UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

EQ-4B GLOBAL HAWK, T/N 04-2017

12th RECONNAISSANCE SQUADRON
9th RECONNAISSANCE WING
BEALE AIR FORCE BASE

LOCATION: AFGHANISTAN

DATE OF ACCIDENT: 20 AUGUST 2011

BOARD PRESIDENT:
LIEUTENANT COLONEL MARK C. LOZIER

Conducted IAW Air Force Instruction 51-503

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION
EQ-4B, T/N 04-2017, Afghanistan
20 AUGUST 2011

On 20 August 2011, at approximately 1711 Zulu (Z) time, the mishap remotely piloted aircraft (MRPA), EQ-4B Global Hawk, tail number (T/N) 04-2017, crashed in Afghanistan, 9.4 hours after takeoff, while conducting a tasked communications relay mission. No injuries, damage to other government property, or damage to private property occurred as a result of the mishap.

The aircraft was assigned to the 9th Reconnaissance Wing at Beale Air Force Base (AFB), California, and was forward deployed to the 380th Air Expeditionary Wing in support of Operation ENDURING FREEDOM. The pilot flying the aircraft at the time of the mishap (MP1) was from the 12th Reconnaissance Squadron, Beale AFB, CA.

After normal pre-flight checks, the MRPA taxied and departed a Forward Operating Base (FOB) at 0745Z. Handover procedures from the Launch and Recovery Element pilot to the Mission Control Element (MCE) pilot were uneventful. At 1707Z, MP1 lost satellite link with the MRPA approximately 105 nautical miles (nm) northwest of Kandahar, Afghanistan with no other abnormal indications. The remote site operating the MRPA payload simultaneously lost all links with the payload. The MP1 ran appropriate lost link procedures, but was unable to reestablish communication with the MRPA. Off-board radar tracks showed that the MRPA departed controlled flight and started a high-speed descent approximately 25 seconds after losing satellite link with the MCE. 3 minutes later, the MRPA impacted remote, deserted terrain approximately 4 nm from its last reported position and was destroyed. The estimated loss is valued at $72.8M.

The Accident Investigation Board President could not find a cause supported by clear and convincing evidence; however, the Board President determined by a preponderance of the evidence that a substantially contributing factor was the failure of a single Line Replaceable Unit (LRU). Specifically, a partial separation of the LRU-X-1 JX connector led to interruption of electrical power to aileron and spoiler flight control actuators, rendering the aircraft uncontrollable. To keep this report unclassified and releasable, the generic term LRU or LRU-X-1 is used throughout, in lieu of naming the specific failed component. The Board President was not able to determine the exact cause of the LRU failure since the MRPA's avionics were not recovered from the crash site. The Board President also found, by a preponderance of the evidence, that LRU installation methods were a contributing factor in the mishap.

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.

SUMMARY OF FACTS AND STATEMENT OF OPINION
EQ-4B, T/N 04-2017
20 August 2011

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COMMONLY USED ACRONYMS & ABBREVIATIONS

AC	Alternating Current
ACC	Air Combat Command
AFB	Air Force Base
AFI	Air Force Instruction
AFSAS	Air Force Safety Automated System
AFSC	Air Force Safety Center
AFTO	Air Force Technical Order
AGE	Aircraft Ground Equipment
AIB	Accident Investigation Board
ATC	Air Traffic Control
ATO	Air Tasking Order
AWACS	Airborne Warning and Control System
BACN	Battlefield Airborne Communications Node
BLOS	Beyond Line of Sight
BPO/PR	Basic Post-Flight/Preflight
C-1	Aircraft Lost Link Logic
C-2	Aircraft Return to Base Logic
C-3	Aircraft Emergency Divert Logic
CAOC	Combined Air and Space Operations Center
CDL LOS RFA	Common Data Link Line of Sight Radio Frequency Assembly
COMACC	Commander, Air Combat Command
CND	Could not Duplicate
C/W	Complied With
DC	Direct Current
EAMXS	Expeditionary Aircraft Maintenance Squadron
E&E	Electro-Environmental
ePEX	Database to Track Aircrew Training
FADEC	Full Authority Digital Engine Control
FCB	Flight Critical Bus
FCIF	Flight Crew Information File
FCS	Flight Control System
FLT	Flight
FOB	Forward Operating Base
FOL	Forward Operating Location
GHOC	Global Hawk Operations Center
HE	Hawkeye
IAW	In Accordance With
ISS	Integrated Sensor Suite
IMDS	Integrated Maintenance Data System
IMMC	Integrated Mission Management Computer
INMARSAT	International Maritime Satellite
IO	Investigating Officer
ISB	Interim Safety Board
ISR	Intelligence, Surveillance, and Reconnaissance
Ku Link	Primary BLOS Command and Control Link
L	Local Time
L3	Subsidiary contractor to Northrop Grumman
LMR	Land Mobile Radio
LNO	Liaison Officer
LRE	Launch and Recovery Element
LRU	Line Replaceable Unit
MC	Mishap Crew(s)
MCE	Mission Control Element
mIRC	Internet Relay Chat software
MM	AIB Maintenance Member
MM(#)	Mishap Maintainer
MO	Maintenance Officer
MOA	Military Operating Area
MOC	Maintenance Operations Center
MP (#)	Mishap Pilot
MRPA	Mishap Remotely Piloted Aircraft
MSL	Mean Sea Level
MW(#)	Maintenance Witness
MWA	Military Weather Advisory
MX	Maintenance
OIC	Officer in Charge
ORM	Operational Risk Management
Ops Supe	Operations Supervisor
PCE-L	Payload Control Element - Launch
PCE-M	Payload Control Element - Mission
PLA	Power Lever Angle
QA	Quality Assurance
QRC	Quick Reaction Checklist
ROZ	Restricted Operating Zone
RPA	Remotely Piloted Aircraft
RS	Reconnaissance Squadron
RW	Reconnaissance Wing
SIB	Safety Investigation Board
T/N	Tail Number
Smoke House	BACN Maintenance area designation
TCTO	Time Compliance Technical Order
TO	Technical Order
U-2	High Altitude Manned Aircraft
UAV	Unmanned Aerial Vehicle
US	United States
USAF	United States Air Force
VOIP	Voice Over Internet Protocol
VSB	Vehicle Start Bus
Z	Zulu or Greenwich Mean Time (GMT)

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 21 Sep 11, Lieutenant General William J. Rew, Vice Commander Air Combat Command (ACC) appointed Lieutenant Colonel Mark C. Lozier to conduct a legal investigation of the 20 Aug 11 crash of an EQ-4B Global Hawk aircraft, tail number (T/N) 04-2017. The crash occurred in Afghanistan. The investigation, which was conducted at Beale Air Force Base (AFB) from 23 Sep 11 to 22 Oct 11, was carried out in accordance with (IAW) Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*. A Legal Advisor, Maintenance Member and Recorder were also appointed to the Accident Investigation Board (AIB). A Doctor of Aerospace Medicine was detailed as a Functional Area Expert (Tab Y-3 to Y-6).

b. Purpose.

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

2. ACCIDENT SUMMARY

The Mishap Remotely Piloted Aircraft (MRPA) EQ-4B, T/N 04-2017, lost satellite link with its controlling ground station during a mission on 20 August 2011, departed controlled flight and impacted the ground approximately 105 nautical miles (nm) northwest of Kandahar, Afghanistan (Tab J-5, CC-5). The aircraft was totally destroyed upon impact with the loss valued at $72.8M (Tab P-3). No further damage to government or private property occurred.

3. BACKGROUND

a. Units and Organizations

(1) Air Combat Command (ACC)

ACC, headquartered at Joint Base Langley-Eustis, Virginia, is a major command of the United States Air Force and primary force provider of combat airpower to America's warfighting commands. Its mission is to organize, train, equip, and maintain combat-ready forces for rapid deployment and employment while ensuring strategic air defense forces are ready to meet the challenges of peacetime air sovereignty and wartime air defense.

ACC operates fighter, bomber, reconnaissance, battle-management, and electronic-combat aircraft. It also provides command, control, communications, and intelligence systems and conducts global information operations. ACC's forces are organized under a direct reporting unit, three numbered air forces and one Air Force Reserve numbered air force. ACC's workforce is comprised of more than 96,000 active duty members and civilians, and when mobilized, more than 57,000 Air National Guard and Air Force Reserve members. In total, they operate more than 2,000 aircraft (Tab EE-3 to EE-5).

(2) 12th Air Force (12 AF)

The 12 AF, headquartered at Davis-Monthan AFB, Arizona, is responsible for the combat readiness of 10 active-duty wings and three direct reporting units in the western United States. The fighter and bomber wings possess 430 aircraft and more than 33,000 active-duty military and civilian personnel. The 12 AF also ensures the operational readiness of four Air Force Reserve wings and 13 Air National Guard wings, featuring an additional 18,800 people and more than 260 aircraft (Tab EE-7).

(3) 9th Reconnaissance Wing (9 RW)

The 9 RW, located at Beale AFB, California, is responsible for providing national and theater command authorities with timely, reliable, high-quality, high-altitude reconnaissance products. To accomplish this mission, the wing is equipped with the nation's fleet of U-2 Dragon Lady, RQ-4 Global Hawk, and MC-12W Liberty aircraft and associated support equipment. The wing also maintains a high state of readiness in its expeditionary combat support forces for potential deployment in response to theater contingencies. The 9 RW is composed of more than 3,000 personnel in four groups at Beale and multiple overseas operating locations (Tab EE-9 to EE-10).

(4) 12th Reconnaissance Squadron (12 RS)

The 12 RS, located at Beale AFB, California, provides theater commanders with near real-time intelligence, surveillance, and reconnaissance (ISR) and target acquisition data. The squadron operates and maintains deployable, long-endurance RQ-4B aircraft and ground-control elements to fulfill training and operational requirements generated by the Joint Chiefs of Staff in support of unified commanders and the Secretary of Defense (Tab EE-12 to EE-13).

b. Aircraft: EQ-4B Global Hawk

The Global Hawk is a high-altitude, long-endurance remotely piloted aircraft (RPA) that offers a wide variety of employment options. Unlike the ISR missions performed by the RQ-4B Global Hawk, the EQ-4B adaptation is designed to carry a communications payload known as BACN, or Battlefield Airborne Communications Node. BACN enables real-time information exchanges between different tactical data link systems, providing commanders both on the ground and in the air with instant access to critical information (Tab EE-18).

The Global Hawk aircraft is launched by a Launch and Recovery Element (LRE) located at the aircraft's forward operating base. Control is then handed off to the Mission Control Element (MCE), which controls the aircraft for the bulk of the mission. Pilots control the RPA from both the LRE and MCE ground stations (Tab EE-15 to EE-16).

4. SEQUENCE OF EVENTS

a. Mission.

The mishap sortie was a communications relay mission flown from the 380th Air Expeditionary Wing in support of Operation ENDURING FREEDOM and was authorized by an Air Tasking Order (ATO) (Tab CC-3). The pilot in command of the MRPA at the time of the mishap (MP1) was assigned to the 12th Reconnaissance Squadron (RS), 9th Reconnaissance Wing (RW), Beale Air Force Base (AFB), California (Tab V-1.2). Forward deployed maintenance personnel responsible for generating and launching the mishap sortie were assigned to the 380th Expeditionary Aircraft Maintenance Squadron (EAMXS) (Tab R-23 to R-45).

The MRPA's mission profile consisted of a crew from the LRE launching the aircraft and two crews from the MCE performing the ATO assigned mission (Tab R-3 to R-9, R-12 to R-22). The tasked mission for the MRPA was to provide both real-time information exchanges between different tactical data link systems, and line-of-sight (LOS) and beyond line-of-sight (BLOS) voice relay between tactical voice communication systems (Tab CC-3, EE-18).

MP1 assumed control of the MRPA at 1400 Zulu (Z) time, approximately 6.3 hours into the mission. MP1 controlled the MRPA for 3.1 hours until the lost link event occurred at 1707Z (Tab T-3, V-2.3). Hand-off operations with the prior MCE pilot (MP2) were uneventful and all prior crewmembers cited no significant abnormalities with MRPA systems or performance (Tab R-6, R-20 to 21, V-2.3 to 2.4, V-3.3).

b. Planning.

MP1 planned the mishap sortie in accordance with 12 RS standard procedures. Prior to assuming control of the MRPA, MP1 attended a step briefing, which included mission timing, requirements, weather, geography, intelligence, threats, and airspace constraints relevant to the mission (Tab R-5, CC-3). A designated Operations Supervisor verified that

MP1 was current with all training and go/no-go requirements, and cleared MP1 to proceed to the MCE to assume control of the MRPA (Tab K-2, T-4, T-5).

c. Preflight.

380th EAMXS maintenance crews prepared the MRPA for flight and towed the aircraft to its engine start location (Tab R-27 to R-33, R-38 to R-41, R-45). The "Hawkeye" pilot (HE), responsible for aircraft oversight during pre-launch ground operations, completed inspection of the aircraft maintenance forms and a visual inspection of the exterior of the MRPA. HE then notified the LRE pilot (MP3) that the aircraft was ready for engine start (Tab R-12 to R-14, V4.3, V4.4). After engine start, LOS communications links between the MRPA and the LRE, and BLOS satellite links between the MRPA and MCE were established. During the ground operations, MP3 followed the appropriate flight manual procedures to correct 4 link configuration problems, 3 avionics overheat faults, 1 navigation system fault, and 1 fuel pressure problem. These faults were routine and most rescinded prior to, or shortly after, takeoff. All were deemed non-factors in the mishap. MP3 performed the launch without further incident (Tab V-3.2, V3.3).

d. Summary of Accident.

The MRPA departed from its Forward Operating Base (FOB) at 0745Z on 20 August 2011 (Tab T-3). Handoff of MRPA control from MP3 to MP2 and subsequent transit to the mission orbit area were uneventful. All enroute MRPA and payload anomalies encountered were considered routine and were corrected through the use of flight manual procedures. MP2 verified that the mission orbit area was clear of any conflicting traffic or weapons firing areas as the MRPA approached the on-orbit location (Tab V-2.3, V-3.3). 6.3 hours into the mission, MP1 assumed control of the MRPA (Tab T-3). MP1 operated the MRPA in the mission orbit for approximately 3 hours with similar MRPA fault occurrences, corrective actions, and aircraft performance (Tab V-1.3).

At 1707Z, 9.4 hours into the mishap flight, MP1 lost all BLOS satellite communication links with the MRPA. The remote site payload operator simultaneously lost all communication links with the aircraft payload (Tab J-5). BLOS and BACN payload links depend on electrical power supplied from aircraft Direct Current (DC) flight critical (FCB) and vehicle start buses (VSB), as well as Alternating Current (AC) power from the engine driven primary AC generator. Regardless of electricity source, these links receive power via the aircraft Line Replaceable Unit (LRU) 'X-1' (Tab CC-9 to CC-11). To keep this report unclassified and releasable, the generic term LRU or LRU-X-1/2 is used throughout, in lieu of naming the specific failed or related components.

For the next 23 seconds following link loss, ground radar sites showed the MRPA maintaining within 10 degrees of its previously commanded easterly heading and staying within 300' of its commanded altitude. This small variance in altitude was consistent with normal atmospheric disturbances and indicated continued engine operation and ruddervator control (Tab J-5, J-7). However, the varying heading indicates a loss of aileron and spoiler control, and that the aircraft aerodynamics remained unchanged. Without roll axis authority, normal atmospheric turbulence caused the aircraft to depart controlled flight. At 17:07:52Z, radar plots then showed the MRPA starting an uncommanded high-speed descent. The erratic flight path, ground speed and extreme rate of descent indicate that the MRPA departed controlled flight above 51,000' Mean Sea Level (MSL) altitude (Tab J-8, J-9, M-8). Transponder equipment on the MRPA continued to report aircraft altitude to ground radar sites until 17:08:40Z, indicating that aircraft electrical power was still available to some MRPA sub-systems, through both LRU-X-1 and LRU-X-2, for the first minute after link loss. Similarly, the BACN payload sent out one final autonomous message at 17:07:47Z, also indicating that power was available to the payload after link loss (Tab J-5). Due to the electrical system design of the RQ-4, BACN payload power also indicates the engine and both primary AC and DC generators were operating as the MRPA departed controlled flight (Tab CC-9).

Ground radar continued to track the MRPA as it descended out of 50,000' MSL until losing radar contact at approximately 25,000' MSL. Radar tracks indicate that this 25,000' loss of altitude took approximately 1.5 minutes (Tab J-5). Photographs of the wreckage show that both wings and at least one of the lower aft fuselage fairings separated from the MRPA during the rapid descent (Tab J-11, J-12, S-25 to S-30).

A summary of the key points relative to the mishap sequence and RQ-4 design specifics follows:

- Aircraft and payload links fail simultaneously at 17:07:24Z; the links are powered independently, but are all controlled via LRU-X-1 (Tab J-5, CC-9 to CC-11)
- Even though links to the BACN remote site controller had failed, the BACN payload was still powered at 17:07:47Z (Tab J-5)
- MRPA maintained altitude and course until 17:07:52Z (Tab J-5, J-7)
- With an intact VSB and FCB bus, complete loss of aileron control is only plausible with internal damage near the JX connector of LRU-X-1 (Tab CC-12, CC-13)
- Aircraft engine and primary generators were operating as the aircraft departed controlled flight (Tab CC-9)
- MRPA IMMC, transponder, LRU-X-2, and partial LRU-X-1 power provided altitude information to radar sites until 17:08:40Z (Tab J-5, CC-11)
- Wing segments separated due to excessive aerodynamic loads after MRPA departed controlled flight (Tab J-11, J-12, S-15)

e. Impact.

Based on radar data, aircraft T/N 04-2017 impacted the terrain at approximately 1711Z on 20 August 2011 (Tab J-5). The wreckage of the MRPA was located approximately 4 nm east of its last reported position (Tab S-5). The fuselage was burned in a post-impact fire and subsequently destroyed during aerial bombardment by US forces (Tab S-25, S-31).

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.

Maintenance is documented on Air Force Technical Order (AFTO) 781 series forms and in the Integrated Maintenance Data System (IMDS). AFTO 781 series forms are hard copy forms used to document various maintenance actions and are maintained in a binder that is specifically assigned to each aircraft. IMDS is an automated database of aircraft discrepancies, maintenance repair actions, and flying history. A comprehensive review of all AFTO 781 series forms and IMDS was accomplished and revealed the MRPA was airworthy prior to the mishap sortie. At the time of the mishap, the MRPA total flight time was 1575.8 hours (Tab D-4).

All required Time Compliance Technical Orders (TCTO) had been completed at the time of the mishap or were appropriately deferred for later action (Tab D-15). All deferred TCTOs were reviewed and determined to be non-factors in the mishap.

Historical records in IMDS and the aircraft jacket files including aircraft weight and balance records, mission debriefs, inspections, and document review histories revealed only one recurring maintenance problem: intermittent engine faults associated with 7-10% higher than expected fuel flow (Tab U-9). With no evidence of in-flight fire and no plausible fuel-flow related scenarios to explain the systems failures on the MRPA (Tab S-25 to S-30, U-9, CC-3, CC-12, CC-13), the intermittent engine faults were determined to be non-factors in the mishap.

Review of all maintenance forms documentation revealed no factors in the mishap.

b. Inspections.

Preflight (PR) inspections are required to be conducted prior to each flight. A PR was accomplished on the MRPA on the day prior to the mishap (Tab D-4). A production superintendent signed an exceptional release, which serves as a certification that the active forms were reviewed and ensures the aircraft is safe for flight. The PR inspection was completed at 1200L on 19 August 2011 (Tab D-4).

The EQ-4B does not have requirements for periodic major inspections. However, there are interval inspections due at various flight hour and sortie intervals. The most recent inspection of the MRPA was accomplished on 19 August 2011. Maintenance personnel performed a scheduled 500-hour engine inspection as well as 500-hour airframe and flight control inspections/free-play checks the day prior to the mishap sortie (Tab D-14). Engine records and Comprehensive Engine Management System (CEMS) data were reviewed; all engine internal and external inspections were current (Tab U-5 to U-7).

All scheduled inspections had been satisfactorily completed with the exception of an overdue aircraft wash (Tab D-14). Aircraft inspections were determined to be non-factors in the mishap.

c. Maintenance Procedures.

Multiple tasks were completed to include: preflight servicing, inspections, operational checkouts (all passed with satisfactory results), launch and recovery operations, and ground handling (Tab D-4 to D-13). Review of maintenance history and procedures revealed the LRU-X-1 was installed in the MRPA on 2 June 2011 (Tab U-3). During a post-mishap field inspection of in-service LRU-X-1s, 6 of 8 aircraft inspected had loose cap screws securing the LRU-X-1s in their cradles (Tab U-23, CC-13). Installation methods in use for LRU-X-1 were determined to be contributory to the mishap (Tab U-23).

d. Maintenance Personnel and Supervision.

Personnel assigned to the 380th Expeditionary Maintenance Squadron performed all maintenance actions on the mishap aircraft (Tab R-24 to R-43). It is evident that maintenance personnel were not adequately trained on the concept of prevailing torque or fully aware of the difference between the RQ-4A and RQ-4B model LRU-X installation procedures, specifically the requirement to use thread locking compound on B models. The installation procedure directs application of thread locking compound and setting torque on the cap screws 18-22 inch-pounds above prevailing torque (Tab U-23). A review of the training records for the maintenance personnel who performed maintenance on the MRPA in the days prior to the mishap indicate they were otherwise properly qualified on the maintenance tasks performed (Tab G-123 to G-153).

e. Fuel, Hydraulic and Oil Inspection Analysis.

Analysis of the fuel, oil, and hydraulic fluids could not be conducted because they were consumed by post-impact fire. Post-accident fluid analysis of the servicing equipment was conducted with normal results (Tab U-21). Fuel, hydraulic, and oil fluids used on the MRPA were determined to be non-factors in the mishap.

f. Unscheduled Maintenance.

Unscheduled maintenance was performed during the ground interval between previous flight of the MRPA and the mishap event. Aircraft and payload pre-flight preparations, servicing, and other minor maintenance tasks were accomplished. Aircraft batteries were disconnected and reconnected, engine power runs were conducted, and the mid-nacelle panels were removed and reinstalled. The Common Data Link Radio Frequency Assembly (CDL RFA) was replaced to correct a discrepancy reported during the previous mission. Upon installation, all operational checkouts were satisfactory (Tab D-6 to D-13).

Civilian contractors removed and replaced one component of the BACN payload, which was installed on the mishap aircraft. This was done to facilitate the maintenance being performed on the CDL RFA (Tab D-7, D-12).

No expendables or other items were replaced, repaired, tested, or overhauled in preparation for mission launch. All other necessary repairs or replacements were properly made when required, independent of maintenance schedules. Unscheduled maintenance performed prior to the mishap sortie was determined to be a non-factor in the mishap.

6. AIRCRAFT AND AIRFRAME SYSTEMS

a. Condition of Systems.

Aircraft condition summation is limited since the aircraft wreckage was destroyed for operational security of sensitive materials. Various structures were identified in images taken of the crash site, including flight control surfaces, large sections of both wings, the aft fuselage section (boat tail), and engine (Tab S-25 to S-31).

There are no manufacturers or vendors of components, accessory systems, or products that may be linked to the cause of the accident. Depot level overhaul, repair, or testing of any components, accessory systems, or units is not suspected as a factor in the mishap. Until the lost link event, required aircraft equipment was functioning adequately.

The LRE and MCE shelters were impounded following the mishap in order to secure existing flight data and to test for proper operation. Both shelters were subsequently cleared for further flight operations, released from impound, and were determined to be non-factors in the mishap (Tab U-12 to U-17).

b. Testing.

Northrop Grumman and Raytheon contractors analyzed the data logger files from the LRE and MCE ground segments. Both LRE and MCE ground segments were verified operational and returned to service on 27 August, 2011 and 10 September, 2011 respectively (Tab U-13, U-17). Aircraft components were not recoverable from the crash site; therefore, no subsequent testing or teardown analysis of MRPA components was possible.

Northrop Grumman performed testing on similar equipment to assess the adequacy of installation design and the guidance in the TO installation procedure for the LRU-X-1. Results supported the possibility of partial disengagement of the JX connector leading to loss of aileron control (Tab DD-4, DD-5).

7. WEATHER

The forecasted weather at mission altitude over Afghanistan at the time of the incident predicted variable winds at 10 knots, ambient temperatures below -70° Celsius, with no turbulence or other weather hazards. There were no other significant weather issues in the forecast (Tab F-3 to 17).

Classified telemetry from the MRPA confirmed the accuracy of the forecasted weather (Tab CC-3). Weather was within operational limits, and there was no evidence to suggest weather was a factor in the mishap.

8. CREW QUALIFICATIONS

a. Mishap Pilot 1 (MP1)

(1) Training

MP1 completed initial Global Hawk qualification on 13 June 2008 and upgraded to mission instructor pilot on 27 August 2010 (Tab G-24, G-13). MP1 had just completed requalification training on 18 August 2011 after returning from an extended deployment (Tab G-5, G-6).

(2) Experience

Prior to the mishap sortie, the MP1's total flight time was 1573.3 hours, which includes 350.2 hours in the RQ-4 (Tab G-35). MP1's flight time during the 90 days before the mishap is as follows (Tab G-36, G-37):

Note: Flight time logged 61-90 days prior to the mishap was in the MC-12W airframe while MP1 was deployed.

	Hours	Sorties
30 days	20.6	8
60 days	24.6	10
90 days	119.5	29

b. MCE Pilot (MP2)

(1) Training

MP2 completed initial Global Hawk qualification on 18 April 2011 (Tab G-54).

(2) Experience

Prior to the mishap sortie, the MP2's total flight time was 3598.7 hours, which includes 86.1 hours in the RQ-4 (Tab G-102). MP2's flight time during the 90 days before the mishap is as follows (Tab G-103):

	Hours	Sorties
30 days	61.9	15
60 days	80.7	22
90 days	88.5	27

c. LRE Pilot (MP3)

(1) Training

MP3 completed initial Global Hawk qualification on 9 March 2011 and completed LRE qualification on 14 August 2011 (Tab T-7, T-14).

(2) Experience

Prior to the mishap sortie, MP3's total flight time was 2132.5 hours, which includes 193.3 hours in the RQ-4 (Tab T-9). MP3's flight time during the 90 days before the mishap is as follows (Tab T-10):

	Hours	Sorties
30 days	15.9	5
60 days	26.4	10
90 days	98.4	25

d. Hawkeye Pilot (HE)

(1) Training

HE completed initial Global Hawk qualification on 17 March 2011 (Tab T-16).

(2) Experience

Prior to the mishap sortie, HE's total flight time was 4873.4 hours, which includes 129.9 hours in the RQ-4 (Tab T-18). HE did not log flight time on the mishap sortie, so the flight summary for the previous 90 days is not shown.

9. MEDICAL

a. Qualifications.

All crewmembers were medically qualified for flight duty at the time of the mishap (Tab CC-7).

b. Health.

A review of the post-accident medical examination records in the Armed Forces Health Longitudinal Technology Application (AHLTA), as well as the Interim Safety Investigation Board memorandum and the Medical Record Review from the 9 AMDS/SGPF, revealed that health factors were not related to the accident (Tab CC-7).

c. Toxicology.

A review of the results of post-mishap toxicology reports revealed that toxicological factors were not related to the mishap (Tab CC-7).

d. Lifestyle.

After reviewing the 72 hour and 14 day histories, etc, there is no evidence that unusual habits, behavior or stress (on the part of the mishap pilots or maintainers) contributed to the accident (Tab CC-7).

e. Crew Rest and Crew Duty Time.

All crew rest and crew duty time requirements were met and therefore are not a factor in this investigation (Tab CC-7).

10. OPERATIONS AND SUPERVISION

a. Operations.

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

b. Supervision.

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

11. HUMAN FACTORS ANALYSIS

There is no evidence that human factors contributed to this mishap (Tab CC-7).

12. ADDITIONAL AREA OF CONCERN

Post-mishap analyses of in-service LRU-X-1 cap screws reflect a significant departure from required TO values of 18-22 inch-pounds above prevailing torque (Tab U-23, CC-13). The installation procedure for the cap screws was revised with the introduction of the RQ-4B to include steps 6-8, which direct cap screw removal, lock washer inspection, and use of thread locking compound during cap screw re-installation to properly restrain the LRU in its mounting cradle (Tab U-23, V-7.3). Improper torque, insufficient use of thread locking compound or re-use of a deformed lock washer could allow the cap screws to vibrate loose during flight operations. Proper restraint of the LRU is required to ensure the inboard JX connector supplies continuous electrical power to the aircraft subsystems and components managed by the LRU-X-1 (Tab CC-11, CC-13). Although not deemed causal, insufficient cap screw torque is a probable contributory factor to the mishap.

13. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications.

1. AFI 11-2RQ-4, Volume 1, *RQ-4 Crew Training*, 3 February 2007
2. AFI 11-2RQ-4, Volume 2, *RQ-4 Crew Evaluation Criteria*, 9 January 2007
3. AFI 11-2RQ-4, Volume 3, *RQ-4 Operations Procedures*, 14 September 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*, 15 September 2011
7. AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010
8. AFI 91-204, *Safety Investigations and Reports*, 24 September 2008
9. # Technical Order 1Q-4(R)A-2-WA-2 version 10.12.016, *Global Hawk Operation and Maintenance Manual Set*, 15 September 2011

b. Maintenance Directives and Publications.

1. # Technical Order 1Q-4(R)A-2-WA-2 version 10.12.016, *Global Hawk Operation and Maintenance Manual Set*, 15 September 2011
2. AFI 21-101, *Aircraft and Equipment Maintenance Management*, 26 July 2010
3. * Technical Order 00-20-1, *Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures*, 15 June 2011
4. # Technical Order 1-1A-8, *Structural Hardware*, 1 October 2009
5. * Technical Order 1-1B-50, *Weight and Balance*, 1 April 2008

Notes:

- All AFIs are available at: http://www.e-publishing.af.mil/
- * TO available at: http://www.tinker.af.mil/technicalorders/index.asp
- # TO contains technical data whose export is restricted by the Arms Export Control Act (Title 22 U.S.C. SEC 2751, et seq.) or the Export Administration Act of 1979, as amended, Title 50, U.S.C., App 2401 et seq. Dissemination is controlled under DoD Directive 5230.25.

3 February 2012

MARK C. LOZIER, Lt Col, USAF
President, Accident Investigation Board

STATEMENT OF OPINION
EQ-4B, T/N 04-2017, ACCIDENT
20 AUGUST 2011

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:

Based on aircraft telemetry captured in the shelter data logs, radar information, maintenance records, witness interviews, and information provided by functional area experts, I find by a preponderance of the evidence that a substantially contributing factor was the failure of the Line Replaceable Unit (LRU) 'X-1' due to partial separation of the JX connector. This led to internal electrical damage to the LRU and subsequent inability of either Integrated Mission Management Computer (IMMC) to command both aileron and spoiler position. Unable to adjust aileron and spoiler position, the Mishap Remotely Piloted Aircraft (MRPA) departed controlled flight and crashed. Furthermore, I find by a preponderance of the evidence that LRU-X-1 installation methods were a contributing factor in the mishap. To keep this report unclassified and releasable, the generic term LRU or LRU-X-1 is used throughout, in lieu of naming the specific failed component.

2. DISCUSSION OF OPINION:

On 20 August 2011, EQ-4B tail number 04-2017 lost satellite links with its controlling ground station and crashed. Initially, the MRPA maintained level flight with small heading deviations, and continued to broadcast altitude data via the aircraft transponder, as well as a payload message 23 seconds after link loss. This data indicates that the engine, both primary electrical generators, the ruddervators, at least one IMMC, and electrical power to the B side of the Vehicle Start Bus (VSB) were all still operating when the aircraft departed controlled flight. At an undetermined point within that 23-second window, the redundant power paths from the A and B side Flight Control Buses (FCB) and VSBs to the wing flight control actuators failed due to internal damage to LRU-X-1. Although the FCB bus was still operating, the IMMCs were unable to position the ailerons to control the roll attitude of the MRPA. Normal atmospheric disturbances would have then created enough of a roll imbalance to cause the MRPA to depart controlled flight approximately 30 seconds after link loss. At this point, an IMMC and a flight critical bus were known to be operating, since the aircraft transponder continued to transmit altitude responses to ground radar site interrogations.

It was determined that complete aileron failure, with a known operational FCB bus, could only be tied to a partial disconnect of the LRU-X-1 JX connector, coupled with further electrical damage to the adjacent B side VSB or 1553 data buses. All other possible failure modes of LRU-X-1 that could result in complete loss of aileron control were deemed implausible due to: the known operating states of the Battlefield Airborne Communications Node payload, aircraft transponder operation after the MRPA lost link and departed controlled flight, and redundancy of the RQ-4 design.

During the uncontrolled descent, radar sites recorded two abrupt course reversals and speeds well in excess of aircraft design limits. Based on identification of most of the wing structures near the impact site of the fuselage, and the initial aircraft performance after link loss, separation of a flight control surface was ruled out as causal to the event. Separation of wing sections from the MRPA fuselage also occurred below an altitude of 50,000 feet, well after the MRPA had departed controlled flight.

Other MRPA subsystem failures that could have resulted in LRU-X-1 damage were all ruled out. Crash site imagery, both classified and unclassified, show all fire damage to the fuselage to be post-impact. Recurring high fuel flow indications could not be tied to the symptoms demonstrated during the mishap. With no active restricted airspace near the MRPA associated with artillery fire, no other aircraft nearby, and no threat systems in the area capable of damaging the MRPA, all scenarios external to the MRPA capable of inducing damage to LRU-X-1 were similarly ruled out.

During our investigation, we discovered loose wedge-lock cap screws on another RQ-4B Global Hawk at Beale AFB. Subsequent inspection of in-service LRU-Xs on a total of 10 RQ-4Bs at multiple bases revealed 6 LRU-X-1s and 9 LRU-X-2s that were improperly restrained in their mounting cradles. Witness testimony and Northrop Grumman research also indicated that some Air Force maintainers and Northrop Grumman technicians were unfamiliar with appropriate Technical Order steps governing LRU-X installation on the B model Global Hawk.

Multiple possibilities exist that could lead to separation of the JX connector. Incomplete engagement of the JX connector could be the result of an obstruction at the JX plug, tightening the wedge-lock cap screws out of sequence during install, or loose wedge-lock cap screws due to: in-flight vibration, insufficient use of thread locking compound, re-use of deformed lock washers, and/or applying incorrect torque settings during installation. None of these can be conclusively labeled as causal since the recovery of the MRPA LRU-X-1 was not possible; however, a preponderance of the evidence supports the conclusion that the LRU-X-1 on the MRPA was improperly secured, and that LRU-X-1 installation methods were therefore a contributing factor in the mishap.

3 February 2012

MARK C. LOZIER, Lt Col, USAF
President, Accident Investigation Board

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