UNITED STATES AIR FORCE
ABBREVIATED AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

MQ-9A, T/N 11-4129

SECOND SPECIAL OPERATIONS SQUADRON
919TH SPECIAL OPERATIONS WING
KANDAHAR INTERNATIONAL AIRPORT

LOCATION: AFGHANISTAN
DATE OF ACCIDENT: 18 MAY 2015
BOARD PRESIDENT: LIEUTENANT COLONEL DAWN JUNK

Conducted Pursuant to Chapter 11 of Air Force Instruction 51-503

United States Air Force Abbreviated Accident Investigation Board Report

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
ABBREVIATED AIRCRAFT ACCIDENT INVESTIGATION

MQ-9A, T/N 11-4129
AFGHANISTAN
18 MAY 2015

On 18 May 2015, at approximately 1159 hours zulu time (z), an MQ-9A, tail number 11-4129, assigned to the 27th Special Operations Wing at Cannon Air Force Base (AFB), and deployed to Kandahar International Airport, crashed in a remote area of Afghanistan after the aircraft was inadvertently flown into a thunderstorm. While in the thunderstorm, at 1155z the mishap aircraft (MA) stopped responding to control inputs from the mishap mission control element (MMCE). The MA then took a sharp descending left turn and continued to descend rapidly until approximately 5,000 feet mean sea level, at which time all connection between the MMCE and the MA was lost. The MA and its payload of four missiles crashed in a remote area in Afghanistan and consequently destroyed. The value of the estimated total loss was $12,911,715. There were no fatalities and no damage to private property.

A launch and recovery element (LRE) at Kandahar International Airport launched the MA at 0006z. Shortly after an uneventful take-off, the LRE transferred control of the MA to the mission control element (MCE) at Hurlburt Field, FL under the 2d Special Operations Squadron. The weather at that time was mostly clear in the area where the aircraft would operate, with some scattered storms farther to the northeast. For nearly 10 hours of uninterrupted flight time, four MCE crews controlled the MA. None of the first four MCE crews noticed any anomalies with the aircraft. There were some scattered clouds, but the weather was not a significant obstacle for the first four crews. At 1000z, the MMCE crew took control of the aircraft and at 1115z directed the aircraft to a new area of operations. Enroute to the new area of operations, cumulus clouds were rapidly forming in the assigned area. Once in the assigned location, the MMCE crew navigated to avoid the developing thunderstorms. At approximately 1144z, the MA began to encounter significant turbulence, icing conditions and obstructed vision as they inadvertently entered a cloud concealing substantial inner cloud lightning energy. At approximately 1155z, the MA lost connection with the MMCE and stopped responding to control inputs by the mishap pilot (MP). The aircraft then took a sharp descending left turn and displayed numerous and significant warning messages to the MMCE until 1159z, when all connectivity from the MMCE to the MA was lost.

The Abbreviated Accident Investigation Board President found, by a preponderance of the evidence, that the cause of the mishap was a direct or near lightning strike to the MA, resulting in multiple aircraft system failures and loss of aircraft controllability.

SUMMARY OF FACTS AND STATEMENT OF OPINION
MQ-9A, T/N 11-4129
18 MAY 2015

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS iii
SUMMARY OF FACTS 1
1. AUTHORITY AND PURPOSE 1
a. Authority 1
b. Purpose 1
2. ACCIDENT SUMMARY 1
3. BACKGROUND 1
a. Air Force Special Operations Command (AFSOC) 2
b. 919th Special Operations Wing (919 SOW) 2
c. 2d Special Operations Squadron (2 SOS) 2
d. MQ-9A Reaper 2
e. Thunderstorm Lightning 3
4. SEQUENCE OF EVENTS 4
a. Mission 4
b. Planning 4
c. Preflight 4
d. Summary of Accident 5
e. Impact 7
f. Egress and Aircrew Flight Equipment (AFE) 8
g. Search and Rescue (SAR) 8
h. Recovery of Remains 8
5. MAINTENANCE 8
a. Forms Documentation 8
b. Inspections 8
c. Maintenance Procedures 8
d. Maintenance Personnel and Supervision 8
e. Fuel, Hydraulic, and Oil Inspection Analyses 9
6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS 9
a. Structures and Systems 9
(1) Lightning Strike Protection 9
b. Evaluation and Analysis 9
7. WEATHER 10
a. Forecast Weather 10
b. Observed Weather 10
c. Space Environment 10
d. Operations 10
8. CREW QUALIFICATIONS 10
a. Mishap Pilot 11
b. Mishap Sensor Operator 11

9. MEDICAL 11
a. Qualifications 11
b. Health 12
c. Pathology 12
d. Lifestyle 12
e. Crew Rest and Crew Duty Time 12
10. OPERATIONS AND SUPERVISION 12
a. Operations 12
b. Supervision 12
11. HUMAN FACTORS 12
12. GOVERNING DIRECTIVES AND PUBLICATIONS 13
a. Publically Available Directives and Publications Relevant to the Mishap 13
b. Other Directives and Publications Relevant to the Mishap 13
c. Known or Suspected Deviations from Directives or Publications 13
STATEMENT OF OPINION 14
1. SUMMARY 14
2. BACKGROUND 14
3. CAUSE 15
4. SUBSTANTIALLY CONTRIBUTING FACOTRS 15
5. CONCLUSION 15
INDEX OF TABS 16

ACRONYMS AND ABBREVIATIONS

1 SOW	1st Special Operations Wing
2 SOS	2d Special Operations Squadron
432 WOC	432d Wing Operations Center
919 SOW	919th Special Operations Squadron
AF	Air Force
AFB	Air Force Base
AFE	Air Flight Equipment
AFI	Air Force Instruction
AFTO	Air Force Technical Order
AFSOC	Air Force Special Operations Command
AGM	Air to Ground Missiles
AIB	Accident Investigation Board
AOA	Angle of Attack
CD	Compact Disk
ETA	Estimated Time of Arrival
FOS	Flight Operations Supervisor
HUD	Heads-Up Display
Intel	Intelligence
IR	Infrared
Ku	Kurtz-under Band
LRE	Launch and Recovery Element
Lt Col	Lieutenant Colonel
MA	Mishap Aircraft
MAJCOM	Major Command
MCE	Mission Control Element
MCE P 1	Mission Control Element Pilot 1
MCE P 2	Mission Control Element Pilot 2
MCE P 3	Mission Control Element Pilot 3
MCE SO1	Mission Control Element Sensor Operator 1
MCE SO2	Mission Control Element Sensor Operator 2
MCE SO3	Mission Control Element Sensor Operator 3
MIC	Mission Intelligence Coordinator
MIRC	Microsoft Internet Relay Chat
MMCE	Mishap Mission Control Element
MP	Mishap Pilot
MSL	Mean Sea Level
MSO	Mishap Sensor Operator
MTS	Multi-Spectral Targeting System
NM	Nautical Miles
NOTAMs	Notices to Airmen
NV	NV
ORM	Operational Risk Management
OSS	Operation Support Squadron
RCM	Redundant Control Module
ROCW	Reaper Operation Cell Weather
RPA	Remotely Piloted Aircraft
SA	Situational Awareness
SAR	Search and Recovery
SMS	Stores Management System
SPMA	Switch Mode Power Amplifier
SQ/CC	Squadron Commander
TCTO	Time Compliance Technical Order
T/N	Tail Number
UARB	Universal Asynchronous RS-422
WOC	Wing Operations Command
z	Zulu

The above list assembled 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 2 February 2016, Major General Morris E. Haase, Vice Commander, Air Force Special Operations Command (AFSOC), appointed Lt Col Dawn Junk to conduct an abbreviated aircraft accident investigation of a mishap that occurred on 18 May 2015 involving an MQ-9A aircraft in Afghanistan (Tab Y-3). The abbreviated aircraft accident investigation was conducted in accordance with Air Force Instruction (AFI) 51-503, *Aerospace and Ground Accident Investigations*, Chapter 11, 14 April 2015, at Hurlburt Field, FL, from 8 February 2016 through 24 February 2016. Board members included a Major Legal Advisor, and a Senior Airman Recorder (Tab Y-3). Subject Matter Experts appointed to assist the board included a Captain Pilot and a Master Sergeant Maintainer (Tab Y-6).

b. Purpose

In accordance with AFI 51-503, *Aerospace and Ground Accident Investigations*, this accident investigation board conducted a legal investigation to inquire into all the facts and circumstances surrounding this Air Force aerospace accident, prepare a publicly releasable report, and obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative action.

2. ACCIDENT SUMMARY

On 18 May 2015, at approximately 1159 hours zulu time (z), an MQ-9A, tail number 11-4129, assigned to the 27th Special Operations Wing at Cannon Air Force Base (AFB), and deployed to Kandahar International Airport, crashed in a remote area of Afghanistan after the aircraft was inadvertently flown into a thunderstorm (Tabs V-1.10, AA-3, AA-6, DD-41). While in the thunderstorm, at 1155z the mishap aircraft (MA) stopped responding to control inputs from the mishap mission control element (MMCE) (Tab J-5). The MA then took a sharp descending left turn and continued to descend rapidly until approximately 5,000 feet mean sea level (MSL), at which time all connection between the MMCE and the MA ceased (Tab J-4). The MA and its payload of four missiles crashed in a remote area in Afghanistan and consequently destroyed (Tab P-2). The value of the estimated total loss was $12,911,715 (Tab P-2). There were no fatalities and no damage to private property (Tabs P-2, and DD-35).

3. BACKGROUND

The mishap pilot (MP) was assigned as a guest pilot to the 2d Special Operations Squadron (2 SOS), 919th Special Operations Wing, Air Force Special Operations Command (AFSOC), at Hurlburt Field, FL (Tabs V-1.13, and CC-8). The mishap sensor operator (MSO) is assigned to 2

SOS at Hurlburt Field, FL (Tab G-18). The MA belonged to the 27th Special Operations Wing, AFSOC, at Cannon AFB, NM, deployed to Kandahar International Airport (Tabs AA-3).

a. Air Force Special Operations Command (AFSOC)

AFSOC's primary mission is to organize, train and equip Airmen to execute global special operations as America's Air Commandos (Tab CC-3). AFSOC is one of ten Air Force major commands (MAJCOM) and is the Air Force component of United States Special Operations Command (Tab CC-3). AFSOC has more than 19,500 active duty, Air Force Reserve, Air National Guard, and civilian personnel operating in several subordinate units, including the 919th Special Operations Wing at Duke Field, FL (Tab CC-4 to CC-5). The core missions of AFSOC include, among others, battlefield air operations, combat support, precision strike, information operations, specialized air mobility and intelligence, surveillance and reconnaissance (Tab CC-4).

b. 919th Special Operations Wing (919 SOW)

The 919 SOW, located at Duke Field, FL is the only special operations wing in the Air Force Reserve (Tab CC-9). In wartime or a contingency, the wing reports to AFSOC as the gaining MAJCOM (Tab CC-8). Among other missions, the 919 SOW employs unmanned aerial systems geographically separated but associated with the 27th Special Operations Wing, Cannon Air Force Base AFB, NM (Tab CC-8). The 919 SOW is comprised of three groups and 13 squadrons, including 2 SOS (Tab CC-8 to CC-9).

c. Second Special Operations Squadron (2 SOS)

The 2 SOS is the remotely piloted aircraft unit of the 919 SOW, operating the multi-role aircraft MQ-9A (Tab CC-16). The 2 SOS consists of approximately 140 Air Force reservists (Tab CC-16). Formely based at Nellis AFB, NV, 2 SOS moved operations to Hurlburt Field, FL and switched from the MQ-1 to the MQ-9A in 2014 (Tab CC-16).

d. MQ-9A Reaper

The MQ-9A Reaper is an armed, medium-altitude, long endurance aircraft that is employed primarily to strike dynamic execution targets and secondarily for intelligence collection (Tab CC-18). The MQ-9A provides unique capabilities for strike coordination and reconnaissance against high value, fleeting and time sensitive targets because of its significant loiter time, wide-range sensors, multi-mode communications suite and precision weapons (Tab CC-18). In addition to its primary uses, the MQ-9A also performs close air support, combat search and rescue, target development and terminal air guidance, among others, making it uniquely qualified for irregular warfare operations (Tab CC-18). It can employ up to four Air to Ground Missiles (AGM)-114 Hellfire missiles, which provide highly accurate, low-collateral damage,

anti-armor and anti-personnel engagement capabilities (Tab CC-18). A Launch and Recovery Element (LRE) ground control station operates the MQ-9A for take-off and landing segments at a forward operating location, while a crew at another location controls the remainder of the mission with beyond line-of-sight satellite links (Tab CC-19). The crew consists of a rated pilot to control the aircraft and command the mission and an enlisted aircrew member to operate sensors (Tab CC-20).

e. Thunderstorm Lightning

According to Air Force Instruction (AFI) 11-203VI, *Weather for Aircrews*, 12 January 2012, lightning strikes and electrical discharges are the leading causes of reportable weather related aircraft accidents in the Air Force (Tab BB-7). Lightning occurs at all levels in a thunderstorm (Tab BB-6). The majority of lightning discharges never strike the ground but occur between clouds or within a cloud (Tab BB-6). Lightning also occurs in the clear air around the top, sides and bottom of storms (Tab BB-6). The aircraft itself can trigger electrical discharges very similar to natural lightning (Tab BB-7). Electrical charges build on the aircraft as it flies through clouds, precipitation or solid particles, such as dust or ice (Tab BB-7). The aircraft's electrical field may then interact with charged areas of the atmosphere resulting in an electrical discharge (Tab BB-7). Research has shown that aircraft more commonly trigger strikes or discharges when, among other conditions, it is in light precipitation (Tab BB-7).

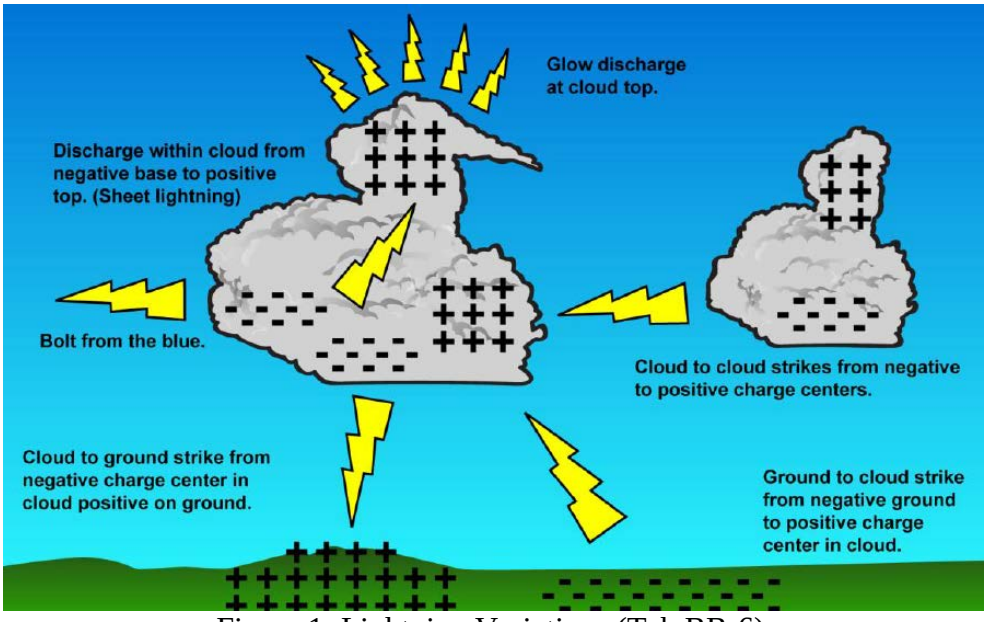

Figure 1: Lightning Variations (Tab BB-6).

Lightning strikes and electrical discharges have varied effects on aircraft (Tab BB-8). Typically, structural damage is minor but damage to aircraft electrical systems are common (Tab BB-8). MQ-9A pilots are to keep aircraft 25 nautical miles away from known thunderstorm activity (Tab BB-15). However, thunderstorms can move rapidly and form quickly in previously clear areas (Tab V-5.1). In the mountainous regions of Afghanistan, it is common for thunderstorm clouds to develop from a ceiling of 8,000 feet MSL up to 40,000 feet MSL in less than 15 minutes (Tab V-5.1). The MQ-9A has no built in protection against lightning and is not equipped with weather

radar equipment (Tabs BB-10, and V-11.3). The exact effects of lightning strikes are unknown on the MQ-9A; however, a direct strike could be expected to seriously damage, disable, or destroy the aircraft (Tab BB-10). The effects of lightning striking close to the aircraft could also be catastrophic, disabling aircraft electronics and interrupting the satellite link (Tab BB-10).

4. SEQUENCE OF EVENTS

a. Mission

The mission of the MA was to perform routine intelligence, surveillance and reconnaissance as authorized by the Combined Forces Air Component Commander in theater through a classified air tasking order (Tab V-11.1). An LRE crew at Kandahar International Airport launched the MA then performed a hand over, which transfers control of the MA from the LRE crew to an MCE crew at Hurlburt Field, FL (Tab V-7.1). Approximately every three hours a new MCE crew would take control, commonly referred to as a "crew swap" (Tabs V-2.3, and V-11.1). The final MCE crew on the day of the mishap was the mishap crew (Tab AA-6).

b. Planning

The LRE crew in Afghanistan and the MCE crews at Hurlburt Field completed mission planning (Tabs V-1.3, and V-7.1). The LRE crew received the mission tasking from squadron leadership at the 62nd Expeditionary Reconnaissance Squadron at Kandahar (Tab V-7.1). The MCE crew used standard mission planning procedures (Tab V-1.2). The LRE crew planned for executing the preflight, taxi, takeoff and handover of the MA to the MCE (Tab V-7.1). The LRE conducted mission planning according to standard procedures (Tab V-7.1).

At the MCE, mission planning consisted of a mass brief at approximately 2230z on 17 May 2015 (Tab V-1.13). All pilots and sensor operators for the mission attended this mass briefing, which the Flight Operations Supervisor (FOS) provided (Tab V-2.13). The mass briefing covered the general nature of the mission, location and weather (Tab V-2.13). The FOS stated at the mass briefing that there would be areas of restricted flying due to poor weather conditions, but that these areas were farther to the north and east of planned mission areas (Tab V-2.2). An additional individual crew briefing was conducted by the mishap crew approximately 15 minutes before taking control of the aircraft at 1000z (Tab V-1.2). The individual crew briefing was standard and covered tasking, aircraft condition, updated weather information, intelligence, tactical and emergency procedures (Tab V-1.2, and V-6.1).

c. Preflight

Prior to the scheduled 0000z take-off, the LRE crew conducted a walk-around of the aircraft and review of relevant aircraft maintenance forms (Tabs V-7.1, and AA-8). Prior to launch, the crews reviewed currencies, Notices to Airmen (NOTAMs), and weather reports (Tab V-7.1). Additionally, each pilot completed a standard Operation Risk Management (ORM) assessment used to identify and mitigate risks before flying the mission (Tab AA-13).

d. Summary of Accident

The MA took off from Kandahar at 0006z (Tab AA-6). The LRE pilot controlled the MA for approximately 18 minutes before transferring control to the first MCE crew at Hurlburt Field (Tabs V-7.1, AA-6). The take-off was routine and without issue, as were the first several minutes of flight (Tab V-7.1). The weather at Kandahar at the time was mostly clear with some scattered clouds (Tab V-7.1). The transition from LRE Crew to the MCE was smooth with no issues (Tab V-7.1).

Leadership at 2 SOS established a flying schedule where each MCE crew could fly any given MQ-9A in nine hour shifts (Tab V-11.1). During these shifts the crew would typically fly the aircraft for three hours, take a three-hour break for ancillary duties, exercise and food, and then return to the MCE for another three-hour flight (Tab V-11.1).

The first MCE crew gained control of the MA at 0024z and flew the MA to its designated area of operations (Tabs V-7.1, and AA-6). There were no issues with the performance of the MA during the first MCE crew's operation (Tab V-8.1). The weather at that time was mostly clear, with a thin and scattered cloud ceiling under the MA (Tab V-8.1). The first MCE sensor operator recalled the MA climbed through the clouds, but she did not see any thunderstorms (Tab V-8.1).

The second MCE crew took control of the MA at 0230z and controlled the MA until 0400z (Tab AA-6). The second MCE pilot reported his flying time on the day of the mishap as "typical" with no issues (Tab V-4.1).

The third MCE crew took control of the aircraft at 0400z and flew until 0700z with no issues as the aircraft preformed normally (Tabs V-3.1, and AA-6).

At 0700z, the fourth MCE crew swap occurred with the returning crew that flew from 0230z to 0400z (Tab AA-6). The fourth crew flew for three hours during which the aircraft continued to perform without issue in a "typical" mission (Tab V-4.1). The fourth MCE pilot stated they were operating south of any reported weather conditions (Tab V-4.1). The MA did not experience any icing conditions, did not fly through any weather and the fourth MCE pilot did not see any thunderstorms (Tab V-4.1).

At 1000z another crew swap occurred and the MMCE took control of the MA (Tab AA-6). Before each crew swap, the preceding MCE crew briefs the in-coming crew on any noteworthy issues (Tab V-1.2). Soon after the MMCE took control of the MA, the mission was on pause because of cloud cover in the area (Tab V-2.3). At approximately 1105z, the MMCE received a request for support in a different region (Tab V-2.3). The MP received clearance from air traffic control while the MSO completed standard checks (Tab V-1.2). The MSO obtained a visual depiction of the weather in the area and noted there was an unfavorable weather condition north of the new area and conditions appeared clear in the new area (Tab V-1.2).

The 2 SOS manning document does not support a weather position (Tabs V-2.13, and V-11.1). Aircrews at 2 SOS receive weather support from the 432nd Wing Operations Center (WOC) at Creech AFB, NV (Tab V-9.1). 432 WOC forecasts weather and provides updated information to remotely piloted aircraft (RPA) crews across the globe (Tab V-9.1). This information is available

through a classified website that updates frequently and that RPA crews may view during operations (Tabs V-2.3, and V-9.1). Additionally, MCE crews at 2 SOS may call weather personnel at the Reaper Operations Center at Cannon AFB for real time weather data (Tab V-2.13).

For the next 20 minutes, from 1115z until 1135z, MP flew the MA to the new target area (Tab V-2.4). Along the way, the mishap crew noticed some clouds to the left and in front of the MA, but the clouds were lower than the MA's altitude (Tab V-1.3). The MP and the MSO discussed the clouds and determined they were not a concern because they did not appear to be thunderstorms and were not directly in the MA's flight path (Tab V-1.3). The MMCE intended to orbit a particular location for their mission (Tab V-1.3). Once the MA reached the orbiting location at 1135z, the MP noticed there were clouds forming underneath the MA (Tab V-1.3). The MP then told the MSO and the mission intelligence coordinator (MIC) that he was not sure if the MA could remain in the area, but continued until the MA reached the far edge of its intended orbiting location (Tab V-1.3). At about the same time, the MP and the MSO noticed precipitation on the MA's multi-spectral targeting system (MTS) camera (Tab V-1.3). This camera provides limited situational awareness for the aircrew (Tab V-2.5). After seeing precipitation, the MP decided to request maneuver space for weather and a new tasking as the current area was unusable because of low cloud coverage and building cloud cells (Tab V-1.3).

While coordinating a new tasking, the MA was flying in a wide orbit at a slight left turn of approximately 20 degrees (Tab V-1.3). The MP and the MSO then noticed a rapidly rising cloud mass and the MP responded by asking the MSO to keep an eye on the cloud formation while the MP entered a right turn to avoid the clouds while staying within their designated airspace (Tab V-1.3).

Due to the camera's limited angle of view, the aircrew does not have complete situational awareness like a manned aircraft (Tab V-2.16). Aircrew members often refer to this limitation of viewing the surroundings through a camera lens as the "soda straw" effect (Tab V-2.5). Understanding the visual limitations and the requirement to stay within cleared airspace, a common technique used to safely exit an unsafe area is to turn the aircraft around 180 degrees (Tab V-2.5). This was the technique employed by the MMCE to exit the area after recognizing the rapidly deteriorating weather conditions (Tab V-2.5).

During the attempt to exit the area, the MA encountered icing conditions (Tab V-1.4). The MSO noticed icing on the camera (Tab V-2.4). Consequently, the MMCE accomplished all tasks on the emergency checklist for icing (Tab V-1.3). The MA also encountered four distinct areas of turbulence between 1135z and 1155z and entered a cloud at 1144z, obstructing any views (Tab J-5, and DD-40).

At this time, the aircraft was at 26,000 feet MSL where the outside air temperature fluctuated between -22 and -10 degrees Celsius (Tabs J-4 to J-5, and DD-40). The MP, a very experienced pilot with nearly 3,500 total flight hours, later stated the icing encountered by the MA was light and had a minimal effect on the MA (Tabs G-5, and V-1.4). However, both the MP and the MSO understood the weather made the area unsafe for flight and their primary objective at this time was to exit the area (Tab V-1.4).

During MMCE's attempt to exit the assigned airspace, the MSO stated he was surprised to see how quickly clouds had overcome the assigned airspace (Tab V-2.5). After being in the clouds for approximately nine minutes, the camera went black at 1155z (Tab DD-40). From 1146z until 1159z, the camera was intermittently black for a total of approximately 120 seconds (Tab DD-40 to DD-41). The camera also shows a whiteout screen at 1146z (Tab DD-40). The MMCE also reported seeing multiple warnings and errors reported by the MA (Tab V-2.6). Specifically, the MSO noted the MA notified the MMCE of a "transmission loss" and "engine kill hardware failure" (Tab V-2.5). Also at 1155z the aircraft stopped responding to the MP's control inputs and entered a sharp left turn, eventually reaching a left turn of 60 degrees or more with a high angle of attack and a vertical decent of 2,000-5000 feet per minute (Tab J-4, V-1.4). The MA did not respond to any control inputs after the camera went black at 1155z (Tab V-1.4). Between 1155z and 1159z, while the MA descended in a left turn, the MA provided intermittent video with a final view of the ground from approximately 5,000 feet MSL (Tab DD-40 to DD-41).

Subsequent technical analysis confirmed the MMCE's description of the MA not responding to any control input after 1155z, at which time it entered an un-commanded steep descending left turn (Tab J-5). Analysis showed no electrical anomalies with the starter-generator, but multiple engine and electrical failures occurred simultaneously at 1155z, the same moment the MA stopped responding to the MP's control inputs (Tab J-5).

Time	**Event**
0006z	MA takes off from Kandahar International Airport
0024z	LRE crew transfers control of MA to MCE crew at Hurlburt
0230z	Second MCE crew conducts crew swap
0400z	Third MCE crew swap
0700z	Fourth MCE crew swap
1000z	MMCE conducts crew swap and takes control of the MA
1105z	MMCE receives direction to move MA to new target
1115z	MMCE begins transiting MA to new target
1135z	MA arrives at new target
1144z	MA enters cloud
1144z	MMCE sees black screen intermittently until 1159z
1146z	MA encounters icing conditions
1146z	MMCE sees whiteout on screen
1155z	MA stops responding to control inputs from MMCE
1159z	All connection with MA is lost

Figure 2: Timeline (Tabs J-5, V-2.2, AA-6, and DD-40 to DD-41).

e. Impact

The MA impacted the ground at approximately 1159z in a remote area of Afghanistan (Tabs V-2.7, and DD-35). The last known parameter of the MA was approximately 5,000 above MSL with the MA at a roll angle of 60 degrees to the left and was descending at rate of 2,000 vertical feet

per minute (Tab J-4 to J-5). Another aircraft confirmed the MA crashed with visual description of flaming debris near the last known location of the MA (Tab V-7.1).

f. Egress and Aircrew Flight Equipment (AFE)

Not applicable.

g. Search and Rescue (SAR)

Not applicable.

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

Review of Air Force Technical Order (AFTO) 781 series forms, which document maintenance actions and inspections revealed the MA's maintenance records complied with applicable guidance and regulations (Tab U-3). Additionally, review of all Time Compliance Technical Orders (TCTO) revealed no significant issues with the MA (Tab U-3). The use of TCTOs is the process for aircraft system changes, such as part and software upgrades (Tab U-3). There was one TCTO noted as outstanding, but was in abeyance status and was not relevant to the mishap (Tab U-3).

b. Inspections

All scheduled inspections were current at the time of the mishap and satisfactorily completed (Tab U-3). The aircraft had 1521.7 flight hours on the day of the mishap (Tab U-3). The last scheduled inspections completed on the MA were 200 hour airframe and 200 hour engine inspections (Tab U-3). Both inspections were completed at 1385.0 flight hours with no discrepancies noted (Tab U-3).

c. Maintenance Procedures

The completion of maintenance procedures and practices were in accordance with applicable technical orders and there is no evidence to suggest maintenance procedures were factors in this mishap (Tab U-3).

d. Maintenance Personnel and Supervision

All maintenance personnel had the appropriate supervision and the preflight servicing of the MA was in accordance with applicable technical orders (Tab V-10.1).

e. Fuel, Hydraulic, and Oil Inspection Analyses

Fuel and oil analyses from the mishap aircraft, post-mishap, were not completed (Tab U-3). The MA was unavailable for analysis because it was destroyed in the crash (Tab U-3). A fuel sample from the fuel vehicle that serviced the mishap aircraft prior to flight was completed, with no discrepancies noted (Tab U-3). All sample results were within limits (Tab U-3).

f. Unscheduled Maintenance

On 14 May 2015, the MA had a Code 2 write-up for Angle of Attack showing plus 5-6 degrees during level flight at cruise airspeeds (Tab U-3). Maintainers replaced the Alpha/Beta probe, which are sensors for the Angle of Attack, on the MA and all follow-on operational checks were completed (Tab U-3). All maintenance procedures conducted were in accordance with applicable technical orders (Tab U-3). There is no evidence to suggest the replacement of the Alpha/Beta probe or any other maintenance issues were factors in the mishap (Tab U-3).

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

Post-mishap analysis of the MA's components was not accomplished because the MA was destroyed on impact and was not recovered (Tab U-3).

(1) Lightning Strike Protection

While many aircraft have structures or systems of electrical conduction to mitigate damage from lightning strike or electrical discharge, the MQ-9A has no lightning protection (Tab BB-10). It is unknown what the exact effects of lighting might be, but the flight manual for the MQ-9 states a strike could seriously damage, disable or destroy aircraft electronics (Tab DD-40). The MA was functioning normally up until 1155z (Tab DD-40). At 1155z, while flying through a cloud, the MA experienced a sudden failure of the read-only memory in the Redundant Control Module (RCM) (Tab DD-40). The RCM is where the aircraft receives and routes commands for execution (Tab DD-40). Additionally, the MA simultaneously experienced catastrophic faults in a significant number of nodes in the Universal Asynchronous (UARB) Bus (Tab DD-40). The RCM routes flight control commands through the UARB network (Tab DD-40). The aircraft also receives feedback through the UARB network, the nodes of which are located in the wings (Tab DD-40).

Following the mishap, the manufacturer of the MA, General Atomics, analyzed and reported on the MA the day of the mishap and included a comparison with previous known or suspected cases of lightning strike on the MQ-9 and MQ-1 (Tab DD-7 to DD-9). The report provided by General Atomics states that a review of the MA's Heads-Up Display (HUD) video displayed a quick flash whiteout, not associated with the camera view cycle, observed at 1155:22 (Tab DD-7). The report states this whiteout was most likely a visual display of lightning within the clouds (Tab DD-7). Previous instances of lightning strike included a known MQ-1 strike, where lightning entered through one wing tip and exited the other, resulting in loss of some aircraft control capability (Tab

DD-7). Similarly, MQ-9s struck by lightning reported multiple, critical UARB failures (Tab DD-8). The MA's immediate failure of redundant systems occurring at 1155z is consistent with previous known or suspected lightning strikes on the MQ-1 and MQ-9 (Tab DD-7 to DD-9).

b. Evaluation and Analysis

Following the mishap, General Atomics provided a report and analysis of the MA's datalogs, recorded data from the MA on the day of the mishap (Tab J-4). The General Atomics report confirmed the MP's reported loss of control and descending left turn beginning at 1155z (Tab J-4 to J-5). Post mishap analysis of the MA's components was not accomplished because the MA was destroyed on impact and was not recovered (Tab U-3).

7. WEATHER

a. Forecast Weather

The forecast weather, as provided by 432 WOC, consisted of small, scattered showers in the morning (Tab V-9.1). 432 WOC expected the showers to build up throughout the day with thunderstorms expected to develop over mountainous terrain in the afternoon (Tab V-9.1). 432 WOC also predicted the thunderstorms to begin at approximately 1030z (Tab V-9.1). The forecast for thunderstorms included a prediction of lightning, hail and turbulence as possible conditions (Tab V-9.1).

b. Observed Weather

On the day of the mishap, the observed weather for Afghanistan included a calm morning with some scattered clouds (Tab V-6.1). Thunderstorms developed later in the afternoon and lightning strikes were identified in the eastern part of the country beginning around 1030z (Tab V-9.1). From the MA's HUD video, cumulus clouds showed, reaching flight level of approximately 25,000 feet MSL and turning into cumulonimbus (Tab V-5.1). The video also shows icing conditions and lightning near the MA shortly before 1155z. (Tab V-5.1).

c. Space Environment

Not applicable.

d. Operations

AFI 11-2-MQ-1&9V3, *MQ-1 and MQ-9 Operations Procedures*, 1 November 2012, states aircraft must remain 25 nautical miles from known thunderstorm activity (Tab BB-15). The MA entered airspace with rapidly forming cumulonimbus clouds (Tab V-5.1). According to both the MP and the MSO, before traveling to this area they checked earlier forecasts, which did not show thunderstorm activity expected in this specific airspace (Tab V-1.2).

8. CREW QUALIFICATIONS

Each crewmember was current and qualified to accomplish the specific tasks related to the mission (Tabs G-5, and G-18).

a. Mishap Pilot

The MP was a current and qualified Pilot in the MQ-9A (Tab G-5). He had 3481.5 total flight hours, which includes 2087.2 hours in RPAs that comprises his 229.7 hours in the MQ-9A (Tab G-5). The MP was a current and qualified Instructor Pilot and Evaluator Pilot (Tab G-5). The MP had 806.2 hours of Instructor time and 82.2 hours of Evaluator Time (Tab G-5).

Recent flight time is as follows (Tab G-7):

	Hours	Sorties
Last 30 Days	16.1	6
Last 60 Days	29.1	10
Last 90 Days	59.5	19

b. Mishap Sensor Operator

The MSO was a current and qualified Sensor Operator in the MQ-9A (Tab G-18). He had 1398.3 total RPA flight hours, which includes 768.8 hours of MQ-9A (Tab G-18). The MSO was a current and qualified Instructor and Evaluator Sensor Operator in the MQ-9A (Tab G-18). The MSO had 241.4 hours Instructor Sensor Operator and 4.6 hours Evaluator Sensor Operator time (Tab G-18).

Recent flight time is as follows (Tab G-19):

	Hours	Sorties
Last 30 Days	48.6	14
Last 60 Days	67.7	22
Last 90 Days	75.6	26

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

9. MEDICAL

a. Qualifications

(1) Mishap Pilot

The MP was medically qualified for flying duties at the time of the mishap (Tab X-3). There is no evidence to suggest physical or medical qualifications of the MP were factors in this mishap (Tab X-3).

(2) Mishap Sensor Operator

The MSO was medically qualified for flying duties at the time of the mishap (Tab X-3). There is no evidence to suggest physical or medical qualifications of the MSO were factors in this mishap (Tab X-3).

b. Health

The MP and the MSO's pre and post-mishap medical records and verbal testimony reflect they were both in good health and had no recent performance-limiting illnesses prior to this mishap (Tabs X-3, V-1.13, V-2.12, and AA-13). The MP's records reveal he had no relevant injury or illness (Tab X-3). The MP was not using any over-the-counter or prescribed medication (Tab X-3). The MSO's records likewise reveal no relevant injury or illness (Tab X-3). The MSO was not using any over-the-counter or prescribed medication (Tab X-3). No evidence suggests the health of any crewmember was a factor in this mishap.

c. Pathology

Not applicable.

d. Lifestyle

Immediately after the mishap, both the MP and the MSO recorded their activities and diet in the 72 hours and 14 days preceding the mishap (Tabs R-2 to R-3, and X-3). There is no evidence to suggest patterns or behaviors for either the MP or the MSO were factors in the mishap (Tab X-3).

e. Crew Rest and Crew Duty Time

The MP and the MSO had adequate crew rest at the time of the mishap (Tabs V-1.13, and V-2.12). The MP and the MSO described their duty time as "normal" and within prescribed limits under AFI 11-202, Volume 3, *General Flight Rules*, 22 October 2010 (Tabs V-1.13, and V-2.12). There is no evidence to suggest crew rest or crew duty time were factors in this mishap.

10. OPERATIONS AND SUPERVISION

a. Operations

The 2 SOS began MQ-9 operations at Hurlburt Field in June, 2014 (Tab CC-16). Since that time the operations tempo of the unit has been very high, but still within their capabilities (Tab V-11.1). Manning at 2 SOS was described by squadron leadership as adequate to meet their tasked operations (Tab V-11.1). Both the MP and the MSO were very experienced and the squadron leadership had great confidence in their abilities (Tab V-11.1). There is no evidence to suggest that the operations tempo or experience level of the mishap crew were factors in the mishap.

b. Supervision

Supervision from 2 SOS provided adequate oversight of the mission during planning and execution (Tab V-11.1 to V-11.2). There is no evidence to suggest supervision was a factor in the mishap.

11. HUMAN FACTORS ANALYSIS

Not applicable.

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 11-2MQ-1&9, Volume 3, *MQ-1 and MQ-9 Operating Procedures*, 1 November 2012

(2) AFI 11-203, Volume 1, *Weather for Aircrews*, 12 January 2012

(3) AFI 51-503, *Aerospace and Ground Accident Investigations*, 14 April 2015

(4) AFI 11-202, Volume 3, *General Flight Rules*, 22 October 2010

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

b. Other Directives and Publications Relevant to the Mishap

(1) Technical Order 1Q-9(M)A-1, *Flight Manual MQ-9A Aircraft*, 1 December 2014

c. Known or Suspected Deviations from Directives or Publications

None.

//SIGNED//
24 FEBRUARY 2016 DAWN L. JUNK, Lt Col, USAF
President, Accident Investigation Board

STATEMENT OF OPINION

MQ-9A, T/N 11-4129
Afghanistan
18 May 2015

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. SUMMARY

I find, by a preponderance of the evidence, that the cause of the mishap was a direct or near lightning strike to the mishap aircraft (MA), resulting in multiple aircraft system failures and loss of aircraft controllability.

I developed my opinion by analyzing factual data from historical records, Air Force directives and guidance, engineering analysis, witness testimony, flight data, flight video and information provided by technical experts.

2. BACKGROUND

On 18 May 2015, at approximately 1159 hours zulu time (z), an MQ-9A, tail number 11-4129, assigned to the 27th Special Operations Wing at Cannon Air Force Base (AFB), and deployed to Kandahar International Airport, crashed in a remote area of Afghanistan after the aircraft was inadvertently flown into a thunderstorm. While in the thunderstorm, at 1155z the MA stopped responding to control inputs from the mishap mission control element (MMCE). The MA then took a sharp descending left turn and continued to descend rapidly until approximately 5,000 feet mean sea level, at which time all connection between the MMCE and the MA ceased. The MA and its payload of four missiles crashed in a remote area in Afghanistan and consequently destroyed. The value of the estimated total loss was $12,911,715. There were no fatalities and no damage to private property.

A launch and recovery element (LRE) at Kandahar International Airport launched the MA at 0006z. Shortly after an uneventful take-off, the LRE transferred control of the MA to the mission control element (MCE) at Hurlburt Field, FL under the 2d Special Operations Squadron. The weather at that time was mostly clear in the area where the aircraft would operate, with some scattered storms farther to the northeast. For nearly 10 hours of uninterrupted flight time, four MCE crews controlled the MA. None of the first four MCE crews noticed any anomalies with the aircraft. There were some scattered clouds, but the weather was not a significant obstacle for the first four crews. At 1000z, the MMCE crew took control of the aircraft and at 1115z directed the aircraft to a new area of operations. Enroute to the new area of operations, cumulus clouds were rapidly forming in the assigned area. Once in the assigned location, the MMCE crew navigated to

avoid the developing thunderstorms. At approximately 1144z, the MA began to encounter significant turbulence, icing conditions and obstructed vision as they inadvertently entered a cloud concealing substantial inner cloud lightning energy. At approximately 1155z, the MA lost connection with the MMCE and stopped responding to control inputs by the mishap pilot (MP). The aircraft then took a sharp descending left turn and displayed numerous and significant warning messages to the MMCE until 1159z, when all connectivity from the MMCE to the MA was lost.

2. CAUSE

The cause of the MQ-9A, Tail Number 11-4129 mishap by a preponderance of the evidence was a direct or near lightning strike to the MA. The following evidence supports this conclusion:

Upon arriving at the assigned area of operations, there were noticeable clouds below the MA. Avoiding growing clouds, the MP took a left turn to avoid significantly developing weather. After turning towards the left, they inadvertently entered into a cloud. The MMCE crew took appropriate corrective actions and ran appropriate checklists in an attempt to exit the clouds. For nine minutes, while in the clouds, multiple lightning flashes occurred before the MA became completely nonresponsive at 1155z.

The aircraft functioned normally prior to the suspected direct or near lightning strike. However, a direct or near lightning strike, most likely significantly degraded aircraft controllability and resulting in uncontrolled flight, rapid decent and loss of connectivity between MA and the MMCE.

The MA acted consistent with historical MQ-9 lightning strike cases given from the manufacturer. The review from the manufacturer highly suggests a direct or near lightning strike. The weather forecaster, predicted thunderstorms in the general area of operations of the MA. The review of the Heads-Up Display (HUD) video suggests a direct or near lightning strike. The witness statements all suggest a direct or near lightning strike. In addition, the weather expert, after review of HUD video suggests a direct or near lightning strike event.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

None.

4. CONCLUSION

I find, by a preponderance of the evidence, that the cause of the mishap was a direct or near lightning strike to the MA. There were rapidly developing cumulonimbus clouds concealing substantial inner cloud lightning energy, which quickly surrounded the MA.

//SIGNED//

24 FEBRUARY 2016

DAWN L. JUNK, Lt Col, USAF
President, Accident Investigation Board

INDEX OF TABS

Safety Investigator Information ..... A

Not used ..... B

Not used C

Maintenance Report, Records, and Data ..... D

Not used ..... E

Weather And Environmental Records and Data ..... F

Personnel Records ..... G

Egress, Aircrew Flight Equipment, and Impact Crashworthy Analysis ..... H

Deficiency Reports I

Releasable Technical Reports and Engineering Evaluations ..... J

Mission Records and Data ..... K

Factual Parametric, Audio, and Video Data From On-Board Recorders L

Data From Ground Radar And Other Sources ..... M

Transcripts Of Voice Communications ..... N

Any Additional Substantiating Data and Reports ..... O

Damage Summaries ..... P

AIB Transfer Documents ..... Q

Releasable Witness Testimony ..... R

Releasable Photographs, Videos, Diagrams, and Animations ..... S

Personnel Flight Records Not Included In Tab G ..... T

Maintenance Report, Records, And Data Not Included In Tab D ..... U

Witness Testimony And Statements V

Weather And Environmental Records, and Data Not Included In Tab F ..... W

Statements of Injury or Death X

Legal Board Appointment Documents ..... Y

Photographs, Videos, Diagrams, and Animations Not Included In Tab S ..... Z

Flight Documents ..... AA

Applicable Regulations, Directives, and Other Government Documents ..... BB

Factsheets CC

Additional Supporting Documents ..... DD