UNITED STATES AIR FORCE
AIRCRAFT ACCIDENT INVESTIGATION
BOARD REPORT

MQ-1B, T/N 99-3061

15th Reconnaissance Squadron
432d Air Expeditionary Wing
Creech Air Force Base, Nevada

LOCATION: Kandahar Air Base, Afghanistan

DATE OF ACCIDENT: 3 January 2011

BOARD PRESIDENT: Lt Col Karl Fischbach

Conducted IAW Air Force Instruction 51-503
Abbreviated Accident Investigation pursuant to Chapter 11

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION
MQ-1B, T/N 99-3061, KANDAHAR, AFGHANISTAN
3 JANUARY 2011

On 3 January 2011, at approximately 0605 zulu (Z) time, the mishap remotely piloted aircraft (MRPA), a MQ-1B Predator, tail number 99-3061, operated by the 15th Reconnaissance Squadron (RS) from Creech AFB, crashed west of Kandahar Air Base after completing 18 hours of a tasked surveillance mission. The crash site was remote desert terrain. The MRPA's structure and mechanical components were destroyed as a result of the impact with terrain. There were no injuries and there was no damage to other government or private property.

After normal maintenance and pre-flight checks, the mishap remotely piloted aircraft (MRPA) taxied and departed from Kandahar Air Base at approximately 1204 zulu (Z) time on 2 Jan 11. At 0537Z on 3 Jan 11, the mishap crew (MC) lost satellite link with the MRPA after receiving a momentary alternator power warning. When the satellite link was re-established at 0539Z, the MC had indications that the alternators were off-line and that the MRPA was operating solely on back-up battery power. At 0603Z, approximately 30 minutes from the first alternator power warning, the MC lost satellite link permanently. The last know position of the MRPA was approximately 100 nautical miles (nm) west of Kandahar. The MRPA continued flying for some time after losing the satellite link when it exhausted back-up battery power and crashed southwest of its last known position.

The Abbreviated Accident Investigation Board (AAIB) President determined by clear and convincing evidence that the cause of the mishap was the failure of the front bearing in Alternator Number One (Alternator #1). As the front bearing failed, friction caused speed variations inside the Alternator #1 which triggered erratic bus voltage, alternator current and engine revolutions per minute (RPM). Due to voltage variations on the power bus, the Dual Alternator Regulator (DAR) performed an automatic rebalance of the alternators, switching between the two alternator output several times. With the DAR unable to tightly balance alternator output, a high voltage spike was sensed by both the DAR and PPDM, and the satellite link was severed. Because the alternator outputs are connected together and the DAR was unable to determine which alternator caused the event, it shut down both to protect the electrical system. When the link was re-established, the MC had indications that both alternators had failed and the MRPA was operating on back-up battery power. The MC realized that the MRPA would lose power before they could return to base or fly to an emergency divert, so they controlled the MRPA heading away from a known populated area. The MRPA continued flying for some time after losing the satellite link. As the battery voltage dropped, the MRPA electronics began to shutdown. The MRPA crashed and was destroyed when it impacted terrain. The estimated loss is valued at $4.4M.

SUMMARY OF FACTS AND STATEMENT OF OPINION
MQ-1B, T/N 99-3061
3 January 2011

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

15 RS	15th Reconnaissance Squadron
432 WG	432d Wing
432 OG	432d Operations Group
ACC	Air Combat Command
AEW	Air Expeditionary Wing
AF	Air Force
AFB	Air Force Base
AFETS	Air Force Engineering and Technical Services
AFI	Air Force Instruction
AFTO	Air Force Technical Order
AGL	Above Ground Level
AIB	Aircraft Investigation Board
ALT	Altitude
BFS	Battlespace Flight Services
BSA	Basic Surface Attack
C	Centigrade
CAMS	Consolidated Aircraft Maintenance System
COMACC	Commander Air Combat Command
CONUS	Continental United States
Dash 1	T.O. 1Q-1(M)B-1 Flight Manual
EGT	Exhaust Gas Temperature
FAE	Functional Area Expert
GA ASI	General Atomics Aeronautical Systems, Incorporated
GCS	Ground Control Station
GDT	Ground Data Terminal
HUD	Heads Up Display
In Hg	Inches of Mercury
IPI	Initial Process Inspection
IQT	Initial Qualification Training
KIAS	Knots Indicated Airspeed
kPa	Vapor Pressure
KTL	Key Task List
L	Local Time
Lbs	Pounds
LOS	Line of Sight
LR	Launch and Recovery
LRE	Launch and Recovery Element
MAJCOM	Major Command
MAP	Manifold Absolute Pressure
MDT	Mountain Daylight Time
MIC	Mission Intelligence Coordinator
MP	Mishap Pilot
MRPA	Mishap Remotely Piloted Aircraft
MSL	Mean Sea Level
MSO	Mishap Sensor Operator
MTS	Multi-spectral Targeting System
NV	Nevada
NM	Nautical Miles
PSI	Pounds per Square Inch
RPM	Revolutions Per Minute
SAT	Satellite
SATCOM	Satellite Communications
SPMA	Sensor Processor Modem Assembly
TCTO	Time Compliance Technical Order
T/N	Tail Number
T.O.	Technical Order
UAS	Unmanned Aerial System
U.S.	United States
U.S.C.	United States Code
USAF	United States Air Force
VPP	Variable Pitch Propeller
VSI	Vertical Speed Indication
WG	Wing

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, PURPOSE, AND CIRCUMSTANCES

a. Authority

On 28 January 2011, Lt Gen William Rew, Vice Commander, Air Combat Command, United States Air Force (USAF), appointed Lieutenant Colonel Karl Fischbach as the Accident Investigation Board (AIB) President, Captain AIB LA (Legal Advisor), and Master Sergeant AIB Rec (Recorder), to investigate the 3 January 2011 crash of a MQ-1B Predator, tail number (T/N) 99-3061, near Kandahar, Afghanistan. An abbreviated AIB was conducted at Nellis AFB, NV, from 9 February through 25 February 2011, pursuant to Chapter 11 of Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations* (Tab Y-3). Functional Area Experts (FAE) detailed to the investigation were Captain AIB PM (Pilot FAE), Captain AIB Doc (Medical FAE), and Master Sergeant AIB MM (Maintenance FAE) (Tab Y-5).

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

After normal maintenance and pre-flight checks, the mishap remotely piloted aircraft (MRPA) taxied and departed from Kandahar Air Base on 2 Jan 11 at approximately 1204 zulu (Z) time to execute a surveillance mission (Tab CC-3). Approximately 17 ½ hours into the flight at 0533Z, on 3 January 2011, the mishap crew (MC) consisting of the mishap pilot (MP), mishap sensor operator (MSO), and mishap mission intelligence coordinator (MMIC) lost satellite link with the MRPA after receiving a momentary alternator power warning (Tab V-3.4, N-2, V-4.4). When the satellite link was re-established at 0539Z, the MC had indications that the alternators were off-line and that the MRPA was operating solely on back-up battery power (Tab V-3.5, V-4.4). The MRPA was west of Kandahar AB and the MC elected to return to base (RTB) (Tabs CC- 3 – 4, V-3.6). At 0603Z, approximately 30 minutes from the first alternator power warning, the MC lost satellite link (Tab N-10, EE-7). The last known position of the MRPA was approximately 100 nm west of Kandahar (Tabs CC-4, EE-18). The MRPA continued flying for some time after losing the satellite link when it exhausted back-up battery power and crashed southwest of its last known position (Tab EE-4, EE-9).

3. **BACKGROUND**

The MRPA was an asset of the 15th Reconnaissance Squadron (RS). The 15th RS is a component of the 432 WG, based at Creech AFB, NV (Tab DD-9). The 432 WG is a component of 12th Air Force Air Force and USAF Southern Command, headquartered at Davis-Monthan AFB, Arizona (Tab DD-5). The 12th Air Force is a component of Air Combat Command, headquartered at Langley AFB, VA (Tab DD-4).

a. **432d Wing**

The 432 WG, also known as the 432d Air Expeditionary Wing "Hunters", consists of combat-ready Airmen who fly the MQ-1B Predator and MQ-9 Reaper aircraft to support United States and Coalition warfighters. The 432 WG conducts remotely piloted aircraft (RPA) initial qualification training for aircrew, intelligence, weather, and maintenance personnel. The 432 WG oversees operations of the 432d Operations Group (432 OG), 432d Maintenance Group, 11 Reconnaissance Squadron, 15th Reconnaissance Squadron, 17th Reconnaissance Squadron, 18th Reconnaissance Squadron, 30th Reconnaissance Squadron, 42d Attack Squadron, 432d Aircraft Maintenance Squadron (432 AMXS), 432d Maintenance Squadron, and the 432d Operations Support SquadronTab DD-9).

b. **15th Reconnaissance Squadron**

The 15th Reconnaissance Squadron, one of the first armed RPA squadrons, provides combatant commanders with persistent intelligence, surveillance and reconnaissance (ISR) capability, full-motion video and precision weapons engagement. Its 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 DD-9).

c. **MQ-1B Predator System**

The MQ-1B Predator is a medium-altitude, long-endurance, RPA. The Predator's primary missions are close air support, air interdiction, and intelligence, surveillance and reconnaissance, or 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 (Tab DD-12).

The MQ-1B Predator is a system, not just an aircraft. A fully operational system 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 (Tab DD-12).

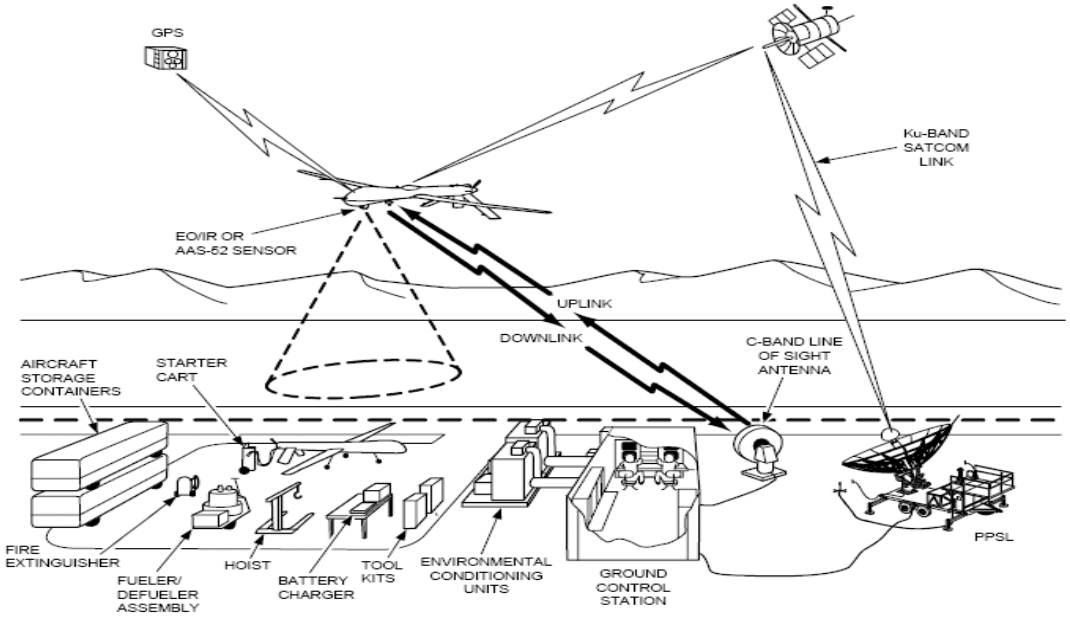

Diagram displaying typical system components of MQ-1B Predator

The basic crew for the Predator is a rated 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 the GCS via a line-of-sight data link or a satellite data link for beyond line-of-sight operations (DD-12).

The MQ-1B Predator carries the Multi-spectral Targeting System (MTS), which integrates an infrared sensor, a color/monochrome daylight TV camera, an image-intensified TV camera, a laser designator and a laser illuminator into a single package. 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 (DD-12).

The system can be deployed for worldwide operations. The Predator aircraft can be disassembled and loaded into a container for travel. The ground control system and PPSL are transportable in a C-130 Hercules (or larger) transport aircraft. The Predator can operate on a 5,000 by 75 foot (1,524 meters by 23 meters) hard surface runway with clear line-of-sight to the ground data terminal antenna. The antenna provides line-of-sight communications for takeoff and landing.

The PPSL provides over-the-horizon communications for the aircraft and sensors (DD-12).

An alternate method of employment, Remote Split Operations, employs a GCS for takeoff and landing operations at the forward operating location while the CONUS based crew executes the mission via beyond-line-of-sight links (DD-12).

The aircraft has an ARC-210 radio, an APX-100 IFF/SIF with Mode 4, and an upgraded turbocharged engine. The latest upgrades, which enhance maintenance and performance, include notched tails, split engine cowlings, braided steel hoses and improved engine blocks (DD-13).

4. SEQUENCE OF EVENTS

a. Mission

The mishap sortie was an intelligence, surveillance, and reconnaissance mission flown in support of Operation ENDURING FREEDOM and was authorized by an Air Tasking Order (ATO) (Tab CC-3). The mishap crew (MC) consisted of the mishap pilot (MP), mishap sensor operator (MSO), and mishap mission intelligence coordinators (MMIC), and were assigned to the 15 RS, 432 WG, Creech AFB, NV (Tab V-3.3, V-4.3, V-5.2).

The MRPA's mission profile consisted of a crew from the Launch and Recover Element (LRE) launching the aircraft and several crews from the Mission Control Element (MCE) performing the ATO assigned mission, including the MC. The MP assumed control of the MRPA at 0200Z, approximately 14 hours into the mission and at that time the MSO had already been flying for about 2 hours (Tabs V-4.3, V-3.3, AA-3). The MMIC replaced the previous mission intelligence coordinator MIC at approximately 0500Z (Tab AA-3). Together, the MC controlled the MRPA for one hour and three minutes until the final lost link event occurred at 0603Z (Tab AA-3). Hand-off operations with the prior MCE crew were uneventful and the prior crew cited no abnormalities with the MRPA (Tabs R-7, R-8, V-3.4).

b. Planning

The MC planned the mishap sortie in accordance with Squadron Operating Procedures. The MC attended a mass briefing prior to assuming control of the MRPA, including weather, geography, terrain and airspace constraints associated with this mission (Tab CC-2).

c. Preflight and Launch

The mission was delayed for approximately 1.5 hours due to a Multi-Spectral Targeting System (MTS) malfunction that required maintenance personnel to replace a faulty component (Tab R-8). The LRE crew taxied and performed the launch without incident (Tab R-7).

d. **Summary of Accident**

The MRPA departed from Kandahar AB, Afghanistan at 1204Z on 2 Jan 11(AA-3.) During the first 16 hours of the mishap sortie, several crews, including the MC, executed the surveillance mission and experienced no abnormalities (Tabs EE-4, V-3.4,V-5.3).

At 0533Z on 3 January 2011, while in a surveillance orbit the MC observed a momentary "AV1 Power Supply Amps Low" warning and an "AV2 Power Supply Amps Low" warning (Tabs V-3.4, N-2, V-4.4). The power warnings cleared, however the crew discussed a return to base action and divert considerations (Tabs V-3.6, V-4.4). Roughly three minutes later, the MC observed a High Voltage warning and then lost satellite link with the MRPA for about 85 seconds (Tabs N-3). When the satellite link was re-established at 0539Z, the MC had indications that both alternators were off-line and that the MRPA was operating solely on back-up battery power (Tabs V-3.5, V-4.4, N-3). At 0539Z the MRPA was west of Kandahar AB and the MC elected to return to base (RTB) (Tab CC-3 – 4). The MC then executed the Dual Alternator Failure Checklist, and turned off all unnecessary components and accelerated the aircraft to 115 knots indicated airspeed (KIAS) to expedite the RTB (Tabs N-3, V-3.6, V-3.9, V-3.10, V-5.4). The MC also coordinated their RTB profile with the Squadron Operations Supervisor, the Launch and Recovery Element (LRE) in Kandahar, and the regional air traffic control (Tab CC-3). The MC attempted to give control of the MRPA to the LRE crew during the RTB but was unsuccessful due to the distance to the ground control station (GCS) (Tabs N-9, CC-3). At 0601Z, anticipating they were minutes from losing control of the MRPA, the MP turned the MRPA 20 degrees to the left to avoid crashing in populated area (Tabs N-10, V-3.7). At 0603Z, approximately 30 minutes from the first power warning, the MC lost satellite link permanently (Tabs N-10, EE-7, V-3.7). The last known position of the MRPA was approximately 100 nm west of Kandahar (Tabs CC-4, EE-Fig 8). The MRPA continued flying for some unknown amount of time after losing the satellite link when it exhausted back-up battery power and crashed southwest of its last known position (Tab EE-7.)

e. **Impact**

The MA crashed at some unknown time after 0603Z, on 3 J anuary 2011. The wreckage of the MRPA was located southwest of its last known position.

f. **Life Support Equipment, Egress and Survival**

Not applicable.

g. **Search and Rescue (SAR)**

Not applicable.

h. **Recovery of Remains**

Not applicable.

5. MAINTENANCE

a. Forms Documentation

All forms were documented in accordance with (IAW) Technical Order (T.O.) 00-20-1. There was one open discrepancy noted on the aircraft maintenance forms for the check flight of the Multi-spectral Targeting System MTS, but was not relevant to the mishap (Tab U-5).

b. Inspections

All scheduled inspections were accomplished within scheduled time limits, and there were no overdue aircraft Time Compliance Technical Orders (TCTO). The next scheduled inspection for the MRPA was the 150 hour airframe phase inspection that was due in 55 flight hours (Tab D-63).

c. Maintenance Procedures

On 27 Dec 2010 Engine E3221 was replaced with E3944 IAW T.O. 1Q-1(M)B-2-72-00-2 (Tab D-2). In process inspections (IPI) and Quality Assurance (QA) inspections were completed IAW T.O. 1Q-1(M) B-2-61JG-00-1 (Tabs D-10 – 11, D-19).

On 1 Jan 2011, approximately eleven hours before the mishap sortie, the batteries were topped off in accordance with (IAW) 1Q-1(M)B-2-12JG-10-1 (Tab D-62).

There were two maintenance procedural errors that were not relevant to the mishap (Tab CC-9).

d. Maintenance Personnel and Supervision

MQ-1B Predator aircraft maintenance services at Kandahar, Afghanistan are performed exclusively by Battlespace Flight Services BFS employees. There is no evidence in the training records for the BFS personnel who performed maintenance on the MRPA in the days prior to the mishap to indicate they were not properly qualified on the maintenance tasks performed. Maintenance personnel and supervision for the MRPA were not relevant to the mishap.

e. Fuel, Hydraulic and Oil Inspection Analysis

Fuel samples from the Kandahar AB fuel supply were quarantined. There is no evidence to suggest fuel was a factor in the mishap (Tab J-1).

The MQ-1 does not have a hydraulic system.

The MRPA was serviced with commercial 1 qt oil containers and no oil lot existed to draw post mishap oil samples. As is standard procedure, there are no pre-flight oil samples taken.

Due to the MRPA being destroyed on impact, there were no post flight fuel or oil samples available. There is no evidence to suggest petroleum, oils or lubricants contributed to the mishap.

f. Unscheduled Maintenance

There were no unscheduled maintenance actions on the MRPA relevant to the mishap (Tab CC-9).

6. AIRCRAFT AND AIRFRAME

a. Condition of Systems

The MRPA was completely destroyed on impact with terrain. Due to extensive scavenging by local nationals, most of the aircraft was not recovered. Several items recovered included the secondary control module (SCM), the Dual Alternator Regulator (DAR), various electronic cables and miscellaneous components (Tab S-4 – 7).

b. Testing

There were no system tests other than post mishap component testing completed.

c. Functionality of Equipment

Alternator #1 experienced a front bearing failure that caused its temperature to rise abnormally for over 90 minutes. When Alternator #1's front bearing failed completely, random drag on the belt induced erratic alternator current, voltage and engine RPM. There is no evidence of a disconnected cooling air hose or electrical failure, both of which would have resulted in rapid temperature increase (Tab EE-8).

Due to voltage variations on the power bus, the DAR automatically attempted to rebalance the alternator output (Tab EE-4). Alternator #1 was disabled for five seconds, leaving Alternator #2 carrying the entire bus load of around 70 amps. After 5 seconds, the alternators switched, and Alternator #1 was re-enabled and Alternator #2 was disabled, leaving Alternator #1 carrying the entire bus load of around 70 amps. After another five seconds, Alternator #2 was re-enabled, allowing both alternators to share the load of around 35 amps each (Tab EE-5).

With the DAR unable to tightly balance alternator output due to the switching, a high voltage bus spike was sensed by both the DAR and payload power distribution module (PPDM) (Tab EE-10). The satellite link system is powered through the PPDM, so when the PPDM disabled its output, the satellite link was disabled. Once the bus voltage dropped to a safe level, power was restored to the PPDM outputs. The lost satellite link event lasted 85 seconds, roughly the amount of time necessary for the satellite link system to reboot itself (Tabs EE-6, EE-9). While the DAR attempted to rebalance the alternator loads, Alternator #1 caused a second over-voltage event while Alternator #2 was being brought on-line, the DAR took both alternators off-line

permanently. This is because the alternator outputs are connected together and when the DAR is unable to determine which alternator causes an event, it shuts down both (Tab EE-8).

d. **Post Mishap Component Testing**

The recovered DAR assembly successfully passed its Production Test Procedure (PTP), indicating normal load regulation and load-balancing, and confirmed that the fuses were intact. Thermal temperature testing showed normal operation over a range of -55° C to +71° C (Tab EE-9).

The recovered secondary control module (SCM) had two open fuses. Because the fuses are on the high-side of the remote mounted relays, the fuses were blown open upon impact due to random electrical shorts occurring as the airframe broke up. If the fuses had been open before the start of the mission, the pre-flight ignition test could not have been completed. Even if the fuses had opened in flight, they in no way could have affected engine operation. Other than the fuses, the SCM was operating normally (Tab EE-9).

It was concluded that the DAR and SCM functioned properly and did not contribute to the mishap (Tab EE-9).

7. WEATHER

Weather was within operational limits, and there was no evidence to suggest weather was a factor in the mishap (Tab CC-3).

8. CREW QUALIFICATIONS

a. **Mishap Pilot**

(1) Training

The MP has been a qualified MQ-1B pilot since 30 April 2009. He upgraded to mission instructor pilot on 21 November 2010. Additionally, the MP was qualified as a launch and recovery (LR) pilot since 4 November 09 (Tab G-16).

(2) Experience

At the time of the mishap, the MP's total flight time is 1260.0 hours, which includes 1011.6 hours in the MQ-1B (Tab G-2).

The MP's flight time during the 90 days before the mishap is as follows (Tab G-3):

MP	Hours	Days Flown
Last 30 Days	44.9	11
Last 60 Days	117.5	27
Last 90 Days	181.1	42

b. **Mishap Sensor Operator**

(1) Training

The MSO has been a qualified MQ-1B sensor operator since 9 December 2009 (Tab AA-4).

(2) Experience

The MSO's total MQ-1B flight time is 809.7 hours (Tab G-9).

The MSO's flight time during the 90 days before the mishap is as follows (Tab G-10):

MSO	Hours	Days Flown
Last 30 Days	53.6	10
Last 60 Days	79.1	20
Last 90 Days	164.0	36

There is no evidence to suggest crew qualifications were a factor in this mishap.

c. **Mishap Mission Intelligence Coordinator**

(1) Training

The MMIC has been a qualified MQ-1B mission intelligence coordinator since 18 June 2010 (Tab T-3).

(2) Experience

At the time of the mishap, the MMIC had over 6 months operational experience as MQ-1B mission intelligence coordinator (Tab V-5.2).

9. MEDICAL

a. **Qualifications**

At the time of the mishap, all personnel were fully medically qualified for flight duty without medical restrictions or waivers.

b. **Health**

The 72-hour histories and the 14-day histories for the MP, MSO, and MMIC revealed no significant health concerns. There is no evidence to suggest that the health of the MP, MSO, or MMIC were relevant to the mishap.

c. **Toxicology**

Immediately following the mishap, commanders directed toxicology testing for all personnel involved in the flight and the launch of the MRPA. Blood and urine samples were submitted to the Armed Forces Institute of Pathology (AFIP) for toxicological analysis. This testing included carbon monoxide and ethanol levels in the blood and drug testing of the urine.

The carboxyhemoglobin saturation in the blood samples of MP, MSO and MMIC were within normal limits.

AFIP examined the blood for the presence of ethanol at a cutoff of twenty milligrams per a deciliter. AFIP detected no ethanol in the blood of the MP, MSO, or MMIC.

Furthermore, AFIP screened the urine of MC members and maintenance members for amphetamine, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates and phencyclidine by immunoassay or chromatography. AFIP detected none of these drugs in the MP, MSO, MMIC or maintenance members (Tab CC-7).

d. **Lifestyle**

There is no evidence that unusual habits, behavior or stress on the part of the MP, MSO, MMIC or maintenance crew members contributed to this accident. The 72-hour and 14-day histories revealed no evidence that suggests lifestyle factors, including unusual habits, behavior or stress contributed to the mishap.

e. **Crew Rest and Crew Duty Time**

Air Force Instructions require pilots have proper "crew rest," as defined in AFI 11-202, Volume 3, *General Flight Rules*, 22 Oct 10, prior to performing in-flight duties. AFI 11-202 defines normal crew rest as a minimum 12-hour non-duty period before the designated flight duty period (FDP) begins. During this time, 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.

A review of the duty cycles of the MP, MSO and MMIC leading up to the mishap indicated that they had adequate crew rest. The MP, MSO and MMIC complied with the crew rest and duty day requirements on the day of the mishap. None of the crew indicated they suffered from stress, pressure, fatigue or lack of rest prior to or during the mishap sortie. There is no evidence to suggest that fatigue was a factor in this mishap.

10. OPERATIONS AND SUPERVISION

The 15 RS operations tempo was moderate at the time of the mishap. Launch and recovery qualified aircrew fill normal deployment rotations in support of OPERATION ENDURING FREEDOM and OPERATION NEW DAWN. Sorties flown by the 15 RS are broken into 8 hour shifts with opportunities for at least a 2 hour break during the shift. There were no issues with supervision in the 15 RS at the time of the mishap. There is no evidence to suggest that operations tempo or supervision were a factor in the mishap.

11. HUMAN FACTORS

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. AFI 11-2MQ-1, Volume 1, MQ-1 Aircrew Training, 21 January 2010
2. AFI 11-2MQ-1, Volume 2, MQ-1 Crew Evaluation Criteria, 28 November 2008
3. AFI 11-2MQ-1, Volume 3, MQ-1 Operations Procedures, 29 November 2007
4. AFI 11-202, Volume 3, General Flight Rules, 22 October 2010
5. AFI 11-401, Aviation Management, 10 December 2010
6. AFI 11-418, Operations Supervision, 21 October 2005, incorporating Change 1, 20 March 2007
7. T.O. 1Q-1(M)B-1, USAF Series MQ-1B and RQ-1B Systems, 1 November 2003, incorporating Change 13, 8 April 2009
8. T.O. 1Q-1(M)B-1CL-1, USAF Series MQ-1B and RQ-1B Systems Flight Checklist, 1 November 2003, incorporating Change 15, 8 April 2009

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 August 2008
4. 1Q-1(M)B-2-72JG-00-1, MQ-1B Job Guide, Engine Reciprocating, General – Volume I, 1 September 2007
5. 1Q-1(M)B-2-53JG-00-1, MQ-1B Job Guide, Fuselage, Structures – General, 1 December 2006
6. 1Q-1(M)B-2-05JG-10-1, MQ-1B Job Guide, Aircraft General Ground Handling, 1 December 2006, incorporating Interim Operational Supplement, 17 April 2007

7. 1Q-1(M)B-6WC-1, MQ-1B Inspection Workcard, Preflight, Thruflight, Basic Postflight, Combined Basic Postflight/Preflight Inspection Requirements, 15 January 2007, incorporating Change 1, 5 March 2007
8. 1Q-1(M)B-6WC-2, MQ-1B Inspection Workcard, Aircraft Periodic Inspections and Maintenance Requirements, 21 August 2008

The AFIs listed above are available digitally on the AF Departmental Publishing Office internet site at: **http://www.e-publishing.af.mil.**

c. **Known or Suspected Deviations from Directives or Publications**

There are no known or suspected relevant deviations from directives or publications by the MC or maintenance members. Non-relevant deviations are discussed in Tab CC-9.

13. ADDITIONAL AREAS OF CONCERN

None.

8 March 2011

KARL FISCHBACH, Lt Col, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

MQ-1B, T/N 99-3061, ACCIDENT
3 January 2011

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 that the cause of the mishap was a failed front bearing in Alternator Number One (Alternator #1). As the front bearing failed, friction caused speed variations inside the Alternator #1 which triggered erratic bus voltage, alternator current and engine revolutions per minute (RPM) The Dual Alternator Regulator (DAR) was unable to compensate for the electrical variations, and disabled both alternators. Although the DAR is a fully redundant dual alternator controller, the MRPA aircraft uses a single power bus and alternator outputs are tied together. An over-voltage bus event caused by either alternator would make the DAR take both alternators off-line due to the DAR being unable to differentiate which alternator caused the event. With the alternator power sources disabled, flight continued on back-up power until battery power was exhausted, satellite link was severed, resulting in loss of control and subsequent crash of the MRPA.

2. DISCUSSION OF OPINION

Evidence shows that Alternator #1 experienced a front bearing failure that caused its temperature to rise abnormally for over 90 minutes. When Alternator #1's front bearing failed completely, random drag on the belt induced erratic alternator current, voltage and engine RPM. There is no evidence of a disconnected cooling air hose or electrical failure, both of which would have resulted in rapid temperature increase.

Due to voltage variations on the power bus, the DAR automatically attempted to rebalance the alternator output. Alternator #1 was disabled for five seconds, leaving Alternator #2 carrying the entire busload of 70 amps. After 5 seconds, the alternators switched, and Alternator #1 was re-enabled and Alternator #2 was disabled, leaving Alternator #1 carrying the entire bus load of 70 amps. After another five seconds, Alternator #2 was re-enabled, allowing both alternators to share the load of 35 amps each.

With the DAR unable to tightly balance alternator output, a high voltage bus spike was sensed by both the DAR and payload power distribution module (PPDM). The MC noticed initial high

voltage warning indications and then a lost link. The satellite link system is powered through the PPDM, so when the PPDM disabled its output, the satellite link was disabled. Once the bus voltage dropped to a safe level, power was restored to the PPDM outputs. The lost satellite link event lasted 85 seconds, roughly the amount of time necessary for the satellite link system to reboot itself.

While the DAR attempted to rebalance the alternator loads, Alternator #1 caused a second over-voltage event while Alternator #2 was being brought on-line, the DAR took both alternators off-line permanently. Because the alternator outputs are connected together and the DAR was unable to determine which alternator caused the event, it shut down both.

When the link was re-established, the MC had indications that both alternators had failed and the MRPA was operating on back-up battery power. They made the decision to terminate the current mission and executed the correct emergency procedures for dual alternator failure. The crew effectively coordinated their RTB profile with the Squadron Operations Superintendent, the Launch and Recovery Element (LRE) in theater, and regional air traffic control. The MC made an attempt to handover control to the LRE since it was possibly within range, but due to the distance to the airfield, the hand-off was unsuccessful. Although there was LRE line of sight control link being received by the aircraft, there was no evidence of a line of sight link being a contributing factor in the mishap.

The MC realized that the MRPA would lose power before they could make the airfield, so they controlled the MRPA heading away from a known populated area. The MRPA continued flying for some time after losing the satellite link. As the battery voltage dropped the MRPA electronics began to shutdown and the MRPA crashed southwest of its last known position.

I arrived at my opinion by examining the MRPA associated components, GA ASI Engineering Memorandum, recorded MRPA flight data, and witness testimony. All evidence points to a failure of the front bearing in Alternator Number One (Alt #1). After the initial power faults, alternator failure indications, and lost link conditions, the crew regained control of the MRPA and flew on back-up battery power for 18 minutes. During the event the MC exercised sound emergency procedures, mission execution considerations and crew coordination befitting a well qualified operational team.

8 March 2011

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