Federal Aviation Administration

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Unmanned Aircraft System Accident Investigation

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12:34:02

Overview

- UAS overview
  - Types
  - Components
  - Monitoring
- Example Accident (Predator Border Patrol 4_06)
- Checklist
  - What
  - Where
  - Hazards
  - Operation

UAS Integration into the NAS

From "Modernization and Reform Act of 2012, H.R. 658 Section 332 (a) Required Planning for Integration"

(3) DEADLINE.—The plan required under paragraph (1) shall provide for the safe integration of civil unmanned aircraft systems into the national airspace system as soon as practicable, but not later than September 30, 2015.

UAS Development

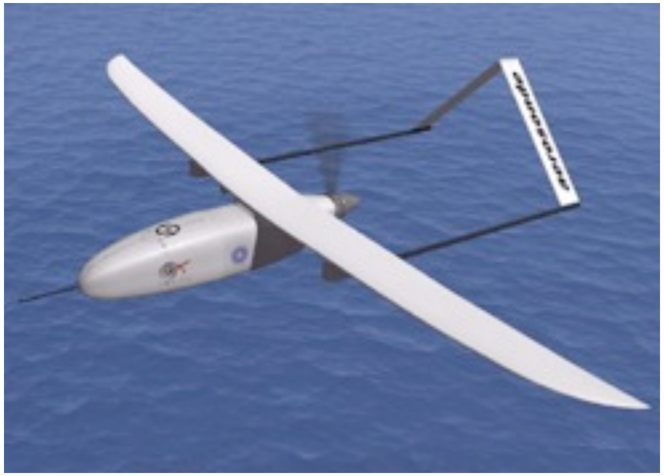
- Over 1880 types of unmanned aircraft systems in existence
- Over 200 UAS manufacturers
- 43 countries are developing UAS (including North Korea and Iran)
- 70% of the current systems are for military use, however, the number of non-military applications is increasing
- In the US, non-military applications include border patrol, emergency situation awareness (e.g., Hurricane Katrina aftermath), and scientific applications such as crop inspection and atmospheric measurements.

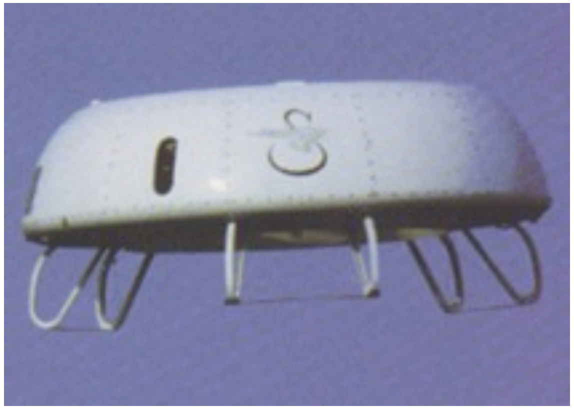
List of current or potential uses of UAS

Geomorphic Modelling	Train Crash Assessment	Golf Course Alligator Warning
Law Enforcement	Forest Fire Mapping	Plant Disease Detection
Pollution Monitoring	Volcano Monitoring	Weed Mapping
Oil Spill Tracking	Remote Aerial Mapping	Invasive Plant Monitoring
Avalanche Prevention and Alerting	Mineral Exploration	Highway Design
Ice Pack Monitoring	Crop Pollination	Parking Utilization
Poaching Patrol	Forest Fire Surveillance	FedEx Unmanned Cargo
Insurance Claims Adjustment	Atmospheric Profiling	Crop Dusting
Public Safety	Cinematography	Coastline Surveillance
Firefighting	Precision Agriculture	Pavement Roughness Measurement
Golf Resort Marketing	Photogrammetry	Anti-Whaling Efforts
Search and Rescue	Tidal Zone Mapping	Flood Warning
Stadium Events	Solar Panel Inspection	Avalanche Monitoring
Pipeline Inspection	Anti-Piracy	Mosquito Breed Detection
Power Restoration	Algae Proliferation Monitoring	Crime Scene Photography
Newspaper Delivery	Rail Track Bed Inspection	Geomorphology
Fire Prevention	Ocean Research	Entomology
Wind Turbine Inspection	Saltwater Infiltration Monitoring	Forestry Inspection
Fire Risk Assessment	Illegal Ship Bilge Venting Surveillance	Fisheries Management
Marine Sanctuary Monitoring	Emergency Communications	Species Conservation Efforts
River Discharge Monitoring	Terrain Mapping	Wildlife Inventory
Ship Collision Risk Assessment	Sand Bank Shift Monitoring	Cell Tower Inspection
Maritime Mammal Assessment	Hydrometric Mapping	Plant Fertility Assessment
Flood Risk Assessment	Traffic Accident Surveillance	Plant Water Content Measurement
Insect Attack Warning	Selective Harvesting	Canopy Management
Herd Tracking	Telecommunications	High Altitude Imagery
Maritime Surveillance	Traffic Monitoring	Disaster Relief
Real Estate Photography	Meteorology	Hurricane Monitoring
Cryospheric Research	Bridge Inspection	Transmission Line Inspection
HAZMAT Inspection	Emergency Medical Supply	Aerial Surveying
Concert Security	Sports Video	Runway Inspection
Virtual Tours	Coffee Harvest	Shark Watch

Size (from Weibel and Hansman, 2005)

Airframes and Engines





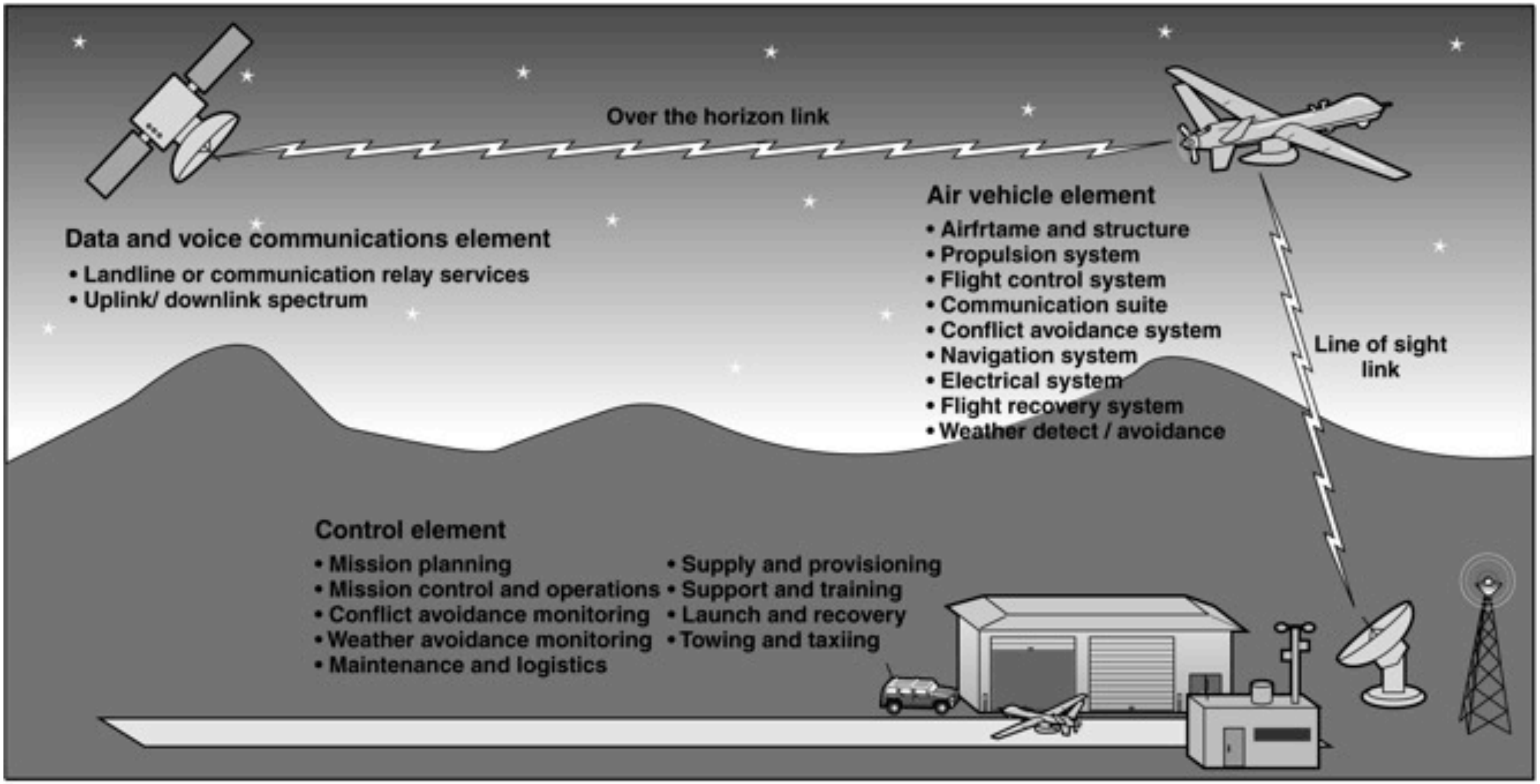
Controls Vary Widely Across Systems

Control Station Design

System Components

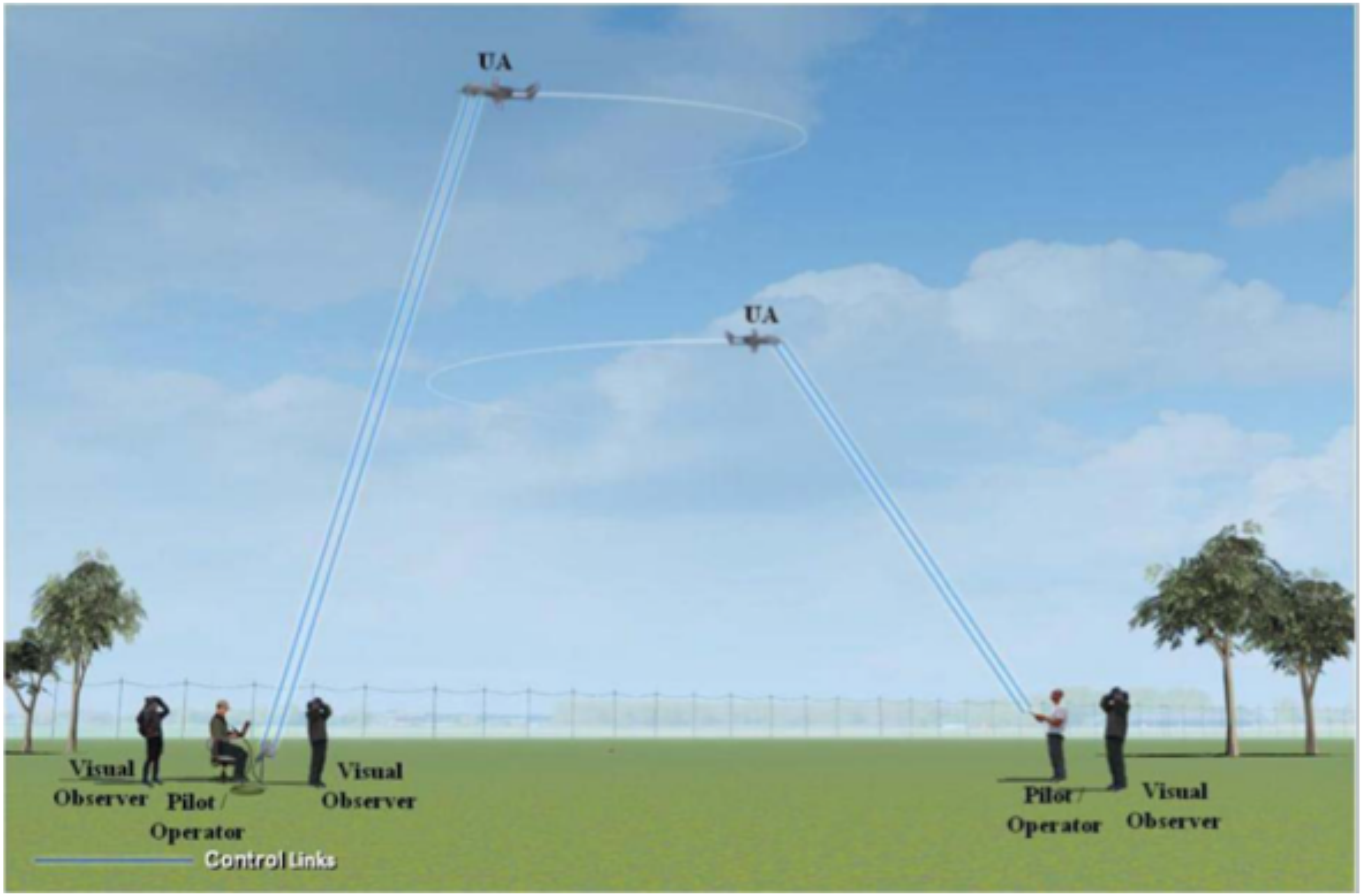
- The control station(s) and antenna systems
- All associated software and health monitoring systems
- Communications data links (ground/air and air/ground)
- Data terminals for payload management
- The flight termination system
- Launch and recovery systems
- Ground support and maintenance equipment
- Power generation, distribution, and supply
- Air Traffic Control communications equipment (voice and data)
- Handling, storage, and transport equipment
- All required flight manuals, maintenance manuals, and any documentation required for a safe flight

System Components



Sources: GAO and NASA.

Monitoring the UA – Visual Line-of-Sight



Rules governing UAS

NOTICE **U.S. DEPARTMENT OF TRANSPORTATION**

FEDERAL AVIATION ADMINISTRATION N 8900.207

National Policy Effective Date: 1/22/13

Cancellation Date: 1/22/14

SUBJ: Unmanned Aircraft Systems (UAS) Operational Approval

•**Where You Can Find This Notice.** You can find this notice on the MyFAA Web site at https://employees.faa.gov/tools_resources/orders_notices/.

- Inspectors can access this notice through the Flight Standards Information Management System (FSIMS) at http://fsims.avs.faa.gov.
- Air carriers and operators can find this notice on the FAA's Web site at: http://fsims.faa.gov.
- This notice is available to proponents and the public at http://www.faa.gov/regulations_policies/orders_notices.

Approval process

- Proponents requesting approval of public aircraft operations by UAS will use the COA application process.
- In contrast, proponents for civil operations approval will use the special airworthiness certificate process.
- Part 91, § 91.319(a)(2) specifically prohibits operation of an aircraft that has an experimental certificate from “carrying persons or property for compensation or hire.”
- COA applications for UAS flight operation approvals will be coordinated through the ATO component of AFS-80 and AVS.
- Special airworthiness certificates will be coordinated through the Aircraft Certification (AIR-240) staff as well as the ATO and AFS component of AFS-80 for final approval and disposition.

Airworthiness

- All UAS must be in an airworthy condition to conduct flight operations in the NAS.
- An “airworthy condition for UAS subject to a COA” means that the UAS meets the applicable standards and requirements of its operating agency and is capable of operating in compliance with the applicable requirements in 14 CFR part 91.
- The FAA recognizes that some of the requirements can differ from those for manned aircraft and appropriate changes can be defined.
- As with airworthiness standards, maintenance technician requirements will be addressed as part of the review process.

Lost Link Requirement

- There are many acceptable approaches to satisfy lost link requirements. The intent of any lost link procedure is to ensure airborne operations remain predictable. Proponents will comply with the UAS lost link procedures as specified in the COA.
- **Note:** Lost link is not considered fly-away. Refer to definitions in Appendix A.
- (1) Unless otherwise authorized, lost link solutions must comply with the last ATC clearance (if ATC clearance is required), for a period of time sufficient for ATC to ensure conflict resolution without loss of required separation.

Pilot in Command

- PIC Rating Requirements. Rating requirements for the UAS PIC depend on the type of operation conducted; they fall into two categories:
  - Operations that require at least a private pilot certificate or FAA-recognized equivalent, or
  - Operations that do not require at least a private pilot certificate or FAA-recognized equivalent.

Certificate required when:

- The PIC must hold, at a minimum, an FAA private pilot certificate or FAA-recognized equivalent for all operations listed below:
    - Flight in Class A, B, C, D, E, and G (400 feet above ground level (AGL)) airspace.
    - IFR (must have instrument rating) operations.
    - Night operations.
    - At joint use or public airfields.
    - Requiring a chase aircraft.
    - At any time the FAA has determined the need, based on the UAS characteristics, mission profile, or other operational parameters.

Certificate not required when:

Operations without a pilot certificate may be allowed when all of the following conditions are met:

- The PIC has successfully completed, at a minimum, FAA private pilot ground instruction and passed the FAA Private Pilot written examination or FAA-recognized equivalents. (Airman Test Reports are valid for the 24 calendar-month period preceding the month the exam was completed, at which time the instruction and written examination must be repeated.)
- Operations are during daylight hours.
- The operation is conducted in a sparsely populated location.
- Operations are approved and conducted solely within visual line-of-sight in Class G airspace.
- Visual line-of-sight operations are conducted no further than ½ NM laterally from the UAS pilot and at an altitude of no more than 400 feet AGL at all times. Refer to Appendix A for the visual line-of-sight definition.
- Operations are conducted no closer than 5 NM from any FAA-designated airport or heliport other than the airport from which the aircraft is operating.
- The operation is conducted from a privately owned airfield, military installation, or off-airport location.

Global Hawk Accident
July 11, 2002

"For a July 2002 mishap, Air Force investigators blame an engine malfunction on "failure of a single fuel nozzle in the high-flow position that eventually caused internal failure of the engine," leading to a crash during an attempted emergency landing … operators did not know why the Global Hawk was losing altitude - because the aircraft's telemetry did not indicate a reason." (emphasis added)

Source: Peck, Michael. "Global Hawk Crashes: Who's to Blame?" National Defense Magazine, May 2003

Predator Accident, September 14, 2000

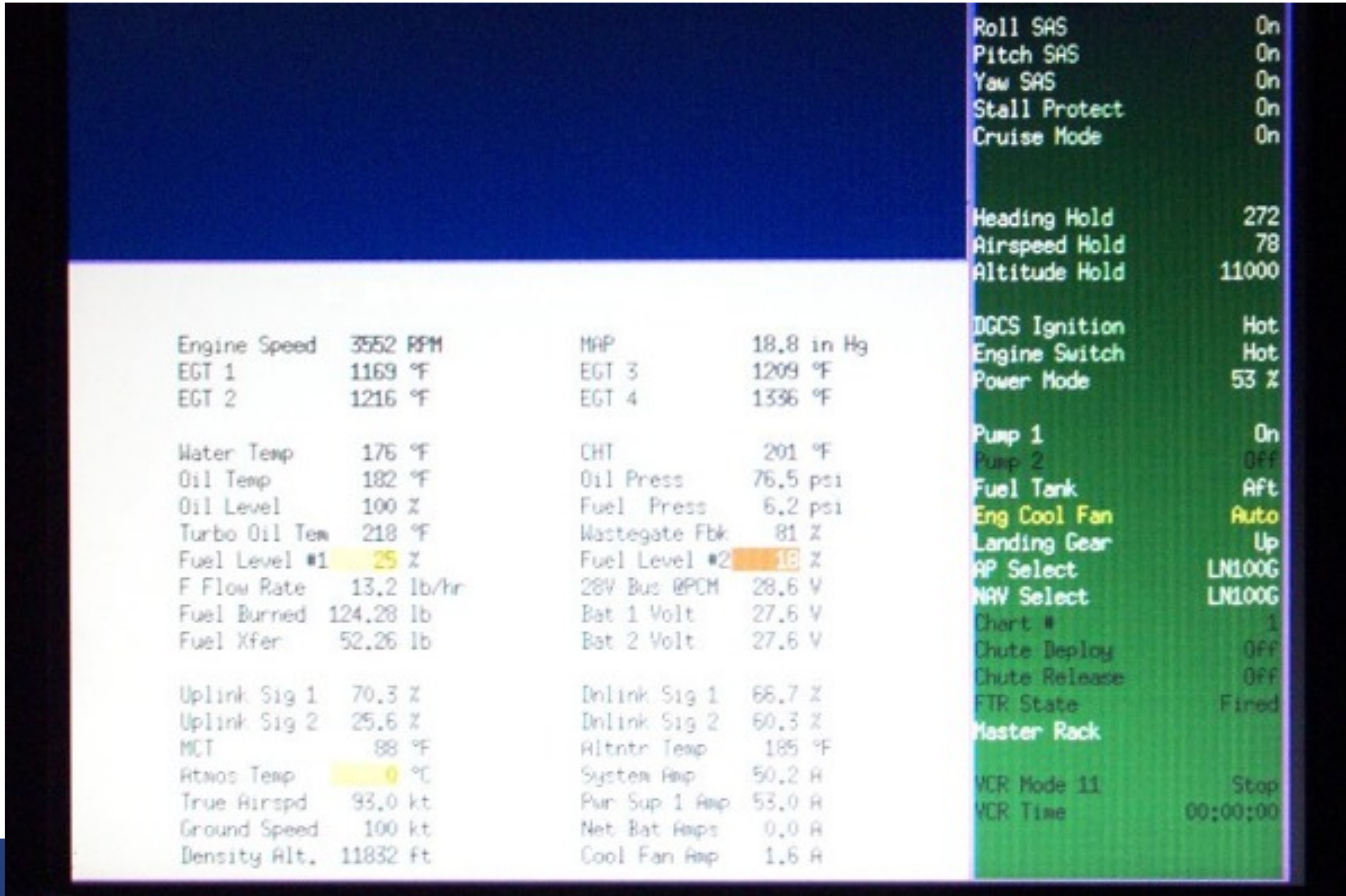
The crash … was caused by operator error… The pilot … inadvertently cleared the primary control module's random access memory, simply by inputting the wrong command into the system.

This anomaly broke the datalink between the UAV and the ground station, and the ground crew was unsuccessful in reestablishing the link. The Predator stalled shortly after the link was broken and crashed several minutes later.

The crash report noted that the basic design of the Predator control system was also a factor in the crash. The menu system, which allowed a crewmember to place the Predator into a hazardous condition without any warning, was one of the significant factors that caused the crash, the report said.

Source: Defense Daily. Feb. 5, 2001

Variable Information Table (VIT)



HF Analysis - HDD

- HDD primary interface between AVO and aircraft
  - Operate UAV functions through key strokes related to menu pages
    - 41 variable information tables (VITs) → information stovepipes or "keyhole view" of vehicle status → denies AVO continuous readings accessible by routine instrument scan
    - Multi-step processes to access and change system parameters → ⇑ time to perform tasks → ⇑ workload & ⇓ efficiency

Increasing number of displays taxes operators mental model of status of vehicle

EA501 Design Deficiency

Hunter System

- EP to IP mishap
- Maintenance crewman turned off autopilot function
- IP pilot failed to notice nonfunctional autopilot

Shadow System

- IP to IP handoff
- 2 aircraft involved
- TALS failure and “kill” command
- Completion of command with 2nd aircraft

Fire Scout System

Damage to antenna during ground handling

Hovering at 500ft but readout was 2ft

Predator Accident – Arizona, April 2006

Predator Accident – Arizona, April 2006

martes, 15 de julio de 14

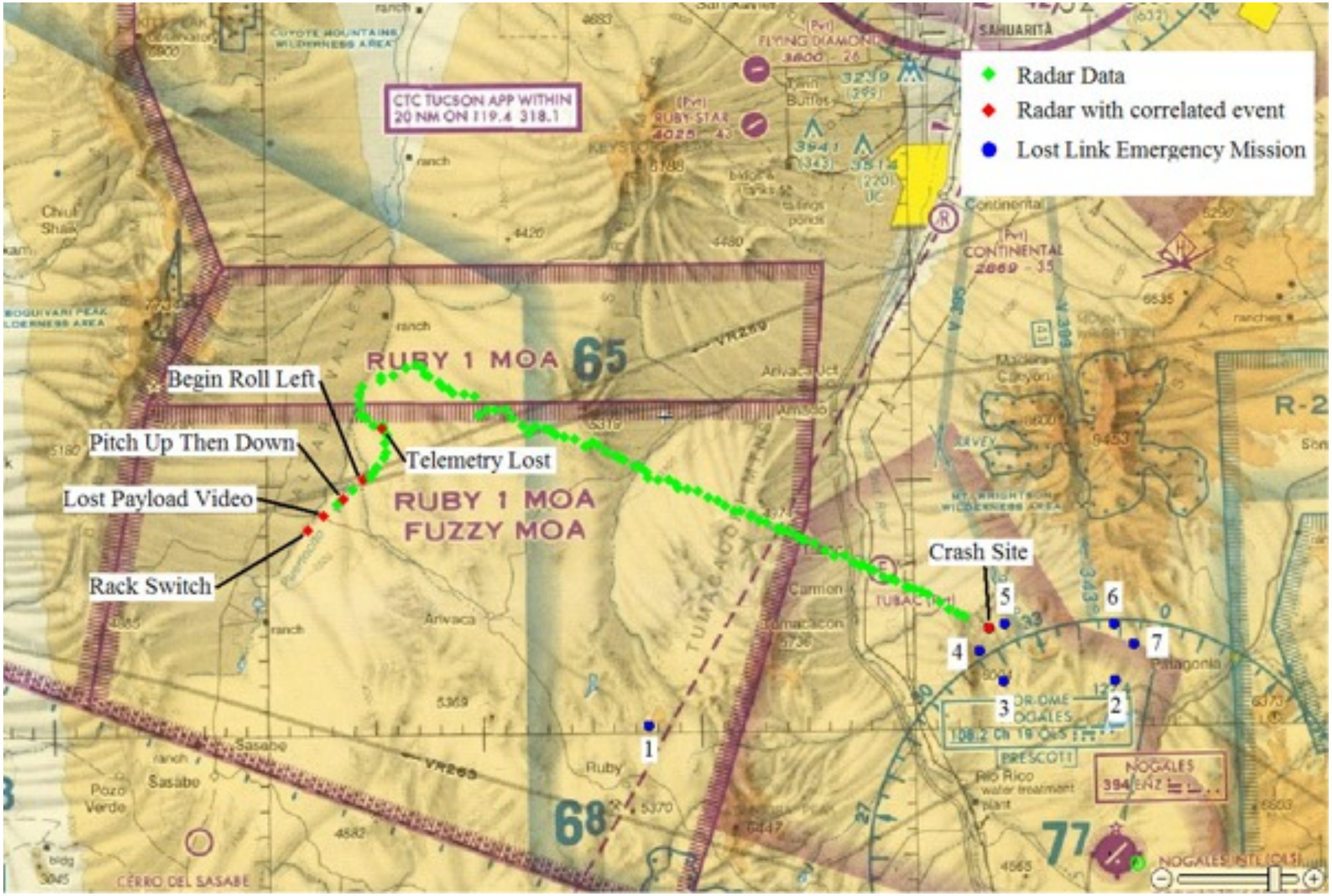
Predator B Specifications

- 36 feet in length
- 66 foot wingspan
- 10,000 lbs gross weight
- endurance – 30hrs.
- altitude max. 50,000 ft
- turboprop engine
- cruise – 220 kts

Accident Summary

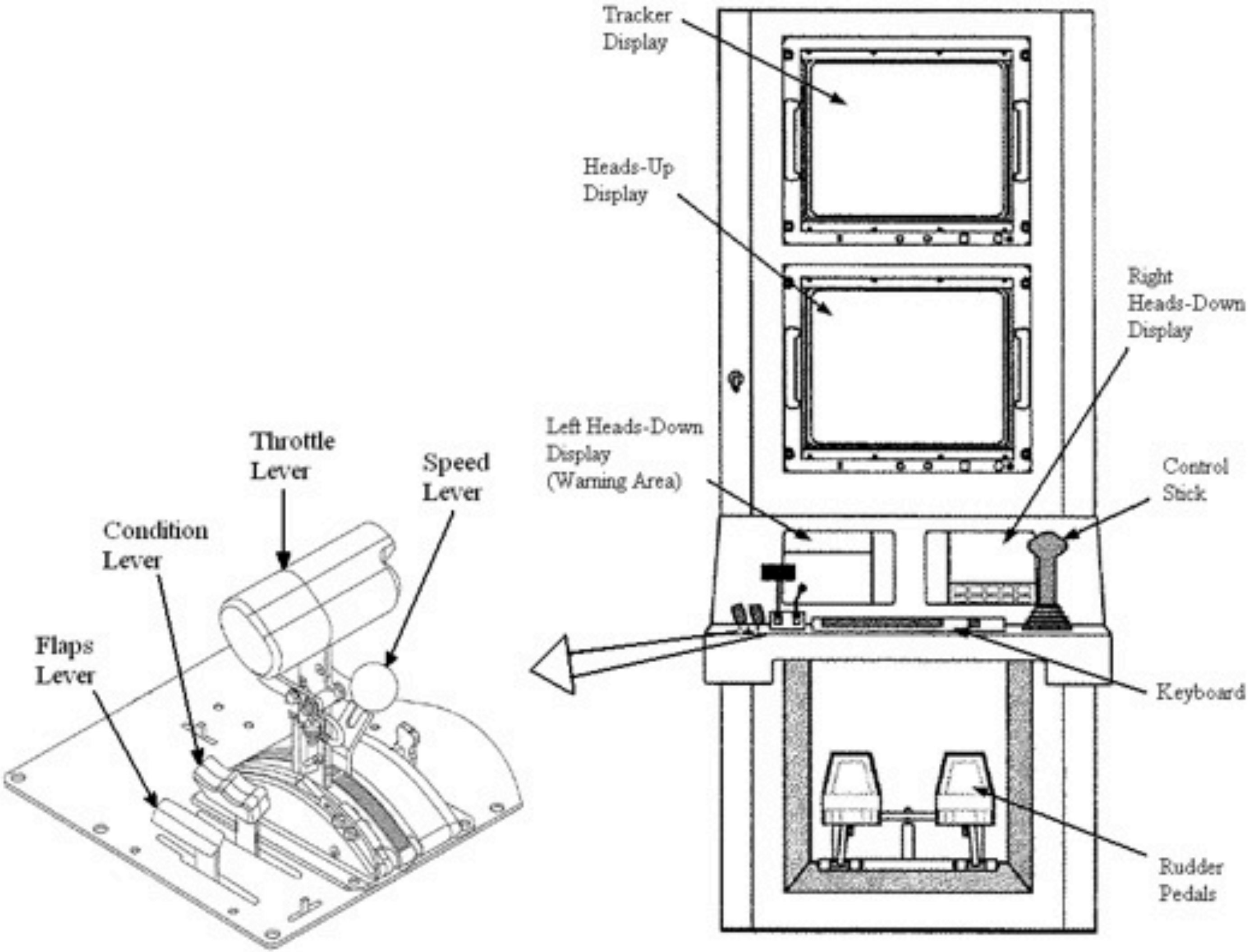
On April 25, 2006, about 0350 mountain standard time, a MQ-9 (Predator B) aircraft, serial number BP-101, call sign OMAHA 10, collided with the terrain approximately 10 nautical miles northwest of the Nogales International Airport (OLS), Nogales, Arizona. The unmanned aircraft system (UAS) was owned 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.

Predator Accident – Arizona, April 2006



Predator Control Station

Throttle Quadrant



Console Center Control “Condition” Lever Functions

Lever Position	Pilot Function	Payload Operator Function
Forward	Opens fuel valve to the engine	Increases camera iris opening
Center	Closes fuel valve to the engine (shuts down engine)	Locks camera iris setting
Aft	Feathers the propeller	Decreases camera iris opening

Accident Flight Timeline

Time	
1700	Difficulty establishing communication with GCS pilot station (switch main processor cards)
1900	Initial pilot is replaced by accident pilot who has just arrived
2100	Accident pilot goes on break
0300	Accident pilot resumes control, flight normal to this point
0315	Pilot lower monitor screen goes blank, reappears, but with no telemetry data
0325	Pilot "decides" to switch control to right side, payload operator leaves GCS
0333	Control Transfer from PPO-1 to PPO-2 took place

Accident Flight Timeline

Time	
0333	Feather Lever was in the stop position
0333	Engine Out Detected Warning was displayed on the heads down display (pilot does not see)
0333	Lost Payload Video
0333	Speed Priority Warning and Pitch Up Then Down
0334	UA Entered a Left Turn
0335	Lost All Telemetry and video Data
0350	Aircraft impacts terrain

Important Points

- Avionics technician advised pilot to switch control to left side
- Pilot calls senior (instructor) pilot for assistance
- Pilot had only 27 hours flight time in Pred B (500 in Pred A, 3000+ in manned aircraft)
- Did not follow company procedures or Certificate of Authorizatioin (COA) procedures
- Satellite (iridium) link could not be established because of load shedding
- Auditory alarm was non-specific

UAS Accident Checklist

What is the system?

System Name:

Manufacturer:

Size:

Performance:

Powerplant:

Launch/Recovery Methods:

Data Link Capabilities:

Control Station(s) Description (control schemes):

UAS Accident Checklist

Where is the system?

Aircraft:

Control Station(s):

Pilots:

Crew and support personnel:

Aircraft Hazards?

Powerplant:

Payload:

Flight termination system:

UAS Accident Checklist

What was the Operation?

- Operational Description:
- Operational Requirements:
    - Crew:
    - Control Stations:
    - Data Link:
    - Payload:
    - Procedures:
- ATC coordination:

Questions?