UNITED STATES AIR FORCE AIRCRAFT MISHAP INVESTIGATION BOARD REPORT

MQ-1B, T/N 08-3229

163d Reconnaissance Wing
March Joint Air Reserve Base, California

LOCATION: Southern California Logistics Airport, Victorville, California

DATE OF MISHAP: 20 April 2010

BOARD PRESIDENT: Lt Col Neil L. Neaderhiser

Conducted IAW Air Force Instruction 51-503, Chapter 11

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR COMBAT COMMAND
LANGLEY AIR FORCE BASE, VIRGINIA

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AUG 1 8 2010

MEMORANDUM FOR ACC/JA

SUBJECT: Accident Investigation Board Report: MQ-1B, T/N 08-3229, 196 RS, March AFB, CA, 20 April 2010

I have reviewed the Accident Investigation Board Report regarding the MQ-1B, T/N 08-3229, which crashed and was destroyed during student training near Victorville, CA on 20 April 2010. The report prepared by Lieutenant Colonel Neil L. Neaderhiser complies with the requirements of AFI 51-503 and is approved.

WILLIAM J. REW
Lieutenant General, USAF
Vice Commander

Attachment:
Accident Investigation Board Report

EXECUTIVE SUMMARY

AIRCRAFT MISHAP INVESTIGATION
MQ-1B, T/N 08-3229, SOUTHERN CALIFORNIA LOGISTICS AIRPORT
20 April 2010

On 20 April 2010, at 1057 local time (PDT), a remotely piloted aircraft (RPA), MQ-1B tail number 08-3229 ("RPA 08-3229," "RPA," "aircraft," or "mishap aircraft"), impacted the ground at Southern California Logistics Airport (KVCV, the former George AFB) in Victorville, California. The aircraft and one inert Hellfire training missile were a total loss. Damage to government property was estimated at $3,743,211.00. The crash did not result in any injuries to people, but did result in minor damage to non-military property (a runway light).

After normal maintenance and pre-flight checks, the mishap crew began conducting launch and recovery training at KVCV with RPA 08-3229. The aircraft was piloted remotely by a student aircrew from the 3rd Special Operations Squadron (3 SOS), Cannon Air Force Base, New Mexico, under the supervision of an instructor aircrew from 163rd Reconnaissance Wing (163 RW), California Air National Guard. The student and instructor crews were physically located at KVCV. The student crew was experienced in Mission Control Element operations and was qualifying in Launch and Recovery Element (LRE) operations in anticipation of a deployment. Approximately 50 minutes into the mission, the mishap aircrew was conducting a touch-and-go landing on runway 17 when the RPA experienced a sudden loss of lift due to low airspeed likely exacerbated by gusting wind conditions. This caused the RPA to descend suddenly to a hard landing on the left landing gear. The ground reaction force on the left landing gear exceeded the design load limit for the gear, causing it to break. Subsequently the left wingtip dragged on the ground and caused the aircraft to depart the prepared surface. The RPA came to rest approximately 300 feet from the initial touchdown location, after completing a left 180 degree turn. The fuselage broke into two main sections, and numerous smaller parts were liberated from the aircraft.

The Mishap Investigation Board President determined, by clear and convincing evidence, that the main cause of the mishap was failure of the student pilot and instructor pilot to recognize that the aircraft's speed was too low for the weather conditions at KVCV. The most significant contributing factor was the mishap pilot's experience level and lack of preparatory training. Other significant factors were MQ-1 LRE Instructor Pilot training program deficiencies, poor pilot to vehicle interface, and unexpectedly difficult wind conditions. Investigation also revealed a manufacturing flaw, an inverted element, in the landing gear box, but there was insufficient evidence to determine whether the flaw contributed to the mishap.

SUMMARY OF FACTS AND STATEMENT OF OPINION
MQ-1B, T/N 08-3229
20 April 2010

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COMMONLY USED ACRONYMS AND ABBREVIATIONS

27 SOW	27th Special Operations Wing
3 SOS	3rd Special Operations Squadron
163 RW	163rd Reconnaissance Wing
163 MXG	163rd Maintenance Group
ACC	Air Combat Command
AF	Air Force
AFB	Air Force Base
AFI	Air Force Instruction
AFTO	Air Force Technical Order
AFSOC	Air Force Special Operations Command
AGL	Above Ground Level
AIB	Aircraft Investigation Board
AMXS	Aircraft Maintenance Squadron
AOR	Area of Operations
AWOS	Automated Weather Observing
System	
CA	California
CAP	Combat Air Patrol
CDCS	Containerized Dual Control Station
Dash 1	T.O. 1Q-1(M)B-1 Flight Manual
DO	Director of Operations
EP	Emergency Procedures
FCIF	Flight Crew Information File
FOS	Flight Operations Supervisor
FTU	Formal Training Unit
GA	General Atomics Aeronautical Systems, Incorporated
GCS	Ground Control Station
GDT	Ground Data Terminal
HDD	Heads Down Display
HUD	Heads Up Display
IAW	In Accordance With
IOS	Interim Operational Supplement
IP	Instructor Pilot (Mishap IP)
IR	Infrared Camera
ISR	Intelligence Surveillance and Reconnaissance
KIAS	Knots Indicated Airspeed
KVCV	Southern California Logistics Airport
KTL	Key Task List
L	Local
LOS	Line-of-sight
LRE	Launch and Recovery Element
MAP	Manifold Air Pressure
MC	Mission Coordinator
MCE	Mission Control Element
MDS	Mission Designation Series
MIP	Mishap Instructor Pilot
MISO	Mishap Instructor Sensor Operator
MP	Mishap Pilot (Student Pilot)
MSL	Mean Sea Level
MSO	Mishap Sensor Operator
MTS	Multi-spectral Targeting System
MTT	Mission Task Trainer
AMXS	Aircraft Maintenance Squadron
OG	Operations Group
PMATS	Predator (MQ-1) Mission Aircrew Training System
PROP	Propeller
QA	Quality Assurance
ROS	Restricted Operating Space
RPA	Remotely Piloted Aircraft
RPM	Revolutions Per Minute
RS	Reconnaissance Squadron
RSO	Remote Split Operations
SAT	Satellite
SATCOM	Satellite Communications
SCA	Southern California Aviation
SEPT	Standardization Evaluation Procedures Training
SOS	Special Operations Squadron
TCTO	Time Compliance Technical Order
T/N	Tail Number
T.O.	Technical Order
UAS	Unmanned Aerial System
U.S.	United States
U.S.C.	United States Code
USAF	United States Air Force
VVI	Vertical Velocity Indicator
WG	Wing

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

SUMMARY OF FACTS

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority

On 24 May 2010, Lieutenant General William J. Rew, Vice Commander, Air Combat Command, United States Air Force (USAF), appointed Lt Col Neil L. Neaderhiser as the Aerospace Accident Investigation Board (AIB) President to investigate the 20 April 2010 crash of an MQ-1B, tail number 08-3229, at Southern California Logistics Airport near Victorville, CA. An abbreviated AIB was conducted at March Joint Air Reserve Base (ARB), California, from 10 June 2010 through 25 June 2010, pursuant to Chapter 11 of Air Force Instruction (AFI) 51-503, *Aerospace Mishap Investigations*. Technical Advisors appointed to the AIB were Lieutenant Colonel Marshall L. Wilde (Legal Advisor and Air National Guard (ANG) Member), and Technical Sergeant Brian D. Meeker (Recorder).

b. Purpose

The purpose of this investigation is to provide a publicly releasable report of the facts and circumstances surrounding the mishap, to include a statement of opinion on the cause or causes of the mishap; to gather and preserve evidence for claims, litigation, disciplinary, and administrative actions; and for other purposes.

c. Circumstances

The AIB was convened to investigate the Class A mishap involving, a remotely piloted aircraft (RPA), an MQ-1B MQ-1, T/N 08-3229 (RPA or aircraft) assigned to the 163rd Reconnaissance Wing (163 RW), March Joint Air Reserve Base, California. The crash occurred at Southern California Logistics Airport (KVCV) on 20 April 2010 at approximately 1057 hours local time. (Tab J1)

2. MISHAP SUMMARY

On 20 April 2010, 3rd Special Operations Squadron (3 SOS) trainees, under the supervision of 163 RW instructors, piloted RPA 08-3229 to conduct launch and recovery element (LRE) training at KVCV as part of the ACC-approved MQ-1B Launch and Recovery Element (LRE) Training Course (dated September 2008). The student pilot had completed the first syllabus flight event over two sorties. The mishap sortie was his third flight of the program, but only his second of six graded flight events. The crew successfully completed two simulated flameout approaches to runway 21, followed by four closed patterns approaches to runway 21. Due to reported change in the wind direction, the crew switched to runway 17.

The first closed pattern to runway 17 resulted in the mishap landing, approximately 50 minutes into the mission. Normal approach speed would be approximately 76 knots indicated air speed

(KIAS). The calculated stall speed for the aircraft configuration was just under 57 KIAS. During the mishap approach, the aircraft accelerated to 93 KIAS, initiating cruise mode. Cruise mode alters the aircraft handling characteristics, limiting maneuverability. The Mishap Pilot (MP) throttled back to idle power to slow the aircraft to normal approach speed, noting the cruise mode shut off at 71 KIAS.

The aircraft continued to decelerate to 64 KIAS as it passed the runway threshold. At about 30 feet above ground level, the MP added power, but the aircraft continued to decelerate to 61 KIAS. Additionally, the aircraft began to drift from the centerline toward the left side of the runway. Cockpit voice recordings were not available, but witnesses concur that at approximately this point the Mishap Instructor Pilot called for a go-around to avoid landing too far to the left on the runway.

In addition to applying backstick pressure to arrest the descent, the MP attempted to turn the aircraft right to return to the runway centerline to avoid potential conflicts with other airfield traffic. The MQ-1 lacks a separate rudder, so control inputs in multiple axes can affect an individual control surface. Multiple axis inputs can cause the control surface to lose effectiveness. Observations by the Supervisor of Flying (SOF) and an employee of Southern California Aviation also suggest that a gust of wind occurred during this time.

Despite the pilot's selection of full power, the aircraft continued to settle to the runway, contrary to the expectations of the crew. From approximately 30 feet above the runway with the aircraft at 0 degrees of bank, the RPA descended to a hard landing at -10.4 degrees bank (left), hitting on the left landing gear only. The descent rate at impact was approximately 430 feet per minute (FPM) and accelerating at touchdown, which caused acceleration in excess of 2.6 Gs on the aircraft's left landing gear. The resulting ground reaction force on the gear exceeded its design ultimate load limit, causing it to break. Subsequently, the left wingtip dragged on the ground and impacted a runway light. The drag force of the contact with the ground and light pulled the aircraft further left. The RPA departed the prepared surface off the left side of runway 17. The nose gear collapsed soon after departing the prepared surface, severely damaging the Multispectral Targeting System (MTS) sensor ball. The fuselage broke into two main sections aft of the sensor ball, causing the aircraft to rotate 180 degrees and come to an abrupt stop approximately 300 feet from the initial touchdown point. Numerous smaller parts, including the propellers, wingtips, and tail control surfaces, were liberated from the aircraft.

The aircraft cost was $3,743,211.00, including the aircraft and an inert (dummy) training missile. There were no injuries and the only additional damage was the broken runway light. (Tab P-3) The light was quickly repaired to allow continued operation of the airport.

3. BACKGROUND

The mishap RPA was an ANG aircraft from the 163d Reconnaissance Wing at March Joint Air Reserve Base, operated by members of the 3 SOS under the supervision of instructors from the 163 Operations Group Formal Training Unit (OG/FTU) at March Joint Air Reserve Base, CA. The FTU operates administratively as part of the 196 RS, but under direct supervision of the 163 OG. The FTU and 196 RS are part of the 163rd Reconnaissance Wing (163 RW), March

ARB, CA. Due to Federal Aviation Administration (FAA) restrictions on the use of RPAs in commercial airspace near March ARB, the FTU operates a detachment out of KVCV to conduct LRE training. The MRPA was operated from that location at the time of the mishap.

a. United States Air Combat Command (ACC)

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

b. Air National Guard (ANG)

The Air National Guard has a federal and state mission. Its federal mission is to provide a well-trained, well-equipped force available for prompt mobilization during national emergencies as well as supporting contingency operations such as Operation ENDURING FREEDOM (OEF) and Operation IRAQI FREEDOM (OIF). The Air National Guard provides almost half of the Air Force's tactical airlift support, combat communications functions, aeromedical evacuations, and aerial refueling, as well as being responsible for providing the total air defense of the entire United States.

c. California Air National Guard

The California Air National Guard (CA ANG) has four flying wings, including the 163 RW at March Joint Air Reserve Base.

d. March Joint Air Reserve Base, CA.

March Joint Air Reserve Base is home to the Air Force Reserve Command's largest air mobility wing of the Fourth Air Force, including units that support Air Mobility Command, ACC, and Pacific Air Forces. March is also the home of units from the Army Reserve, Navy Reserve, Marine Corps Reserve, and the CA ANG, which includes the 163 RW**.**

e. 163rd Reconnaissance Wing

In November 2006, the 163 RW stood up and became the first Air National Guard unit to receive the MQ-1. It was also the first to become a fully functional ANG Flying Training Unit and Field Training Detachment for the MQ-1. The 163 RW is currently the only FTU for Launch and Recovery Element operations, outside of the active duty Air Force. The 163 RW is a tenant unit at March Joint Air Reserve Base.

f. 196th Reconnaissance Squadron

The 196th Reconnaissance Squadron (196 RS) is a unit of the 163 RW and the CA ANG. The squadron conducts operational missions and formal training. The Formal Training Unit (FTU) has instructed Mission Control Element (MCE) operations and Launch and Recovery Element (LRE) operations since 2009. This FTU was created to relieve some of the training pressure from the 432 WG at Creech AFB as the Air Force expanded RPA operations. The FTU is administratively part of the 196 RS, but operationally reports directly to the 163 OG. The LRE launches aircraft from a detachment at Southern California Logistics Airport in Victorville, the former George AFB. The instructor pilots and sensor operators for the FTU are assigned to the 196 RW.

g. 3rd Special Operations Squadron

The 3 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 missions supporting special operations forces.

h. Southern California Logistics Airport (KVCV)

Southern California Logistics Airport is a public airport in the city of Victorville, California (ICAO: KVCV). Prior to 1992, it was an active duty Air Force Base (George AFB). It has two runways: 17/35, which is 15,050 feet long and 150 feet wide (the second longest public use runway in the US); and 03/21, which is 9,138 feet long and 150 feet wide. The airport elevation is 2,885 feet. When George AFB closed, the conversion plan included the use of the facility as an intermodal transportation gateway, taking advantage of the proximity of I-15. Since conversion, it has expanded to include use as a logistics gateway to the US Army's National Training Center at Fort Irwin, CA, a Military Operations in Urban Terrain (MOUT) site, and a commercial airliner maintenance and storage facility (a boneyard). The Air National Guard selected KVCV as an operating location after comparing it with several other locations in the area.

163 RW began operations at KVCV in February 2009. While the site requires the use of contractor-flown chase aircraft to escort the RPA's to military airspace its proximity to March ARB (62 miles) allows 163 RW instructor personnel to reside near the base. This permits wing personnel to instruct in both MCE at March ARB and LRE at KVCV.

i. MQ-1B System

The MQ-1B is a medium-altitude, long endurance, remotely piloted aircraft. Its primary missions are interdiction and conducting armed reconnaissance against critical perishable targets. The MQ-1B is a fully operational system, not just an aircraft. This system consists of four aircraft (with sensors), a Ground Control Station (GCS), a Predator Primary Satellite Link (PPSL), and operations and maintenance personnel for deployed 24-hour operations. A smaller control station, the Containerized Dual Control Station (CDCS) can replace the GCS for LRE operations. The CDCS controls are identical to those in a GCS. The basic crew for the MQ-1B is one pilot and one sensor operator. They fly the MQ-1B from inside the GCS via a line-of-sight (LOS) radio data link and via a satellite data link for beyond LOS flight. The GCS consists of two seats, one for the pilot and one for the sensor operator, with their respective controls. 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 LOS and the beyond line-of-sight portions of the flight are not necessarily flown from the same location. Typical MQ-1B missions last for several hours. Multiple aircrews operate the aircraft throughout these extended missions.

The MQ-1B is equipped with a color nose camera (generally used by the pilot for flight control), an infrared nose camera, 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 also carries the Multi-spectral Targeting System which integrates electro-optical, infrared, laser designator and laser illuminator into a single sensor package.

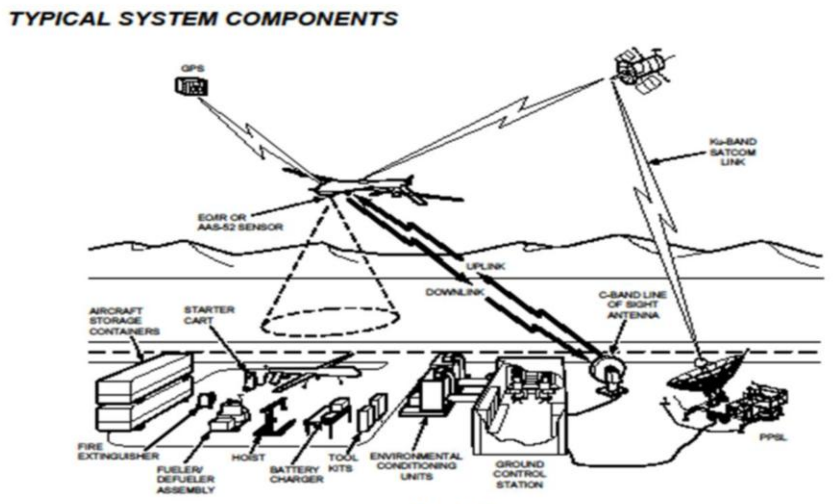

Figure 1-2

The MQ-1B is manufactured by General Atomics Aeronautical Systems Inc. (GA) headquartered in San Diego, CA, and it is the technical expert for the weapon system.

4. SEQUENCE OF EVENTS

a. Mission

The mission was an MQ-1B Launch and Recovery Element training sortie authorized and conducted by the 196 RS. Local agreements with the FAA do not require a flight plan, but do require an observer or chase plane for all RPA operations. For LRE training, the Supervisor of Flying (SOF) positions himself near the runway and serves as both SOF and observer. The mishap crew flew RPA 08-3229 from a containerized dual control station (CDCS) at KVCV. The crew conducted launch operations by a line-of-sight (LOS) radio link using a ground data terminal located on the ground at the airfield. (Tab J1) The nature of the mission did not require a handoff between GCS stations. Control of the aircraft remained with the CDCS at KVCV for the entire sortie.

b. Planning

The mishap aircrew received a daily brief, weather brief and emergency procedure discussion by the supervisor of flying (SOF) prior to going on shift. (Tab V13) The IP conducted a flight briefing about the specifics of the mission. The Instructor Sensor Operator (ISO) was not present for the flight brief but was back briefed by the IP prior to the flight. (Tab V13) This is an authorized practice and is not relevant to the mishap. The aircrew also received a maintenance brief for RPA 08-3229 immediately prior to their scheduled sortie. The mishap crew understood their mission. (Tab V2)

c. Preflight

Standard maintenance and pilot preflights were performed on RPA 08-3229 by 163 RW maintenance and pilot members. These included the aircraft's exceptional release, which is a normal check for all military aircraft prior to flight, conducted by the maintenance production superintendent and an aircrew walk-around inspection conducted by the SOF (Tabs V10, V11). Having the SOF conduct the walk-around saved time and allowed for an earlier launch of the aircraft. (Tab V13) The crew anticipated that winds would become an issue later in the day and planned to complete the sortie early. (Tab V13)

d. Flight Operations Prior to 1050

Under the supervision of the instructor crew, the mishap flight crew launched the sortie uneventfully at 1005 hours local (1705 zulu). (Tabs V2, V13) They proceeded to conduct two Simulated Flame Out (SFO) approaches to runway 21, then two touch-and-go landings on runway 21, and finally a go-around approach to runway 21. (Tab V13) The winds shifted, so the instructor and crew decided to switch to runway 17. (Tab V13) They intended to complete a touch-and-go landing, then a full stop landing, as the winds were increasing more quickly than they had expected. (Tab V13) The mishap occurred on the planned touch-and-go approach, their first on runway 17. (Tab V13) The crew described the sortie as uneventful prior to the mishap approach. (Tabs V2, V13)

e. Summary of Mishap

The Board gathered and reviewed evidence from the mishap and instructor crew, data logs, the SOF and from a Southern California Aviation (SCA) employee conducting work in the civilian aircraft boneyard adjacent to runway 17 to reconstruct the events leading up to the mishap. All four mishap crewmembers (mishap pilot, mishap instructor pilot, mishap sensor operator, and mishap instructor sensor operator) largely agree in their statements. (Tabs V2, V4, V6, V13) As they described the events, the mishap RPA built up too much speed early in its approach, reaching speeds over 90 KIAS. (Tab V13) To avoid overspeeding the landing gear (100 knots or more), the mishap pilot throttled back the engine to idle to decelerate the RPA starting 28 seconds before impact. (Tab V13) As he approached short final, he strayed too far left of centerline on the runway, causing the instructor pilot to direct a go-around at somewhere between 30 and 100 feet above ground level. (Tabs V2, V13) At this time, the RPA was traveling at approximately 61 to 64 KIAS, at the very low end of the touchdown envelope for the RPA in calm conditions. (Tab V13) The crews stated that, in normal weather, this should provide adequate time to conduct a successful go-around. (Tabs V2, V13)

The mishap pilot recalls throttling up and pitching the RPA up slightly to execute the go-around. (Tab V2) The instructor pilot began to have some concerns about his roll control as he struggled to keep the RPA level. (Tab V13) The aircraft suddenly lost altitude unexpectedly, "falling out of the sky" in the words of the instructor pilot, causing the him to take control of the aircraft by holding the control stick with his right hand. (Tab V13) He attempted to stabilize the RPA, but was unable to do so before it impacted the runway, breaking the left landing gear. (Tabs V13, J4) As the RPA bounced down again, the broken landing gear allowed the left wingtip to drag, causing the RPA to become uncontrollable and crash. (Tabs V13, J4) The witnesses generally described the same events, but differed in their recitations as to the specific order and timing of events. (Tabs R3, V2, V4, V6, V13)

The data logs provide the definitive chronology of the facts recited by crews. The times used in the engineering analysis start at the beginning of the recording and are the ones referenced in this narrative. The AIB produced additional data logger graphs utilizing GMT (Zulu) for ease of reference. The mishap crew flew the RPA normally on approach until it reached 30 feet above ground level, with an average glide slope of 4.6 degrees over the last nautical mile before touchdown. (Tab J4) On final approach, at flight time = 3024.1 seconds, the RPA was flying at 64 knots, roughly 7 knots above stall speed and within the normal landing envelope for the RPA. (Flight times hereinafter will simply use the last three digits.) (Tab J4) However, the recommended approach speed for the weight of the RPA and wind conditions was 80 knots, with a recommended touchdown speed of 59 to 75 knots. (Tab J4) The pitch was normal for a MQ-1 final approach, as was the Angle of Attack (AOA). (Tab V13) The RPA had a zero roll angle, with a 0.4 degrees right roll commanded to counter winds. The RPA recorded winds at 7 knots at 192 degrees. (Tab J4)

At time 24.3 seconds, the RPA began rolling left, consistent with gusty winds, although the 1 Hertz wind sensor update rate prevented measurement of sudden gusts. (Tab J4) In response, the MP commanded a right roll angle of 3.1 degrees, which the RPA reached at about 26 seconds. At that time, the MP increased the throttle from idle to full throttle. (Tab J4) The engine began to increase speed at 26.5 seconds. (Tab J4) Simultaneously to increasing the throttle, the MP changed the roll angle to -5.8 degrees left roll and pitch angle commanded from about 0 degree to 11.7 degrees up. (Tab J4) However, the RPA responded by decreasing the pitch angle to -1.2 degrees, again consistent with gusty winds. (Tab J4) The RPA reached a maximum of 6.1 degrees right roll before responding to the MP's left roll command. (Tab J4)

At time 26.9 seconds, the RPA began to respond to the MP's left roll command. (Tab J4) Simultaneously, the MP increased the left roll commanded to -19.2 degrees left. Because of the wind conditions, slow initial speed, and maneuvering, the airspeed had dropped to 54.2 knots, below the stall speed for those conditions. (Tab J4) The AOA was reported at +10 degrees. (Tab J4) These conditions caused an Aileron Tip Stall Warning, which continued through impact. (Tab J4) The combination of large commanded changes in pitch and roll increased aileron deflections, reduced the lift from the wings, increased drag and increased sink rate. The RPA began to yaw to the right at 5.6 degrees per second, despite the MP commands of -17.5 left roll angle and +13.6 degrees up pitch angle. (Tab J4)

The instructor pilot's intervention occurred at approximately 27 seconds. (V13) However, despite the intervention, the RPA touched town at a roll angle of -10.4 degrees left roll and 7.2 feet per second (432 FPM) descent rate. (Tab J4) This produced a ground reaction force on the left main landing gear of over 4300 pounds, well in excess of the normal design limit of 2254 pounds and the 3381 pound ultimate load limit, including a 50% safety factor. (Tab J4) This caused the left main landing gear to fracture and at least partially collapse.

After the touchdown, the MP commanded a 53 degree right roll in an attempt to right the RPA. However, the collapse of the gear made the RPA uncontrollable. (Tabs V2, V13) At the measured landing attitude, absent the failure of the left main landing gear, the left tail would have been only 6 inches from the runway surface, while the wingtip would have been approximately 18 inches off the ground. (Tab J4) The witness accounts suggest that the left wingtip dragged, eventually causing some part of the left wing to impact a runway light. (Tabs R3, V12)

The GA analysis of the data logs showed that, during two time periods prior to touchdown, the RPA roll angle opposed the commanded roll angle from the MP. (Tab J4) GA analysts attributed this to possible wind gusts, but noted the limits of the 1 Hertz reporting rate for winds from the RPA made it impossible to tell if this was the case. (Tab J4)

Observations by the SOF and SCA employee also largely corroborate the crew's recitation of events. Both noted that the aircraft dropped suddenly, appearing "to have been pushed into the ground" in the words of the SCA employee. (Tab R3) The SCA employee noted a simultaneous increase in windspeed to about 30 mph. (Tab R3) The SOF also noted a sudden descent and unexpected wind gusts. (Tab V12)

f. Impact

At 1057 local (L), RPA 08-3229 impacted the approach end of runway 17 approximately 2000 ft down the runway and 3 feet right of the painted left runway edge marking. It is clear from tire marks that the left gear impacted the runway 9 ½ feet before the right gear. (Tab S) The impact collapsed the left landing gear. Once on the ground, the broken left gear caused the left wingtip to drag and the aircraft to strike a runway light. The RPA departed the prepared surface, breaking into two main pieces. The wreckage was recovered for analysis; however, the damage was not economically repairable, making the aircraft a total loss.

g. Life Support Equipment, Egress and Survival

Not applicable.

h. Search and Rescue (SAR)

Not applicable.

i. Recovery of Remains

Not applicable.

5. MAINTENANCE

A review of the maintenance records and interviews with the maintenance crew revealed no maintenance items relevant to the mishap. (Tabs D, V10, V11)

6. AIRCRAFT AND AIRFRAME

a. Condition of Systems

The mishap aircraft was a total loss.

b. Testing

While RPA 08-3229 was airborne, it constantly transmitted the status of aircraft systems and sensors to the CDCS, where the flight data was recorded. Flight data was recorded against a time stamp (in seconds) that began during aircraft preflight when the aircrew powered on the recorders and is referred to as data-logger files or data logs. RPA 08-3229's data logs were retrieved and provided to Det 3, 703 Aeronautical Systems Group (AESG) and GA ASI for initial analysis. (Tabs J1-4) The left landing gear was also recovered and sent to the University of Dayton Research Lab for testing of the composites. (Tab J3) Both Det 3, 703 AESG and GA analyzed the data-logger files. (Tabs J1-2)

Det 3, 703 AESG determined that the Ground Control System was functioning normally at the time of the mishap. The aircraft had a normal line-of-sight data link delay of 0.2 seconds. Det 3, 703 AESG's staff opined that the GCS was operating normally and was not the cause of the incident. (Tab J1)

GA analysts determined the aircraft was functioning normally, but was being operated at stall speed prior to touchdown, most likely increasing the sink rate at touchdown. (J4) They noted that the pilot commanded an excessive roll of -19.2 degrees left immediately before landing, causing the aircraft to touchdown at a roll angle greater than -10 degrees. (Tab J4) (Left roll angles are negative numbers, while right roll angles are positive.) They believe this caused the aircraft to bounce and continue to roll to the left, reaching a maximum of -35 degrees. (Tab J4)

Because of asymmetric hard landing and failure of the left main landing gear, the Air Force Research Lab (AFRL) and GA also conducted testing on the left landing gear and strut. (Tab J3) AFRL determined that the landing gear's box beam suffered a general compression failure at the aft and forward sides, and the tire and wheel evidence showed the tire was impacted from the outboard direction when the aircraft rolled in the left direction. (Tab J3) AFRL also noted one of the components of the gear (the USK 1 component) was inverted when compared with the manufacturer's drawings. (Tab J3) AFRL recommended stress analysis of the gear's box beam, taking into consideration a hard landing, a one main landing gear touchdown, a general compression failure, and an inverted USK 1 component of the outboard side of the beam. (Tab J3)

GA conducted the requested analysis. The documents they produced showed Quality Assurance (QA) testing of the box beam at 1250 and 2000 pounds, with no discrepancies. GA was not provided the gear for testing, using AFRL's data instead. GA noted that, with a 1.5 safety factor, the gear was designed to withstand a 3381 pound vertical load, or to withstand a 1.97 g hard landing. (Tab J4) GA's engineers opined that, per the observed wind, the approach speed should have been increased by 2.5 knots, per the Flight Manual, which would have allowed for proper aircraft control immediately prior to touchdown in gust conditions. (Tab J4)

Of note, the control tower reported winds of 180 at 12 knots at the beginning of the mishap approach. (Tab N2) The pilot asked about overall airport winds and tower reported that the highest winds overall for KVCV were 12 knots with gusts to 24 knots. (Tab N2) Upon receiving clearance to land, winds for runway 17 were reported as variable from 190 to 210 at 9 knots. (Tab N2) The RPA's inadequate speed, in conjunction with the significant changes in the pitch and roll axes at the same time, reduced the lift from the wings, resulting in an increased sink rate. The MP's further attempts to pitch up and roll left caused an aileron tip stall warning activation, deflecting the wings' trailing edges up and reducing roll authority. (Tab J4) The left tail reached -16 degrees to pitch the aircraft up, causing it to stall due to a high angle of attack. This caused a right yaw at touchdown. (Tab J4)

GA's analysts concluded that the aircraft hit the runway at 2.64 g, in excess of the 1.97 g hard landing limit. (Tab J4) The aircraft attitude at touchdown was -10.4 degrees (a left roll) and 0.5 degrees nose up pitch. (Tab J4) This would have put the left tail about 6 inches off the ground at initial impact, while the left wingtip would have been 1.5 feet off the ground. (Tab J4) GA's analysts calculated the ground reaction force of the left main gear at 4301 pounds. This placed it over the design ultimate load limit, causing the failure of the left main landing gear and the subsequent destruction of the aircraft. (Tab J4) GA's analysts further opined that, since the ground reaction force significantly exceeded the design limits, the inverted element in the left main gear did not significantly contribute to the mishap. (Tab J4)

c. Functionality of Equipment

The maintenance logs, witness interviews and post-mishap analysis disclosed two deficiencies in the functionality of the equipment. Normal procedure is for the pilot to utilize the left PSO (Pilot/Sensor Operator) rack, which was the case in this mishap. The left PSO rack in the CDCS recorded data and video normally, except for the Head Up Display (HUD) overlay. (Tab D1) The HUD projected normally during the sortie, but resulted in the lack of pilot flight data being available in its normal presentation format after the flight. While not a contributing factor to this mishap, this situation made it difficult to reconstruct the pilot's perspective. This is of greater than usual importance as an MQ-1 pilot relies exclusively on visual cues for all aircraft performance indications.

As discovered in later testing, the second deficiency was the inverted element in the left main landing gear box beam. (Tab J3) Det 3, 703 AESG discovered the issue, but GA claimed that it did not contribute to the mishap, as the ground reaction force they calculated exceeded the design ultimate load limit for the box beam. (Tabs J3, J4) As a practical matter, there is no way to determine whether the box beam, if properly assembled, would have withstood the excessive ground reaction force from the hard landing.

d. Design – RPA

The military requested, and GA designed, the MQ-1 to be an aircraft with extremely long endurance to accomplish its original surveillance and reconnaissance missions and subsequent interdiction/attack missions. Its low weight to wing area ratio puts it closer to the category of powered glider than most conventional light aircraft. This characteristic makes the aircraft more susceptible to crosswinds and gusts on landing, giving the aircraft a narrower landing window than other Air Force aircraft.

Further, to lower the aircraft's weight and improve its endurance, the RPA is equipped with carbon fiber retractable landing gear with a shock absorber on the front landing gear only. Its design relies on the springiness of the carbon fiber itself to absorb the ground reaction force upon landing. The relative fragility of the MQ-1 landing gear is a known and accepted weakness of the aircraft. Navy test variants have incorporated stronger landing gear to address the rigors of carrier landings.

7. WEATHER

Weather significantly contributed to the mishap. An FAA interview with the tower manager revealed that AWOS-reported winds often differ from those reported by the tower operators. (Tab R2) This is a potential problem with runway 17, where dozens of large commercial aircraft are parked east of the runway and can create turbulence or losing wind shear. They were not relevant to this mishap however, as the winds were from the south and southwest. (Tab R2) The airport has three wind sensors, located at the approach end of runway 17, the approach end of runway 21 and where the runways meet at the approach end of runways 03 and 35. (Tab R2) The distances of these sensors from each other and the variable terrain around the airport can result in significant wind sensor readings. (Tab V12) Additionally, the real time readout from these sensors is only presented in the tower, not in a place accessible to aircrews in real time. Thus a reported airfield wind could be significantly different than that for the intended touchdown zone.

The tower manager stated that the observed winds were from the west to southwest at more than 20 knots, a conflict with AWOS reported winds, which were more southerly at less than 20 knots. (Tab R2) An interview of an SCA inspector who was working in the vicinity of the incident site corroborates this. (Tab R3) He estimated winds had increased to 30 mph out of the southwest immediately prior to the incident, approximately 1 minute after tower had reported winds of 9 knots out of the south-southwest. (Tab R3) It should be noted that this witness is not a trained weather observer.

The incident crew and instructors were aware of the forecast of higher winds later in the day. (Tab V13) This is a common weather pattern at KVCV, and the instructor staff routinely accommodates these conditions by flying earlier in the day. (Tab V13) They planned to complete operations early in the day to prevent significant crosswinds that would impact their operations. (Tab V13) Prior to the mishap, the instructor, crew and tower switched from runway 21 to runway 17 to minimize crosswinds. (Tabs V2, V13) The mishap approach was planned to be the second to last because of increasing winds. (Tab V13) The mishap pilot and instructor both noticed that the increasing winds had pushed the aircraft farther to the left of the runway centerline than they preferred, causing the instructor to direct a go-around. (Tabs V2, V13) During go-around operations, a sufficient down draft or losing wind sheer can cause an aircraft to continue to descend despite application of power. Wind data at KVCV is not recorded, so the presence of a down draft or losing wind shear cannot be verified.

Winds continued to increase after the mishap. The maximum recorded winds were 33 mph later that afternoon. (Tab W) The Wing Safety Officer estimated the actual winds at 45 mph by the time he arrived later in the afternoon.

8. CREW QUALIFICATIONS

a. Mishap Instructor Pilot

(1) Training

The pilot has been a qualified MQ-1B pilot since 5 July 2006 and an instructor since 23 September 2009. (Tab G-2.1.1)

(2) Experience

The pilot's total flight time is 1634.2 hours, which includes 1351.3 hours in the MQ-1B. (Tab G-1.1.1) Prior to flying the MQ-1B, the pilot was a KC-135 pilot. (Tab G-1.1.1)

The pilot's flight time during the 90 days before the mishap is as follows (Tab G-1.1.1):

MP	Hours	Sorties
Last 30 Days	13.3	11
Last 60 Days	23.4	21
Last 90 Days	27.8	29

b. Mishap Instructor Sensor Operator

(1) Training

The sensor operator has been a qualified MQ-1B sensor operator since 17 January 07. (Tab G-2.3.1) He completed his instructor sensor operator upgrade training on 20 December 2007. (Tab G-2.3.1) In addition to flying the MQ-1 in the 163 RW, the ISO also flies MQ-1s as a civilian contractor. He has amassed significant time and recency that is not reflected in the following numbers.

(2) Experience

The sensor operator's total flight time is 1287.5 hours in the MQ-1B. (Tab G-1.3)

The sensor operator's flight time during the 90 days before the mishap is as follows (Tab G-1.3.1):

MSO	Hours	Sorties
Last 30 Days	9.0	4
Last 60 Days	9.7	5
Last 90 Days	9.7	5

c. Mishap Student Pilot

(1) Training

The pilot has been a qualified MQ-1B pilot since 26 November 2008.

(2) Experience

The pilot's total flight time is 2443.2 hours, which includes 945.3 hours in the MQ-1B. (Tab G-1.2.1) Prior to flying the MQ-1B, the pilot was a MC-130 navigator. (Tab G-1.2.1)

The pilot's flight time during the 90 days before the mishap is as follows (Tab G-1.2.2):

MP	Hours	Sorties
Last 30 Days	30.8	5
Last 60 Days	67.6	15
Last 90 Days	102.5	22

d. Mishap Student Sensor Operator

(1) Training

The sensor operator has been a qualified MQ-1B sensor operator since 11 Dec 09. (Tab G-2.4.1)

(2) Experience

The sensor operator's total flight time is 254.7 hours in the MQ-1B. (Tab G-1.4.1)

The sensor operator's flight time during the 90 days before the mishap is as follows (Tab G-1.4.2):

MSO	Hours	Sorties
Last 30 Days	54.4	9
Last 60 Days	164.2	24
Last 90 Days	221.2	38

MEDICAL

a. Qualifications

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

b. Health

The 72-hour histories and 14-day histories for the mishap aircrew revealed no significant health concerns. There is no evidence to suggest that the health of the aircrew was relevant to the mishap.

c. Toxicology

Immediately following the mishap, commanders directed toxicology testing for all personnel involved in the flight and the launch of RPA 08-3229. Blood and urine samples were submitted to the Armed Forces Institute of Pathology for toxicological analysis. Toxicology reports were reviewed, with no discrepancies found.

d. Lifestyle

There is no evidence that unusual habits, behaviors or stresses on the part of the mishap pilot, sensor operator, or maintenance crew members contributed to this mishap. Witness testimonies, 72-hour histories, and 14-day histories revealed no evidence that suggests lifestyle factors, including unusual habits, behavior or stress contributed to the mishap.

e. Crew Rest and Crew Duty Time

Air Force Instructions (AFI) require pilots have proper "crew rest," as defined in AFI 11-202, Volume 3, *General Flight Rules*, 16 February 2005, prior to performing in-flight duties. AFI 11-202v3 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 leading up to the mishap indicated that they each had adequate crew rest. The aircrew complied with the crew rest and duty day requirements on the day of the mishap. The aircrew denied they suffered from stress, pressure, fatigue or lack of rest prior to or during the mishap sortie or aircraft. The mishap aircrew also stated that they were adequately rested and not suffering from any illnesses prior to or at the time of the mishap. (Tabs V2, V4, V6, V13) There is no evidence to suggest that fatigue was a factor in this mishap.

9. OPERATIONS, SUPERVISION AND MISHAP SIMULATION

a. Operations

The mishap pilot described did not have any operational concerns. While one interviewee stated that there was some pressure to get students through the FTU, all agreed that these pressures did not result in flying under inappropriate conditions. They all also agreed that ORM worksheets were used correctly to identify potential issues and ultimately prevent mishaps. (Tabs V2, V4, V13) In particular, on the day of the mishap, they knew that winds would constitute a risk later in the day, so they mitigated the risk by planning to terminate operations before the winds exceeded operating limits. (Tab V13)

b. Supervision

Supervision at all levels of the 163 RW organizational structure was appropriate for the given mission. The board looked extensively into the qualifications of the Mishap Instructor Pilot and his role as the senior pilot for the mishap sortie. At the time of the mishap, he had been an IP for 12 days and had only logged 3.6 hours of instructor time. He had, however, flown as an LRE pilot for over a year. The unique nature of MQ-1 operations makes it difficult for an MCE IP to gain the LRE experience necessary to become a good LRE IP. Although the MIP was a new IP, he was one of the wing's best choices to become an LRE IP. By all accounts his FTU instructor upgrade went very well. He is a highly regarded pilot and had met all current requirements to perform his role that day.

Several witnesses noted that they believed the instructor pilot's interventions in both calling a go-around and stabilizing the stick were timely under normal flight and weather conditions. (Tabs V2, V13) However, under the suspected wind conditions on the field at the time and with the aircraft nearing its stall speed, the intervention was not able to prevent the mishap. In a matter of a few seconds, the speed dropped off precipitously. The MIP called for the go-around based on runway alignment, but, per his testimony did not realize how slow the speed had become. The physical limitations of the GCS compounded the situation and are discussed below at 10.a.

c. Mishap Simulation

The Board President and the Director of Operations of the Formal Training Unit conducted multiple approaches in an MQ-1B Predator Mission Aircrew Training System (PMATS) simulator. The Board President is a current F-16 pilot, but was a qualified MQ-1 LRE pilot in 2004 and last flew the MQ-1 in 2006. The FTU/DO has current MQ-1 pilot, instructor pilot, FTU instructor pilot and Standards and Evaluation Flight Examiner (SEFE) qualifications for MCE and LRE operations and is a former F-16 pilot. He is the most experienced MQ-1B pilot in the 163 RW and one of the most experienced MQ-1 pilots in the entire CAF.

For the simulation, the aircraft weight and configuration matched the mishap aircraft's at the time of the mishap approach. Weather conditions were gradually worsened to simulate suspected conditions at the time of the mishap approach. The weather conditions included both steady and gusty wind conditions. In several iterations, the FTU/DO and Board President were barely able to successfully complete a go-around from 30 feet above the runway and 61 KIAS under no wind conditions. As crosswinds were increased and gusts were added, it became nearly impossible to accomplish a successful go-around. With foreknowledge of the pending gust, a go-around from 30 feet and 61 KIAS with a moderately gusting wind 20 degrees off runway heading at a minimum speed of 10 knots was only successful once out of approximately eight attempts. Under these conditions, even an experienced pilot would have had a hard landing and could easily have a similar mishap.

10. HUMAN FACTORS

A human factor is any environmental or individual physical or psychological factor a human being experiences that contributes to or influences his performance during a task. Air Force Pamphlet (AFPAM) 91-211, Appendix 8 provides human factors to consider. Studies have shown that 60 to 80 percent of Class A mishaps are directly related to human factors. Human factors are divided into two categories: environmental and individual.

a. Environmental – Design – GCS (Aircraft/Cockpit Design Factors)

The design of the MQ-1 Ground Control Station has several design limitations that increase the difficulty of both flying and instructing on the aircraft. The GCS provides only visual data to the pilot, depriving the crewmembers of "seat of the pants" somatosensory, auditory, vestibular and some visual peripheral information. There is no feedback or "feel" through the control stick or rudders. (Tabs V1, V13) The GCS "cockpit" design does not incorporate the same degree of concern for the pilot's comfort as other aircraft designs, making it uncomfortable to operate for long flights. Similarly, the cockpit design does not seek to emulate the design of a manned aircraft cockpit, limiting a pilot's ability to rely on habits or intuition developed from piloting manned aircraft when flying the RPA.

Specifically, the controls create pilot fatigue and react differently than in other aircraft. The control stick and throttle are significantly higher than in other aircraft. This causes the pilot to reach up in an uncomfortable position to fly the airplane, which results in increased pilot fatigue. It also results in the pilot display being above a neutral eye level, causing further fatigue. Finally, the method of stick input makes the airplane difficult to fly. Unlike virtually every other aircraft, stick movement is interpreted as actual aircraft orientation, rather than a position of the control surfaces. For instance, a 10 degree right bank input commands the RPA to hold 10 degrees of bank as long as it is held. In a normal aircraft, this would command 10 degrees of right roll, which would gradually increase the aircraft's bank angle as long as it is held. The pilot can trim these inputs in by hitting the trim button and re-centering the stick, another feature unique to the MQ-1/9 GCS.

Unlike a manned aircraft, the GCS does not have dual controls for training. (Tab V13) While the sensor operator console can be used to control the aircraft, the controls are not slaved to the primary pilot console. Switching control to the sensor operator consol during a critical phase of flight would be very risky and is not encouraged. As a result, instruction in the GCS is conducted "over the shoulder" and the instructor pilot has a limited ability to intervene.

Typically, if an actual physical intervention is required, the IP reaches beside the seated student pilot and takes control of the stick from the student. The angle of the IP's arm when controlling the stick from this position is approximately 30 degrees different from the seat and reaches the stick from a higher position. These positional differences create a different feel for the controls than sitting in the seat. An instructor pilot cannot operate both the throttle control on the student's left and the control stick on the student's right simultaneously. (Tab V13) Also, it is impossible for the IP to control the rudder pedals without having the student pilot get up from the seat and taking his place, which is impossible in a time-sensitive phase of flight.

Ultimately, most intervention relies on the IP telling the student pilot what to do and having him execute that command. The inherent delays and potential lack of precise execution mechanics adds significant risk to MQ-1 LRE training. The cumulative effect of having visual only inputs and no dual controls is that IP intervention is significantly more difficult in the MQ-1/9 GCS than a typical aircraft with dual controls, and nearly impossible in a time-critical phase of flight.

b. Environmental – Operations/Training

(1) Pilot Pipelines

MQ-1 pilots come into the career field through three distinct pipelines. Undergraduate Pilot Training graduates, including both those previously qualified in another aircraft and those assigned to the MQ-1B as their first mission designation series (MDS), can be assigned to qualify in MCE at one of the Formal Training Units. A pilot may also come from a second pipeline for prior service rated aircrew (Navigators, Electronic Warfare Officers (EWOs) & Weapon System Officers (WSOs)) who obtain their civilian commercial flight ratings and apply for cross training. The MP in this incident came through this pipeline. Finally, the Air Force recently approved a third pipeline for officers not previously holding a rating. Commonly referred to as "beta test case" or "betas," this is an effort to produce pilots specifically for RPAs.

The three pipelines produce RPA pilots with different skill sets. Undergraduate Pilot Training (UPT) graduates have a common background of "stick and rudder" experience in manned aircraft from a DoD training course, which translates most directly into airmanship during LRE operations. Prior rated non-pilots have significant rated experience and air-sense, but varying degrees of "stick and rudder" and takeoffs and landing experience. For example, WSOs from the F-15E have flying experience from a crew position with flight controls, whereas Navigators and EWOs do not typically have access to flight controls. For all three rated non-pilot career fields, their civilian commercial pilot rating is accomplished entirely outside of DoD channels. Beta program trainees have the least experience with flying operations and are an evolving career field.

In this mishap, the pilot had completed navigator training and obtained a commercial pilot rating from the FAA. By his own admission, he did not have much experience or recency in takeoff and landings. His private pilot certificate, the takeoff and landing intensive phase of training, was awarded over 10 years ago. He did not fly as a pilot again until accomplishing an intensive commercial pilot course in 2008 to complete eligibility to become an RPA pilot. (Tab V2) After completing RPA training, he rarely hand-flew the MQ-1. For several months prior to beginning the LRE course, most of his sorties were as an MCE IP, so he had very little hands on flying time. This put him at a relative disadvantage to his UPT graduate classmates. (Tabs V1, V13) Despite being rated as one of his top performers by his squadron commander in MCE operations, the instructor staff rated him as below average in LRE operations. (Tabs R1, V1, V13) In essence, he had greater than average "big picture" aviation experience, but significantly below average mechanical flying experience. This information was not readily apparent to the FTU prior to the beginning of LRE training.

(2) Structure of MQ-1B Operations/LRE Qualification/LRE Syllabus

The initial MQ-1B classes qualified on both MCE and LRE. Over time, it became apparent that most MQ-1B pilots could not stay current on LRE operations, as most were conducting MCE operations exclusively. With the increasing use of RPAs and the consequent need to produce greater numbers of aircrew in a shorter period of time, course training was streamlined to make LRE an additional qualification. This training was usually provided to aircrews about to deploy to the AOR to fill LRE billets or ones assigned to stateside LRE functions.

The skill sets for MCE and LRE are markedly different. (Tab V1) At altitude, pilots of the MQ-1B rely on an autopilot for most maneuvering. There is very little "stick and rudder" maneuvering. The roughly 2 second transmission delay during satellite operations encourages slow and deliberate maneuvering. In contrast, line-of-sight operations have only a .2 second delay. During takeoff and landing, using line-of-sight control, swift reactions to crosswinds and other sudden inputs are more important, requiring more experience with stick and rudder maneuvering and local conditions. (Tab V1)

In the mishap, the student pilot had little experience with landing manned or remotely piloted aircraft. He obtained his commercial flight rating in the shortest time possible and had never had LRE experience in the MQ-1B prior to the course. He did little stick and rudder maneuvering of the MQ-1B during his extensive MCE experience. He had only two prior flights of real MQ-1B takeoff and landing experience prior to the mishap sortie. (Tabs G2.2, V2)

The ACC standardized LRE syllabus does not address the student's preparation. While the instructor staff assured the board that students received individual evaluations regarding their skills, the syllabus does not formally address the probability that a student could have little takeoff and landing experience. Initial IP assessments may implicitly address those deficiencies, but they are not explicitly part of the curriculum. Similarly, despite most MQ-1 LRE facility's frequent crosswinds and gusty conditions, the curriculum does not explicitly address landing the MQ-1B under these conditions. (Tab AA) It focuses primarily on launch and recovery system differences and does not take the opportunity to introduce student pilots to adverse weather conditions. The mishap pilot knew the correct way to account for crosswinds and gusty conditions, but was not able to correctly and timely apply these techniques in a real world situation. (Tab V2)

(3) LRE FTU Instructor Pilot Training Syllabus

Like most MDSs, the Formal Training Unit Instructor program is different from the basic Instructor Pilot upgrade. The current ACC-approved syllabus was approved in January 2006, prior to the introduction of the high fidelity Predator Mission Aircrew Training System (PMATS) simulators. (Tab AA) In the syllabus, the LRE IP qualification is designed as a top-off qualification of the MCE IP program. It is not possible for an IP to be LRE only. The board looked into what training is accomplished in regards to intervening during student sorties.

The MCE portion of the instructor syllabus includes academic portions discussing intervention techniques. MCE operations are conducted at higher altitudes and operated via the delayed satellite link. As such, students have a limited ability to make potentially fatal control inputs. The MCE simulator and flight syllabus does not include any instruction on physically intervening or "taking the controls," since such intervention is rarely necessary. The current ACC-approved LRE IP top-off syllabus contains no academics, no simulators and only two flights. It focuses on the events unique to LRE operations, but does not include intervention techniques. The 163 RW has recognized the limitations in the program and has added two PMATS (simulator) events to the LRE IP program. As these events are not directed by the ACC syllabus, they are not graded, but they do take advantage of the PMATS capabilities and focus on checklist procedures and emergencies. (Tab AA)

To address the potential impact of the limited LRE IP syllabus on the current situation, the board compared the MQ-1 FTU IP syllabus with those for T-6 instructors and F-16 FTU instructors. The F-16 syllabus has a more direct correlation, as it is designed to teach instructors how to train newly qualified students who just completed undergraduate pilot training. It begins with six events on various device trainers followed by four flights in the transition phase. The focus of this phase is to teach new FTU IPs how to fly, teach and intervene from the back seat. This includes events such as a "paddle-off exercise" that require the student IP to intervene. There are also specific performance standards for numerous rear cockpit events. The T-6 instructor syllabus trains IPs to fly with brand new students who have little flying experience. It would not normally have a direct correlation with the MQ-1 FTU syllabus, except that in this case the student pilot had no formal military takeoff and landing training and had not even done civilian takeoff and landings recently. The T-6 syllabus includes 111.3 hours of academics, with 14.5 hours of IP Basics focusing on such topics as "Instructor/Student Relationship" and "Airborne Instruction." For the simulator and flying portion, student IPs have to demonstrate proficiency in identifying student errors and intervening in a timely manner. Anecdotally, one T-6 PIT instructor told the Board President that, "it takes about a month to teach new IPs to intervene at the right time."

Given the wide variance in MQ-1 pilot backgrounds and training, the LRE IP syllabus does not address the worst case scenario of a inexperienced student pilot involving the aircraft in a situation requiring physical IP intervention. It lacks any training on how to intervene or how to fly the aircraft from a position other than the pilot seat. The syllabus does not take advantage of the capabilities offered by the PMATS system and the opportunity to teach new instructors how to intervene in dangerous situations and fly the aircraft "over the shoulder."

(4) Local Conditions/Lack of Local Familiarization Flights

Currently, there is no provision for RPA pilots to fly manned aircraft in the line of duty. Actual flying a manned aircraft usually occurs only at the pilot's expense. Students do not have the opportunity to experience the feel of piloting an aircraft in variable wind conditions at any of the MQ-1 training or operational bases. The sensory limitations of the GCS complicate MQ-1B landings even for pilots familiar with the local conditions from manned aircraft flights. In this case, the mishap pilot lacked familiarity with local weather conditions from either previous manned flights or unmanned experience. (Tab V2)

The board inquired extensively about the selection of KVCV as the LRE location and the weather conditions/reporting capability there. Six locations were considered throughout Southern California. Criteria included facility availability, proximity to special use airspace, airport use volume, and proximity to unit facilities (March ARB). KVCV clearly offered the best combination of the criteria. The actual wind conditions are no worse than those at Creech AFB or any other MQ-1 operating location.

The lack of onsite weather reporting presented a challenge to initiating operations at KVCV. The 163 RW mitigates this through continuous forecasting by the 163d Operations Support Squadron (OSS) weather personnel at March ARB. The weather data is conveyed to LRE crews via a detailed morning briefing, updates through a continuously monitored chat room, and phone calls when necessary.

KVCV also has wind reporting limitations. The real time wind readings are only available in the control tower and are not recorded. There also does not seem to be a consistent or automatic timeline for tower personnel to determine gust magnitude. There are no civilian or military weather personnel based at KVCV. These factors lead to the possibility that reported airfield winds may not match actual winds for a given approach.

11. 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

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, 1December 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

There are no known or suspected deviations from directives or publications by the aircrew or maintenance members.

12. NEWS MEDIA INVOLVEMENT

Media coverage has been minimal. A short article appeared in the Victorville Daily Press and was reposted at various websites. (Tab Y)

13. ADDITIONAL AREAS OF CONCERN

None.

25 June 2010

NEIL L. NEADERHISER, Lt Col, USAF
President, Mishap Investigation Board

STATEMENT OF OPINION

MQ-1B, T/N 08-3229, MISHAP
20 April 2010

Under 10 U.S.C. 2254(d), any opinion of the mishap investigators as to the cause of, or the factors contributing to, the mishap set forth in the mishap investigation report may not be considered as evidence in any civil or criminal proceeding arising from the mishap, 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 Remotely Piloted Aircraft (RPA) 08-3229's mishap was the failure of the mishap student pilot (MP) and mishap instructor pilot (MIP) to recognize the aircraft's speed was too low for the aircraft configuration and weather conditions. The most significant contributing factor was the MP's experience level and lack of preparatory training. Other significant factors were MQ-1 Launch and Recovery Element (LRE) Instructor Pilot training program deficiencies, poor pilot-to-vehicle interface, and unexpectedly difficult wind conditions.

2. DISCUSSION OF OPINION

The MQ-1B's design makes it a difficult aircraft to control on final approach, especially in windy conditions. The design considerations that allow it to remain airborne for extended periods of time, in particular its low wing loading, make it particularly susceptible to winds on landing. The lack of normal flying sensory feedback and visual cues and the tail configuration further exacerbate the difficulty of landing the MQ-1. Of the eight aircraft types I have flown, from Cessna 152s to F-16s, the MQ-1 is by far the hardest to land.

On the mishap approach, the mishap pilot departed the base position (perch) with good flight parameters, but inadvertently allowed the aircraft's speed to increase. Twenty-eight seconds prior to impact, the speed approached the landing gear overspeed limit of 100 KIAS, causing him to retard the throttle all the way back to idle. The aircraft's speed was in an acceptable range until 12 seconds prior to impact. Unfortunately, the power remained at idle until 3 seconds prior to impact, allowing the aircraft to slow to 61 KIAS at 30-50 feet above ground level. The calculated stall speed for the MQ-1B's configuration was 57 KIAS. (Tabs J1-4, V2, V13) The MP selected full power three seconds prior to impact, but the aircraft was so near stall speed that the control surfaces became ineffective.

As the pilot fought to maintain control of the RPA it apparently experienced a left tail stall, causing it to descend uncontrollably. (Tabs R3, J4) General Atomic's (GA) analysts felt that the simultaneous pitch up and roll left commands caused the left tail to stall due to high angle of attack, resulting in a yaw, which is substantiated by the data logs. (Tab J4) Put simply, I believe the aircraft stalled and dropped the last 30 feet onto the runway. Control inputs after the stall had little effect on this mishap.

The mishap pilot's lack of experience and training in piloting manned aircraft and in takeoff and landing operations contributed significantly to this mishap. The mishap pilot was not an Undergraduate Pilot Training Graduate, instead entering the career field as an experienced MC-130 navigator with essentially the minimum training necessary to obtain his commercial flight rating from the Federal Aviation Administration (FAA) for the sole purpose of becoming eligible to fly MQ-1s. (Tab V2) While an accomplished and well-regarded instructor of misson control element (MCE) operations, he had very little experience hand flying the MQ-1 autopilot off. His lack of a significant background of landing experience made it even more difficult to interpret the few cues that the MQ-1 ground control station (GCS) affords the pilot. It also caused an inadequate cross check which resulted in the slow aircraft speed.

Wind gusts of up to 12 knots likely exacerbated the situation, but the presence of gusts on this approach could not be confirmed with the available data. (Tabs J4, R3) Normal procedures would require adding 3 knots to the approach speed for that gust, so the aircraft was flying right at the stall speed plus 3 knot margin (57+3=60). If flying with wind gusts of 12 knots, the RPA should have been flying at least 15 knots faster.

The airspeed went from the low end of normal approach speed to near stall speed in about 6 seconds at idle power. The Instructor pilot did not recognize this situation as he was concentrating on the student pilot's runway alignment and left drift trend. The student pilot had a history of drifting left of centerline known to the IP. (Tab U)

The IP of record is responsible for all things that occur during a flight. However, he would have had to react flawlessly in about a five second window to prevent this mishap. An intervention under those conditions is nearly impossible in the MQ-1. The ergonomics of the GCS and lack of dual controls make IP intervention in these circumstances extremely difficult.

The lack of instruction on hands-on intervention in the ACC-approved Formal Training Unit (FTU) Instructor Syllabus and LRE instructor top-off contributed to this mishap. The mishap instructor pilot had successfully completed the formal program with high marks from his instructors. He was experienced in LRE operations and fully qualified for this sortie. The FTU instructor syllabus, however, does not teach instructors how to intervene.

Weather contributed to the incident. While we could not verify the gusty winds through mechanical means, the witnesses described gusty wind conditions on the ground and GA's opinion suggests that differences between the pilot-commanded attitudes and the actual attitude of the RPA were due to winds. (Tabs J4, R3) We can say for certain that high winds were forecast for later that day, the crew switched runways due to increasingly unfavorable winds, and that the crew only planned one more approach after the mishap approach due to the worsening winds. We can also say with reasonable certainty that crosswinds caused the aircraft to drift left of course, which became a significant distracter and contributed to the pilot's not recognizing the slow airspeed.

The selection of KVCV as the operating location was looked at and it was determined not to have contributed to the mishap. All other possible alternative sites had similar weather conditions or unrelated insurmountable obstacles. The conditions at KVCV are no worse than those at other MQ-1 operating locations.

The RPA's relatively high downward velocity and left roll angle at touchdown caused the left main landing gear to fail. From that point on the aircraft was out of control. (Tabs J4, V13) The decision to use lighter composite landing gear on the RPA makes it less likely to survive a hard landing than aircraft with more robust gear. GA's analysts did not feel that the improperly manufactured composite element in the left main gear substantially contributed to the incident, since the total ground reaction force was approximately 25% over even the ultimate load limit for correctly assembled landing gear. (Tab J4) While the analysis shows that the gear would have withstood ground reaction force within the design load limits, data is not available to state how much total ground reaction force the landing gear could have sustained if properly manufactured.

I arrived at my opinion by examining RPA 08-3229's data-loggers, GA Engineering Memoranda, the mishap site, witness statements, applicable technical data, and the aircraft. All evidence points to the mishap arising from a final approach near stall airspeed for the wind conditions at the time.

25 June 2010

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President, Mishap Investigation Board

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