UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

MQ-1B PREDATOR, S/N 06-3161

432D EXPEDITIONARY WING
CREECH AIR FORCE BASE, NEVADA

62D EXPEDITIONARY RECONNAISSANCE SQUADRON
451ST AIR EXPEDITIONARY WING
KANDAHAR AIRFIELD, AFGHANISTAN

ACCIDENT LOCATION: NORTHWEST OF KANDAHAR AIRFIELD, AFGHANISTAN

DATE OF ACCIDENT: 20 NOVEMBER 2009

BOARD PRESIDENT: LIEUTENANT COLONEL TIM R. CARTER

Conducted as an Abbreviated Accident Investigation
In Accordance with Air Force Instruction 51-503; Pursuant to Chapter 11

EXECUTIVE SUMMARY

ACCIDENT INVESTIGATION BOARD REPORT
MQ-1B PREDATOR, S/N 06-3161
NORTHWEST OF KANDAHAR AIRFIELD, AFGHANISTAN
20 NOVEMBER 2009

On 20 November 2009, shortly after 1708 Greenwich Mean Time (GMT), an MQ-1B Predator remotely-piloted aircraft (RPA), serial number 06-3161, impacted the ground 7 miles northwest of Kandahar Airfield (KAF), Afghanistan, while conducting a combat support mission in support of Operation ENDURING FREEDOM. The RPA was an asset of the 432d Air Expeditionary Wing, Creech Air Force Base, Nevada. It was destroyed on impact, and the cost of the aircraft damage was $4,588,282. There were no reported injuries and there was no known damage to other government or private property.

After normal maintenance and pre-flight checks, the RPA departed KAF at 1648 GMT for its mission. The RPA was being flown by a Launch and Recovery Element (LRE) mishap crew (MC), consisting of a pilot and a sensor operator. At 1708 GMT, the MC experienced a lost link condition with the RPA. A lost link condition refers to a situation in which Predator aircraft cannot transmit or receive data or commands from any control element via satellite or line of sight communications. All attempts by the MC and datalink specialists to reestablish a communications link with the RPA were unsuccessful. At the same time as the lost link condition occurred, Air Traffic Control (ATC) lost the RPA's transponder signal and the radar image of the aircraft.

The wreckage was located on 28 December 2009, 7.2 nautical miles northwest of KAF, near its last recorded position. Since the RPA could not initially be located and exhaustive efforts were made to reestablish a link with the aircraft; the RPA was not declared lost until 0200 GMT on 22 November 2009 when it would have run out of fuel. Previous Air Force references to this accident have used a 22 November 2009 mishap date. This report uses the actual mishap date of 20 November 2009.

The Accident Investigation Board President determined, by clear and convincing evidence, that the cause of this mishap was a catastrophic electrical system failure. The failure was most likely caused by a short circuit in an alternator cable in the 28 volt power system. A catastrophic electrical failure accounts for the lost link condition, the loss of the transponder signal, the inability of the aircraft to perform its preprogrammed emergency mission and is supported by the fact the wreckage was found near its last known position. The loss of electrical power resulted in loss of control of the RPA and its subsequent crash.

Under 10 U.S.C. 2254(d), any opinion of the accident investigators as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report 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.

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

62 ERS	62d Expeditionary Reconnaissance Squadron
432 WG	432d Wing
432 AEW	432d Air Expeditionary Wing
451 AEW	451st Air Expeditionary Wing
451 EAMXS	451st Expeditionary Aircraft Maintenance Squadron
ACC	Air Combat Command
AEW	Air Expeditionary Wing
AFB	Air Force Base
AFI	Air Force Instruction
AFTO	Air Force Technical Order
AIB	Accident Investigation Board
AOR	Area of Responsibility
ATC	Air Traffic Control
ATO	Air Tasking Order
BFS	Battlespace Flight Services
CONUS	Continental United States
DAR	Dual Alternator Regulator
EAMXS	Expeditionary Aircraft Maintenance Squadron
GA-ASI	General Atomics Aeronautical Systems Inc.
GCS	Ground Control Station
GMT	Greenwich Mean Time
HEA	Hellfire Electronics Assembly
IFF	Identify Friend or Foe
ISR	Intelligence, Surveillance, and Reconnaissance
KAF	Kandahar Airfield
LLC	Limited Liability Company
LOS	Line of Sight
LRE	Launch and Recovery Element
MC	Mishap Crew
MCE	Mission Control Element
MP	Mishap Pilot
MSO	Mishap Sensor Operator
NV	Nevada
O&M	Organization and Maintenance
OCONUS	Outside Continental United States
PCM	Primary Control Module
PPSL Link	Predator Primary Satellite
RPA	Remotely-Piloted Aircraft
RS	Reconnaissance Squadron
PTP	Production Test Procedures
PWAs	Printed Wire Assemblies
SCM	Secondary Control Module
S/N	Serial Number
TCTO	Time Compliance Technical Order
T.O.	Technical Order
USAF	United States Air Force
USCENTCOM	United States Central Command
USAFCENT	United States Air Forces Central
USAFSOUTH	United States Air Forces Southern
V	Volt
WG	Wing

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

SUMMARY OF FACTS

ACCIDENT INVESTIGATION BOARD REPORT
MQ-1B PREDATOR, S/N 06-3161
NORTHWEST OF KANDAHAR AIRFIELD, AFGHANISTAN
20 NOVEMBER 2009

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority

On 21 April 2010, Lieutenant General William J. Rew, Vice Commander, Air Combat Command (ACC), United States Air Force (USAF), appointed Lieutenant Colonel Tim R. Carter as President of an abbreviated Accident Investigation Board (AIB) convened to conduct the investigation of the 20 November 2009 aircraft mishap involving an MQ-1B Predator aircraft, serial number (S/N) 06-3161 (Tab J-2 to J-5). The investigation was conducted pursuant to Chapter 11 of Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*, dated 16 July 2004 first at Nellis Air Force Base (AFB), Nevada (NV), from 20 April 2010 through 30 April 2010, And then, after additional parts testing, electronically from XX June to XX June. Additional members appointed to the AIB were Captain Christopher P. Sheridan (Legal Advisor) and Technical Sergeant Tonya L. Vallie (Recorder) (Tabs J-2 to J-5). Subject matter experts who assisted the AIB as Technical Advisors from the 432d Wing at Creech Air force Base, Nevada were a Predator pilot from the 432d Operations Group and a Predator maintainer from the 432d Aircraft Maintenance Squadron (Tab M-5).

b. Purpose

The purpose of this investigation is to provide a publicly releasable report of the facts and circumstances surrounding the accident, to generate a statement of opinion on the cause or causes of the accident; to gather and preserve evidence for claims, litigation, disciplinary, and adverse administrative actions; and for all other purposes (Tab K-3).

c. Circumstances

The AIB was convened to investigate a Class A mishap involving an MQ-1B Predator, S/N 06-3161, assigned to the 432d Air Expeditionary Wing (AEW), Creech AFB, NV, and operated by the 62d Expeditionary Reconnaissance Squadron (ERS), 451 AEW, which occurred during a classified mission northwest of Kandahar Airfield (KAF), Afghanistan on 20 November 2009 (Tabs J-2 to J-5, I-25, M-5). Previous Air Force references to this accident have used a 22 November 2009 mishap date which was when it was declared lost. This report uses the actual mishap date of 20 November 2009 (Tab M-5).

2. ACCIDENT SUMMARY

On 20 November 2009, at 1648 Greenwich Mean Time (GMT), after normal maintenance and pre-flight checks, a remotely-piloted aircraft (RPA), an MQ-1B Predator, S/N 06-3161, taxied

and departed KAF to conduct a classified mission (Tabs A-2 to A-17, E-3, I-25). The takeoff occurred without incident and the RPA was controlled by the Launch and Recovery Element (LRE) mishap crew (MC) at KAF (Tab I-25).

At the time of the mishap, the RPA was being hand flown by the LRE pilot (Tab I-25). At 1708 GMT, the MC experienced a lost link condition with the RPA (Tabs D-4, I-25). A lost link condition refers to a situation in which Predator aircraft cannot transmit or receive data or commands from any control element via satellite or line-of-sight (LOS) communications. The MC was unable to recover the communications link with the RPA (Tab I-25). Shortly thereafter, the RPA impacted the ground and was destroyed. The RPA was carrying one AGM-114P Hellfire missile. The aircraft loss was valued at $4,558,282 (Tab H-2). The mishap caused no known ground injuries or damage to other government or private property (Tab M-5).

3. BACKGROUND

The RPA was an asset of the 432 AEW, Creech AFB, NV (Tab L-13). The 432 AEW belongs to Air Combat Command, headquartered at Langley Air Force Base, Virginia (Tabs L-5, L-9).

At the time of the mishap, the RPA was launched by the LRE crew from KAF. Both members of the MC were stationed at KAF, and assigned to the 62 ERS (Tab I-25). The 62 ERS is a unit within the 451 AEW. The 451 AEW is operationally assigned to the US Air Forces Central (USAFCENT) (Tab L-12).

a. 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 L-5).

b. 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 AOR sites (Tab L-10).

c. 432d Wing / 432d Air Expeditionary Wing (Creech AFB, NV)

The 432d Wing (WG), the Air Force's first remotely-piloted aircraft (RPA) wing, stood up on 1 May 2007 at Creech AFB, NV. Due to the

increasing requirement for RPA support to the Global War on Terrorism, the 432 WG was designated an Air Expeditionary Wing (AEW) in May of 2008. The 432 AEW has dual reporting responsibilities to 9th Air Force and USAFCENT Command at Shaw AFB, South Carolina, as well as to 12th Air Force (ACC) and United States Air Forces Southern (USAFSOUTH) at Davis-Monthan AFB, Arizona. The 432 AEW has command and control over two active duty units and more than 250 ANG personnel flying the MQ-1 Predator that are a part of units in California, North Dakota, Texas and Arizona (Tab L-13).

d. 451st Expeditionary Aircraft Maintenance Squadron (KAF, Afghanistan)

The 451 Expeditionary Aircraft Maintenance Squadron (EAMXS) is part of the 451 AEW located at KAF, Afghanistan. The 451 EAMXS is responsible for aircraft maintenance and sortie generation in support of Operation ENDURING FREEDOM, as well as launch, recovery and servicing support for military aircraft. The squadron works directly with Battlespace Flight Services, LLC personnel to provide the necessary maintenance support to the MQ-1B Predator in theater (Tab L-14 to L-15).

e. Battlespace Flight Services, LLC (Based out of Las Vegas, NV)

Battlespace Flight Services (BFS), Limited Liability Company (LLC) provides high level Organization and Maintenance (O&M) support for MQ-1 aircraft systems at tasked locations world-wide. The company provides management and supervisory personnel and organizational maintenance personnel at Continental United States (CONUS) and Outside Continental United States (OCONUS) locations. BFS support includes aircraft maintenance management, Aerospace Ground Equipment and Ground Support Equipment maintenance, supply support, Command, Control, Communications, Computer, Intelligence Surveillance and Reconnaissance Systems, Quality Assurance, and an Environmental, Safety and Health Program. BFS is currently under contract with the USAF for O&M support for the MQ-1 Predator (Tab L-14). Organizationally, BFS personnel located at KAF, Afghanistan fall under the 451 EAMXS (Tab M-5).

f. Kandahar Airfield, Afghanistan

KAF is home to both the 62 ERS, and the larger host-wing 451 AEW. It is located outside of Kandahar, Afghanistan (Tab L-15).

g. 451st Air Expeditionary Wing, ACC

The 451 AEW provides a persistent and powerful airpower presence in the Afghanistan area of operations. 451 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 L-15).

h. 62d Expeditionary Reconnaissance Squadron, ACC

62 ERS is an 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 (Tabs L-15 to L-20, M-5).

i. 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 L-18).

The MQ-1B Predator is a system, not just an aircraft (see diagram next page). 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 L-18).

The basic crew for the Predator is a pilot and sensor operator. The crew flies 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 L-18).

The MQ-1B Predator carries the Multi-Spectral Targeting System 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 L-18).

MQ-1B Predator, S/N 06-3161, 20 November 2009

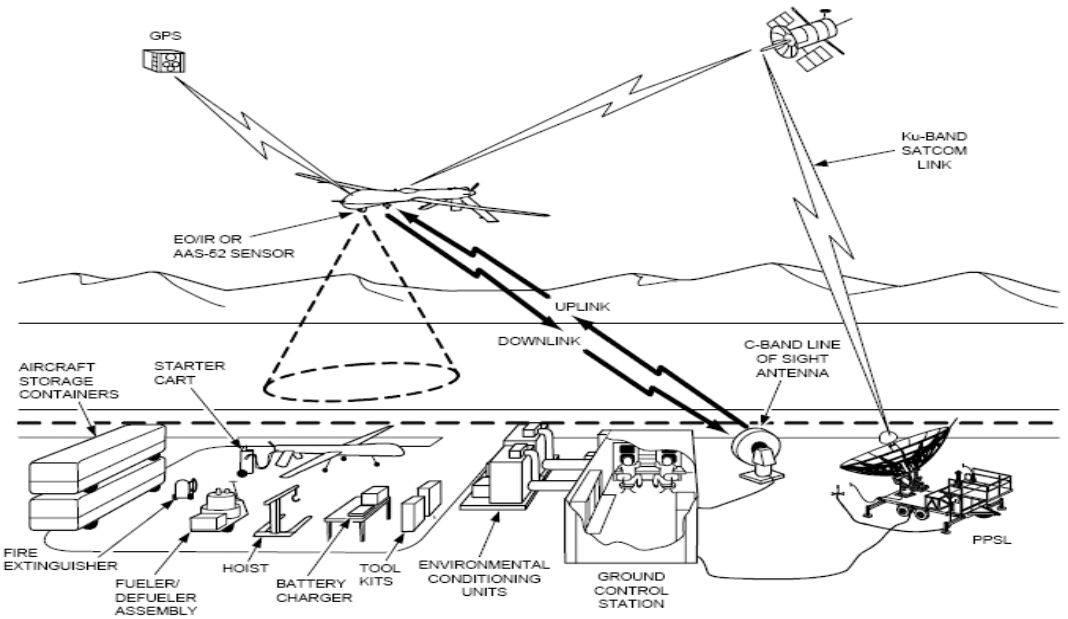

Diagram displaying typical system components of MQ-1B Predator

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 L-18).

When deployed to a forward location, MQ-1 Predator aircraft are controlled by a LRE crew via LOS operations. The LRE crew conducts takeoff and landing operations at the forward deployed location while the Continental United States-based GCS conducts the mission via extended satellite communication links (Tab L-18).

4. SEQUENCE OF EVENTS

a. Mission

On 20 November 2009, the mishap RPA was tasked to fly a classified intelligence, surveillance, and reconnaissance (ISR) mission in support of Operation ENDURING FREEDOM. The RPA was to take off from KAF, Afghanistan, fly to areas of interest in the Area of Responsibility (AOR), then return to KAF, Afghanistan, as tasked by a classified USAFCENT Air Tasking Order ATO) (Tabs E-3 M-5).

b. Planning

The MC attended all mandatory mission briefings. These briefings used classified briefing guides that adequately addressed the following: the briefing requirements of Volume 3 of AFI 11-202, *General Flight Rules*, dated 5 April 2006, and Volume 3, Chapter 2 of AFI 11-2MQ-1, *MQ-1 Operations Procedures*, dated 29 November 2007; all pertinent theater special instructions and rules of engagement; and all local briefing requirements The briefing covered all aspects of the mission, to include, mission requirements, notices to airmen, expectations, weather, and safety concerns. The MC accomplished all required preflight and mission planning actions in accordance with the applicable instructions. The MC was properly briefed and understood their mission (Tabs I-25, M-5).

c. Preflight

The mishap pilot (MP) reviewed the Air Force Technical Order (AFTO) 781 series maintenance forms for the RPA and the GCS, S/N 6110, and found no discrepancies. The MP also performed a walk around inspection of the aircraft, and found no discrepancies. Preflight activities were in accordance with applicable regulations (Tab I-25).

d. Summary of Accident

At 1648 GMT, the RPA taxied normally and departed KAF, Afghanistan under the control of the LRE and was flying within normal parameters (Tabs E-3, M-5, I-25). During departure, the Mission Crew Element (MCE) at Creech AFB, NV that was waiting to take control of the RPA, reported to the LRE crew that they were observing intermittent reception of the Predator's video and data feeds via the satellite link. The MCE asked the LRE MC to adjust the satellite link attenuation settings to gain better reception. This did not alleviate the problem (Tab I-25). The MCE then asked for a reset of the satellite processor modem assembly. After the reset, the MCE pilot reported he had a good video feed (Tab I-25). There is no evidence to indicate the intermittent satellite reception at the stateside MCE GCS was causal or contributory to the mishap.

At 1708 GMT, the MC experienced a lost link condition with the RPA (Tabs D-4, I-25). A lost link condition refers to a situation in which the Predator aircraft cannot transmit or receive data or commands from any control element via satellite or line of sight communications. The MC immediately identified the lost link condition due to their video feed going snowy and the telemetry freezing (Tab I-25). At the same time, the stateside MCE crew that was observing the RPA video feed also reported a lost link condition (Tab I-25). Additionally, Air Traffic Control (ATC) at KAF reported losing the RPA's Identify Friend or Foe (IFF) transponder signal and the RPA disappeared from ATC's radar screen (Tabs D-5, F-2, I-2).

In accordance with normal operating procedure, the MC ran the 2,000 feet Above Ground Level checklist to try and reestablish a link with the RPA. The checklist directs the aircrew to monitor for any communication from the aircraft and to disable outgoing GCS-to-aircraft communications to prevent interference with emergency mission programming. In normal operation, when a Predator aircraft experiences a lost link condition, the Primary Control Module (PCM), the main computer that controls the aircraft, executes emergency mission programming

which directs the aircraft to fly a predetermined route near an airfield where the LRE can attempt to reestablish line-of-sight communication and safely land the aircraft (Tabs I-25, M-5).

After performing the checklist, the MC notified air traffic control and the supervisory chain of command of the lost link condition (Tab I-25). GCS maintenance and communication specialists were called for support in trying to locate the RPA (Tab I-3 to I-25). All uplink frequencies that the aircraft might have been operating on were tried in an attempt to regain link. All possible downlink frequencies were selected in an attempt to pick up a downlink from the aircraft. Various other Ground Data Terminal, GCS and aircraft configuration commands were tried in an attempt to regain link (Tab D-5, D-22). At no time during the recovery attempt was the GCS able to obtain an uplink or downlink with the RPA (Tabs D-5, D-22, I-25). No communications were ever restored with the RPA (Tab I-25).

The emergency mission programmed in the RPA would have directed the aircraft to fly towards the first point in the emergency mission route. Other airborne assets in the area to include other Predators were used to search for the RPA (Tab I-25). The RPA's pre-programmed emergency orbit area was searched to no avail. On 22 November 2009, after the RPA would have exhausted its fuel supply, it was declared lost (Tabs E-2 to E-3, I-25, M-5).

e. Impact

Shortly after 1708 GMT, on 20 November 2009, the RPA impacted the ground in an unpopulated area northwest of KAF and was destroyed (Tabs D-4, D-21, M-5). The aircraft wreckage was discovered on 28 December 2009, a half mile downwind of its last known position (Tabs D-5, D-22, M-5). No photographs were taken of the crash site so an analysis of the crash site, could not be conducted (Tab M-5).

5. MAINTENANCE

a. Forms Documentation

(1) Mishap GCS

A review of the mishap GCS AFTO 781 series maintenance forms was conducted. No documentation errors were discovered in the mishap GCS maintenance forms. The Mishap GCS had no documented discrepancies and no overdue Time Compliance Technical Orders (TCTOs). All scheduled inspections were completed and documented in compliance with applicable technical orders (Tab A-18 to A-20, A-22).

(2) RPA

Maintenance activities and all maintenance documentation for the RPA at KAF was conducted by BFS, LLC, a contracted maintenance support company. A review of the RPA AFTO 781 series maintenance forms was conducted (Tab A-22). No documentation errors were discovered in the RPA maintenance forms (Tab A-2 to A-17, A-22). The RPA had no overdue TCTOs (Tab A-15 to A-17). The RPA had one minor delayed discrepancy for a small paint chip on the left wing (Tab A-17). All scheduled inspections were completed and documented in compliance with applicable technical orders (Tab A-15 to A-17, A-22).

b. Inspections

All RPA and GCS inspections were completed and documented in accordance with applicable technical orders. There were no discrepancies noted (Tab A-15 to A-20, A-22).

c. Maintenance Procedures

Maintenance procedures on the RPA were completed in accordance with applicable technical orders and AFIs. Maintenance procedures on the RPA were not a factor in the mishap (Tab A-2 to A-17).

Maintenance procedures on the mishap GCS were completed in accordance with applicable technical orders and AFIs. Maintenance procedures on the mishap GCS were not a factor in the mishap (Tab A-18 to A-20).

d. Maintenance Personnel and Supervision

The RPA was maintained at the deployed location by BFS, LLC, contracted by the United States Air Force to provide deployed maintenance support (Tab A-22). Aircraft maintenance records and statements provided by maintenance personnel indicated all preflight maintenance and supervisory activities were normal (Tabs A-2 to A-17, A-22, I-12 to I-24). A review of the training and qualification records of the contract maintenance personnel who performed maintenance on the RPA indicated that all personnel were trained and qualified to perform the tasks they executed on the RPA (Tab A-22).

e. Fuel Inspection Analysis

Samples of fuel taken post-mishap from the fuel equipment that serviced the RPA were tested. All fuel samples tested were within limits and were free from contamination, in accordance with technical orders (Tab A-21).

No fluid samples were obtained post-mishap from the RPA due to the wreckage not being discovered for over a month (Tab M-5). There is no evidence to suggest fuel contamination contributed to the mishap.

f. Unscheduled Maintenance

The RPA air aborted its mission and returned to base the previous day for an unusable Ku return signal. That malfunction was reported on the AFTO Forms 781A. Maintenance personnel examined the system and reseated Radio Frequency (RF) connectors on both Ku antenna and the improved modem assembly (IMA). Operational checks were performed for over 20 minutes and no issues were discovered. The discrepancy was signed off as “ops checked good” in accordance with applicable technical orders (Tabs A-4, A-7, I-13). There is no evidence to suggest unscheduled maintenance contributed to the mishap.

6. AIRCRAFT AND AIRFRAME SYSTEMS

a. Condition of Systems

The AIB could not investigate the post-mishap physical condition of all the RPA's wreckage since the majority of it was destroyed in place for operational security reasons after it was discovered. No photographs of the mishap site were provided to the AIB (Tab M-5). However, analysis of the information down linked to the GCS via the data loggers, indicate that immediately prior to the lost link at 1708 GMT, the aircraft and its systems were operating within normal parameters for the mission (Tab D-3, D-20).

b. Testing

Nine parts were recovered from the RPA wreckage and sent to the manufacturer General Atomics Aeronautical Systems, Inc. (GA-ASI) for teardown testing and analysis. GA-ASI manufactured all relevant items and components of the RPA. These parts were: Secondary Control Module (SCM); Dual Alternator Regulator (DAR); Hellfire Electronics Assembly (HEA); two alternators; two tail servo assemblies; Front Bay Power Junction Assembly; and the On Board Battery Charger Contact Unit (Tabs D-6, D-23, M-5).

GA-ASI prepared a report describing the testing of the parts in this mishap for use by Air Force investigation boards. The following are excerpts from the Analysis of Facts section of the GA-ASI report entitled "Contractor Report to USAF Investigation Board:" (Tab D-8, D-25 to D-27)

4.3 Analysis of Facts Pertaining to Hardware Investigation

4.3.1 The SCM successfully passed the Production Test Procedure (PTP) upon return to GA-ASI after the mishap. The SCM was then disassembled and each Printed Wiring Assembly (PWA) was inspected. There were no visible or identified signs of damage or failure to any part of any of the PWAs (i.e. there were no burn indications, bent or loose wires, loose EPROMS, failed board modifications (blue wires), or damaged or loose pins or connectors). The PWAs were clean and there was very little evidence of debris in the SCM housing. The SCM was not a cause of the mishap (Tab D-8, D-25).

4.3.3 The DAR successfully passed the PTP upon return to GA-ASI after the mishap. The DAR was then disassembled and each PWA was inspected. There were no visible or identified signs of damage or failure to any part of any of the PWA (i.e. there were no burn indications, bent or loose wires, failed board modifications (blue wires), or damaged or loose pins or connectors). There was very little evidence of debris on the PWAs. There was no evidence to suggest that the DAR was the cause of the mishap (Tab D-8, D-25).

4.3.7 The HEA was not considered relevant to this investigation and it was not tested. Visual inspection found that the right side (looking forward) had a large dent down the length of the housing. This was most likely caused by the ground impact (Tab D-8, D-26).

4.3.8 Alternator #1 (left) was visually inspected and disassembled, specifically looking for evidence of a short circuit (Tab D-26).

4.3.8.1 Before opening the alternator, the rotor turned freely, with no abnormal mechanical resistance or noise, and there was no external evidence of a short circuit (Tab D-26).

4.3.8.2 With the cover removed, the external alternator connections were inspected, with no evidence of a short circuit found. The resistance between the alternator positive output and chassis measured open circuit (Tab D-26).

4.3.8.3 After opening the alternator, all internal components were inspected, including the stator, diode bridge, brushes and rotor. All internal components looked clean, with no evidence of a short circuit found (Tab D-26).

4.3.8.4 The diode block was removed to inspect for evidence of a short circuit on the back side, with no evidence found (Tab D-26).

4.3.8.5 With no evidence of a short circuit found, Alternator #1 is not considered to be the cause of the mishap (Tab D-26).

4.3.9 Alternator #2 (right) was visually inspected and torn down, specifically looking for evidence of a short circuit (Tab D-26).

4.3.9.1 Before opening the alternator, the rotor turned freely, with no abnormal mechanical resistance or noise, and there was no external evidence of a short circuit (Tab D-26).

4.3.9.2 With the cover removed, the external alternator connections were inspected, with no evidence of a short circuit found. The resistance between the alternator positive output and chassis measured open circuit. (Tab D-26)

4.3.9.3 After opening the alternator, all internal components were inspected, including the stator, diode bridge, brushes and rotor. All internal components looked clean, with no evidence of a short circuit found (Tab D-26).

4.3.9.4 The diode block was removed to inspect for evidence of a short circuit on the back side, with no evidence found (Tab D-26).

4.3.9.5 With no evidence of a short circuit found, Alternator #2 is not considered to be a contributing factor of the mishap (Tab D-26).

4.3.10 The Front Bay Power Junction Assembly was visually inspected and opened, looking for evidence of a short circuit. Although the unit appeared to be damaged externally from ground impact, the PWA inside was not damaged and in good shape. The resistance between +28V and 28VRTN and between +28V and connector shell (chassis) measured open circuit on all connectors. The resistance between +28V Remote Sense and 28VRTN Remote Sense measured open circuit on all applicable connectors. There was no evidence of a short circuit found externally, nor on the PWA. With no evidence of a short circuit found, the Front Bay Power Junction Assembly is not considered to be the cause of the mishap (Tab D-27).

4.3.11 The BCCUs were not considered relevant to this investigation and were not inspected (Tab D-27).

Testing of the mishap GCS at KAF, Afghanistan showed no malfunctions. The GCS was inspected and returned to service (Tab D-15 to D-18).

c. Analysis of Test Results

Based on analysis of the RPA parts and data collected from the data loggers of the Predator system, all aircraft systems to include the powerplant, electrical, communications and autopilot systems were operating normally until the time of the lost link (Tab D-3 to D-10, D-20 to D-29).

The GA-ASI report identified the following facts and provided analysis regarding the functionality of the RPAs electrical system (Tab D-3 to D-4, D-6, D-9, D-20 to D-21, D-23, D-27).

3.0 Statement of Facts:

3.1.3 There were no electrical system anomalies reported in the logs prior to the lost link event. The 28V bus and both batteries were reporting normal voltages, the alternators were supplying normal current, there were no system current spikes reported and the batteries were not sourced (Tab D-3, D-20).

3.1.14 There were no GCS keypresses recorded at the time of the lost downlink (Tab D-4, D-21).

3.6.1 The MQ-1B dual alternator power system installed on P-161 was only redundant and fault tolerant for open circuit alternator and alternator power cable failures. It was not fault tolerant for short circuit alternator and alternator power cable failures (Tab D-6, D-23).

3.6.2 If a major 28V bus fault occurred in an area where there was no fuse protection and there was sufficient short circuit metal-to-metal contact, allowing for a very large amount of current, there would not have been enough current available (from the batteries and the bus capacitance) to clear the fault. A major 28V bus fault could have resulted in total avionics failure and loss of the aircraft (Tab D-6, D-23).

4.4 Analysis of Facts Pertaining to Aircraft Electrical Power System

4.4.1 Catastrophic power shorts have occurred on other mishap aircraft, resulting in a total power loss before telemetry could capture the current spike. Since the LRE and MCE lost link at the same time as the tower reported transponder squawk loss, a catastrophic power loss is a likely failure mode (Tab D-9, D-27).

4.4.2 Although it is possible to see evidence of a major 28V bus fault on the data logger, it could go unobserved prior to loss of link due to the 1 Hz sample rate for system current. No faults were detected in the data loggers for this flight (Tab D-9, D-27).

4.4.3 A 28V bus failure of sufficient magnitude to cause loss of control was possible at several places on the bus. However, due to the large instantaneous current capability of the batteries and bus capacitance, most faults would have been

cleared unless they occurred in either the alternators, alternator power cables (which had Nomex protective wrap), or the DAR. Such a short would have needed to occur between 28V and either 28V return or a cable shield or enclosure. The DAR was tested and found to operate normally. Therefore, the DAR was not a factor in the mishap (Tab D-9, D-27).

4.4.4 If a major 28V bus fault had occurred in an area where there was no fuse protection and there was short circuit metal-to-metal contact, allowing a very large amount of current, there may not have been enough current available (from the alternators, the batteries and the large bus capacitance inside the PPDM) to clear the fault before the 28V bus dropped low enough to shut off all avionics power (Tab D-9, D-27).

In reference to the above analysis, the GA-ASI report indicated the simultaneous loss of C-band, Ku-band and IFF signals is characteristic of a catastrophic short circuit on the 28V bus, likely in an alternator or alternator cable (Tab D-3, D-10, D-20, D-29).

7. WEATHER

a. Forecast Weather

The weather forecast for 20 November 2009 at Kandahar Air Base, Afghanistan was valid from 1300 GMT on 20 November 2009 to 2100 GMT on 21 November 2009. The forecast predicted scattered clouds at 10,000 feet and scattered clouds at 20,000 feet. The term "scattered" means clouds cover less than 50% of the sky. Visibility was forecast to be 5 statute miles with haze near the ground. Winds were forecast to be from a heading of 250° (westerly) at 10 knots. The forecast altimeter setting was 30.15 inches of mercury (Tabs B-2, M-5).

b. Observed Weather

The actual weather observations at the time of the mishap were skies clear with 5 statute miles visibility with haze. Winds were from a heading of 240° (westerly) at 7 knots and the altimeter setting was 30.16 inches of mercury. The temperature was reported to be 13° Celsius (Tab M-5).

c. Space Environment

There was no evidence that any adverse conditions in the space environment affected the RPA or its communication links to the GCS.

d. Conclusion

Neither the forecast weather nor the observed weather indicate weather was causal or contributory to the mishap.

8. CREW QUALIFICATIONS

a. Training

The MP and Mishap Sensor Operator (MSO) attended qualification training in the MQ-1B predator system at Creech AFB, NV. The MC successfully completed all training requirements for this mission, and were current and qualified (Tabs C-2 to C-42, I-25, M-5). There is no evidence to suggest aircrew training were a factor in this mishap.

b. Experience in the MQ-1B Predator Aircraft System

(1) Mishap Pilot

The MP was a current and qualified, experienced MQ-1B Predator pilot for the mission being flown at the time of the mishap (Tabs C-2 to C-27, I-25). As of 20 November 2009, the MP had completed 378 hours flying the MQ-1B, as well as 50.6 hours of time in the MQ-1B simulator (Tab C-18).

(2) Mishap Sensor Operator

The MSO was a current and qualified, experienced MQ-1B Predator sensor operator for the mission being flown at the time of the mishap (Tabs C-28 to C-42, I-25). As of 20 November 2009, the MSO had completed 1220.5 hours of sensor operator duties on the MQ-1B (Tab C-31).

There is no evidence to suggest aircrew qualifications were a factor in the mishap.

9. MEDICAL

There is no evidence that medical histories were relevant to the mishap.

10. OPERATIONS AND SUPERVISION

There is no evidence that operations and supervision issues were relevant to the mishap.

11. HUMAN FACTORS

There is no evidence that human factors were relevant to the mishap.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Flying Operations Directives and Publications

(1) AFI 11-202, Volume 1, *Aircrew Training*, dated 17 May 2007
(2) AFI 11-202, Volume 2, *Aircrew Standardization/Evaluation Program*, dated 8 December 2006, Incorporating Change 1, dated 19 September 2007
(3) AFI 11-202, Volume 2, *Aircrew Standardization/Evaluation Program, Air Combat Command Supplement*, dated 10 December 2007

c. Known or Suspected Deviations from Directives or Publications

There were no known or suspected deviations from directives or publications.

13. NEWS MEDIA INVOLVEMENT

There was no apparent new media involvement regarding this accident.

14. ADDITIONAL AREAS OF CONCERN

There were no additional areas of concern.

18 June 2010

TIM R. CARTER, Lt Col, USAF
President, Accident Investigation Board

c. Known or Suspected Deviations from Directives or Publications

There were no known or suspected deviations from directives or publications.

13. NEWS MEDIA INVOLVEMENT

There was no apparent new media involvement regarding this accident.

14. ADDITIONAL AREAS OF CONCERN

There were no additional areas of concern.

21 July 2010

TIM R. CARTER, Lt Col, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

ACCIDENT INVESTIGATION BOARD REPORT
MQ-1B PREDATOR, S/N 06-3161
NORTHWEST OF KANDAHAR AIRFIELD, AFGHANISTAN
20 NOVEMBER 2009

Under 10 U.S.C. 2254(d), any opinion of the accident investigators as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report 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 this mishap was a catastrophic electrical system failure. The failure was most likely caused by a short circuit in an alternator cable in the 28 volt (V) power system. This system is the main source of power for the entire aircraft.

The manufacturer report states that the simultaneous loss of communications links and Identify Friend or Foe (IFF) transponder signal is characteristic of a catastrophic short circuit on the 28V bus in an alternator or alternator cable. Both alternators were returned to General Atomics Aeronautical System, Inc. (GA-ASI) and inspected, with no evidence of a short circuit found within either alternator. Therefore, the alternators were not considered to be a cause of the mishap. This leaves only the alternator cables, which were not recovered and inspected, as the most likely cause.

Other major components of the 28V power system were inspected with no evidence of short circuits found. A review of the remotely-piloted aircraft (RPA) performance data showed no indications of other system anomalies thus eliminating many other mishap scenarios. A catastrophic electrical failure would account for the simultaneous lost link condition, the loss of the transponder signal and the inability of the aircraft to perform its preprogrammed emergency mission. The loss of electrical power resulted in loss of control of the RPA and the subsequent crash.

2. DISCUSSION OF OPINION

a. Background

On 20 November 2009, shortly after 1708 Greenwich Mean Time (GMT), an MQ-1B Predator remotely-piloted aircraft, S/N 06-3161, impacted the ground in an uninhabited area northwest of Kandahar Airfield (KAF), Afghanistan. The RPA was conducting an intelligence, surveillance, and reconnaissance (ISR) mission in support of Operation ENDURING FREEDOM. The RPA was forward deployed to KAF from the 432d Air Expeditionary Wing, Creech Air Force Base, Nevada. The Launch and Recovery Element (LRE) at KAF launched the RPA and was controlling it at the time of the mishap.

At 1708 GMT, approximately 20 minutes into the flight, the RPA experienced a catastrophic power failure which resulted in the LRE mishap crew (MC) observing a lost link condition. At the same time the stateside mission crew element (MCE) crew that was shadowing the RPA observed the lost link condition as well. Additionally, Air Traffic Control (ATC) reported losing the RPA's IFF transponder signal and the RPA disappeared from ATC's radar screen.

The MC ran the appropriate checklist and tried to reestablish a link with the RPA. Supervision was notified and GCS maintenance personnel were called for support in trying to reestablish the link with the RPA. Other airborne assets in the area to include other Predators were used to search for the RPA. At no time were communications reestablished with the RPA. The RPA's pre-programmed emergency mission area was searched to no avail. After the RPA would have exhausted its fuel supply it was declared lost. The aircraft wreckage was discovered on 28 December 2009, over a month later. The wreckage was found a half mile downwind of its last known position. The RPA and one AGM-114P Hellfire missile was destroyed with loss valued at $4,588,282. There were no reported deaths, injuries, or other property damage associated with this mishap.

b. Analysis

I have concluded that a catastrophic electrical system failure in the 28V power system is the cause of the mishap because this failure accounts for simultaneous loss of aircraft performance information, communications links, and IFF transponder signal. The RPA's crash site was located in close proximity (a half mile downwind) of the lost link location, further indicating that a catastrophic failure occurred.

The MQ-1B dual alternator power system installed on the RPA was only redundant and fault tolerant for open circuit alternator and alternator cable failures. It was not fault tolerant for short circuit alternator and alternator cable failures. If a major 28V bus fault occurred in an area where there was no fuse protection and there was sufficient short circuit metal-to-metal contact, allowing for a very large amount of current, there may not have been enough current available (from the batteries and the bus capacitance) to clear the fault before the 28V bus dropped low enough to shut off all avionics power. Since all other major electrical components of the 28V power system were examined and not found to be causal by GA-ASI, through process of elimination, only the alternator cables remain as the most likely cause of the short circuit.

I arrived at my opinion by examining the GA-ASI report, witness testimony, consulting with subject matter experts, data logger information from the mishap flight, and applicable technical data. All evidence points to a catastrophic electrical failure caused by a short circuit in an alternator cable within the 28V power system.

18 June 2010

TIM R. CARTER, Lt Col, USAF
President, Accident Investigation Board