



U.S. Customs and Border Protection

# Reining in the UAs

BY LINDA WERFELMAN

**The NTSB says the requirements for unmanned aircraft should be just as stringent as those for manned aircraft.**

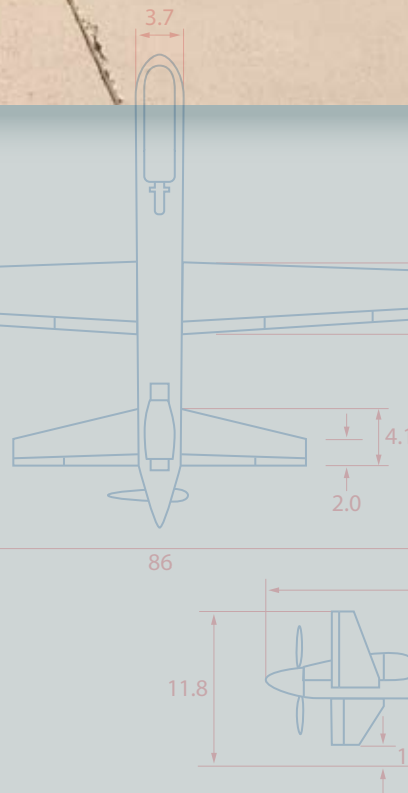
The first investigation by the U.S. National Transportation Safety Board (NTSB) of a crash involving an unmanned aircraft (UA) produced 22 safety recommendations — an action that NTSB Chairman Mark V. Rosenker says illustrates the scope of the safety issues associated with UAs.

“This investigation has raised questions about the different standards for manned and unmanned aircraft and the safety implications of this discrepancy,” Rosenker said.

Documents released after the final NTSB hearing on the April 25, 2006, crash of the

General Atomics Aeronautical Systems (GA-ASI) Predator B indicated that the board was especially concerned about design and certification issues, pilot qualification and training, integration of unmanned aircraft systems (UASs)<sup>1</sup> into the air traffic management system and audio records of UAS communications.

The Predator B was owned by U.S. Customs and Border Protection (CBP) and operated as a public use aircraft. During the accident flight — conducted for surveillance of the U.S.-Mexican border — the Predator B was piloted via data link from a ground control station (GCS) at



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the Libby Army Airfield in Sierra Vista, Arizona, U.S. The aircraft struck the ground about 0350 local time in night visual meteorological conditions in a remote area about 10 nm (19 km) northwest of Nogales International Airport, eight hours after takeoff on an instrument flight rules flight plan from the Army airfield. No one on the ground was injured in the crash, which caused substantial damage to the aircraft.

In the final report on the accident, the NTSB said the probable cause was “the pilot’s failure to use checklist procedures” when switching operational control from a console at the GCS that had become inoperable because of a “lockup” condition. This resulted in the inadvertent shutoff of the Predator B’s fuel valve and the subsequent loss of engine power. The report also cited the “lack of a flight instructor in the GCS, as required by the CBP’s approval to allow the pilot to fly the Predator B.”

The pilot was “not proficient in the performance of emergency procedures,” the NTSB said, and Rosenker added, “The pilot is still the pilot, whether he [or she] is at a remote console or on the flight deck. We need to make sure that the system by which pilots are trained and readied for flight is rigorous and thorough. With the potential for thousands of these unmanned aircraft in use years from now, the standards for pilot training need to be set high to ensure that those on the ground and other users of the airspace are not put in jeopardy.”

The report identified factors in the accident as “repeated and unresolved console lockups, inadequate maintenance procedures performed by the manufacturer and the operator’s inadequate surveillance of the UAS program.”

### Different Functions

The GCS where the pilot was stationed contained two pilot payload operator (PPO) consoles designated as PPO-1 and PPO-2; their functions differed, depending on whether they were being used to control the UA or the camera that it carried.

“When PPO-1 controls the UA, movement [of] 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,” the report said. “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” (Figure 1, p. 44).

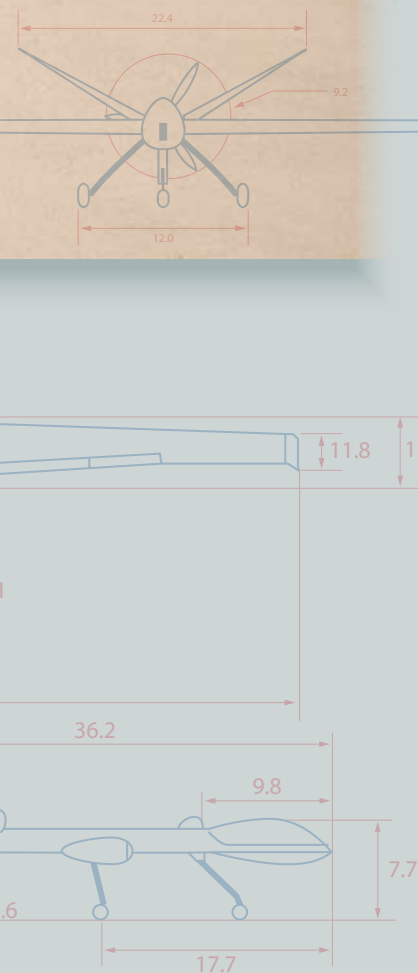
Usually, a pilot controls the UA from PPO-1 and a payload operator controls the UA’s camera from PPO-2. During the accident flight, however, technical problems involving PPO-1 prompted the pilot to switch control of the UA to PPO-2 soon after 0300. He told the CBP agent who had been operating PPO-2 that they needed to switch positions, and the agent left the GCS.

“The pilot stated that he verified the ignition was ‘hot’ on PPO-2 and that the stability augmentation system was on,” the report said. “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.”

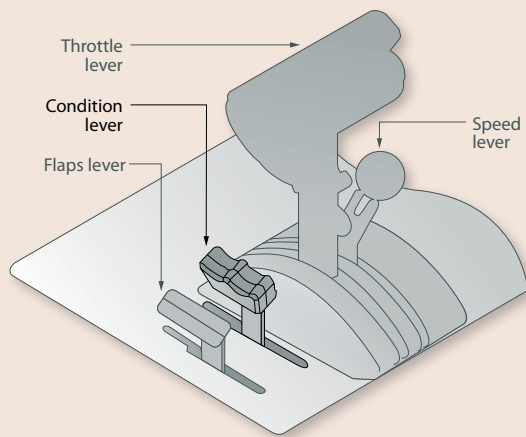
Checklist procedures call for pilots to be at both PPO-1 and PPO-2 before control of the UA is switched from one console to the other. CBP procedures are for an avionics technician to work as copilot to help with checklist items before switching from one console to the other. In this instance, the procedures were not followed, the report said.

The pilot told investigators that he did not use a checklist when switching consoles and that, because he had been in a hurry, he had not matched the control positions on the two consoles. When the switch was made, the condition lever on PPO-2 was in the fuel-cutoff position; as a result, the transfer of control to PPO-2 resulted in a cutoff of fuel.

“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,” the report said. He did not immediately notice



### Location of Condition Lever



Source: U.S. National Transportation Safety Board

**Figure 1**

that the PPO-2 condition lever was in the fuel-cutoff position.

The pilot said that he shut down the ground data terminal — an action that should have begun the “lost-link” procedure, in which the UA autonomously climbs and flies a predetermined course until the data link is reestablished. Instead, the UA descended below line-of-sight communications,

and contact could not be reestablished. Without electrical power from the engine, the UA began operating on battery power — thereby eliminating power to the transponder and preventing air traffic control (ATC) from detecting a Mode C transponder return on radar.

The instructor pilot entered the GCS soon after the ground data terminal was shut off, and observed that the controls were positioned incorrectly, but he was unable to reestablish remote control of the Predator B because the aircraft was too low.

The pilot had been in contact with the Albuquerque (New Mexico, U.S.) Air Route Traffic Control Center, and an air traffic controller told the pilot about 0340 that radar contact with the UA had been lost; at the same time, the controller blocked the airspace from the surface to 15,000 ft. Seconds later, the pilot told the controller that the data link had been lost. Neither the pilot nor the controller declared mayday, although ATC considered the loss of radar contact and radio communication an emergency.

### UA Flight Time

The accident pilot was employed by the Predator B’s manufacturer, GA-ASI. He held a commercial pilot certificate with ratings for single-engine land, multi-engine land and

instrument flight; a flight instructor certificate with the same ratings; an advanced ground instructor certificate; and a first-class medical certificate.

He had 3,571 flight hours, including 519 flight hours associated with the Predator A and 27 flight hours with the Predator B, of which five hours were training flights. A key difference between the two models is that control consoles for Predator A do not have condition levers that must be matched up between PPO-1 and PPO-2 when switching from one console to the other.

At the time of the accident, CBP required 200 flight hours in manned aircraft and 200 flight hours in UASs; the agency did not require type-specific training. CBP also required that pilots be certified by GA-ASI as “fully capable of maintaining and operating the Predator B UA and its associated equipment.” Training was conducted by GA-ASI in accordance with a syllabus that had been approved for pilots who would operate the CBP UAS for the U.S. Air Force.

Forms filed with the U.S. Department of Defense and Air Force forms documented the accident pilot’s training: In February 2006, the Air Force government flight representative (GFR) approved the start of training; in March 2006, the pilot completed training; and in May 2006 — after the accident — the GFR disapproved his request to serve as a Predator B pilot because he “had not completed some training modules,” the report said.

“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,” the report said. “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.”

During the accident flight, pilots operated the UA in two-hour shifts. The accident pilot had flown from 1900 to 2100 on April 24 and took the controls again at 0300 April 25.

## 14-Hour Missions

The accident aircraft typically was flown on 14-hour missions four days a week and on a shorter mission on a fifth day.

The report said the CBP was, at the time of the accident, “unable to certify to the [U.S. Federal Aviation Administration (FAA)] that [the aircraft] was airworthy. Because of national security issues and past experience with similar UAs, the FAA temporarily waived this requirement for the issuance of the certificate [of] authorization to operate in the national airspace system.”

The accident flight had been delayed by difficulty in establishing a data link between the UA and PPO-1 during the initial power-up. The report said that at the time, the avionics technician did not attempt to establish a data link with PPO-2. He told investigators that he contacted his supervisor and technical support personnel, who said that they “had not seen this type of problem before” and suggested that he switch the main processor cards on PPO-1 and PPO-2. After doing so, he was able to establish uplinks on both consoles, the report said. The technician said that he switched the cards rather than replacing the card in PPO-1 because very few spare parts had been purchased with the UAS.

Investigators found that numerous console lockups had occurred since the UAS began operations; during the three months preceding the accident, there were nine lockups, including two before takeoff on the accident flight. The report said, “Troubleshooting before and after the accident did not determine the cause of the lockups.”

## Emergency Procedures

Citing concerns that “deficiencies exist in various aspects of ... ATC and air traffic management of UASs in the [national airspace],” the NTSB addressed five of its 22 safety recommendations to Acting FAA Administrator Robert A. Sturgell.

Those recommendations included a call for the procedures already in place for “piloted-aircraft emergencies” to also be applied to UAS emergencies. The FAA also should require

operators of all UASs to file written reports with the FAA within 30 days of all “incidents and malfunctions that affect safety”; to analyze incident and malfunction data “in an effort to improve safety”; and to evaluate the data “to determine whether programs and procedures ... remain effective in mitigating safety risks.”

The NTSB also recommended that the FAA require UAs to have operating transponders providing altitude information “at all times while

## Predator B



U.S. National Aeronautics and Space Administration

The Predator B — designed for long-endurance, high-altitude unmanned flights for surveillance, scientific research and other uses — was developed in 2000 by General Atomics Aeronautical Systems and first flown in 2001. The Predator B is longer and heavier than its predecessor, the Predator A, and has a more complex engine and engine controls. It also is able to fly twice as high and twice as fast, and to carry loads five times heavier.

The Predator B is 36 ft (11 m) long with a wingspan of 66 ft (20 m) and has a Honeywell TPE 331-10T engine mounted at the rear of the fuselage. The composite fuselage incorporates impregnated graphite skin and Nomex honeycomb panels. Maximum gross takeoff weight is 10,500 lb (4,763 kg), with an internal payload capacity of 850 lb (386 kg), an external payload capacity of 3,000 lb (1,361 kg) — carried in six wing stations — and fuel capacity of 4,000 lb (1,814 kg). The Predator B can be remotely piloted or fully autonomous.

It can be operated at maximum altitudes of 50,000 ft, with maximum endurance of more than 30 hours and maximum airspeeds of more than 240 kt.

Source: General Atomics Aeronautical Systems, U.S. National Transportation Safety Board

airborne,” require that all conversations involving UA pilots be recorded and retained in accordance with existing U.S. Federal Aviation Regulations, and require periodic operational reviews between UAS operational personnel and ATC facilities. These operational reviews should include discussion of lost-data-link procedures and the unique emergencies associated with UAs, the NTSB said.

In 17 recommendations to the CBP, the NTSB cited “ineffective and inadequate safety controls” that had been identified during the accident investigation and expressed concern that “the CBP operation may lack an effective plan to control safety risks in the future.”

“The CBP must develop an operational safety plan using a methodical system safety process,” the safety recommendation letter said. “This process could help the CBP address the widespread deficiencies noted in this investigation, as well as other presently unmitigated safety risks. It also could ensure development of a suitable monitoring program that tracks and analyzes malfunctions and incidents and incorporates lessons learned from other operators of similar UASs. This monitoring program could ensure that the safety plan remains effective throughout the UAS’s life cycle.”

After the accident, the CBP “performed a program review and developed policies, procedures and training that provide much stronger operational control and safety oversight of its UAS program,” the NTSB said in the letter, addressed to CBP Commissioner W. Ralph Basham. Nevertheless, the NTSB said that deficiencies remained “in the design, operation and safety management” of the CBP UAS program and in the CBP’s coordination of activities with ATC.

“The reasons for console lockups are varied, and when a lockup occurs,

the cues may not be readily apparent to the pilot,” the letter said. “The system does not diagnose the nature, cause or extent of a lockup and does not display a fault message to the pilot. ... In the event of a lockup, the pilot may become aware of the problem because some parameters are not updating as frequently as expected or all visual cues may freeze.”

The safety recommendations included a call for the CBP to require GA-ASI to modify the UAS “to ensure that inadvertent engine shutdowns do not occur” and to “provide adequate visual and aural indications of safety-critical faults, such as engine-out conditions and console lockups and present them in order of priority, based on the urgency for pilot awareness and response.”

The NTSB criticized existing procedures to be followed in the event of a lost data link between the UA and a GCS because they are based on the assumption that the UA would continue on a predetermined course until the data link was reestablished or the UA ran out of fuel and crashed. NTSB recommendations called for developing predetermined courses that “minimize the potential safety impact to persons on the ground, optimize the ability to recover the data link and, in the absence of data-link recovery, provide the capability to proceed to a safe zone for a crash landing.”

Other safety recommendations to the CBP included the following:

- Require modifications in the UAS to ensure continued transponder operation after an in-flight engine shutdown;
- Develop a method of restarting a UA engine — for use during lost-data-link emergency procedures — that does not rely on line-of-sight data-link control;

- Implement a documented maintenance and inspection program that “identifies, tracks and resolves the root cause of systemic deficiencies and that includes steps for in-depth troubleshooting, repair and verification of functionality before returning [a UA] to service”;
- Develop minimum equipment lists and dispatch deviation guides for UASs, and evaluate spare-parts requirements to ensure that critical parts will be available;
- Revise the pilot-training program to ensure pilot proficiency in emergency procedures;
- Require that a backup pilot or someone else “who can provide an equivalent level of safety” be readily available during UA operations; and,
- Develop a safety plan to identify risks presented by UAs to other aircraft and to people on the ground and take the actions required to mitigate those risks. ●

*This article is based on NTSB accident report CHI06MA121 and related documents, including NTSB safety recommendations A-07-65 through A-07-86.*

#### Note

1. An *unmanned aircraft (UA)* refers to an aircraft designed to operate without a human pilot aboard. An *unmanned aircraft system (UAS)* refers not only to the aircraft but also to the supporting system — such as a console operated by a ground-based pilot — that enables its flight. UAs and UASs also are, or have been, known by other names, including “unmanned aerial vehicles,” “remotely operated aircraft” and “remotely piloted vehicles.”

#### Further Reading From FSF Publications

FSF Editorial Staff. “See What’s Sharing Your Airspace.” *Flight Safety Digest* Volume 24 (May 2005).