)

(1) Training

The MSO has been a qualified MQ-1B SO since 13 April 2009. Additionally, the MSO was qualified as an LRE SO on 20 December 2012. (TAB G-18, TAB G-21)

(2) Experience

The MSO's total MQ-1B flight time is 2,185.9 hours. (TAB G-12) The MSO was fully current and qualified at the time of the mishap. The MSO's flight time during the 90 days before the mishap is as follows: (TAB G-9)

MSO	Hours	Sorties*
Last 30 Days	9.8	14
Last 60 Days	14.1	19
Last 90 Days	17.5	22

* ARMS products do not count multiple LRE flights on the same day as separate sorties. Therefore, in the charts above for the MP and MSO, the number in the sorties column equates to the number of days flown, rather than the number of actual sorties.

9. MEDICAL

a. Qualifications

(1) MCE (Mission Control Element) – At the time of the mishap, the MCE crew (MCE Pilot (MCEP), MCE Sensor Operator (MCESO), and MCE Mission Coordinator (MCEMC) were all medically qualified for flight duty without medical restrictions or waivers. Preventive Health Assessments were all current for the MCE crew.

(2) LRE (Launch/Recovery Element) – At the time of the mishap, the LRE crew (MP, MSO) were both medically qualified for flight duty. The MP has an unrestricted medical waiver for allergic rhinitis, a long-standing condition that has not caused any issues. The MSO has no medical waivers. Preventive Health Assessments were all current for the LRE crew.

b. Health

A review was accomplished on the hardcopy medical records, Armed Forces Health Longitudinal Technology Application (electronic) medical records, and the 72-hour and 14 day histories provided. Records revealed all individuals were in good health and had no performance-limiting condition or illness prior to the mishap.

There was no evidence that any medical conditions contributed to the mishap.

There were no injuries or fatalities associated with this mishap, and therefore, no post-mishap injury reports. No immediate post-mishap medical examination of the LRE crew was obtained other than the toxicology reports and 72 hour and 14 day histories.

c. Toxicology

Immediately following the mishap, commander-directed toxicology was performed. The Armed Forces Institute of Pathology examined above specimens for the presence of alcohol, amphetamine, barbiturate, benzodiazepine, cannabinoids, cocaine, opiates and phencyclidine (by immunoassay or chromatography) and all results were NEGATIVE.

d. Lifestyle

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

e. Crew Rest and Crew Duty Time

Air Force Instructions require aircrew members have proper "crew rest," as defined in AFI 11-202, Volume 3, *General Flight Rules*, 05 April 2006, 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 begins. During this time, an 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.

No crew rest or crew duty time factors were found to be relevant to the mishap.

10. OPERATIONS AND SUPERVISON

a. Operations Tempo

At the time of the mishap, operations tempo for both the MP and MSO was average and sustainable for LRE operations in the AOR. On the day of the mishap, the MC participated in one additional landing event prior to the mishap event. The mishap event was the MC's final event of the day (TAB V-1.3). There is no evidence to suggest that operations tempo contributed to this mishap.

b. Experience Level

Both crewmembers involved in the mishap were experienced in RPA operations as defined by AFI 11-2MQ-1 Volume 1. There is no evidence to suggest that the experience level of either crewmember contributed to this mishap.

c. Supervision

On the day of the mishap, the MC received their daily brief from a qualified Operations Supervisor. The MP is also qualified as an Operations Supervisor but testified that he was only fulfilling pilot duties at the time of the mishap (TAB V-1.2). There is no evidence to suggest that supervision contributed to this mishap.

11. HUMAN FACTORS

Possible Human Factors contributing to the reported mishap were evaluated using the Department of Defense (DoD) Human Factors Analysis and Classification System (DoD-HFACS). The DoD-HFACS describes four main tiers of factors that may contribute to a mishap. From most individual to most general they are: Acts, Pre-Conditions, Supervision, and Organizational Influences. Acts are those factors that are most closely tied to the mishap, and can be described as active failures or actions committed by the operator that result in human error or unsafe situations. Preconditions are factors in a mishap

if active and/or latent preconditions such as conditions of the operators, environmental or personnel factors affect practices, conditions or actions of individuals and result in human error or an unsafe situation. Supervision is a factor in a mishap if the methods, decisions or policies of the supervisory chain of command directly affect practices, conditions, or actions of individuals and result in human error or an unsafe situation. Organizational Influences are factors in a mishap if the communications, actions, omissions or policies of upper-level management directly or indirectly affect supervisory practices, conditions or actions of the operator(s) and result in system failure, human error or an unsafe situation.

After reviewing the facts of the investigation, including witness testimony, there is no evidence that these human factors were a factor in this mishap.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications

(1) AFI 11-2MQ-1, Volume 1, MQ-1 Crew 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 Operations Procedures, 1 November 2012
(4) AFI 11-202, Volume 3, General Flight Rules, 22 October 2010
(5) AFI 11-401, Aviation Management, 15 September 2011
(6) AFI 11-418, Operations Supervision, 15 September 2011
(7) T.O. 1Q-1(M)B-1, Flight Manual, USAF Series MQ-1B and RQ-1B Systems, 13 December 2010 incorporating Change 4, 10 December 2012
(8) T.O. 1Q-1(M)B-1CL-1, Flight Checklist, USAF Series MQ-1B and RQ-1B Systems, 13 December 2010, incorporating Change 4, 10 December 2012
(9) AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010
(10) AFI 91-204, *Safety Investigations and Reports*, 24 September 2008

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

b. Maintenance Directives and Publications

(1) AFI 21-101, Aircraft and Equipment Maintenance Management, 26 July 2010
(2) T.O. 00-20-1, Aerospace Equipment Maintenance Inspection, Documentation, Policies and Procedures, 30 April 2003, Incorporating Change 4, 1 September 2006
(3) 1Q-1(M)B-6, MQ-1B Technical Manual, Aircraft Scheduled Inspection and Maintenance Requirements, 21 January 2010
(4) 1Q-1(M)B-2-72JG-00-2, MQ-1B Job Guide, Engine Reciprocating, General-Volume I, 8 June 2010
(5) 1Q-1(M)B-2-61JG-00-1, MQ-1B Job Guide, Propeller General, 8 February 2010, Incorporating Change 1, 11 March 2010
(6) 1Q-1(M)B-2-05JG-10-1, MQ-1B Job Guide, Aircraft General Ground Handling, 9 June 2009, Incorporating Change 5, 21 July 2010

(7) 1Q-1(M)B-6WC-1, MQ-1B Inspection Workcard, Preflight, Thruflight, Basic Postflight, Combined Basic Postflight/Preflight Inspection Requirements, 21 January 2010
(8) 1Q-1(M)B-6WC-2, MQ-1B Inspection Workcard, Aircraft Periodic Inspections and Maintenance Requirements, 21 January 2010, Incorporating Change 1, 27 August 2010
(9) 1Q-1(M)B-2-12CL-2, Fueling and Defueling Verification Checklist, 28 June 2010

c. Known or Suspected Deviations from Directives or Publications

Not applicable.

13. ADDITIONAL AREAS OF CONCERN

Not applicable.

29 May 2013

/JUSTIN R. WYMORE, LT COL, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

AIRCRAFT ACCIDENT INVESTIGATION
MQ-1B PREDATOR, T/N 04-3133
NEAR KANDAHAR AIRFIELD, AFGHANISTAN
2 MARCH 2013

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 2 March 2013, at approximately 0213Z, the MRPA, an MQ-1B, tail number 04-3133 assigned to the 3d SOS, 27th SOW, being flown by a LRE assigned to the 62d ERS, 451st AEW, Kandahar Air Field Afghanistan, experienced a SCM malfunction causing abnormal flight control outputs to the aircraft's left tailboard (ruddervator), entered into an unrecoverable spin, and impacted the ground approximately 7 nm southwest of Kandahar Air Field. There were no injuries or fatalities nor damage to private property. The MRPA was destroyed upon impact.

I find by clear and convincing evidence that the cause of the mishap was the failure of an Erasable Programmable Read-Only Memory (EPROM) chip on the circuit board within the SCM that controls the left ruddervator. Failure of the EPROM chip led to uncommanded and unpredictable movements of the left ruddervator, eventually resulting in a trailing-edge down position beyond 10 degrees – likely to a full 25 degrees trailing-edge down position – departure from controlled flight, and impact with the terrain.

I developed my opinion by analyzing factual data from the flight recordings, reconstructed data logger files, the General Atomics contractor report, witness testimony, applicable technical orders, and consulting with subject matter experts. All evidence is consistent with a loss of aircraft control due to the failure of the EPROM chip on the SCM circuit board controlling the left ruddervator.

2. CAUSE

I find by clear and convincing evidence that the cause of the mishap was the failure of an EPROM chip on the circuit board within the SCM that controls the left ruddervator.

After reviewing more than six months of maintenance history, flight data from the entire flight, and interviewing all operations and maintenance personnel who participated in the mishap flight from pre-flight to mishap, I determined that the first event in the mishap sequence was failure of

the MRPA EPROM chip in the SCM responsible for controlling the left tail. The failure triggered the warning "Tail Computer Left - ROM Failed" on the MC's HDD, indicating that the SCM self-test had detected an error in the left tail controller software and that the instructions to the ruddervator and information coming from the ruddervator were unknowable. Of this warning, the DASH-1 states, "Left tail may be inoperative. Ability to remain in controlled flight is unlikely. Pitch commands will cause undesirable yaw, and yaw commands will cause undesirable pitch." I determined that, within the constraints of available time, the MC took appropriate actions to maintain coordinated flight.

According to General Atomics engineers, there are three possible causes of the warning "Tail Computer Left - ROM Failed" – a bad connection on the EPROM and/or central processor unit (CPU) integrated circuit socket; a physical or electrical failure of the EPROM, CPU chip, or address latch chip; or, although unlikely, a physical change in the contents of the EPROM due to cosmic rays. A normally-operating tail circuit board will command the ruddervator to 24 degrees trailing-edge up to intentionally stall the aircraft if it does not receive network commands for three seconds. Because this did not occur, I determined that it was unlikely that a bad connection was responsible for the message. Therefore, the most likely cause of the message was a physical or electrical failure of the EPROM.

After failure of the EPROM chip, I determined that the ruddervator initially remained within 10 degrees of the neutral position. Based on General Atomics simulations, an uncoordinated deflection of less than 10 degrees would not result in loss of an aircraft as the opposite tail would be able to maintain controlled flight. Further, the same simulations indicated that the tail was likely at an average position of -3.4 degrees (trailing edge up) during this timeframe.

The next event in the mishap sequence was an uncommanded (by the MC) deflection of the MRPA left ruddervator to a significantly trailing-edge down position. The cause of the deflection is unknowable because the SCM was not reporting the ruddervator information due to the EPROM failure. The General Atomics simulations indicated that it was likely that the left ruddervator of the MRPA had moved to a full trailing-edge down position of -25 degrees.

I determined that the MRPA left ruddervator remained in a significantly trailing-edge down position for the remainder of recorded flight. I reviewed the available aircraft data, which indicated that the MRPA suddenly pitched down violently with an angle-of-attack (AOA) exceeding 60 degrees nose-down – the software reporting limit – and normal acceleration exceeding -2.5 Gs. In my review of the MRPA video, I further determined that the MRPA AOA actually exceeded 90 degrees nose-down attitude while simultaneously rolling right and thereby appeared to enter an inverted flat spin immediately prior to the loss of video. The aerodynamic forces acting upon the MRPA as it performed these violent maneuvers did not reorient the left ruddervator from its trailing-edge down configuration, indicating that it was most likely either still being driven by the servo to that position or had become mechanically fixed (jammed) in that position. However, the ruddervator on the MQ-1B is a single aerodynamic surface that pivots at approximately the center position rather than a traditional fixed leading edge and movable trailing edge configuration, it is possible that the aerodynamic forces the aircraft

experienced would not have reoriented the ruddervator even if it was simply unpowered. Impact with the terrain and subsequent use of a controlled explosion by Explosive Ordnance Disposal team to render the Hellfire missile safe damaged the left MRPA ruddervator too extensively for General Atomics' post-mishap analysis to determine the cause of the failure.

The MC forced the aircraft lost-link in a last-ditch effort to force the MRPA to recover and fly its emergency mission. This was a reasonable action by the MC, as they had already accomplished the **boldface** procedures for loss of aircraft control.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

None.

4. CONCLUSION

I arrived at my opinion by analyzing factual data from the flight recordings, reconstructed data logger files, the General Atomics contractor report, witness testimony, applicable technical orders, and consulting with subject matter experts. All evidence is consistent with a loss of aircraft control due to the failure of an EPROM chip on the circuit board within the SCM that controls the left ruddervator.

29 May 2013

JUSTIN R. WYMORE, LT COL, USAF
President, Accident Investigation Board