UNITED STATES AIR FORCE
ABBREVIATED ACCIDENT INVESTIGATION BOARD REPORT

MQ-1B, T/N 01-3075

11th Reconnaissance Squadron
432d Wing
Creech Air Force Base, Nevada

LOCATION: Near Creech Air Force Base, Nevada

DATE OF ACCIDENT: 13 May 2013

BOARD PRESIDENT: Lieutenant Colonel David C. Trucksa

Conducted in accordance with Air Force Instruction 51-503
Abbreviated Accident Investigation pursuant to Chapter 11

EXECUTIVE SUMMARY

ABBREVIATED ACCIDENT INVESTIGATION
MQ-1B PREDATOR, T/N 01-3075
NEAR CREECH AIR FORCE BASE, NEVADA
13 MAY 2013

On 13 May 2013, at approximately 2113 hours Zulu time (Z), an MQ-1B remotely piloted aircraft (RPA), hereinafter referred to as the mishap RPA (MRPA), tail number 01-3075, impacted the ground approximately 11 nautical miles west of Creech Air Force Base (AFB), Nevada (NV), 5.6 hours into a local training mission. The MRPA was operated by the 11th Reconnaissance Squadron (11 RS), 432d Wing (432 WG), Creech AFB, NV. The MRPA and one M-36 training missile were destroyed on impact. The total damage to United States government property was assessed to be $4,511,500.00. There were no injuries or damage to other government or civilian property.

On 13 May 2013, at approximately 1536Z, the MRPA departed for takeoff and landing practice at Creech AFB, NV. At 15:44:57Z, approximately 19 seconds after full power was applied to the MRPA, the propeller pitch angle unintentionally became fixed at 14.5 degrees and remained in that position for the next 5.4 hours. Three crews cycled through the ground control station (GCS) and conducted syllabus-directed training before handing over MRPA control to the mishap crew (MC). Beginning at 21:11:04Z, the propeller pitch decreased to -3 degrees, which generated a reverse thrust situation, and remained at that position for the duration of the flight. By 21:11:21Z, the MRPA had descended 300 feet below the commanded altitude. The MRPA continued to descend with a vertical velocity exceeding -1,000 feet per minute (FPM). At 21:11:22Z, the MC, which consisted of the mishap pilot (MP), mishap evaluator sensor operator (MESO), and mishap upgrade sensor operator (MUSO), received a propeller pitch servomotor failure warning message, among others, on the heads down display (HDD). These messages were the first indication to the MC of a problem with the variable pitch propeller (VPP) servomotor, which controls propeller pitch angles. Shortly thereafter, the MC lost link to the MRPA and it impacted the ground at approximately 2113Z.

The Abbreviated Accident Investigation Board (AAIB) president found, by clear and convincing evidence, that the cause of the mishap was a VPP system failure. A cable that provides electrical current to the VPP servomotor was found to have produced inconsistent electrical current. This lack of electrical power to the VPP servomotor resulted in a fixed propeller position of 14.5 degrees for 5.4 hours, followed by a subsequent un-commanded propeller pitch shift down to -3 degrees, which put the MRPA into a thrust deficient situation from which it could not recover. The AAIB president also found, by a preponderance of the evidence, that the human factor of misinterpreted instrument readings substantially contributed to the mishap.

SUMMARY OF FACTS AND STATEMENT OF OPINION
MQ-1B, T/N 01-3075
13 MAY 2013

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

AAIB	Abbreviated Accident Investigation Board
ACC	Air Combat Command
AFB	Air Force Base
AFI	Air Force Instruction
AFTO	Air Force Technical Order
AOA	Angle of Attack
Capt	Captain
FAE	Functional Area Expert
FOD	Foreign Object Debris
FPM	Feet Per Minute
GA	General Atomics
GCS	Ground Control Station
HDD	Heads Down Display
HUD	Heads Up Display
IP	Instructor Pilot
ISO	Instructor Sensor Operator
LOS	Line-Of-Sight
Lt Col	Lieutenant Colonel
MC	Mishap Crew
MESO	Mishap Evaluator Sensor Operator
MP	Mishap Pilot
MRPA	Mishap Remotely Piloted Aircraft
MSL	Mean Sea Level
MUSO	Mishap Upgrade Sensor Operator
NTTR	Nevada Test and Training Range
NV	Nevada
PPSL	Predator Primary Satellite Link
Prop	Propeller
RPA	Remotely Piloted Aircraft
RPM	Revolutions Per Minute
SCAR	Strike, Coordination, and Reconnaissance
SEPT	Simulated Emergency Procedure Training
Servo	Servomotor
SP	Student Pilot
SSO	Student Sensor Operator
SSgt	Staff Sergeant
T/N	Tail Number
TCTO	Time Compliance Technical Order
VPP	Variable Pitch Propeller
VVI	Vertical Velocity Indicator
Z	Zulu Time
11 RS	11th Reconnaissance Squadron
432 WG	432d 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 AND PURPOSE

a. Authority

On 7 August 2013, Lieutenant General Lori J. Robinson, Vice Commander, Air Combat Command (ACC), appointed Lieutenant Colonel (Lt Col) David C. Trucksa as the Abbreviated Accident Investigation Board (AAIB) president in order to conduct an investigation into the 13 May 2013 mishap of an MQ-1B Predator, tail number (T/N) 01-3075, hereinafter referred to as the mishap remotely piloted aircraft (MRPA), near Creech Air Force Base (AFB), Nevada (NV). (Tab Y-2) The AAIB was conducted in accordance with Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*, 26 May 2010, Chapter 11, at Nellis AFB, NV, from 23 August 2013 to 17 September 2013. The following board members were also appointed: a legal advisor, a recorder, a pilot functional area expert (FAE), and two mechanical FAEs. (Tab Y-2 to 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

On 13 May 2013, at approximately 2113 hours Zulu time (Z), the MRPA impacted the ground approximately 11 nautical miles west of Creech AFB, NV, 5.6 hours into a local training mission. (Tab DD-3 to 4, 19 to 20) The MRPA was operated by the 11th Reconnaissance Squadron (11 RS), 432d Wing (432 WG), Creech AFB, NV. (Tab K-4 to 5) The MRPA and one M-36 training missile were destroyed on impact. (Tab P-4) The total damage to United States government property was assessed to be $4,511,500.00. (Tab P-4) There were no injuries or damage to other government or civilian property. (Tab P-3)

On 13 May 2013, at approximately 1536Z, the MRPA departed for takeoff and landing practice at Creech AFB, NV. (Tab AA-2) At 15:44:57Z, approximately 19 seconds after full power was applied to the MRPA, the propeller pitch angle unintentionally became fixed at 14.5 degrees and remained in that position for the next 5.4 hours. (Tab DD-3) Three crews cycled through the ground control station (GCS) and conducted syllabus-directed training before handing over MRPA control to the mishap crew (MC). (Tabs K-8 to 9, AA-2 to 3) Beginning at 21:11:04Z, the propeller pitch decreased to -3 degrees, which generated a reverse thrust situation, and remained at that position for the duration of the flight. (Tab DD-4) By 21:11:21Z, the MRPA had descended 300 feet below the commanded altitude. (Tab DD-4) The MRPA continued to descend with a vertical velocity exceeding -1,000 feet per minute (FPM). (Tab DD-4) At 21:11:22Z, the MC, which consisted of the mishap pilot (MP), mishap evaluator sensor operator

(MESO), and mishap upgrade sensor operator (MUSO), received a propeller pitch servomotor failure caution message, among others, on the heads down display (HDD). (Tabs N-2, V-4, 6, 11, DD-3 to 5) These messages were the first indication to the MC of a problem with the variable pitch propeller (VPP) servomotor, which controls propeller pitch angles. (Tab V-4, 6, 11) Shortly thereafter, the MC lost link to the MRPA and it impacted the ground at approximately 2113Z. (Tabs S-4 to 7, AA-2)

3. BACKGROUND

The MRPA was an asset of the 11 RS, 432 WG, Creech AFB, NV. The 432 WG falls under ACC, headquartered at Joint Base Langley-Eustis, Virginia. At the time of the mishap, the MRPA was being controlled by the MC out of a GCS at Creech AFB, NV.

a. Air Combat Command

ACC is the primary force provider of combat airpower to America's warfighting commands. (Tab CC-6) To support the global implementation of national security strategy, ACC operates fighter, bomber, reconnaissance, battle-management, and electronic-combat aircraft. (Tab CC-6) It also provides command, control, communications and intelligence systems, and conducts global information operations. (Tab CC-6)

b. 432d Wing

The 432 WG flies and maintains the MQ-1B Predator and MQ-9 Reaper aircraft to support United States and coalition war-fighters. (Tab CC-5) The 432 WG conducts remotely piloted aircraft (RPA) initial qualification training for aircrew, intelligence, weather, and maintenance personnel. (Tab CC-5) The 432 WG oversees numerous global operations, including the 432d Operations Group and the 432d Maintenance Group, as well as the following squadrons: 11 RS, 15th Reconnaissance Squadron, 18th Reconnaissance Squadron, 20th Reconnaissance Squadron, 42d Attack Squadron, 432d Operations Support Squadron, 432d Aircraft Maintenance Squadron, 432d Maintenance Squadron, and 432d Aircraft Communications Maintenance Squadron. (Tab CC-5)

c. 11th Reconnaissance Squadron

Following inactivation in 1994, the 11 RS was re-designated and re-activated in July 1995. (Tab CC-2 to 4) In 1996, it became the first RPA squadron in the Air Force. (Tab CC-2 to 4) From 1996 through 2002, it provided deployable, long-endurance, serial reconnaissance and surveillance. (Tab CC-2 to 4) Since 2003, it has conducted flight training on the MQ-1B Predator RPA. It is headquartered at Creech AFB, NV. (Tab CC-2 to 4)

d. Predator System

The MQ-1B Predator is an armed, multi-mission, medium-altitude, long-endurance RPA that is employed primarily as an intelligence-collection asset and secondarily against dynamic execution targets. (Tab CC-7) Given its significant loiter time, wide-range sensors, multi-mode communications suite, and precision weapons, it provides a unique capability to perform strike, coordination, and reconnaissance (SCAR) against high-value, fleeting, and time-sensitive targets. (Tab CC-7)

Predators can also perform the following missions and tasks: intelligence, surveillance, reconnaissance, close air support, combat search and rescue, precision strike, buddy-lase, convoy/raid overwatch, route clearance, target development, and terminal air guidance. (Tab CC-7) The MQ-1's capabilities make it uniquely qualified to conduct irregular warfare operations in support of combatant commander objectives. (Tab CC-7)

The Predator is part of a RPA system. (Tab CC-7) A fully operational system consists of four sensor/weapon-equipped aircraft, a GCS, Predator primary satellite link (PPSL), and spare equipment, along with operations and maintenance crews for deployed 24-hour missions. (Tab CC-7)

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 as well as a mission coordinator, when required. (Tab CC-7) The crew employs the aircraft from inside the GCS via a line-of-sight (LOS) data link or a satellite data link for beyond LOS operations. (Tab CC-7)

4. SEQUENCE OF EVENTS

a. Mission

On 13 May 2013, the MRPA was scheduled for an 8 hour mission, with four separate crews cycling through to accomplish MQ-1B launch and recovery sorties in accordance with the training mission of 11 RS and at the direction of the commander of 11 RS. (Tabs K-4 to 6, 8 to 9, V-2 to 14, 16, AA-2 to 3) The first three crews concentrated the majority of their flying in the local traffic pattern; the MC was conducting a mission evaluation for the MUSO and was established in a flight area 15 miles west of Creech AFB at the time of the mishap. (Tabs V-2 to 14, 16, DD-19 to 20)

b. Planning

On 13 May 2013, the MC arrived prior to the scheduled shift start time to go through preflight briefings. (Tab V-4, 6, 11) The standard briefings were conducted. (Tab V-4, 6, 11) The MP led the preflight brief with the MUSO briefing the sensor operator portion. (Tab V-11)

Following the brief among the MC, operations supervision briefed the MC. (Tab V-11) There is no evidence to suggest mission planning was a factor in this mishap.

c. Preflight

Preflight of the MRPA was performed by the first crew of the four scheduled to fly that day, the MC being the fourth. (Tabs K-8, R-19, 23, 27, V-3, 8, 14, 16) Preflight procedures were accomplished without incident. (Tabs R-19, 23, 27, V-3, 8, 14, 16) There is no evidence to suggest preflight procedures were factors in this mishap.

d. Summary of Accident

On 13 May 2013, after routine preflight checks, the MRPA took off at approximately 1536Z. (Tab AA-2) At 15:44:57Z, approximately 19 seconds after full power was applied to the MRPA, the propeller pitch angle unintentionally became fixed at 14.5 degrees and remained in that position for the next 5.4 hours. (Tab DD-3) Three crews cycled through the GCS and conducted syllabus-directed training before handing over MRPA control to the MC. (Tabs K-8 to 9, AA-2 to 3) The crew swap from the third crew to the MC occurred at approximately 2100Z. (Tab AA-2) The third crew and the MC completed all required checklist items at crew swap. (Tab V-4, 6 to 7, 9 to 11, 13) The MP then commanded the MRPA's autopilot at 8500' mean sea level (MSL); minimum safe altitude was 8100' MSL. (Tabs N-2, V-4, DD-4) At 21:10:22Z, the propeller pitch angle suddenly increased from 14.5 degrees to 22 degrees, then gradually decreased to 19.25 degrees over the next 42 seconds. (Tab DD-4) Beginning at 21:11:04Z, the propeller pitch decreased from 19.25 degrees to -3 degrees over a 19 second period and remained at that position for the remainder of the flight. (Tab DD-4) By 21:11:21Z, the MRPA had descended 300 feet below the commanded altitude and the power command had reached 100 percent. (Tab DD-4) The MRPA continued to descend with a vertical velocity exceeding -1,000 FPM. (Tab DD-4)

At 21:11:22Z, the MC received the following warnings on the HDD: "angle of attack (AOA) stall, revolutions per minute (RPM) overspeed" and "propeller (prop) servomotor (servo) - pot failed"; these messages were the MC's first indication of a VPP servomotor problem. (Tabs N-2, V-4, 6, 11) The MP made the comment "Ok, interesting, we are falling out of the sky." (Tab N-2) The MUSO relayed to the MC that the propeller feedback was at -3 degrees. (Tab N-2) The MP then initiated critical action procedures. (Tabs V-4, 6) The MP turned the MRPA in an attempt to circumvent a mountain ridge and eventually land. (Tabs N-2, V-4) The MUSO and the MESO switched positions, with the MESO taking over as sensor operator. (Tab N-2) The MRPA continued its descent with vertical velocity indicator (VVI) rates exceeding -1,000 FPM. (Tab DD-4) Shortly thereafter, the MC lost link to the MRPA and it impacted the ground at approximately 2113Z. (Tabs S-4 to 7, AA-2)

e. Impact

The MRPA experienced lost link at 21:13:38Z. (Tab DD-4) The MRPA had a descent rate exceeding -1,000 FPM at the time of lost link. (Tab DD-4) The MRPA was unsuccessful in achieving its lost link profile and impacted the ground shortly thereafter, approximately 11 nautical miles west of Creech AFB, NV. (Tab DD-3 to 4, 19 to 20)

f. Life Support, Egress, and Aircrew Flight Equipment

Not applicable.

g. Search and Rescue

Not applicable.

h. Recovery of Remains

Not applicable.

5. MAINTENANCE

a. Forms Documentation

The AAIB reviewed the Air Force Technical Order (AFTO) 781-series forms for the MRPA. The AAIB found the forms documented in accordance with applicable maintenance guidelines, and there were no faults or known malfunctions noted in the forms that suggested the MRPA was subject to electrical problems or issues. (Tabs D-2 to 77, U-2 to 150) Additionally, a review of the forms indicated that there were no overdue aircraft time compliance technical orders (TCTOs). (Tabs D-2 to 77, U-151 to 154)

b. Inspections

All required inspections were satisfactorily accomplished on the MRPA. (Tabs D-2 to 77, U-2 to 154) In response to an alert bulletin issued by the manufacturer, General Atomics (GA), regarding the MRPA's W320 cable, the Air Force issued a TCTO directing a one-time inspection of the existing W320 cable on the MRPA. (Tab V-17) The MRPA's W320 cable passed the inspection on 22 November 2011. (Tab U-152) The Air Force also changed the standing maintenance technical order requiring inspections each time a W320 cable is handled to ensure proper position and function of the cable, to include proper electrical current. (Tab V-17) A review of these inspections noted no discrepancies, with the last VPP inspection taking place on 24 April 2013. (Tabs D-2 to 77, U-2 to 154, DD-7) There is no evidence to suggest that inspections were factors in this mishap.

c. Maintenance Procedures

A review of maintenance procedures noted no discrepancies. (Tabs D-2 to 77, U-2 to 150)

d. Maintenance Personnel and Supervision

Aircraft maintenance records indicated that all preflight maintenance and supervisory activities on the MRPA were normal. (Tabs D-2 to 77, U-2 to 150) All individual training records indicate that the maintainers were trained and qualified. (Tab EE-2 to 307) There is no evidence to suggest that maintenance personnel or supervision were factors in this mishap.

e. Fuel, Hydraulic, and Oil Inspection Analyses

Maintenance personnel properly serviced fuel tanks and oil reservoirs in accordance with technical data. (Tabs D-2 to 77, U-2 to 150) The servicing certification on the AFTO Form 781H reflected adequate oil and fuel levels on the day of the mishap. (Tab U-142 to 143) There is no evidence to suggest that fuel or oil inspections were factors in this mishap. The MRPA did not contain any hydraulic systems.

f. Unscheduled Maintenance

There were no unscheduled maintenance inspections since the last inspection. (Tabs D-2 to 77, U-2 to 150) All other necessary repairs or replacements were properly made when required, independent of maintenance schedules. (Tabs D-2 to 77, U-2 to 150) There is no evidence to suggest that unscheduled maintenance was a factor in this mishap.

6. AIRFRAME, MISSILE, OR SPACE VEHICLE SYSTEMS

a. Structures and Systems

A review of the maintenance records, forms, and data logs for the MRPA revealed no evidence of anomalies or malfunctions that would contribute to the mishap. (Tabs D-2 to 77, U-2 to 150) The MRPA wreckage was located after the mishap. (Tab S-3 to 29) The following components were recovered and delivered to GA for analysis: engine, VPP assembly, W320 cable, VPP servomotor, secondary control module, spinner assembly, fuel control, propeller pitch servomotor cable, heads up display (HUD) videos, and data files. (Tab Q-2, DD-6)

b. Evaluation and Analysis

GA analyzed the recovered wreckage and flight data logs from the MRPA. (Tab DD-3) The GA report concluded that the MRPA experienced a VPP system failure which resulted in a fixed propeller pitch of 14.5 degrees for approximately 5.4 hours of flight. (Tab DD-3) An abrupt increase to 22 degrees pitch and then a rapid decrease to a negative 3 degrees (minimum reportable) occurred near the end of the flight, as explained further below. (Tab DD-3) The negative pitch angle caused the aircraft to lose thrust and descend until LOS link was lost. (Tab

DD-3) A separate analysis done by Detachment 3, Headquarters Air Force Life Cycle Management Center, supports GA's conclusion about the VPP system failure. (Tab J-2 to 6)

According to the GA report, fatigued solder joints at the inductive coils L1 and L2, single leg side (-/+Prop Motor) wires of the W320 cable most likely resulted in insufficient and/or inconsistent current to the VPP servomotor to control propeller pitch. (Tab DD-3) GA performed a detailed, staged disassembly of the W320 and W422 cables. (Tab DD-13) GA discovered a fatigued solder joint at the inductive coil (L2) single leg side wire (- Prop Motor) at J2 of the W320 cable. (Tab DD-13) The solder joint of L1 (+ Prop Motor) adjacent to L2 also indicated fatigue. (Tab DD-13) The W320 over-braid shielding in the area of L1 and L2 had evidence of heat generation. (Tab DD-13) Both L1 and L2 were single-leg, lapped solder joints and had evidence of cold or unclean solder joints and/or stress, including the following: cracks, discoloration, absence of solder flow within the stands of the wire, and lack of proper bonding. (Tab DD-13) Sub-system testing replicated propeller pitch stagnation when power was interrupted at the (- Prop Motor) utilizing a breakout test box. (Tab DD-13) In addition to the product test procedure, the propeller pitch servomotor was disassembled. (Tab DD-13) Gears, motor, brake, and other internal components appeared normal. (Tab DD-13) Motor and brake test results were within normal parameters. (Tab DD-13)

The propeller pitch stagnation at 14.5 degrees for the majority of the flight indicated a locked propeller pitch gear rack and blade cup gear train. (Tab DD-14) The fatigued solder joints suggested degradation over time and were consistent with the datalogs indicating degraded servomotor driving capability. (Tab DD-14) This was indicated by the absence of significant servomotor current and temperature rise during the period of time when the propeller pitch remained constant at 14.5 degrees. (Tab DD-14) The small propeller pitch current and temperature fluctuations while the propeller pitch was constant at 14.5 degrees were not indicative of any applied current to the propeller servomotor. (Tab DD-14) Similar behavior was observed during sub-system testing when the servomotor power wires were disconnected. (Tab DD-14) The sudden increase to 22 degrees indicated that the brake released and the servomotor was powered for a brief period of time. (Tab DD-14) Power to the servomotor was likely interrupted before the propeller pitch achieved the commanded position and before the brake was applied. (Tab DD-14) Aerodynamic forces then drove the pitch angle to a negative position. (Tab DD-14) Analysis of data logs from previous flights did not indicate similar propeller pitch behavior. (Tab DD-14)

The GA report noted that it issued an alert bulletin in 2010 which recommended upgrades to VPP servomotor W320 cables with serial numbers from UPA76465-1 to UPA78085-1, which contained wire splicing improvements; this bulletin was issued after a failed UPA76465-1 cable was determined to have caused a mishap. (Tab DD-10) The bulletin directed certain serial numbers of the VPP servomotor W320 UPA76465-1 cables to be removed from service. (Tab DD-11) The MRPA's VPP servomotor W320 cable was not one of these. (Tab DD-11) Revision B of the GA bulletin, issued 1 July 2011, added that all VPP servomotor W320 UPA76465-1 cables should be replaced with UPA78085-1 cables as the new cables become available. (Tab DD-11) The MRPA's VPP servomotor W320 cable had the serial number UPA 76465-1. In response to the alert bulletins, the Air Force issued a TCTO directing a one-time inspection of the existing W320 cable on the MRPA. (Tab V-17) The Air Force also changed the standing maintenance technical order requiring inspections each time a W320 cable is handled to ensure proper position and function of the cable, to include proper electrical current. (Tab V-17)

According to the GA report, evidence of foreign object debris (FOD) was found in the VPP rack upon disassembly. (Tab DD-3, 13) The gears had evidence of FOD, including the presence of torque seal and a wire strand. (Tab DD-13) The FOD may have been transferred from a piece of safety wire or a wire crimp swedge. (Tab DD-14 to 15) The FOD possibly restricted propeller pitch changes. (Tab DD-13) The GA report said that the stagnant 14.5 degree propeller pitch feedback indication for approximately 5.4 hours is consistent with a mechanically jammed propeller pitch mechanism. (Tab DD-14 to 15)

7. WEATHER

a. Forecast Weather

The forecast for the area in which the MRPA was operating at the time of the mishap was for clear skies and light winds for the majority of the sortie, but with gusty wind conditions starting at the scheduled land time. (Tab F-2 to 10)

b. Observed Weather

The weather at the time of the mishap was clear conditions with light winds. (Tab F-11 to 12) There is no evidence to suggest weather was a factor in this mishap.

8. CREW QUALIFICATIONS

The squadron's simulated emergency procedure training (SEPT) program was reviewed and found to have met the intent of applicable regulations, with no discrepancies noted. (Tab AA-4 to 13, BB-2 to 4) All members of the MC were current on their SEPT and were in the green to fly on 13 May 2013. (Tabs V-4, 6, 11, AA-14 to 16)

a. Mishap Pilot

The MP has been a qualified MQ-1B pilot since 5 September 2010; the MP became qualified as an instructor on the MQ-1B on 3 May 2011. (Tab T-2) At the time of the mishap, the MP had a total flight time of 173.6 hours in the MQ-1B. (Tab G-6, 17) The MP was previously qualified to pilot the F-16 and MQ-9. (Tab T-2)

Recent flight time is as follows (Tab T-3):

	Hours	Sorties
Last 30 Days	2.0	1
Last 60 Days	3.3	2
Last 90 Days	11.5	6

b. Mishap Evaluator Sensor Operator

The MESO has been a qualified MQ-1B sensor operator since 1 November 2010, becoming instructor qualified on 29 May 2012, and qualified as an evaluator on 29 October 2012. (Tab T-4) At the time of the mishap, the MESO had a total flight time of 801.1 hours, all in the MQ-1B. (Tab G-22, 33)

Recent flight time is as follows (Tab T-5):

	Hours	Sorties
Last 30 Days	4.4	3
Last 60 Days	11.0	7
Last 90 Days	22.6	15

c. Mishap Upgrade Sensor Operator

The MUSO has been a qualified MQ-1B sensor operator since 16 October 2006. (Tab T-6) At the time of the mishap, the MUSO had a total flight time of 1569.9 hours in the MQ-1B. (Tab G-36, 45) The MUSO also recently qualified on the RQ-170. (Tab G-36, 45, T-6)

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

	Hours	Sorties
Last 30 Days	5.1	4
Last 60 Days	5.1	4
Last 90 Days	5.1	4

9. MEDICAL

a. Qualifications

A records review indicated that the MC was medically qualified for duty at the time of the mishap. (Tab T-8 to 10)

b. Health

A review of the medical records and the 72-hour and 14-day histories was accomplished. Records revealed that all members of the MC were in good health and had no performance-limiting condition or illness prior to the mishap. (Tabs R-2 to 16, T-8 to 10)

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

c. Toxicology

Immediately following the mishap, drug and alcohol tests were conducted on the three members of the MC. (Tab V-15) All results were negative. (Tab V-15)

d. Lifestyle

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

e. Crew Rest and Crew Duty Time

Aircrew members must have proper rest, as defined in AFI 11-202, Volume 3, *General Flight Rules* (ACC Supplement), 28 November 2012, prior to performing in flight duties. AFI 11-202 defines normal crew rest as a minimum 12-hour non-duty period before the designated flight duty period begins, during which time an aircrew member may participate in meals, transportation, or rest.

Multiple members of the various flight crews that flew the MRPA on 13 May 2013 indicated that operations tempo was normal within 11 RS at the time of the mishap. (Tab V-2, 3, 8) The MC's 72-hour and 14-day histories revealed adequate crew rest. (Tabs R-2 to 16) There is no evidence to suggest crew rest or crew duty time were factors in this mishap.

10. OPERATIONS AND SUPERVISION

a. Operations

At the time of the mishap, the operations tempo for the aircrews was average and sustainable. (Tab V-2, 3, 8) The MC was less than 15 minutes into its flight time when the mishap occurred. (Tab AA-2)

b. Supervision

On 13 May 2013, the MC arrived prior to the scheduled shift start to go through preflight briefings. (Tab V-4, 6, 11) The standard briefings were conducted. (Tab V-4, 6, 11) The MP led the preflight brief with the MUSO briefing the sensor operator portion. (Tab V-11) Following the brief among the MC, operations supervision briefed the MC. (Tab V-11) There is no evidence to suggest that supervision was a factor in this mishap.

11. HUMAN FACTORS

Possible human factors contributing to the mishap were evaluated using the Department of Defense Human Factors Analysis and Classification System as described in AFI 91-204, *Safety Investigations and Reports*, 24 September 2008, incorporating guidance memorandum 1, 8 April 2013, attachment 5. The system describes four main tiers of factors that may contribute to a mishap. From most individual to most general, they are: acts, preconditions, supervision, and organizational influences. (AFI 91-204, attachment 5) Acts are those factors that are most closely tied to the mishap and can be described as active failures or actions committed by the operator that result in human error or unsafe conditions. (AFI 91-204, attachment 5) Preconditions are factors in a mishap if active and/or latent preconditions, such as conditions of the operators, environmental, or personnel factors, affect practices, conditions, or actions of individuals, result in human error or an unsafe situation. (AFI 91-204, attachment 5) Supervision is a factor in a mishap if the methods, decisions, or policies of the supervisory chain of command directly affect practices, conditions, or actions of individuals and result in human error or an unsafe situation. (AFI 91-204, attachment 5) Organizational influences are factors in a mishap if the communications, actions, omissions, or policies of upper-level management directly or indirectly affect supervisory practices, conditions, or actions of the operator and result in system failure, human error, or an unsafe situation. (AFI 91-204, attachment 5)

There is evidence of multiple human factors leading up to the mishap. There is evidence of a misinterpreted/misread instrument, which is a factor when an individual is presented with a correct instrument reading but its significance is not recognized, it is misread, or it is misinterpreted. (AFI 91-204, attachment 5, PC 505) The aircrews prior to the MC were conducting take-off and landing practice in accordance with the training mission of 11 RS. (V-2 to 14, 16) The take-off and landing phases of flight are considered critical phases of flight according to AFI 11-2MQ-1&9, Volume 3, 1 November 2012, attachment 1. During these critical phases, the members of each aircrew conducted operations checks of the propeller pitch, among other things, in accordance with applicable guidance, paying particular attention to the emphasis item of turbo oil temperature. (Tab V-2 to 14, 16) AFI 11-2MQ-1&9, Volume 3, 1 November 2012, paragraph 3.9.2.1, states that the aircrew must perform operations checks at least once per hour; these checks must include, at a minimum, fuel level, oil level, propeller pitch operation, electrical, datalink, engine parameters, and emergency mission status. Despite multiple comments on poor aircraft performance, which included references to speed, climb rates, descent, manifold pressure, and turbo oil temperature, the operations checks and crew swaps were normal and without incident. (Tabs V-2 to 14, 16, FF-2) During this time, however, the propeller pitch was stagnant. (Tab DD-3) The VPP system failed nine minutes into the 5.6 hour flight. (Tab DD-3) This means the 14.5 degree fixed propeller pitch existed for 5.4 continuous hours of flight. (Tab DD-3) Thus, the aircrews misinterpreted the stagnant propeller pitch value during operations checks as proper propeller pitch function.

There is evidence of channelized attention, which is a factor when an individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others of a subjectively equal or higher or more immediate priority, leading to an unsafe situation. (AFI 91-204, attachment 5, PC 102) The MC channelized its attention during the rapid descent of the MRPA by focusing on clearing a nearby mountain ridge. (Tabs N-2, V-4) This channelized attention precluded the MC from fully recognizing and handling the VPP system failure in a timely manner. (Tabs N-2, V-4)

There is evidence of challenge and reply, which is a factor when communications do not include supportive feedback or acknowledgement to ensure that personnel correctly understand announcements or directives. (AFI 91-204, attachment 5, PP 108) The MC involved the challenge and reply factor when the MUSO stated that propeller pitch was at -3 degrees, but that was not acknowledged by the MP until 60 seconds later. (Tab N-2)

There is evidence of assertiveness, which is a factor when individuals failed to state critical information or solutions with appropriate persistence. (AFI 91-204, attachment 5, PP 105) The MUSO and MESO were not assertive when they stated the warnings that were being relayed to the GCS, but did not ask the MP how the MP wanted to respond until 45 seconds later. (Tab N-2)

Finally, there is evidence of temporal distortion, which is a factor when the individual experiences a compression or expansion of time relative to reality leading to an unsafe situation. (AFI 91-204, attachment 5, PC 511) The MESO commented after the mishap that the rapid descent occurred over the course of "like 30 seconds," when in reality over two minutes passed between the initial warnings and the lost link. (Tabs N-2 to 3, FF-3)

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(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, certified current 8 January 2013
(3) AFI 11-2MQ-1&9, Volume 3, *MQ-1 and MQ-9--Operations Procedures*, 1 November 2012
(4) AFI 11-202, Volume 3, *General Flight Rules* (ACC Supplement), 28 November 2012
(5) AFI 11-401, *Aviation Management* (ACC Supplement), 25 March 2013
(6) AFI 11-418, *Operations Supervision*, 15 September 2011, incorporating change 1, 1 March 2013
(7) AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010
(8) AFI 91-204, *Safety Investigations and Reports* (ACC Supplement), 16 November 2007, certified current 7 July 2010
(9) AFI 91-204, *Safety Investigations and Reports*, 24 September 2008, incorporating guidance memorandum 1, 8 April 2013

(10) AFI 21-101, *Aircraft and Equipment Maintenance Management*, 26 July 2010, incorporating change 1, 16 August 2011, incorporating guidance memorandum 4, 19 April 2013

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

b. Other Directives and Publications Relevant to the Mishap

(1) AFI 11-202, Volume 2, *General Flight Rules* (Creech AFB Supplement to ACC Supplement), 28 July 2013

c. Known or Suspected Deviations from Directives or Publications

Not applicable.

13. ADDITIONAL AREAS OF CONCERN

The VPP system failure checklist is not defined as a critical action procedure, that is, a bold face item requiring memorization by the flight crew. (Tab V-11) During the interview process, at least one aircrew member indicated that propeller pitch is considered a non-standard bold face or, in other words, a checklist item that warrants memorization but does not require it. (Tab V-11) Given the rapid descent of the MRPA after the catastrophic -3 degree (thrust reversing) pitch position, the flight manual's categorization of, and guidance on, VPP system failure is an area of concern. It does not appear that guidance is clear enough on how aircrews should recognize and react to VPP system failures.

21 October 2013

., Lt Col, USAF
President, AAIB

STATEMENT OF OPINION

ABBREVIATED ACCIDENT INVESTIGATION
MQ-1B PREDATOR, T/N 01-3075
NEAR CREECH AIR FORCE BASE, NEVADA
13 MAY 2013

Under 10 U.S.C. § 2254(d), the opinion of the accident investigator as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report, if any, may not be considered as evidence in any civil or criminal proceeding arising from the accident, nor may such information be considered an admission of liability of the United States or by any person referred to in those conclusions or statements.

1. OPINION SUMMARY

On 13 May 2013, at approximately 2113 hours Zulu time (Z), an MQ-1B remotely piloted aircraft (RPA), hereinafter referred to as the mishap RPA (MRPA), tail number 01-3075, impacted the ground approximately 11 nautical miles west of Creech Air Force Base (AFB), Nevada (NV), 5.6 hours into a local training mission. On 13 May 2013, at approximately 1536Z, the MRPA took off. At 15:44:57Z, the propeller pitch angle unintentionally became fixed at 14.5 degrees and remained in that position for the next 5.4 hours. Three crews cycled through the ground control station (GCS) and conducted syllabus-directed training before handing over MRPA control to the mishap crew (MC). Beginning at 21:11:04Z, the propeller pitch decreased to -3 degrees, which generated a reverse thrust situation, and remained at that position for the duration of the flight. By 21:11:21Z, the MRPA had descended 300 feet below the commanded altitude. The MRPA continued to descend with a vertical velocity exceeding -1,000 feet per minute (FPM). At 21:11:22Z, the MC, which consisted of the mishap pilot (MP), mishap evaluator sensor operator (MESO), and mishap upgrade sensor operator (MUSO), received a propeller pitch servomotor failure warning message, among others, on the heads down display (HDD). These messages were the first indication to the MC of a problem with the variable pitch propeller (VPP) servomotor, which controls propeller pitch angles. Shortly thereafter, the MC lost link to the MRPA and it impacted the ground at approximately 2113Z.

I find, by clear and convincing evidence, that the cause of the mishap was a VPP system failure. A cable that provides electrical current to the VPP servomotor was found to have produced inconsistent electrical current. This lack of electrical power to the VPP servomotor resulted in a fixed propeller position of 14.5 degrees for 5.4 hours, followed by a subsequent un-commanded propeller pitch shift down to -3 degrees, which put the MRPA into a thrust deficient situation from which it could not recover. I also find, by a preponderance of the evidence, that the human factor of misinterpreted instrument readings substantially contributed to the mishap.

I developed my opinion by analyzing factual data from the flight recordings, witness testimony, the General Atomics (GA) contractor report, applicable technical orders, and maintenance records. All evidence is consistent with a VPP system failure.

2. CAUSE

I find, by clear and convincing evidence, that the cause of the mishap was a VPP system failure which resulted from inconsistent electrical supply available to the VPP servomotor via the W320 cable. After analyzing factual data from the flight recordings, witness testimony, the GA contractor report, applicable technical orders, and maintenance records, I have determined that the MRPA experienced a VPP system failure. The fixed propeller position of 14.5 degrees for 5.4 hours and the subsequent un-commanded propeller pitch shift down to -3 degrees put the MRPA into a thrust deficient situation from which it could not recover.

A post-accident investigation by GA suggested two possible causes of the VPP system failure: foreign object debris (FOD) and fatigued solder joints in the W320 cable assembly. FOD was discovered in the VPP rack during analysis and GA indicated that it may have jammed the propeller pitch mechanism and restricted propeller pitch changes. After personally viewing a VPP rack on an MQ-1B, consulting with functional area experts, and relying on my two decades of experience in aviation, I have concluded that the FOD was insignificant and would not interfere with movement of the VPP rack in standard operating conditions.

The GA report noted that fatigued solder joints at the inductive coils L1 and L2, single leg side (-/+Propeller (Prop) Motor) wires of the W320 cable most likely resulted in insufficient and/or inconsistent current to the VPP servomotor to control propeller pitch. The propeller pitch stagnation at 14.5 degrees for the majority of the flight indicated a locked propeller pitch gear rack and blade cup gear train. The fatigued solder joints suggested degradation over time and were consistent with the datalogs indicating degraded servomotor driving capability. This was indicated by the absence of significant servomotor current and temperature rise during the period of time when the propeller pitch remained constant at 14.5 degrees. The small propeller pitch current and temperature fluctuations while the propeller pitch was constant at 14.5 degrees were not indicative of any applied current to the propeller servomotor. Similar behavior was observed during sub-system testing with power wires disconnected. The sudden increase to 22 degrees indicated the brake released and the servomotor was briefly powered. Power to the servomotor was likely interrupted before the propeller pitch achieved the commanded position and before the brake was applied. Aerodynamic forces then drove the pitch angle to a negative position. Analysis of data logs from previous flights did not indicate similar propeller pitch behavior. Therefore, it is my opinion that inconsistent electrical supply available to the VPP servomotor via the W320 cable caused the VPP system failure, which subsequently caused the mishap.

3. SUBSTANTIALLY CONTRIBUTING FACTORS

I find, by a preponderance of the evidence, that the human factor of misinterpreted instrument readings substantially contributed to the mishap. The propeller was fixed at 14.5 degrees for 5.4 hours of flight, but the first three crews did not recognize or react to that fixed position. All crews testified that operations checks were conducted in accordance with published guidance, which includes an operations check on propeller pitch operation. All crews noted that there were no abnormal indications, despite multiple comments about poor aircraft performance. I believe that the three crews that preceded the MC did perform operations checks, but they misinterpreted the stagnant value of the propeller pitch. The propeller pitch was within a normal range and the aircrews were not provided any warning that it was stagnant, indicators which they misinterpreted to mean the propeller pitch was functioning properly. I believe this was due to the nature of the sortie, practicing the take-off and landing phases of flight, both of which are considered critical phases of flight. These phases require intense focus and often involve task saturation. Further, the crews were briefed to pay particular attention to turbo oil temperature, which took their attention away from propeller pitch and contributed to the misinterpreted instrument readings. I therefore find, by a preponderance of the evidence, that the human factor of misinterpreted instrument readings substantially contributed to the mishap.

The MC exhibited the human factors of channelized attention, challenge and reply, assertiveness, and temporal distortion while reacting to the VPP system failure. When faced with the rapid descent, the MC channelized its attention on clearing a nearby ridge to the exclusion of fully recognizing and handling the VPP system failure as a crew in a timely manner. The challenge and reply factor was evidenced when the MUSO stated that propeller pitch was at -3 degrees, but the statement was not acknowledged by the MP until 60 seconds later. Additionally, the MUSO and MESO were not assertive when they stated the warnings that were being relayed to the GCS, but did not ask the MP how the MP wanted to respond until 45 seconds later. Finally, temporal distortion was evidenced by the MESO making the comment that the rapid descent occurred over the course of "like 30 seconds" when, in reality, over two minutes passed between the initial warnings and the lost link. Due to the distance away from Creech AFB and the altitude at which the VPP anomaly occurred, it is my opinion that even if the MC had immediately recognized the VPP failure, turned off the engine, and attempted to glide back to Creech AFB, the MC would not have succeeded. I conclude that a preponderance of the evidence does not support the conclusion that the MC's human factors of channelized attention, challenge and reply, assertiveness, and temporal distortion substantially contributed to the mishap.

The Air Force's response to the GA alert bulletin suggesting replacement of W320 cables was also considered as a possible substantially contributing factor. Instead of the recommended material change by GA, the Air Force directed a one-time inspection and adjusted the standing maintenance procedures for W320 cables. The MRPA passed the W320 inspection and the adjusted maintenance procedure specifically directed proper W320 placement and function. I conclude that the Air Force's response was reasonable and a preponderance of the evidence does not support the conclusion that it substantially contributed to the mishap.

4. CONCLUSION

I developed my opinion by analyzing factual data from the flight recordings, witness testimony, the GA contractor report, applicable technical orders, and maintenance records. All evidence is consistent with a VPP system failure.

21 October 2013

, Lt Col, USAF
President, AAIB

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