National Transportation Safety Board
Washington, DC 20594

Brief of Accident

Adopted 10/31/2007

CHI06MA121

File No. 22329	04/25/2006	Nogales, AZ	Aircraft Reg No. None	Time (Local): 03:50 MST

Make/Model: General Atomics / Predator B
Engine Make/Model: Honeywell / TPE-331
Aircraft Damage: Substantial
Number of Engines: 1
Operating Certificate(s): None
Type of Flight Operation: Aerial Observation
Reg. Flight Conducted Under: Public Use

	Fatal	Serious	Minor/None
Crew	0	0	1
Pass	0	0	0

Last Depart. Point: Sierra Vista, AZ
Destination: Local Flight
Airport Proximity: Off Airport/Airstrip

Condition of Light: Night
Weather Info Src: Weather Observation Facility
Basic Weather: Visual Conditions
Lowest Ceiling: None
Visibility: 10.00 SM
Wind Dir/Speed:
Temperature (°C): 10
Precip/Obscuration: No Obscuration; No Precipitation

Pilot-in-Command Age: 35

Certificate(s)/Rating(s)
Flight Instructor; Commercial; Multi-engine Land; Single-engine Land

Instrument Ratings
Airplane

Flight Time (Hours)

Total All Aircraft: 3571
Last 90 Days: 27
Total Make/Model: 27
Total Instrument Time: UnK/Nr

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History of Flight

On April 25, 2006, about 0350 mountain standard time, a MQ-9 (Predator B) aircraft, serial number BP-101, call sign OMAHA 10, collided with the terrain approximately 10 nautical miles northwest of the Nogales International Airport (OLS), Nogales, Arizona. The unmanned aircraft system (UAS) was owned by U.S. Customs and Border Protection (CBP) and operated as a public-use aircraft. The flight was operating in night visual meteorological conditions (VMC). An instrument flight rules (IFR) flight plan had been filed and activated for the flight. The unmanned aircraft (UA) sustained substantial damage. There were no injuries to persons on the ground. The flight originated from the Libby Army Airfield (FHU), Sierra Vista, Arizona, at 1851, on April 24, 2006. The wreckage was located at 0630.

The flight was being flown from a ground control station (GCS) located at FHU. The GCS contains two nearly identical pilot payload operator (PPO) consoles, PPO-1 and PPO-2. Normally, a certified pilot controls the UA from PPO-1, and the camera payload operator (typically a U.S. Border Patrol agent) controls the camera, which is mounted on the UA, from PPO-2. Although the aircraft control levers (flaps, condition lever, throttle, and speed lever) on PPO-1 and PPO-2 appear identical, they may have different functions depending on which console controls the UA. When PPO-1 controls the UA, movement the condition lever to the forward position opens the fuel valve to the engine; movement to the middle position closes the fuel valve to the engine, which shuts down the engine; and movement to the aft position causes the propeller to feather. When the UA is controlled by PPO-1, the condition lever at the PPO-2 console controls the camera's iris setting. Moving the lever forward increases the iris opening, moving the lever to the middle position locks the camera's iris setting, and moving the lever aft decreases the opening. Typically, the lever is set in the middle position.

In addition to the pilot and payload operator, other personnel present in the GCS were an avionics technician and a sensor operator, both of whom are General Atomics Aeronautical Systems, Inc. (GA-ASI) employees. GA-ASI manufactures the Predator B and was contracted by CBP to fly and maintain BP-101.

The flight was originally scheduled to take off at 1700 but was delayed because of the inability to establish a communication link between the UA and PPO-1 during initial power up. The avionics technician stated he powered down the UA and downloaded the system status. He then recycled the power on PPO-1 and PPO-2, but again he was not able to establish an uplink on PPO-1. The technician did not attempt to gain an uplink on PPO-2 during either of these power-ups. The technician reported that he again captured the system status data on his laptop and called his supervisor at the manufacturer's facility in California for assistance. He reported that his supervisor and the technical support personnel with whom he spoke had not seen this type of problem before. They recommended that he switch the main processor cards between PPO-1 and PPO-2. The technician stated that he did this, powered up the system, and was able to establish an uplink on both PPO-1 and PPO-2. He stated that everything operated normally at this point, and he went off duty at 2000.

Because the UA typically stays airborne for extended periods of time, more than one pilot is scheduled to fly during each mission. The pilots rotate flying duties every couple of hours throughout the duration of the flight. The pilot who was flying the initial part of the accident flight, including the takeoff, was not the accident pilot. The accident pilot reported that he was scheduled to work from 1900 on April 24, 2006, until 0500 on the day of the accident. The accident pilot reported that he took control of the flight at 1900 when BP-101 was already airborne and operating in the temporary flight restriction (TFR) airspace. He reported that he flew from 1900 until 2100. At 2100, another pilot resumed control of the flight. The accident pilot took control of the flight again at 0300 and was scheduled to fly until 0500. He stated that the change-over briefing at 0300 was normal and that nothing had changed with the flight.

He reported that, shortly after he resumed control of the flight, the lower monitor screen went blank on PPO-1. The screen then reappeared, but the telemetry (transmitted data) was locked up, so he decided to switch control of the UA to PPO-2. The pilot stated that he informed the Border Patrol agent who was at PPO-2 that he needed to switch positions. The Border Patrol agent stated that he moved away from PPO-2 and left the GCS. The pilot stated that he verified the ignition was "hot" on PPO-2 and that the stability augmentation system was on. He reported that, at some point, he used his cell phone to call another pilot (who had been his instructor) to discuss what was going on. At the time, the instructor was in a hangar building across the ramp.

Checklist procedures state that there should be pilots in both the PPO-1 and PPO-2 seats before switching control of the UA from one PPO to the other. CBP stated that its procedures call for the avionics technician to assume the duties of a co-pilot for the purpose of assisting with the checklist items before switching control from one PPO to the other. This did not occur during the accident sequence.

The pilot stated that he did not use the checklist when making the switch. Checklist procedures state that before switching operational control between the two consoles, the pilot must match the control positions on the new console to those on the console that had been controlling the UA. The pilot stated in an interview that he was in a "hurry" and that he failed to do this. The condition lever on PPO-2 was in the fuel cutoff position when the switch from PPO-1 to PPO-2 occurred. As a result, the fuel was cut off to the UA engine when control was transferred to PPO-2.

The pilot stated that, after the switch to the PPO-2 console, he noticed that the UA was not maintaining altitude, but he did not know why. He decided to shut down the ground data terminal (GDT) so that the UA would begin its lost-link procedure. This procedure called for the UA to autonomously climb to 15,000 feet above mean sea level (msl) and fly a predetermined course until contact could be reestablished. With no engine power, the UA continued to descend below line-of-sight (LOS) communications, and further attempts to reestablish contact with the UA were not successful.

The pilot reported that the instructor pilot entered the GCS shortly after the avionics technician turned off the GDT. He informed the instructor of what occurred, and the instructor looked at the controls and stated that the controls were not positioned correctly. The instructor tried to reestablish contact with BP-101 in both the GCS and the mobile GCS (MGCS); however, BP-101 had already descended below LOS, and contact could not be reestablished.

The avionics technician who was positioned at the multifunction workstation (MFW) in the rear of the GCS recalled the events, as follows. He stated that he heard the pilot say that PPO-1 had locked up. He then noticed that the chart display on his monitor had locked up. The technician stated that he walked up to the front of the GCS and looked at the status-warning screen on PPO-2, which indicated that PPO-1 was locked up. He advised the pilot that they needed to switch control to PPO-2. He then went back to the MFW to open up another program, which showed him what processes were running on PPO-1 so that he could record this information. The technician then returned to the front of the GCS, at which time the pilot was using his cell phone to call for support. He advised the pilot again that they needed to switch control from PPO-1 to PPO-2. The technician stated that the pilot switched control to PPO-2 and that the pilot then stated that PPO-2 was also locked up. He then told the pilot that they needed to send the UA into its lost-link procedure by shutting off the GDT. The technician stated that he pulled the plug to the PPO-1 processor rack then switched off the circuit breaker to the GDT. He told the pilot that they needed to go into the MGCS to try and recover the UA because the MGCS was up and running for the entire flight. He stated that he went into the MGCS to make sure that it was ready for the pilot, and, when he returned to the GCS, the other pilot was already there. He stated that he continued to work with the pilots to try and establish link with the UA.

Personnel information

The pilot, age 35, was employed by GA-ASI. The pilot held a commercial pilot certificate, with single-engine land, multi-engine land, and instrument ratings. He also held a certified flight instructor certificate with single-engine land, multi-engine land, and instrument ratings, along with an advanced ground instructor certificate. The pilot's most recent Federal Aviation Administration (FAA) first-class medical certificate was issued on May 31, 2005. The medical certificate did not contain any limitations.

The pilot reported that he had 3,571 total flight hours, which included 519 hours of Predator A flight time and 27 hours of Predator B hours. The 27 hours of Predator B time were flown throughout 9 flights, 5 hours of which were training flights. The 5 hours of training were conducted at the GA-ASI facility in Palmdale, California. There were no Predator B simulators available before the accident, so all of the flight training was accomplished with the actual UAS. At the time of the accident, CBP flight time requirements were 200 hours manned aircraft time and 200 hours UAS flight time. The UAS time was not required to be type specific.

CBP required that "All operators shall also be certified by the contractor as being fully capable of maintaining and operating the 'Predator B' UA and its associated equipment." GA-ASI used a training syllabus, which had been approved by the Air Force, to train pilots to operate the CBP UAS for the Air Force. Once a pilot completed the training syllabus, GA-ASI would present the completed training records, which had been approved by the Air Force Government Flight Representative (GFR), to CBP. CBP would then either approve or disapprove the specific pilot to operate the CBP UAS. At the time of the accident, CBP did not have a fully trained GFR on its staff.

The pilot's training was documented on several different Department of Defense and Air Force forms. DD Form 2627 indicated that on February 17, 2006, the Air Force GFR approved the pilot to begin MQ-9 training. AFMC Form 68 MQ-9 Pilot Conversion indicated the pilot completed the training on March 24, 2006. On May 5, 2006, which was after the date of this accident, the Air Force GFR disapproved the pilot's request for approval to act as a MQ-9 pilot and cited that the pilot had not completed some training modules.

Five of the training events listed on the AFMC Form 68 MQ-9 Pilot Conversion form were not accomplished during the pilot's training. Those events were: Mission Planning/Briefing/Debriefing, Handover Procedures - Ground, Mission Monitor/MFW Procedures, Operational Mission Procedures, and Handover Procedures - Airborne. The training syllabus states that Air Force grading criteria are used to evaluate the pilot's performance during training.

According to CBP, GA-ASI contacted their person who was being trained as a GFR and requested that the accident pilot be added to CBP's approved pilot list before the Air Force GFR approval. CBP stated that their GFR trainee gave GA-ASI a verbal approval so that the pilot could operate the CBP UAS but only when an instructor pilot was physically present in the GCS. This verbal approval was not standard practice for CBP.

Nowhere in the training records provided to the Safety Board does it list specific training on procedures to switch control of the UAS from one PPO to the other. As previously stated, the majority of the pilot's UAS experience was with the Predator A. The Predator B has different and a more complex engine and engine controls than the Predator A. Also, the control console for the Predator A does not have a condition lever that needs to be matched up between the PPOs when switching from one PPO to the other.

Aircraft Information

The UA was a MQ-9 (Predator B) aircraft, serial number BP-101, manufactured by GA-ASI. The accident occurred on the UA's 118th flight. The UA typically flew 14-hour missions, 4 days per week, and a shorter mission on the 5th day. According to the flight record, the engine and airframe had accumulated a total of 498 and 1,217 hours, respectively.

The Predator B is approximately 36 feet in length with a wingspan of 66 feet. The maximum gross weight is 10,000 pounds. The UA can stay airborne for more than 30 hours at altitudes up to 50,000 feet. The fuselage is a composite structure of impregnated graphite skin and Nomex honeycomb stiffening panels. The fuselage incorporated an avionics bay, fuel bays, an accessory bay, landing gear bays, and an engine bay.

The fuel tank bays consisted of three inline bladder fuel tanks located in the forward, header, and aft fuel tank bays. Each wing also contained an inboard and an outboard fuel tank. The aircraft total fuel capacity was 3,920 pounds.

The UA was powered by a Honeywell TPE 331-10Y turboprop engine. The engine is mounted at the rear of the fuselage and produces 900-shaft horsepower. The engine controls and indicators located in the GCS were similar to the engine controls for a manned aircraft. The engine was equipped with an in-flight restart capability.

A three-bladed, variable pitch McCauley 36FR36C606-B propeller was installed on the aircraft. The pusher propeller was full-feathering and capable of reverse pitch.

The most recent maintenance performed on BP-101 was a 200-hour inspection that was performed on April 21, 2006. Interviews with GA-ASI and CBP personnel revealed that, due to limited funding, there was virtually no stock of spare parts at FHU for the BP-101. They stated that, when they needed a part, they would have to wait for it to be shipped from the manufacturer.

At the time of the accident, CBP was unable to certify to the FAA that BP-101 was airworthy. Because of national security issues and past experience with similar UASs, the FAA temporarily waived this requirement for the issuance of the Certificate of Waiver or Authorization (COA) to operate in the National

Airspace System (NAS).

UA Control System

The accident UA was operated by means of C-band (signal communications), which provided for LOS control. The UA descended below LOS after the engine stopped producing power.

A secondary means of control was provided through the Iridium satellite communication system. However, in the Iridium control mode, there is limited ability to control the UA; under Iridium control, the only way to control the UA is by using autopilot hold modes. All hold modes (altitude, airspeed, and heading) must be active for the Iridium satellite to control of the UA. The hold modes were on before the lost link. If both the Iridium and LOS uplinks are active, the LOS link has priority, and the Iridium data is ignored. However, when the fuel was cut off to the engine and the UA began shedding electrical equipment to conserve battery power, the Iridium system was one of the items that was shed. The UA is also equipped with an auto-ignition system, but this system will not work unless the Iridium system is operable.

Lost Link

A lost data link occurs when the UA is no longer receiving command/control data from the GCS. In the event of a lost data link between the GCS and UA, the UA will enter a flightpath known as the lost-link profile, which is predetermined and performed autonomously, until the GCS operation can be restored and a data link can be reestablished. The lost-link profile, including the initial lost-link heading and altitude, is uploaded to the UA before every mission

Following the accident, it was determined that there were three lost-link profiles stored on the computer in the GCS; only one of which could be active at any given time. The area in which the UA was operating would dictate which profile would be uploaded. The pilot can change any or all of this information during the flight. One of the pilots stated that, during the flight, he moved the first waypoint in the profile to coincide with the second waypoint. It was not unusual for the pilots to move the first waypoint, depending on the location of the UA.

On occasions other than the accident, when the UA goes into a lost-link profile, it will initially turn to a preset lost-link heading, go to full power, and climb for 51 seconds at a commanded airspeed of 105 knots. If the UA is within 200 feet of the lost-link altitude (or higher), this first step is skipped. In the next step, the system generates a waypoint at the preset lost-link altitude, 2.5 nautical miles from the location where the UA started the lost-link profile, in the direction of the lost-link heading, and the UA proceeds to that waypoint. Once the UA reaches that waypoint and the lost-link altitude (or 30 minutes later, whichever comes first), it will proceed to fly the remainder of the lost-link profile. This portion of the lost-link profile consists of a predetermined series of altitudes and locations, which form a path that the UA will autonomously fly. If a data link cannot be reestablished, the UA cannot land, and it will eventually run out of fuel and crash at some location along the lost-link profile route.

Another contractor, Organizational Strategies, Inc. (OSI), provided the coordinates for the lost-link waypoints to CBP. OSI reported that it developed the waypoints using an Internet satellite website. CBP reported that it also used the same Internet satellite website to verify the location of the waypoints. According to this website, some of the website's imagery is 1 to 3 years old. Neither OSI nor CBP used additional methods to confirm that the waypoints were not located over populated areas.

The COA lists the following lost-link procedures:

1. Turn northward toward and proceed within the TFR to the appropriate Lost Link Location.
2. Hold for 30 minutes.

CBP shall ensure that the UAS remains at the last assigned altitude and within the TFR at all times, including while holding.
3. Proceed within the TFR to the adjacent Lost Link Location in the direction of Libby AAF [Army Airfield] (and hold as indicated in step 2). Procedure steps 2 & 3 shall be repeated until the UAS has entered R2303 [restricted airspace].
4. Depending on the status of R2303, the UAS shall:
a. Hold at the Lost Link Location in Area 2 until R2303 becomes active, or
b. Enter R2303, and
Then cancel IFR services with ATC [air traffic control] and proceed to Libby AAF, in accordance with the appropriate Certificate of Authorization.

Engine Controls

The condition lever, which is installed in both the PPO-1 and PPO-2 consoles, serves a different function depending on whether the station is being used by the payload operator or by the pilot. In the payload operator configuration, the lever is used to control the iris of the camera. Moving the lever forward increases the iris opening, moving the lever to the middle position locks the camera's iris setting, and moving the lever aft decreases the opening.

In the pilot configuration, the lever is used to control the engine fuel valve and the propeller feather servo. When in the pilot configuration, the lever has a linear analog range from 0 to 100 percent, which is divided into thirds: "normal," "shutdown," and "feather/shutdown."

The "normal" range is from 0 to 33 percent and is used during normal ground and flight configurations when the engine is operating. The engine can be restarted within this range if the engine control is in the auto mode. An air restart is normally an automated procedure if the propeller speed falls below 1,488 rpm and the condition lever is within the "normal" run range.

The "shut down" range is between 33 and 66 percent. When the lever is within this range, the engine fuel valve will close, shutting off fuel to the engine. The engine cannot be restarted with the lever in this range. When the PPO is configured for payload operations, this range locks the iris for the camera.

The "feather/shutdown" range is between 66 and 100 percent. The propeller will be feathered when the lever is within this range.

Warning Signals

There is an audible warning when an engine failure occurs. However, the same tone is used for every warning; the sound was not distinctive for a loss of engine power. The avionics technician stated that he heard the warning, but thought it was activating because they lost the Iridium satellite. In addition to the aural warning, the pilot should have seen a loss of torque and an exhaust gas temperature warning on the heads-down display.

Meteorological Information

The weather conditions reported at OLS at 0354 were: Calm wind; 10 statute miles visibility; clear skies; temperature 10 degrees Celsius; dew point minus 10 degrees Celsius; altimeter 30.00 inches-of-mercury.

Communications/Air Traffic Control

COA

The COA was issued by the FAA to the Department of Homeland Security/CBP on March 31, 2006, and was valid from April 1, 2006, through February 28, 2007. The COA defined the airspace parameters, guidelines, and limitations under which BP-101 was allowed to operate within the NAS.

Between September 2005 and April 2006, the corridor along the southern border in which the UA was authorized to operate expanded from 38 to 344 miles. However, LOS capabilities limited the UA's operations to only 175 miles of the 344 authorized miles. Additionally, in April 2006, the COA was revised to change the operating altitude from 13,000 to 15,000 feet in order that LOS capabilities could be maintained.

The COA authorized daily UA operations from 0000 to 1500 coordinated universal time, operating at 15,000 feet msl within the authorized altitude block of 14,000 to 16,000 feet msl in the Southern U.S. Border TFR. The COA in effect at the time of the accident identified an area of airspace that was approximately 15 nautical miles wide and 344 miles long immediately north of the southern U.S. border for UA operations. Flight Data Center Notice to Airman (FDC NOTAM) 6/2477 addressed flight restrictions for other aircraft operating within this TFR airspace. The COA specified that takeoffs and landings were to be made from FHU, where the UA would transit through the restricted airspace, R2303, until it reached 15,000 feet, at which, it could transition into the TFR. The COA stated that the pilot was required to notify ATC when requesting to move from one area of the TFR to another.

The COA required that takeoffs and landings be made in VMC and that the UA be operated in accordance with IFR within the boundaries of the TFR.

Special provisions set forth in the COA required that the UA have a means of automatic recovery in the event of lost link. The intent of this requirement was to make the UA operations predictable in the event of lost link.

Air traffic controllers were provided with mandatory training in March 2006 regarding the COA. This training consisted of a 30-minute briefing and PowerPoint presentation.

Communications/Radar

The pilot of BP-101 was in contact with the Albuquerque Air Route Traffic Control Center (ZAB). At 0137, the pilot of BP-101 requested and received clearance to operate in the TFR as defined in the COA. At 0339:45, the ZAB Sector 42 controller lost the Mode C transponder code for BP-101 and transmitted, "Omaha one zero, radar contact lost, reset transponder." When this occurred, the ZAB controller blocked the airspace from 15,000 feet to the surface. At 0340, the UA pilot notified the ZAB watch desk that the data link had been lost with the UA. At 0340:49, the ZAB controller transmitted, "Omaha one zero, Albuquerque Center" but did not get a response. The ZAB controller then observed that a primary target, which he associated with BP-101, tracked northeast and turned to the southeast; then, he lost the primary return. Between 0340 and 0344, the ZAB operations manager in charge (OMIC) coordinated with the Western Air Defense Sector (WADS) to solicit WADS assistance with locating the UA. WADS reported that the last radar contact it had with the UA was at 10,400 feet located at 3149.09N/11057.02W. At 0352, Tucson approach control blocked airspace 15,000 feet and below to protect for the possibility that the UA would transverse Tucson's airspace. At 0412, WADS advised the OMIC that they had tracked BP-101 to a point 10 miles northwest of Nogales, Arizona. At 0447, Tucson approach advised that, based on recorded radar replay, the last recorded position it had on BP-101 was about 25 miles northwest of Nogales, Arizona. At 0625, CBP notified ZAB that BP-101 had been located on the ground.

Both the ZAB controller and the OMIC stated that they expected the BP-101 to fly the same course that it flew on several other lost-link events, which took it through a corridor just north of Nogales, Arizona, at 15,000 feet to a final recovery at FHU. Following the loss of radar contact and radio communications, ATC (the ZAB controller) queried the UA pilot regarding the location of the UA. According to the controller, the UA pilot did not know the location of the aircraft. While ATC considered the loss of radar contact and radio communications with BP-101 an emergency, neither the pilot nor ATC declared an emergency.

The COA states:

In the event of Lost Link, the PIC [pilot-in-command] shall immediately inform ATC of the following:

1. The UAS call sign.
2. UAS IFF [Identification, Friend or Foe] squawk.
3. Lost link profile.
4. Last known position (as per FAA procedures, position information will be given relative to NAVAIDS [navigation aids]).
5. Pre-programmed airspeed.
6. Usable fuel remaining (expressed in hours and minutes).
7. Heading/routing from the last known position to the lost link emergency mission loiter.

There were no communications between ZAB and the UA pilot regarding a specific or preferred lost-link flight profile, as required by the COA.

Following the accident, radar data were provided to CBP from the Air Marine Operations Center (AMOC) in Riverside, California. The AMOC reported that the last Mode C return that it received was at 0335 at coordinates 31.42 N/111.25 W. AMOC also reported that the last primary radar contact was at 0349 at coordinates 31.34 N/110.56 W. Although the AMOC does not provide ATC services for the CBP UA, it constantly monitors the UA's position and status. The radar data monitored by AMOC is provided by other ATC facilities.

Flight Recorders

The GCS is equipped with recording equipment that stores telemetry in computer "data logger" files as well as telemetry information, status messages, and video on videocassette tapes.

The Safety Board took possession of the tapes that were recorded for the accident flight. These tapes recorded the telemetry, status, and video information before, during, and after the time of the accident. The Board also acquired copies (on compact disks) of "data logger" files, which were recorded during the accident. These disks contained only telemetry information.

The telemetry from the data logger files was reviewed during a visit to the GA-ASI facility on May 17-18, 2006. Information retrieved from these files is contained in the systems group chairman's factual report. A playback of the videocassette tapes was accomplished during the same visit. The data were used to confirm the telemetry recorded on the data logger files. The data showed:

03:32:57 Control Transfer from PPO-1 to PPO-2 took place
03:32:58 Feather Lever was in the stop position
03:33:01 Engine Out Detected Warning was displayed on the heads down display
03:33:15 Lost Payload Video
03:33:48 Speed Priority Warning and Pitch Up Then Down
03:34:11 UA Entered a Left Turn
03:35:03 Lost All Telemetry and video Data

The replay of the recorded information also revealed that the pilot who performed the mission setup for the flight (not the accident pilot) programmed an initial lost-link altitude of 9,000 feet and an initial lost-link heading of 260 degrees.

Wreckage and Impact Information

The UA impacted the terrain in a sparsely populated desert area. The geographic coordinates at the accident site were: 31 degrees, 34.002 minutes north latitude; 110 degrees, 56.473 minutes west longitude. The terrain elevation at the accident site was approximately 3,803 feet above msl.

The wreckage path was located on the upslope of rapidly rising, rocky desert terrain. The slope of the terrain was approximately 45 degrees. Just before the initial terrain impact were several small scrub trees, which contained broken limbs. The angle of the breaks was consistent with a near wings level, relatively flat angle of impact. The wreckage path was oriented upward along the rising terrain, on a heading of approximately 100 degrees, with the main wreckage coming to rest on a heading of 90 degrees.

The initial ground impact was near the base of the rising terrain. The UA's vertical fin was separated from the empennage and was located near the base of the slope. The main portion of the fuselage, the wings, and the empennage were located along the up-sloping terrain near the crest of the slope. Portions of the forward fuselage, avionics equipment, and ballast from the forward fuselage bay were located above the crest of the rising terrain. The entire wreckage path was approximately 95 feet long.

The forward section of the fuselage was separated from the rear section near the forward fuel tank. All of the fuselage fuel bladders were ruptured, and the odor of jet aviation fuel was present. The avionics bay had separated from the forward fuselage. The fuselage from the aft fuel tank rearward was damaged but primarily intact. The V-tail elevator surfaces remained attached to the empennage, and they were not damaged. The ventral fin and rudder were separated from the empennage and from each other and were found near the bottom of the rising terrain.

The inboard sections of the left and right wings were located with the main fuselage. A 7-foot section of the outboard portion of the left wing was located in the trees about 25 feet from the debris field at the base of the rising terrain. The left wing's leading edge was damaged, and the forward spar was separated from the skin. The left inboard and outboard flaps, along with the left inboard aileron, remained attached to the portion of the wing that was attached to the fuselage. The left wing outboard aileron remained attached to the separated outboard section of the left wing.

The inboard section of the right wing, which remained attached to the fuselage, exhibited leading-edge deformation, rearward crushing, and bending. The outboard 14 feet of the right wing was detached from the inboard section of the wing and found near the propeller. The right inboard flap was separated from the wing, and the right outboard flap remained attached. The ailerons remained attached to the separated outboard section of the wing.

The left main landing gear was relatively intact and was found in the extended position. The upper portion of the right main landing gear strut remained attached to the fuselage. The lower portion of the right main landing gear strut and the tire were separated from the upper portion of the strut. The upper portion of the strut was extended from the fuselage. The nose landing gear separated from the fuselage in two pieces, and both were located near the main wreckage.

The engine bay portion of the aft fuselage was largely intact. The upper and lower engine access panels remained attached to the fuselage. The signal from the emergency locator transmitter (ELT) was not detected during the search operations for the UA. Examination of the ELT revealed that the antenna cable was separated from the transmitter. The ELT was sent to its manufacturer for operational testing. The test results showed normal operation of the ELT.

The propeller remained attached to the engine. As part of the investigation, the blades were arbitrarily marked A, B, and C. The A blade came to rest in the 12 o'clock position, blade B was at the 4 o'clock position, and the blade C was at the 8 o'clock position. Both the B and C blades came to rest on an outcropping of rocks and boulders. The A blade exhibited leading-edge nicks, chordwise scratches, and gouges on its face. This blade was bent toward its face and was loose in the hub. The B blade exhibited gouges on its outboard face and was bent toward the back of the blade. The C blade exhibited gouges on its back, and it was bent toward the face of the blade. The propeller spinner exhibited localized crushing on its sides. Localized areas of rotational scarring were present on the sides of the spinner.

The UA was powered by a Honeywell TPE 331-10Y engine, serial number P121015C. On-scene inspection of the engine revealed the propeller pitch control setting was 89 degrees, the power lever angle setting was 90 degrees, the underspeed governor setting was 32 degrees, and the hour meter for the engine read 498 hours. All of the engine control cables were connected to their respective servos. The engine controls moved when the servos were manipulated by hand. Engine control continuity was established to the servos. No fuel or oil leaks were noted in the engine bay nor was any debris noted in the inlet assembly ducting. Fluids consistent with engine oil and jet fuel were found in their respective hoses. Debris was found in the starter/generator cooling duct. The starter/generator rotated freely when its fan was turned by hand. The left side igniter had an area of white discoloration. The top igniter's tip contained debris deposits. Mechanical continuity of the engine was observed with the rotation of the impeller, turbine rotor, and propeller shaft. The drive-train connectivity to the oil scavenge pump and to the fuel pump drive shaft was observed in the scavenge port.

The engine was shipped to Honeywell for further examination, which was accomplished on June 15, 2006. The fuel cutoff valve cover sustained impact damage. A liquid consistent with jet fuel was present at the fuel pump inlet and exited the fitting when the engine was rotated opposite the normal direction of rotation. The impeller was rotated, and resistance to its rotation was observed. The resistance increased when the engine was placed in a nose-down attitude. Examination of the gearbox found no anomalies. A borescope examination of the power section revealed no damage to the fuel nozzles. The first- and second-stage compressors exhibited no damage or rub marks. Examination of the first-stage turbine nozzle and the third-stage turbine revealed no damage. No anomalies were noted during the engine examination.

The starter/generator was an engine accessory pad that was a driven, air-cooled, brush-type unit. The starter/generator and the generator control unit (GCU) were tested at the manufacturer's facility and found to be operational.

Tests and Research

Lockups

A lockup is any malfunction that causes the GCS PPO screens to stop updating and to "freeze." A review of the lockup events for BP-101 revealed that two lockups occurred just before the launch of the accident flight. A GA-ASI avionics technician stated that the maintenance action to correct the lockup was to switch the main processor circuit cards between PPO-1 and PPO-2. This action appeared to correct the problem, and the UA was able to depart.

A log that was kept in the GCS indicated that there had been 16 lockups involving BP-101 for various reasons since December 12, 2005. These lockups occurred on both PPO-1 and PPO-2. The log did not provide any supporting data explaining the reason for the lockups.

On May 15-16, 2006, testing was performed on the GCS in an attempt to duplicate the lockups by either simulating an aircraft flight or exercising the suspect circuit boards using debug software. All of the tests performed failed to duplicate the lockups.

Emergency Procedures

The emergency procedures for a rack switch and reboot, as found in the checklist located within the GCS state:

On rack taking control, verify all presets, hold modes, and control commands are the same as the current rack.

1. SAS [Stability Augmentation System] - On
2. IGNITION - HOT
3. STOP & FEATHER - Match Receiving PSO [Pilot/Sensor Operator]
4. SPEED LEVER - Match Receiving PSO
5. POWER LEVER - Match Receiving PSO

Verify all presets, hold modes, and control commands are the same.

With pilots in both seats (be prepared to switch back)

Additional Information

The UAS program began in August 2005 when the U.S. Border Patrol granted a contract to GA-ASI to develop the program. At the end of September 2005, BP-101 was flown to FHU, and its first flight was made operating within R2303. On October 1, 2005, the Office of Air and Marine, Customs and Border Protection, was formed. This office then became responsible for the operation of the UAS program. On October 4, 2005, BP-101 started flying missions.

Parties to the investigation were the FAA, CBP, GA-ASI, and Honeywell.

The National Transportation Safety Board determines the probable cause(s) of this accident as follows.
The pilot's failure to use checklist procedures when switching operational control from PPO-1 to PPO-2, which resulted in the fuel valve inadvertently being shut off and the subsequent total loss of engine power, and lack of a flight instructor in the GCS, as required by the CBP's approval to allow the pilot to fly the Predator B. Factors associated with the accident were repeated and unresolved console lockups, inadequate maintenance procedures performed by the manufacturer, and the operator's inadequate surveillance of the UAS program.