UNITED STATES AIR FORCE AIRCRAFT ACCIDENT INVESTIGATION BOARD REPORT

MQ-1B, S/N 07-3200

27th Special Operations Wing
3rd Special Operations Squadron
Cannon Air Force Base, New Mexico

LOCATION: Cannon Air Force Base, New Mexico

DATE OF ACCIDENT: 28 July 2010

BOARD PRESIDENT: Lt Col Mark T. Kramis

Conducted IAW Air Force Instruction 51-503

EXECUTIVE SUMMARY

AIRCRAFT ACCIDENT INVESTIGATION
MQ-1B PREDATOR, S/N 07-3200
CANNON AIR FORCE BASE, NM
28 JULY 2010

On 28 July 2010, at 1400 Zulu (Z) time, the Mishap Remotely Piloted Aircraft (MRPA), an MQ-1B Predator, serial number (S/N) 07-3200, crashed into a perimeter fence south of the Cannon Air Force Base (AFB) airfield. The Predator and Launch and Recovery Element (LRE) crew were assigned to the 3rd Special Operations Squadron, 27th Special Operations Wing, Cannon AFB, New Mexico. There were no injuries or deaths, but the mishap did result in minor damage to non-military property (corn). Damage to the MRPA and government property is valued at $988,149.

The mishap occurred on day two of the Rapid Reaction Demonstration (RRD), which was intended to validate the feasibility of rapidly deploying the MQ-1 system and team. The MRPA taxied south from a parking location near the south end of Delta taxiway at 1355Z. Approximately four minutes into the taxi, the Mishap Crew (MC) experienced degraded signal strength and increased Datalink Delay (time for signal to travel from the control station to the aircraft) between the MRPA and the Containerized Deployable Control Station (CDCS) 6010. During this period, the MC noticed an uncommanded power increase (without accompanying throttle input) and corresponding increase in ground speed. Mishap Pilot 1(MP1) commanded 100% brakes but the MRPA did not respond to the input. Following emergency procedures, the MC cut power to their Portable Ground Data Terminal (PGDT) in an attempt to stop the MRPA.

At the time the MC identified the problem, the MRPA was taxiing past a building that obstructed its Line Of Sight (LOS) communication link with the controlling PGDT. Mishap Pilot 2 (MP2) was operating (shadowing), without a Sensor Operator (SO), from another location that provided unobstructed LOS communication with the MRPA. While preparing CDCS 6006 to shadow the mission, MP2 deviated from a checklist item by turning her Ground Data Terminal (GDT) transmitter to the ON position. As the signal strength from CDCS 6010 dropped off, the shadow CDCS 6006 linked to the aircraft and took control. As a result, the aircraft experienced an increase in speed, departed the prepared surface and impacted a perimeter fence approximately 1,900 feet from the end of the runway.

The Accident Investigation Board (AIB) President determined, by clear and convincing evidence, the cause of the mishap was a loss of aircraft control due to MP2 deviating from checklist procedures by turning the GDT uplink transmitter to ON. The AIB President found, by a preponderance of evidence, the following three factors substantially contributed to the mishap: (1) failure to comply with required crew compliment; (2) absence of published directives for shadow operations; (3) failure to identify the limitations of the PGDT and the impact of LOS obstructions.

SUMMARY OF FACTS AND STATEMENT OF OPINION
MQ-1B, S/N 07-3200
28 July 2010

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

27 SOW	27th Special Operations Wing
3 SOS	3rd Special Operations Squadron
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AFIP	Armed Forces Institute of Pathology
AFTO	Air Force Technical Order
AFSOC	Air Force Special Operations Command
AIB	Aircraft Investigation Board
BFS	Battlespace Flight Services, LLC
CAMS	Core Automated Maintenance System
CDCS	Containerized Deployable Control Station
CDI	Commander-Directed Investigation
DO	Director of Operations
GA ASI	General Atomics Aeronautical Systems, Incorporated
GCS	Ground Control Station
GDT	Ground Data Terminal
HDD	Heads Down Display
IAW	In Accordance With
ISR	Intelligence Surveillance and Reconnaissance
KIAS	Knots Indicated Airspeed
LOS	Line of Sight
LRE	Launch and Recovery Element
MC	Mishap Crew
MCE	Mission Control Element
MIP	Mishap Instructor Pilot
MMC	Mishap Mission Commander
MRPA	Mishap Remotely Piloted Aircraft
MP	Mishap Pilot
MSO	Mishap Sensor Operator
MTS	Multi-spectral Targeting System
NM	New Mexico
OG	Operations Group
PGDT	Portable Ground Data Terminal
PPSL	Predator Primary Satellite Link
RPA	Remotely Piloted Aircraft
RRD	Rapid Reaction Demonstration
SATCOM	Satellite Communications
S/N	Serial Number
SOMXG	Special Operations Maintenance Group
SOG	Special Operations Group
TCTO	Time Compliance Technical Order
T.O.	Technical Order
U.S.	United States
USAF	United States Air Force
U.S.C.	United States Code
USSOCOM	United States Special Operations Command
VIT	Variable Information Table
WG	Wing

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

SUMMARY OF FACTS

AIRCRAFT ACCIDENT INVESTIGATION
MQ-1B PREDATOR, S/N 07-3200
CANNON AFB, NEW MEXICO
28 JULY 2010

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority

On 20 August 2010, Major General Kurt A. Cichowski, Vice Commander, Air Force Special Operations Command (AFSOC), United States Air Force (USAF), convened an Accident Investigation Board (AIB) in accordance with (IAW) Air Force Instruction (AFI) 51-503, *Aerospace Accident Investigations*, to investigate the 28 July 2010 crash of an MQ-1B Predator aircraft, serial number (S/N) 07-3200, at Cannon Air Force Base (AFB), New Mexico (NM). The following USAF personnel served in the AIB:

Lieutenant Colonel Mark T. Kramis	Board President
Major (Redacted)	Legal Advisor
Major (Redacted)	Medical Member
Major (Redacted)	Pilot Member
Captain (Redacted)	Maintenance Member
Technical Sergeant (Redacted)	Recorder

b. Purpose

The purpose of the AIB is to provide a publically releasable report of the facts and circumstances surrounding the accident, to include a statement of opinion of the cause or causes of the accident; to gather and preserve evidence for claims, litigation, disciplinary and adverse administrative actions; and for all other purposes.

c. Circumstances

The AIB was convened to investigate the 28 July 2010 aircraft mishap involving an MQ-1B Predator aircraft, S/N 07-3200, hereinafter referred to as the Mishap Remotely Piloted Aircraft (MRPA), assigned to the 27th Special Operations Wing (SOW), Cannon AFB, NM. The MRPA was operated out of Cannon AFB during the second day of a Rapid Reaction Demonstration (RRD) in accordance with a Concept of Operations (CONOP) evaluating the feasibility of rapidly mobilizing an MQ-1B aircraft, its equipment, operations and support personnel. The accident investigation was conducted at Cannon AFB, NM and Hurlburt Field, Florida (FL) from 30 August 2010 to 30 September 2010.

2. ACCIDENT SUMMARY

On 28 July 2010, at 1400 Zulu (Z) time, the MRPA, an MQ-1B Predator, S/N 07-3200, crashed into a perimeter fence south of the Cannon AFB airfield. The Predator was an asset of the 3rd Special Operations Squadron (SOS), 27 SOW, Cannon AFB, NM. At the time of the mishap, the MRPA was operated by a Launch and Recovery Element (LRE) crew from the 3 SOS, 27 SOW, Cannon AFB, NM. There were no injuries or deaths but the mishap did result in minor damage to non-military property (corn) (Tab P-10). Damage to the MRPA and government property is valued at $988,149 (Tab P-2).

The mishap occurred on the second day of the RRD which was intended to validate the feasibility of rapidly deploying an MQ-1 system and team. To mitigate the risk of losing an aircraft, the CONOP required a redundant control station (hereinafter referred to as a "shadow") and crew pre-positioned in another Containerized Deployable Control Station (CDCS) with an independent Ground Data Terminal (GDT). In accordance with the CONOP, the shadow CDCS would be pre-flighted and ready to assume control of the MRPA if it lost communication with the primary CDCS (Tab O-21). Although both AFI 11-2-MQ-1, Volume 1 and TO 1Q-1(M)B-1, Section 2 state the required crew compliment for MQ-1 operations is a pilot and a sensor operator (SO) or two pilots, Mishap Pilot 2 (MP2) was the sole operator (no SO or additional pilot) of the shadow CDCS 6006 (Tab V-9.9, 10.3, 12.9).

On the day of the mishap, the MRPA taxied south (left turn out of parking) from a parking location on the south end of delta taxiway at 13:55Z (Tabs DD-3, V-10.3). Approximately four minutes into the taxi, the Mishap Crew [MC, consisting of Mishap Pilot 1 (MP1), Mishap Sensor Operator (MSO) and Mishap Instructor Pilot (MIP)] experienced degraded signal strength and increased Datalink Delay (time for signal to travel from the control station to the aircraft) between the MRPA and CDCS 6010 (Tabs DD-7, O-5). During this same period, the MC noticed an uncommanded throttle increase from 0% to 70% and increased ground speed up to ~18 knots (Tab DD-7). Attempts by MP1 in CDCS 6010 to apply brakes were unsuccessful during the period of degraded signal strength (Tabs DD-3, O-6). Approximately 9 seconds after identifying the loss of control, the MIP cut power to the Portable Ground Data Terminal (PGDT) in an attempt to stop the MRPA (Tabs DD-8, V-10.4, 15.9).

At the time the MC identified a problem, the MRPA was taxiing past a building obstructing its line-of-sight (LOS) communication link with the controlling PGDT (Tab Z-11). While preparing CDCS 6006 to shadow the mission, MP2 deviated from a checklist item and incorrectly turned her GDT transmitter to the ON position (Tabs DD-3, V-15.21). As a result of MP2 turning the GDT transmitter ON, the shadow CDCS/GDT was transmitting simultaneous data to the MRPA. Because MP2 was operating from a location providing unobstructed LOS communication with the MRPA, as the signal strength from CDCS 6010 dropped off, the shadow CDCS 6006 linked to the aircraft and took control. The control settings in the shadow CDCS 6006 were based upon a gaining handover in the air which requires throttles set at 70% and pitot heat ON. Once the shadow CDCS linked to the MRPA, the throttle and pitot heat settings were transmitted to the aircraft (Tabs O-4, Z-5-7). The MRPA increased speed, departed the prepared surface and impacted the perimeter fence approximately 1,900 feet from the south end of taxiway Delta (Tabs DD-6, O-7). The aircraft was recovered from the mishap sight and relocated to a hangar on Cannon AFB.

3. BACKGROUND

MRPA 07-3200 was an asset of the 3 SOS, 27th Special Operations Group (SOG), 27 SOW, Cannon AFB, NM. Launch and Recovery Element (LRE) crews involved in this mishap were assigned to the 3 SOS, 27 SOW, Cannon AFB, New Mexico.

a. Air Force Special Operations Command

AFSOC is headquartered at Hurlburt Field, FL, and is one of ten major Air Force commands. AFSOC provides Air Force special operations forces for worldwide deployment and assignment to regional unified commands. The command's SOF are composed of highly trained, rapidly deployable Airmen conducting global special operations missions ranging from precision application of firepower, to infiltration, ex-filtration, resupply and refueling of SOF operational elements.

b. 27th Special Operations Wing

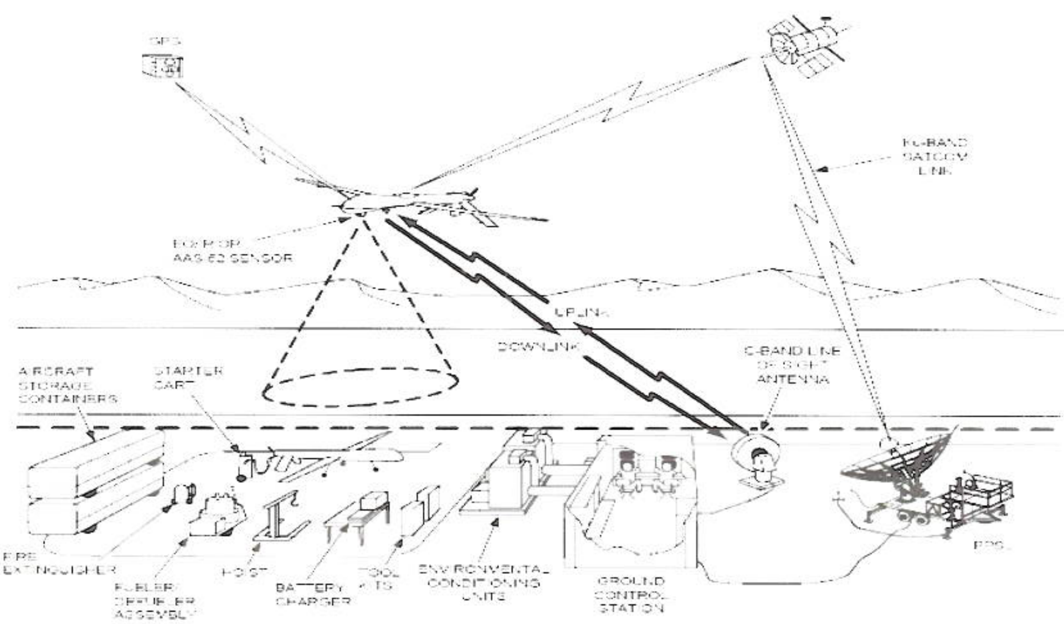
The 27 SOW at Cannon AFB, NM, is one of two Air Force active duty Special Operations wings and falls under AFSOC. The primary mission of the 27 SOW is to plan and execute specialized and contingency operations using advanced aircraft, tactics, and air refueling techniques to infiltrate, exfiltrate, and resupply SOF and provide ISR, and close air support for SOF operations.

c. 3rd Special Operations Squadron

The 3rd SOS accomplishes global special operations tasking as a member of the Air Force component of United States Special Operations Command. It directly supports theater commanders by providing precision weapons employment and persistent intelligence, surveillance, and reconnaissance. It also plans, prepares, and executes MQ-1B Predator missions supporting special operations forces.

d. MQ-1B Predator System

The MQ-1B Predator aircraft is a medium-altitude, long endurance, remotely piloted aircraft. Its primary mission is interdiction and conducting armed reconnaissance against critical perishable targets. The MQ-1B Predator is a fully operational system, not just an aircraft.



The basic system consists of four aircraft (with sensors), a Ground Control Station (GCS), a Predator Primary Satellite Link (PPSL), operations and maintenance personnel for deployed 24-hour operations. The basic crew for the MQ-1B Predator is one pilot and one SO. They fly the MQ-1B Predator from inside the GCS via a LOS radio data link and via a satellite data link for beyond LOS flight. A ground data terminal antenna provides LOS communications for takeoff and landing while the PPSL provides beyond LOS communications during the remainder of the mission. The aircraft is equipped with a color nose camera (generally used by the pilot for flight control), a day variable-aperture television camera, a variable aperture infrared camera (for low light/night), and other sensors, as required. The cameras produce full-motion video. The MQ-1B Predator also carries the Multi-Spectral Targeting System which integrates electro-optical, infrared, laser designator and laser illuminator into a single sensor package. The MQ-1B Predator is manufactured by General Atomics Aeronautical Systems Inc. (GA ASI) headquartered in San Diego, California.

4. SEQUENCE OF EVENTS

a. Mission

The MRPA was tasked to fly a local sortie in support of a planned RRD CONOP. The purpose of the CONOP was to vet a Merlin RAMCo, Inc. (MRI) recommended course of action (COA) demonstrating the feasibility of rapidly deploying a MQ-1 system to an austere airfield. The RRD CONOP included loading the following into two C-130 aircraft: two disassembled MQ-1 aircraft; 1 CDCS; 1 PDGT; aircrew, maintenance and communication personnel. On 27 July 2010 (CONOP day 1), the two C-130 aircraft flew an out-and-back sortie from Cannon AFB simulating an arrival to a deployed location. After landing, the C-130s taxied to Delta taxiway for offload, setup, simulated bivouac and termination of day 1 scheduled events. On 28 July 2010, the launch and recovery demonstration of the MQ-1 was accomplished by 3 SOS aircrews from a CDCS located on a run pad near the southern end of Delta taxiway. Two sorties of 2 to 3 hours each were scheduled for the day of the mishap (Tab V-12.8).

Per the CONOP, a second (shadow) CDCS and crew would be pre-positioned at Pred-South. This redundant control station or "shadow" was intended as a safety measure in the event the primary CDCS lost link with the RPA (Tabs O-21, V-3.9). An extensive search of AF directives combined with witness testimony confirmed there is no published guidance or procedure for shadow procedures (Tab V-2.9, 5.4, 10.6, 12.12, 15.19).

b. Planning

Planning for the RRD was led by members from 27 SOW/XPU, MQ-1 Exercises and Plans, in response to a USSOCOM and AFSOC rapid deployment capability requirements document. From April through July 2010, aircrew and maintenance participated in numerous training, test and evaluation events in preparation for the RRD. Included were CDCS and PGDT taxi and flight checks (Tab V-12.4-5). During the initial test, the PGDT was placed atop a mobile GDT (GDT atop a collapsible scissor type tower that extends to 50 feet) at Pred South (Tabs V-12.18, Z-10). From this location and height, the PGDT would have the same coverage as the fixed GDTs at Pred South. A second test was conducted from the RRD exercise site on Delta taxiway. While both tests were deemed successful, neither required the aircraft to taxi south on Delta taxiway past the large building that caused the disrupted signal (Tab V-12). The RRD CONOP was released on 16 July 2010 outlining the requirements, timeline and events for 27-28 July (Tab O-9).

All crewmembers, with one exception, attended the mission briefing on the date of the mishap. The MIP testified he arrived late due to vehicle trouble but was back-briefed by another pilot crewmember immediately upon arrival (Tab V-15.6). The crew briefing covered standard 3 SOS brief items to include weather, notices to airmen (NOTAMs), individual crew assignments and currency requirements (Tab V-10.3, 12.7).

c. Preflight

The MC reviewed the Air Force Technical Order (AFTO) 781 series maintenance forms for the CDCS 6010 and found no discrepancies. No discrepancies were noted in the AFTO 781 forms for CDCS 6006, although this AIB was unable to determine if the forms were inspected prior to the mishap. Another pilot crewmember performed the pre-flight inspection and walk-around of the MRPA (Tab V-15.5).

d. Summary of Accident

The MC began LR procedures at approximately 1300Z. During the aircraft initial link checklist, the MC enabled the data logger in CDCS 6010 at 1303:39Z (Tab DD-6). The MC started the MRPA engine at 1327:57Z (Tab DD-6). The MC received weather observations at 1329Z and again at 1342Z (Tab F-4). At 1355Z, the MC taxied south on Delta taxiway with intent to back taxi on runway 13/31 for an expected departure from runway 13 (Tabs DD-6, V-4.6). At 1400:09Z, data logger files recorded significant uplink and downlink errors (Tab DD-7). At approximately the same time, the MC noticed degraded picture and signal strength in CDCS 6010 (Tab V-4.4).

Over the next 25 seconds, data logger files continued to record significant link errors while telemetry continued updating. The updated telemetry indicated the MRPA was not lost link (Tab DD-7). The MC continued to observe degraded picture with no significant loss of MRPA control authority (Tab V-4.4). At 1400:35Z, data logger records a Primary Control Module (PCM) throttle command increase of 0% to 70% while the throttle command from CDCS 6010 was 0% (Tab DD-7). Indicated airspeed increased from 16 knots to 30 knots over the next few seconds (Tab DD-7). At this point, the MC received their first indication of an actual loss of command without an associated Heads Down Display (HDD) warning message (Tab V-4.5, 10.4, 15.9).

At 1400:42Z, data logger files recorded full application of brakes with no response from the MRPA (Tab DD-7). The MC testified there were no lost link HDD warning messages (Tab V-4.5, 10.4). Additionally, left and right pitot heat ON is recorded but not commanded by the controlling CDCS 6010 (Tab DD-7). At approximately 1400Z, the data logger recorded the upper directional antenna on the MRPA diverging from its pre-programmed controlling PGDT location, zeroing in on the shadow GDT transmitter location at Pred South (Tab DD-3).

The MC observed the MRPA start an uncontrolled taxi off the prepared surface. Recognizing the MRPA's failing response to MP1's inputs and freezing telemetry (with no associated HDD warnings), MIP applied flight manual critical action procedures (CAPs), **Uplinks Off**, by turning off PGDT power in CDCS 6010. This action was recorded by the data logger at 1400:51Z (Tabs DD-8, V-15.9). The MC lost all remaining return link from the MRPA with application of this procedure thus losing situational awareness of the MRPA's condition and position (Tab V-15.11). When PDGT power was disabled, the MRPA exited the prepared surface heading 182 degrees magnetic at 18 knots ground speed with 70% throttle commanded (Tab DD-8). The MRPA continued for approximately 1,900 feet before impacting a perimeter fence (Tab DD-6).

Per the RRD CONOP, paragraph 6.6.2., MP2 was occupying the back-up CDCS 6006 at Pred South. MP2 did not have data loggers enabled; therefore, no information was recorded from CDCS 6006 (Tab DD-3). Although both AFI 11-2-MQ-1, Volume 1 and TO 1Q-1(M)B-1, Section 2 state the required crew compliment for MQ-1 operations is a pilot and a sensor operator (or second pilot), no sensor operator or additional pilot was present in CDCS 6006 at the time of the mishap (Tab V-9.9, 10.3, 12.9).

Per witness testimony, after powering down the GDT in an effort to cause the MRPA to apply brakes and disable its engine (lost link logic below 40 KIAS) the MIP instructed MP1 to ask MP2 over VHF common frequency, "Do you have a feed from it?" MP2 responded, "It's departing the hard surface into the grass." MIP then instructed MP1, "Tell her to grab the aircraft, grab it, stop it." After a long pause, MIP asked MP1 to transmit, "Do you have the aircraft, did you stop it?" MP2 responded, "The aircraft is up against the fence." (Tab V-15.10).

e. Impact

At approximately 1402Z, the MRPA impacted the perimeter fence approximately 1,900 feet south of the approach end of runway 31 (Tab DD-6). When the mishap aircraft came to rest, its nose was facing 158 degrees magnetic with a commanded power setting of 70% (Tab DD-8). Its lower transmitter antenna and its right wing were sheared off (Tab Z-1). Additional significant damage occurred to the MRPA's Multi-spectral Targeting System (MTS) ball, training missiles, vertical tails, landing gear, radome and various other antennas (Tab Z-1). The estimated cost of repair is $988,148.56 (Tab P-2).

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

(1) General Definitions

Each individual Air Force aircraft and CDCS has its own set of written and electronic maintenance records used to document routine scheduled, as well as unscheduled (e.g., flight or ground reported discrepancies), maintenance. These maintenance actions are documented in writing in the AFTO 781 forms and electronically based Core Automated Maintenance System (CAMS). In addition to capturing historical data, these documents provide an avenue for more effectively troubleshooting and resolving new or recurring maintenance discrepancies.

Time Compliance Technical Orders (TCTO) are system changes, usually parts upgrades, with a specific completion date. A TCTO may also direct inspections or adjustments to equipment of parts already attached to the aircraft or ground support items. TCTOs may be immediate, urgent, or routine, based on the severity of the issue. Time change items are routine maintenance actions in which components are removed and replaced for overhaul at a given number of flight hours.

(2) General Documentation Reviewed

Maintenance activities for the MRPA S/N 07-3200 and for the CDCS 6010 are performed by military maintenance personnel assigned to the 27 SOMXG. Maintenance activities for the shadow CDCS 6006 are performed by Battlespace Flight Services, LLC (BFS), a contracted maintenance support company. A thorough review of CAMS documentation was conducted. This review reflects maintenance conducted 90-days prior to the mishap. The 90-day aircraft forms history revealed no recurring maintenance problems related to the mishap. Also, a thorough review was conducted of the AFTO 781 series forms. A minor discrepancy was found but was unrelated to the mishap. Additionally, there were no overdue TCTOs, time change items or special inspections at the time of the mishap. No discrepancies relevant to this mishap were found in the reviewed maintenance documentation (Tab D-2, 52).

b. Inspections

(1) Mishap Aircraft/CDCS

All scheduled inspections were accomplished within scheduled time limits, and there were no overdue aircraft TCTOs. The next scheduled aircraft inspection is a 60-hour for the aircraft engine (Tab D-10).

(2) Mishap Engine

The Predator RPA requires an engine inspection every 60, 360 and 720 flight hours. The MRPA engine was installed on 9 September 2008. All scheduled inspections were completed on time and there were no overdue inspections or modifications. The engine had flown 21 hours since the last scheduled inspection, the 60 hour engine inspection. The engine had 39 hours remaining until its next scheduled inspection (Tab D-2, 19-20).

c. Maintenance Procedures

Maintenance procedures on the MRPA were completed in accordance with applicable technical orders (TO) and AFIs. Maintenance procedures on the MRPA were not a factor in this mishap. Maintenance procedures for both CDCSs were completed in accordance with applicable TOs and AFIs. Maintenance procedures were not a factor in this mishap for either CDCS.

Approximately 1 week prior to executing the RRD, critical information was shared but lost between a Ground Communications Systems technician and the RRD Mishap Mission Commander (MMC) during set-up of CDCS 6010 and the PGDT. The Communications technician conveyed concerns regarding a LOS obstacle (hush house facility) potentially impeding the PGDT signal strength and creating a possible degraded link situation. This critical information was not relayed by the MMC to the MC. However, the MMC did not recall receiving this information (Tab V-12.20).

During nonstandard operations, a formal method of communicating critical maintenance information is by entering an "Informational Note" in the AFTO 781 series forms in accordance with T.O. 00-20-1, paragraph 3-3, basic publication date 30 April 2003. The informational note may have read, "Hush house presents LOS obstacle heading south on Delta Taxiway." An "Informational Note" in the forms may have prevented the LOS signal degradation.

d. Maintenance Personnel and Supervision

Aircraft maintenance records and statements provided by maintenance personnel indicated all preflight maintenance and supervisory activities were normal (Tab D-5, 29, 41). A thorough review of the training and qualification records of the 27 SOMXG military Ground Communications System maintenance personnel who performed maintenance on the MRPA and CDCS 6010 indicated all personnel were trained and qualified.

A thorough review of the training and qualification records of the BFS contractor who performed maintenance on the shadow CDCS 6006 indicated the individual was trained and qualified. Interviews of maintenance personnel, in conjunction with reviewing training records and special certification rosters, reflect qualified and competent maintenance personnel with appropriate supervision.

e. Fuel, Hydraulic and Oil Inspection Analysis

All Aviation gasoline fuel samples taken tested within limits and were free from contamination, in accordance with TO 42B-1-1 (Tab DD-3). There is no evidence suggesting servicing equipment contributed to the mishap.

f. Unscheduled Maintenance

A review of the unscheduled maintenance actions revealed maintenance was performed and documented correctly. There is no evidence suggesting unscheduled maintenance contributed to the mishap.

6. AIRCRAFT AND AIRFRAME

a. Condition of Systems

The AIB investigated post-mishap photographs of the perimeter fence impact site, the preserved physical evidence of the MRPA's wreckage and the GA engineering analysis report. Photographs taken at the mishap site revealed the MRPA wreckage remained in a fairly compact area at the point of impact (Tab Z-1). All aircraft structures and systems were found in the immediate vicinity of the main fuselage, at or near their original orientation, within close proximity of their normal configuration (Tab Z-1).

The MRPA main fuselage was resting intact on its right wing root with little noticeable external damage. However, the forward fuselage sustained significant internal damage when the nose landing gear drove up through the avionics bay, causing the antenna to pierce the radome (DD-10). The shock mounts from the forward avionics bay were pulled out (Tab DD-10). The MTS was pushed-up through the avionics tray damaging the ball (Tab DD-10). The nose wheel was bent at a 90 degree angle from the strut (Tab DD-10). Both main landing gear were attached (Tab DD-10). The lower antenna was sheared off (Tab DD-10). The A-frame and V-block were torn in pieces and the bulkhead cracked (Tab DD-10). There was evidence the fuselage torqued just aft of the right wing root (Tab DD-10).

The left wing remained attached but had holes in the trailing edge for approximately the last six feet. The right wing was torn-off and incurred damage along the trailing edge at approximately mid-wing. It came to rest inverted in the fence, behind and slightly to the left of the fuselage. The vertical tail remained attached, but was bent 90 degrees. The left tail was attached, but incurred damage to the leading edge. The right tail was torn off and came to rest on the fence, aft and to the left of the fuselage.

Impact site

The engine remained intact. Both engine cowls were cracked through the composite. A separation of the composite occurred forward of the fuel tray near the IFF antenna. The spinner cone remained intact but all propeller blades separated and were found within relative close proximity to the MRPA impact site.

b. Testing

GA engineering personnel analyzed and formulated a report using the data logs from CDCS 6010, post-mishap photographs of the MRPA, photos of several Variable Information Tables (VITs) and status screens from the shadow CDCS 6006. The data logs from the shadowing CDCS 6006 were not recorded during the mishap (Tab DD-3). Based on analysis of these parts and data collected from the MRPA, all aircraft and both CDCS systems were operating normally until the time when the MRPAs datalink signal became degraded and an uplink from shadowing CDCS 6006 took control of the aircraft (Tab DD-3).

Prior to the AIBs arrival, a recreation was performed on Delta taxiway, Cannon AFB, NM, using an MQ-1B, the CDCS 6010 and the PGDT. Based on witness testimony, the recreation demonstrated a degraded datalink signal between the PGDT and the MQ-1B at approximately the same taxiway location as the MRPA (Tab V-13.11-12). The shadow CDCS 6006 was inspected with no defects noted and returned to service.

c. Analysis of Test Results

Based on the geometry between the PGDT and the aircraft taxi location, MRPA experienced a degraded data link from CDCS 6010 due to a building obstructing the line-of-sight. Once the data link became degraded, an uplink from shadowing CDCS 6006 took control of the aircraft and the upper directional antenna pointed at the CDCS 6006's GDT. The lower directional antenna continued to point to CDCS 6010's PGDT. However, due to the obstructed line-of-sight to CDCS 6010, commands from the interfering CDCS were intermittently executed by the aircraft (Tab DD-3).

The shadowing CDCS was commanding 70% throttle and the aircraft gained ground speed. Attempts by the CDCS 6010 pilot to apply brakes were unsuccessful during the period of interference. The PGDT for CDCS 6010 was eventually disabled, which allowed full control by CDCS 6006. Because the aircraft was receiving an uplink at all times, the aircraft did not perform the lost link logic while on the ground, which would have disabled the engine and applied full brakes. The aircraft impacted a perimeter fence approximately 1,900 ft from the last recorded location in the data logs, approximately in line with the last known heading (Tab DD-3).

d. Post Mishap Component Testing

No parts were tested.

7. WEATHER

A. Forecast Weather

The terminal aerodrome forecast at Cannon AFB for the 24 hour period 28 July 2010 at 1000Z through 29 July 2010 1000Z called for wind from the southeast (160 degrees) at 9 knots, unlimited visibility, a few clouds at 15,000 feet, and an altimeter setting of 30.12 inches. Progressing forward on the morning of 28 July 2010 from 1500Z to 1800Z the forecast called for the wind increasing to 12 knots shifting from the south (190 degrees) with wind gusts up to 18 knots and a broken layer of cumulonimbus clouds with the bases beginning at 8,000 feet. A temporary condition beginning at 1900Z throughout the remaining afternoon also called for conditions to worsen at times with winds increasing to 30 knots with gusts up to 40 knots coming from varying directions. This temporary condition included a decreased visibility component of 4,800 meters and called for rain, thunderstorms and small hail with cumulonimbus cloud bases decreasing to 5,000 feet. The forecast called for a daily low temperature of 63 F and a daily high of 83 F (Tab F-3).

B. Observed Weather

The first weather observation on the morning of 28 July 2010 at 1329Z provided for winds coming from the southeast (140 degrees) at 4 knots, visibility 3,200 meters, mist, a very low broken layer at 300 feet and 4,000 feet and a temperature reading of 66 F which was below the dew point temperature of 68 F. The second observation 13 minutes later showed significantly improving conditions with the wind southeast (140 degrees) at 7 knots, visibility increasing to 9 statute miles, the low broken cloud deck improving to a scattered layer at 200 feet, and the dew point decreasing to 64 F (Tab F-4).

The weather conditions at Canon AFB at the time of the mishap improved considerably allowing for MQ-1 ground operations to begin shortly after the scheduled launch time of 1300Z. Weather was within operational limits as prescribed by AFI 11-2MQ-1 V3 and local guidance weather minima. There was no evidence to suggest weather was a factor in the mishap (Tab F-4).

8. CREW QUALIFICATIONS

a. Mishap Pilot 1 (MP1)

(1) Training

MP1 has been a qualified MQ-1B pilot since 16 March 2009. Additionally, MP1 qualified as a LR pilot on 10 December 2009 (Tab G-109).

(2) Experience

MP1's total flight time is 2,396.2 hours, which includes 793.9 hours in the MQ-1B (Tab G-32). Prior to flying the MQ-1B, the MP was an RC-135 pilot (Tab G-30). He had completed 57 MQ-1B launches in the previous 90 days, 0 launches in the previous 30 days with his last launch on 1 June 2010. He was overdue for launch procedures by 11 days, requiring IP instruction. MP1 had completed 65 takeoff and landings in the previous 90 days and 4 takeoff and landings in the previous 30 days. MP1 was current for takeoff and landing procedures (Tab G-35, 55). MP1's flight time during the 90 days before the mishap is as follows (Tab G-55):

MP1	Hours	Sorties
Last 30 Days	57.7	21
Last 60 Days	65.1	37
Last 90 Days	107	140

b. Mishap Pilot 2 (MP2)

(1) Training

MP2 has been a qualified MQ-1B pilot since 15 May 2008. MP2 upgraded to mission instructor pilot on 23 August 2009. Additionally, MP2 qualified as a LR pilot on 05 October 2009 and LR instructor pilot on 22 June 2010 (Tabs G-108, T-4).

(2) Experience

MP2's total flight time is 3,203.1 hours, which includes 1,464.2 hours in the MQ-1B (Tab G-5). Prior to flying the MQ-1B, MP2 was a C-17 pilot (Tab G-6). MP2 had completed 2 MQ-1B launches in the previous 60 days, none in the previous 30 days. Her last launch event was 16 June 2010 (Tab G-7, 27). MP2 had completed 6 takeoffs and 7 landings in the previous 60 days, with only 1 landing within the previous 30 days on 21 July 2010 (G-7, 27). MP2 was current for launch, takeoff, and landing procedures. The MP2's flight time during the 90 days before the mishap is as follows (Tab G-27):

MP	Hours	Sorties
Last 30 Days	24.7	7
Last 60 Days	82.2	22
Last 90 Days	132.4	40

c. Mishap Instructor Pilot (MIP)

(1) Training

The MIP has been a qualified MQ-1B pilot since 3 April 2008. Additionally, the MIP qualified as a MQ-1B LR pilot on 30 January 2009, mission instructor pilot on 10 February 2009 and LR instructor pilot on 12 February 2009. MIP was certified as a MQ-1B evaluator pilot on 21 Oct 2009 (Tabs G-110, T-2).

(2) Experience

The MIP's total flight time is 2,776.7 hours which includes 835 hours in the MQ-1B (Tab G-59). Prior to flying the MQ-1B, the MIP was a MH-53 pilot (Tab G-58). MIP completed 1 MQ-1B launch procedure and 4 takeoff and landing procedures in the last 60 days (G-68). The date of his last launch procedure was 23 June 2010. His last takeoff and launch procedure was 16 June 2010 (G-62). MIP was current for launch, takeoff, and landing procedures. The MIP's flight time during the 90 days before the mishap is as follows (Tab G-68):

MP	Hours	Sorties
Last 30 Days	6.5	1
Last 60 Days	22.2	9
Last 90 Days	51.4	18

d. Mishap Mission Commander (MMC)

(1) Training

The MMC has been a qualified MQ-1B pilot since 25 July 2008. MMC upgraded to MQ-1B LR pilot on 5 June 2009, mission instructor pilot on 28 April 2010 and LR instructor pilot on 22 June 2010 (Tabs G-112, T-6).

(2) Experience

The MMC's total flight time is 2,143.4 hours, which includes 901.9 hours in the MQ-1B (Tab G-91). Prior to flying the MQ-1B, the MMC was a C-130 pilot (Tab G-90). The MMC accomplished 2 launches, 6 takeoffs and 9 landings in the last 30 days (Tab G-107). MMC was current for launch, takeoff and landing procedures (G-94). The MMC's flight time during the 90 days before the mishap is as follows (Tab G-107):

MP	Hours	Sorties
Last 30 Days	48.2	27
Last 60 Days	89.4	59
Last 90 Days	119.6	75

e. Mishap Sensor Operator (MSO)

(1) Training

The MSO has been a qualified MQ-1B sensor operator (SO) since 2 September 1998. MSO upgraded to instructor SO on 3 August 2000 and was certified as an evaluator SO on 16 January 2006. Additionally, the MSO was qualified as a LR SO since 15 October 2007 and LR instructor SO since 12 February 2009 (Tabs G-111, T-5).

(2) Experience

The MSO's total MQ-1B flight time is 4,373.4 hours. Prior to flying the MQ-1B the MSO was a RQ-1 sensor operator. MSO had completed 6 launch and 9 landing procedures in the past 90 days with 2 launch and landing events in the past 30 days. MSO was current on both launch and landing procedures (G-86). The MSO's flight time during the 90 days before the mishap is as follows (Tab G-86):

MSO	Hours	Sorties
Last 30 Days	29.4	9
Last 60 Days	160.3	53
Last 90 Days	205.7	72

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

9. MEDICAL

a. Qualifications

At the time of the mishap, MP1, MP2, MSO and MIP were all medically qualified for flight duty.

b. Health

A review was accomplished of the Armed Forces Health Longitudinal Technology Application, which are the electronic records. The hardcopy medical records were also reviewed and a 72 hour/14 day history was obtained. Preventive Health Assessments were current for crewmembers involved. None of the crew members had any obvious, distracting medical issues at the time of the accident.

c. Toxicology

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

Carbon monoxide is tested by elucidating the carboxyhemoglobin levels. Carboxyhemoglobin saturations (determined by spectrophotometry) of zero to three percent are expected for non-smokers and three to ten percent for smokers. Saturations above ten percent are considered elevated and are confirmed by gas chromatography. Testing on all aircrew and associated maintenance crew members was within normal limits. AFIP examined the blood for the presence of ethanol at a cutoff of twenty milligrams per deciliter. Ethanol results were negative for the aircrew and associated maintenance crew members.

Finally, AFIP screened their urine for amphetamines, barbiturates, benzodiazepines, cannabinoids, cocaine, opiates and phencyclidine by immunoassay (or chromatography). AFIP detected none of these drugs in the aircrew or associated maintenance crew members.

d. Lifestyle

Based on the 72-hour and 14-day histories, as well as witness testimony, it was evident that the operations tempo is chronically high at this particular location and the average workweek involved 12 hour days, five days per week.

Nevertheless, those involved seemed to be well adjusted to this workload and, furthermore, there is no evidence that unusual habits, behavior or stress on the part of the aircrew or maintenance crew members contributed to this accident. MP2 did not turn in a 14-day history.

e. Crew Rest and Crew Duty Time

Air Force Instructions require pilots to have proper "crew rest," as defined in AFI 11-202, Volume 3, *General Flight Rules* (5 April 2006), 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 this time, an aircrew member may participate in meals, transportation or rest, as long as he or she has the opportunity for at least eight hours of uninterrupted sleep.

A review of the duty cycles of the aircrew, via interviews and their written testimony on the 72-hour history indicated that all had adequate crew rest and no issues with crew duty time.

10. OPERATIONS AND SUPERVISION

Operations Tempo

Operations tempo for the aircrew participating in the RRD was high but sustainable. A typical schedule for Mission Control Element (MCE) crews includes a 60-hour work week for the flight crews. The work week is divided into four 12-hour flight duty days, one 12-hour office day, and two days off. As a precautionary measure, the RRD was broken into 2 days to ensure all aircrew were given adequate crew rest prior to executing the LR portion of the demonstration on day 2 (Tab V-12.7).

Experience Level

All crewmembers involved in the mishap were highly experienced in RPA operations. Of the five crewmembers mentioned in this report, including the MMC, one was an evaluator pilot, two were instructor pilots and one was an evaluator SO (Tab G-5, 32, 59, 71, 91).

Supervision

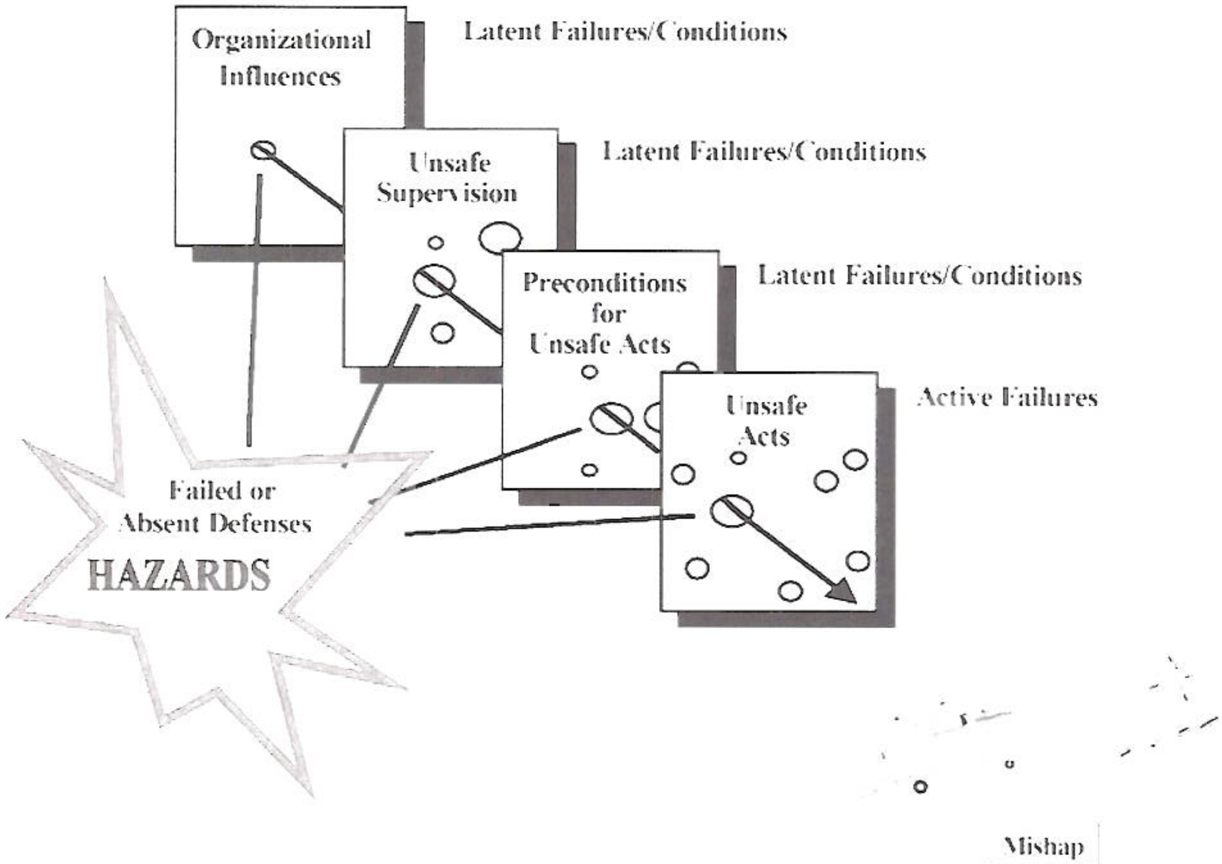
The 3 SOS Commander (CC) and Director of Operations (DO) were recently assigned to the squadron and both were in the process of qualifying in the MQ-1B (Tab V-1.8, 5.3). As a result, neither was present during any of the pre-RRD planning or testing. Responsibility for the executing the RRD was delegated to the MMC (Tabs K-2, 3, V-2.10). The MMC participated in the taxi/flight check on 21 July 2010 and was the only crew member of the RRD with prior experience operating the equipment from the exercise site on Delta taxiway (Tab V-12.5). It was ultimately the decision of the MMC to determine the crew compliment of the CDCSs involved in the mishap (Tab K-2, 3, V-2.10).

11. HUMAN FACTORS

a. Overview

A DoD taxonomy was developed to identify hazards and risks, called the DoD Human Factors Analysis and Classification System (DoD-HFACS). DoD-HFACS describes four main tiers of failures/conditions: **1) Acts, 2) Preconditions, 3) Supervision, and 4) Organizational Influences**.

The investigation process endeavors to detect and identify failed or absent defenses (hazards), which can be visually depicted by the "Swiss Cheese" model (adapted from Reason, 1990), as seen below. Much like the old "Domino Theory", Reason's model promotes the idea that mishaps are the end result of a series of errors made throughout the chain of command. However, what makes the "Swiss Cheese" model particularly useful in mishap investigations is the fact that it forces investigators to address latent failures and conditions within the causal sequence of events.



After reviewing the facts from the investigation (including witness testimony) human factors found to be relevant to this mishap are enumerated below. Also included are the DoD-HFACS taxonomies ***(nanocodes)*** for reference. Working backward from the mishap, the first level of Reason's model depicts any *Unsafe Acts of Operators* that may have led to the mishap:

b. **Acts**

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 an unsafe situation.

Skill-Based Errors (AE1xx) are factors in a mishap when errors occur in the operator's execution of a routine, highly practiced task relating to procedure, training or proficiency and result in an unsafe situation.

(1) **AE102 Checklist Error:** This is a factor when the individual, either through an act of commission or omission makes a checklist error or fails to run an appropriate checklist and this failure results in an unsafe situation.

GA concluded that GCS 6006 was shadowing the MRPA and GCS 6006 most likely was operating with its GDT transmitter on, interfering with the link from GCS 6010. Furthermore, GCS 6010 was commanding 0% throttle, full brakes and no pitot heat. However, the aircraft was operating with 70% throttle, no brakes and pitot heat ON. These parameters were not autonomous in the mode the aircraft was operating in at the time and could have only occurred as described if they were commanded by a GCS (Tab DD-1).

Based on the above mentioned information and additional findings from GA regarding the antenna position on the plane, the temperature of the GDT transmitter and multiple witness testimonies, the AIB concluded the CDCS 6006/GDT transmitter at Pred South was ON at the time of the mishap (Tabs DD-3, 7, V-15.21).

Although no formal written directives define shadow procedures, multiple witnesses testified they could configure a CDCS to shadow using a series of checklists intended to gain control of an airborne RPA (Tabs V-4.8-9, 10.7, 15.20-21). The incorrectly applied item from T.O. 1Q1 (M)B-CL-1, PRESETS checklist, page N-16, step #9, reads as follows: "GDT UPLINK TX – SET (P) with caveats: a. ON – FOR LAUNCH or LOSING; b. OFF – FOR GAINING. Turning the GDT transmitter to **ON** allowed MP2's CDCS to send competing control inputs to the MRPA.

c. **Preconditions**

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 and result in human error or an unsafe situation.

Technological Environment (PE2xx) is a factor in a mishap when cockpit/vehicle/control station/workspace design factors or automation affect the actions of individuals and result in human error or an unsafe situation.

(2) PE208 Communications – Equipment: This is a factor when communication equipment is inadequate or unavailable to support mission demands (i.e. aircraft/ vehicle with no intercom). *This includes electronically or physically blocked transmissions.* Communications can be voice, data or multi-sensory.

GA analysis of overhead imagery indicated that a building was most likely interfering with the LOS datalink between the aircraft and the PGDT. As the aircraft began to pass in the shadow of the building (hush house) the downlink began to degrade significantly. When the link from GCS 6010 weakened due to the building obstruction, the signal from GCS 6006 overpowered the GCS 6010 signal and took control of the aircraft (Tab DD-3).

Based on the above memo and witness testimony regarding a recreation of the mishap, signal strength beyond the hush house was degraded to a point where the MRPA should have executed lost link logic on the ground and disabled the aircraft engine (Tab V-13.11-12).

Personnel Factors (PPxxx) are factors in a mishap if self imposed stressors or crew resource management affect practices, conditions or actions of individuals and result in human error or an unsafe situation

(3) **PP105 Assertiveness**: This is a factor when individuals failed to state critical information or solutions with appropriate persistence.

The MQ-1 Communications Chief testified he informed the MMC a week prior to the incident that the RPA should turn right (north out of parking) on Delta taxiway when initially taxiing to the runway (Tab V-11.7). This was because there was the possibility of signal degradation (due to the hush house obstructing the LOS signal) if the aircraft travelled south. Nevertheless, an Informational Note in the AFTO 781 (an additional method of written communication between maintainers and operators, per TO 00-20-1, 30 Apr 2003) would have been more appropriate than strictly verbal communication.

(4) **PP108 Challenge and Reply:** This is a factor when communications did not include supportive feedback or acknowledgement to ensure that personnel correctly understand announcements or directives.

The challenge and reply format is common on most multi-place aircraft and provides a safeguard against inadvertent actions by a single crewmember. With no other crewmembers present to provide the required challenge and reply method of checklist procedures, MP2 was forced to run the checklist by herself, increasing the likelihood of checklist error (i.e., deviate from checklist by incorrectly turning uplink transmitter to ON) (Tabs V-10.9, 15.22-23).

(5) **PP109 Mission Planning:** This is a factor when an individual, crew or team failed to complete all preparatory tasks associated with planning the mission, resulting in an unsafe situation. Planning tasks include information collection and analysis, coordinating activities within the crew or team and with appropriate external agencies, contingency planning and risk assessment.

The MQ-1 RRD CONOP dated 16 July 2010, section 3.1, states there was a 21 June CDCS/PGDT Taxi Check and on 21 July a CDCS/PGDT Taxi/Flt Test. However, witness testimony makes it clear Delta taxiway was never tested with a MQ-1 (to check for signal degradation) (Tab V-12.5). Had a more comprehensive test been conducted, the RRD planners and aircrew would have been more aware of the need for a taxi plan in the CONOP, which would have restricted the MQ-1 from turning south on Delta taxiway.

(6) **PP110 Mission Briefing:** This is a factor when information and instructions provided to individuals, crews or teams were insufficient, or participants failed to discuss contingencies and strategies to cope with contingencies.

Per multiple witness testimonies, shadow operations were not adequately briefed as part of the morning mission briefing. Therefore, the opportunity to discuss contingencies and strategies was missed. Furthermore, testimony indicates that most of the aircrew involved in the RRD feel shadowing is unnecessary; thus, contingency planning for shadow operations are not given sufficient consideration (Tabs V-5.4, 10.7, 15.25).

d. Supervision

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.

Inadequate Supervision (SIxxx) is a factor in a mishap when supervision proves inappropriate or improper and fails to identify hazard, recognize and control risk, provide guidance, training and/or oversight and results in human error or an unsafe situation.

(7) SI001 Leadership/Supervision/Oversight Inadequate: This is a factor when the availability, competency, quality or timeliness of leadership, supervision or oversight does not meet task demands and creates an unsafe situation. Inappropriate supervisory pressures are also captured under this code.

The minimum Ground Control Station (GCS) crew to operate the MQ-1 is a single pilot; however, a SO or extra pilot is required during critical phases of flight (AFI 11-2MQ-1V3, 29 Nov 2007). The reference further defines a gaining handover (the intent of the shadow GCS is to take the RPA in the air via the Gaining Handover-Airborne checklist) as a critical phase of flight. These witnesses also agreed there should have been a SO or additional pilot present in CDCS 6006 (Tab V-5.5, 10.8, 15.21-22). Witness testimony indicated there were multiple SO's available on the day of the mishap (Tabs K-2, 3 V-15.22).

In this situation, both the MMC and MP2 failed to employ the appropriate risk mitigation factors in the process of determining the crew complement in the shadow CDCS. The 3 SOS Commander commented, "we should have had a higher level of oversight versus a couple of captains, especially when we're talking about a TTP development, talking about an unproven capability, something that we just don't know what the shortfalls and limitations were." (Tabs V-1.10).

e. **Organizational Influences**

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(s) and result in system failure, human error or an unsafe situation.

Organizational Processes (OPxxx) are a factor in a mishap if organizational processes such as operations, procedures, operational risk management and oversight negatively influence individual, supervisory, and/or organizational performance and results in unrecognized hazards and/or uncontrolled risk and leads to human error or an unsafe situation.

(8) OP003 Procedural Guidance/Publications: This is a factor when written direction, checklists, graphic depictions, tables, charts or other published guidance is inadequate, misleading or inappropriate and this creates an unsafe situation.

There is no written guidance or appropriate checklist for shadow operations at Cannon AFB. Nevertheless, the 3 SOS routinely employs the use of shadow crews as a safety measure, particularly while operating new or modified equipment. Witness testimony confirmed that, while most LRE qualified pilots could perform the appropriate checklists to arrive at a shadow configured GCS, not one was able to point to any formal shadow guidance or procedures (Tab V-2.9, 5.4, 10.6, 12.12, 15.19).

12. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Primary Operations Directives and Publications

1. Air Force Instruction (AFI) 11-2MQ-1, Volume 1, MQ-1 Crew Training, 4 May 2007
2. AFI 11-2MQ-1, Volume 2, MQ-1 Crew Evaluation Criteria, 28 November 2008
3. AFI 11-2MQ-1, Volume 3, MQ-1 Operations Procedures, 29 November 2007
4. AFI 11-202, Volume 3, General Flight Rules, 5 April 2006
5. AFI 11-401, Aviation Management, 7 March 2007, incorporating Change 1, 13 August 2007
6. AFI 11-418, Operations Supervision, 21 October 2005, incorporating Change 1, 20 March 2007
7. T.O. 1Q-1(M)B-1, USAF Series MQ-1B and RQ-1B Systems, 1 November 2003, incorporating Change 13, 8 April 2009
8. T.O. 1Q-1(M)B-1CL-1, USAF Series MQ-1B and RQ-1B Systems Flight Checklist, 1 November 2003, incorporating Change 15, 8 April 2009
9. AFI 51-503, *Aerospace Accident Investigations*, 26 May 2010
10. AFI 91-204, *Safety Investigations and Reports*, 24 Sept 2008

b. Maintenance Directives and Publications

1. AFI 21-101, Aircraft and Equipment Maintenance Management, 29 June 2006
2. T.O. 00-20-1, Aerospace Equipment Maintenance Inspection, Documentation, Policies, and Procedures, 30 April 2003, incorporating Change 4, 1 September 2006
3. 1Q-1(M)B-6, MQ-1B Technical Manual, Aircraft Scheduled Inspection and Maintenance Requirements, 21 August 2008
4. 1Q-1(M)B-2-72JG-00-2, MQ-1B Job Guide, Engine Reciprocating, General – Volume I, 1 September 2007
5. 1Q-1(M)B-2-61JG-00-1, MQ-1B Job Guide, Propeller General, 1 December 2006
6. 1Q-1(M)B-2-05JG-10-1, MQ-1B Job Guide, Aircraft General Ground Handling, 1 December 2006, incorporating Interim Operational Supplement, 17 April 2007

7. 1Q-1(M)B-6WC-1, MQ-1B Inspection Workcard, Preflight, Thruflight, Basic Postflight, Combined Basic Postflight/Preflight Inspection Requirements, 15 January 2007, incorporating Change 1, 5 March 2007
8. 1Q-1(M)B-6WC-2, MQ-1B Inspection Workcard, Aircraft Periodic Inspections and Maintenance Requirements, 21 August 2008
9. 1Q-1(M)B-2-12CL-2, Fueling and Defueling Verification Checklist, 1 December 2006

AFI 21-101, listed above, is available digitally on the AF Departmental Publishing Office internet site at: **http://www.e-publishing.af.mil.**

c. Known or Suspected Deviations from Directives or Publications

The MP2 deviated from T.O. 1Q-1(M)B-1CL-1, *Flight Checklist, USAF Series MQ-1B and RQ-1B Systems*, 1 November 2003 incorporating through Change 15, 8 April 2009. MP2 deviated from the T.O. in the following the following way:

(1) The MP deviated from the T.O. 1Q1 (M)B-CL-1, PRESETS checklist. While performing step 9 of the PRESETS checklist, which states, "GDT UPLINK TX – SET (P) with caveats: a. ON – FOR LAUNCH or LOSING; b. OFF – FOR GAINING", MP2 incorrectly turned the GDT uplink transmitter to ON. For a discussion of the Board President's opinion on this deviation, see the *Statement of Opinion*, below.

13. ADDITIONAL AREAS OF CONCERN

None.

27 September 2010

MARK T. KRÁMIS, Lt Col, USAF
President, Accident Investigation Board

STATEMENT OF OPINION
AIRCRAFT ACCIDENT INVESTIGATION
MQ-1B PREDATOR, S/N 07-3200
CANNON AFB, NEW MEXICO
28 JULY 2010

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

1. OPINION SUMMARY

I find by clear and convincing evidence that the cause of the mishap was a loss of aircraft control due to Mishap Pilot 2 (MP2) incorrectly turning the Ground Data Terminal (GDT) uplink transmitter to ON while performing the following checklist item: T.O. 1Q1 (M)B-CL-1, PRESETS checklist, page N-16, step 9, "GDT UPLINK TX – SET (P), with caveats: a. ON – FOR LAUNCH or LOSING; b. OFF – FOR GAINING. With no Sensor Operator (SO) to provide the required challenge and response method of checklist procedures, MP2 was forced to read and accomplish all checklist items without the aid of another crewmember confirming her actions. With the transmitter in the ON position, MP2's shadow Containerized Dual Control Station (CDCS) 6006 "hostilely" took control of the Mishap Remotely Piloted Aircraft (MRPA) when the signal from CDCS 6010 degraded due to a building obstructing the line-of-sight (LOS) transmission. The resulting commands from MP2's CDCS 6006 caused an increase in aircraft power and corresponding increase in speed. The aircraft departed the prepared surface and impacted a perimeter fence approximately 1,900 feet from the taxiway. I find, by a preponderance of evidence, the following three factors substantially contributed to the mishap: (1) failure to comply with required crew compliment; (2) lack of published directives for shadow operations; (3) failure to identify the limitations of the Portable Ground Data Terminal (PGDT) and the impact of LOS obstructions.

2. DISCUSSION OF OPINION

The mishap occurred on the second day of a Rapid Reaction Demonstration (RRD) which was intended to validate the feasibility of rapidly deploying an MQ-1 system and team. To mitigate the risk of losing an aircraft, the Concept of Operations (CONOP) required a redundant control station (hereinafter referred to as a "shadow") and crew pre-positioned in another CDCS with an independent Ground Data Terminal (GDT). In accordance with the CONOP, the shadow CDCS would be pre-flighted and ready to assume control of the Remotely Piloted Aircraft (RPA) if it lost communication with the primary CDCS. As the sole operator (no SO or additional pilot present) of shadow CDCS 6006, MP2 deviated from a checklist item thereby allowing CDCS 6006 to transmit simultaneous data to the MRPA.

The Mishap Crew (MC) in CDCS 6010 completed their pre-flight checks and start-up of the MRPA without incident. At approximately 1400Z, the MRPA taxied south from a "keyhole" parking spot on Delta taxiway. Shortly after passing a large building (hush house) on the west side of the taxiway, the MC in CDCS 6010 noticed a significant drop in signal strength to and from the MRPA. At roughly the same time, the data logger files retrieved by General Atomics (GA) indicated Datalink Delay (time for the signal to travel from the CDCS to the RPA) becoming erratic with reported values between 0 and ~1.0 second. Additionally, the data logger files indicated aircraft power increasing from 0% to 70% while the throttle in CDCS 6010 was set at 0%. Mishap Pilot 1 (MP1) in CDCS 6010 attempted to apply full braking but the MRPA did not respond. Recognizing that the MRPA was not responding, the Mishap Instructor Pilot (MIP), standing behind MP1, immediately turned off the power to the PGDT. Turning off the power to the PGDT will sever the communication link between the PGDT and the RPA resulting in the RPA executing lost link logic on the ground by applying full brakes and disabling the engine. The fact that the MRPA never executed lost link logic on the ground indicated that it was receiving a signal from another source.

Prior to the mishap, MP2 was positioned in CDCS 6006 at the fixed launch and recovery element (LRE) location on the Cannon AFB airfield, referred to locally as Pred South. As directed by the CONOP, MP2's objective was to configure CDCS 6006 for a gaining handover in the air should the MC in CDCS 6010 lose link with the MRPA. This shadow configuration allows another crew to monitor the aircraft while not controlling (receivers - ON, uplink transmitters - OFF). Through a deviation in checklist procedures, MP2 turned her uplink transmitter on while the MRPA was still on the ground. As the MRPA taxied past the infield building and the LOS obstruction caused signal strength to decrease, the upper C-Band directional antennae (LOS antennae) on the MRPA diverged from CDCS 6010/PGDT heading (166 degrees relative to aircraft nose) and indicated a new heading of 099 degrees, corresponding to the location of MP2's CDCS 6006/GDT. At the time MP2's CDCS 6006 took control of the MRPA, her controls were set to 70% power and pitot heat – ON (standard configuration for gaining handover airborne). This sudden increase in power caused the MRPA to accelerate, depart the prepared surface and impact a perimeter fence roughly 1,900 feet from the edge of the taxiway.

Although the data logs from CDCS 6006 were not turned on, the data logs from CDCS 6010 recorded information up to the time the PGDT was powered off. Findings from the GA report and post-mishap photos of CDCS 6006 confirm throttle setting and power input to the MRPA was 70% and pitot heat – ON. Additional supporting evidence from the GA report indicates temperature readings from the shadow CDCS 6006/GDT transmitters (taken approximately 35 minutes after the mishap) were 43C and 25C. The higher transmitter #1 temperature value was consistent with recent transmit operations.

3. CONTRIBUTING FACTORS

Failure to Comply with Required Crew Compliment. I also find, by a preponderance of evidence, a failure to comply with the required crew compliment contributed to this mishap. AFI 11-2-MQ-1V3 defines a minimum Ground Control Station (CDCS in this case is synonymous) crew as a single pilot with a caveat for two crewmembers (either pilot-pilot or pilot-sensor operator) during critical phases of flight. This AFI further defines critical phase of flight as: takeoff, approach, landing, gaining handover (LRE to MCE) and live/actual weapons employment. In the case of MP2 in the shadow CDCS, the rationale for having her in place was to take control of the MRPA in the event of a lost link after takeoff. This involves accomplishing a series of checklists up to and including the GAINING HANDOVER – AIRBORNE checklist, page N-42 of TO 1Q-1(M)B-1. Although the AFI only defines gaining handover as a critical phase of flight for LRE to MCE, the mishap scenario should be deemed just as critical, if not more. Not only would an LRE to LRE handover likely occur closer to the ground but it's a much more uncommon event than an LRE to MCE handover.

Additionally, TO 1Q-1(M)B-1, Section 2, paragraph 2.1.6. CHECKLIST, reads, "This section provides each step of the aircrew checklist. The procedures are presented in a challenge/response format. The pilot will initiate all appropriate checklists. The sensor operator will read the challenge step aloud and the crew position performing the action will respond with the action performed to complete the step." The challenge/response format is common on most multi-place aircraft and provides a safeguard against inadvertent actions by a single crewmember. Testimony from multiple witnesses confirmed the fact that the challenges posed to a single crewmember accomplishing the multitude of checklists in the mishap scenario necessitate an additional crewmember. Both the Mishap Mission Commander (MMC) and MP2 failed to consider either directive and failed to employ the appropriate risk mitigation factors in determining the crew compliment for the shadow CDCS.

Absence of Published Directives for "Shadow" Operations. I also find by, a preponderance of evidence, the absence of published directives for shadow operations contributed to this mishap The 3 SOS routinely employs shadow crews as a safety measure, particularly while operating new or modified equipment (i.e. CDCS, PGDT). Though the term "shadow" is commonly used in the RPA community, there are no published directives or guidance that either define, train to or prescribe how it is performed. Witness testimony confirmed that while most LRE qualified pilots could identify a series of suitable checklists to arrive at a shadow configured GCS, not one of them was able to point to any formal guidance or procedures.

The RRD CONOP, paragraph 6.6.1.3., reads, "The redundant control station will be pre-flighted and "up through step 17" prior to each sortie, to ensure a rapid gaining is possible." With no reference to a checklist name or page number, this use of colloquial language ("up through step 17") presupposes a level of familiarity with a procedure that is undefined.

Failure to Identify the Limitations of the PGDT and the Impact of LOS obstructions. I also find, by a preponderance of evidence, the failure to identify the limitations of the PGDT and the impact of LOS obstructions contributed to this mishap. The PGDT used in this mishap differs from a standard or fixed GDT in many respects. The fixed GDTs used at Cannon AFB sit atop 50 foot towers and are comprised of wide, narrow and omni-directional antenna for use during varying phases of flight. While both are LOS transmitters, the fixed GDT has the advantage of height to provide the best possible coverage anywhere on the airfield. By comparison, the PGDT is placed atop a small stand that raises the transmitter roughly 7 feet above the ground and only transmits via a narrow band antenna.

In the months leading up the mishap, the PGDT was tested during both taxi and in-flight operations. During the initial test, the PGDT was placed atop a mobile GDT (GDT atop a collapsible scissor type tower that extends to 50 feet) at Pred South. From this location and height, the PGDT would have the same coverage as the fixed GDTs at Pred South. A second test was conducted from the RRD exercise site on Delta taxiway. While both tests were deemed successful, neither required the aircraft to taxi south on Delta taxiway past the large building that caused the disrupted signal. The result of both tests provided the aircrews a false sense of confidence in the capabilities of the PGDT.

Had a more comprehensive test been conducted, to include taxi along the entire length of Delta taxiway, the RRD planners and aircrew would have been aware of the need for a taxi plan in the CONOP and restricted the aircrew from turning left out of parking.

4. CONCLUSION

I arrived at my opinion by examining the General Atomics-ASI Report, witness testimony, data logger information from the mishap flight, applicable technical data and consulting with subject matter experts. All evidence is consistent with a loss of aircraft control due to MP2 deviating from checklist procedures by incorrectly turning the GDT uplink transmitter to ON.

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