The Cognitive Challenges of Flying a Remotely Piloted Aircraft

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Three Types of Remotely Piloted Aircraft Systems (RPAS)

Low level
line-of-sight

Low level beyond-
line-of sight

All classes of civil
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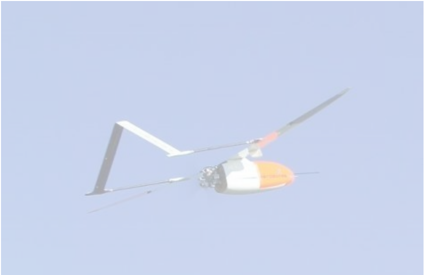


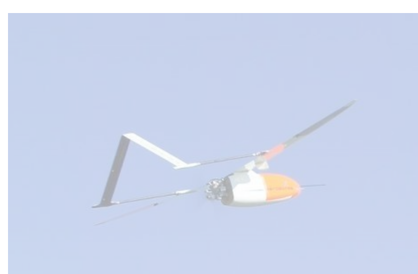
All classes of civil airspace

Three Types of Remotely Piloted Aircraft Systems (RPAS)

Assumptions
Instrument Flight Rules
Controlled by a remote pilot
Not autonomous
Complies with ATC instructions

Low level line-of-sight

Low level beyond-line-of sight



All classes of civil airspace

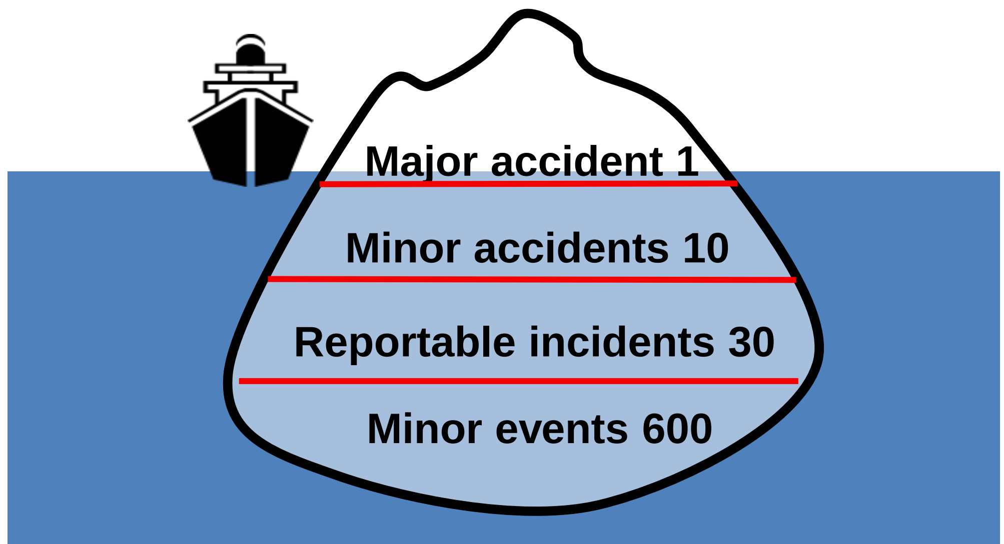
Accident Record

- US Army accident rates[1]:
  - Unmanned aircraft: 49 per 100,000 hours
  - Manned aircraft: 4 per 100,000 hours
- USAF hull-loss rates[2]:
  - MQ-9: 4 per 100,000 hours flown
  - Manned aircraft: 0.4 per 100,000 hours flown
- Small civilian RPA hull-loss rate:
  - ~ 300 per 100,000 flight hours

1. Prather, C. (2013). Online report of Army aircraft mishaps. *Flightfax, 26*. Retrieved from www.safety.army.mil
2. United States Air Force. (2015). *Q-9 flight mishap history*. Retrieved from http://www.afsec.af.mil/

RPAS Critical Incident Study: Rationale

- “Tombstone safety” in the 20th century
- Lack of data on minor RPAS events

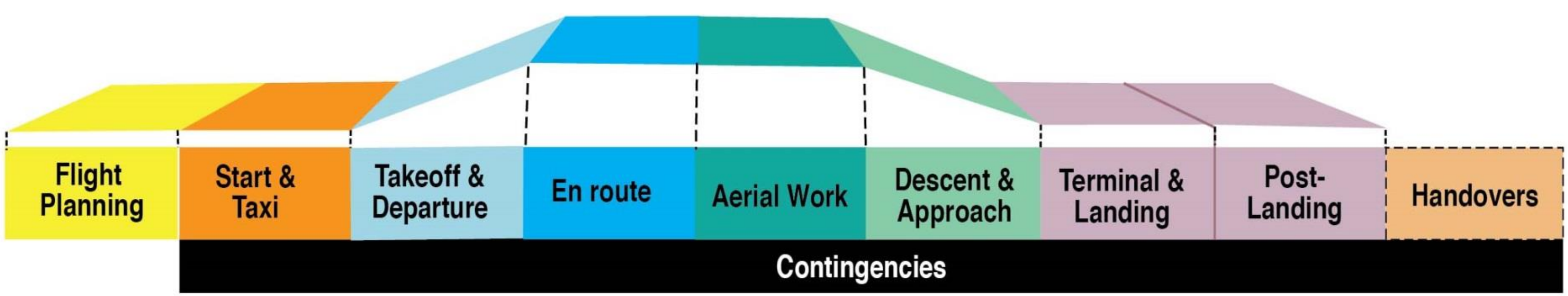


RPAS Critical Incident Study: Goals

- Examine the feasibility of a method to collect the operational experiences of RPAS pilots
- Provide independent and complementary data to supplement NASA simulations and flight tests

RPAS Critical Incident Study: Approach

- Focus groups with 2-3 pilots at a time
- Participants asked to recall events experienced while operating a remotely piloted aircraft
  1. A hazardous situation or error
  2. The rectification of a hazardous situation or error
- Only reports that can be made public

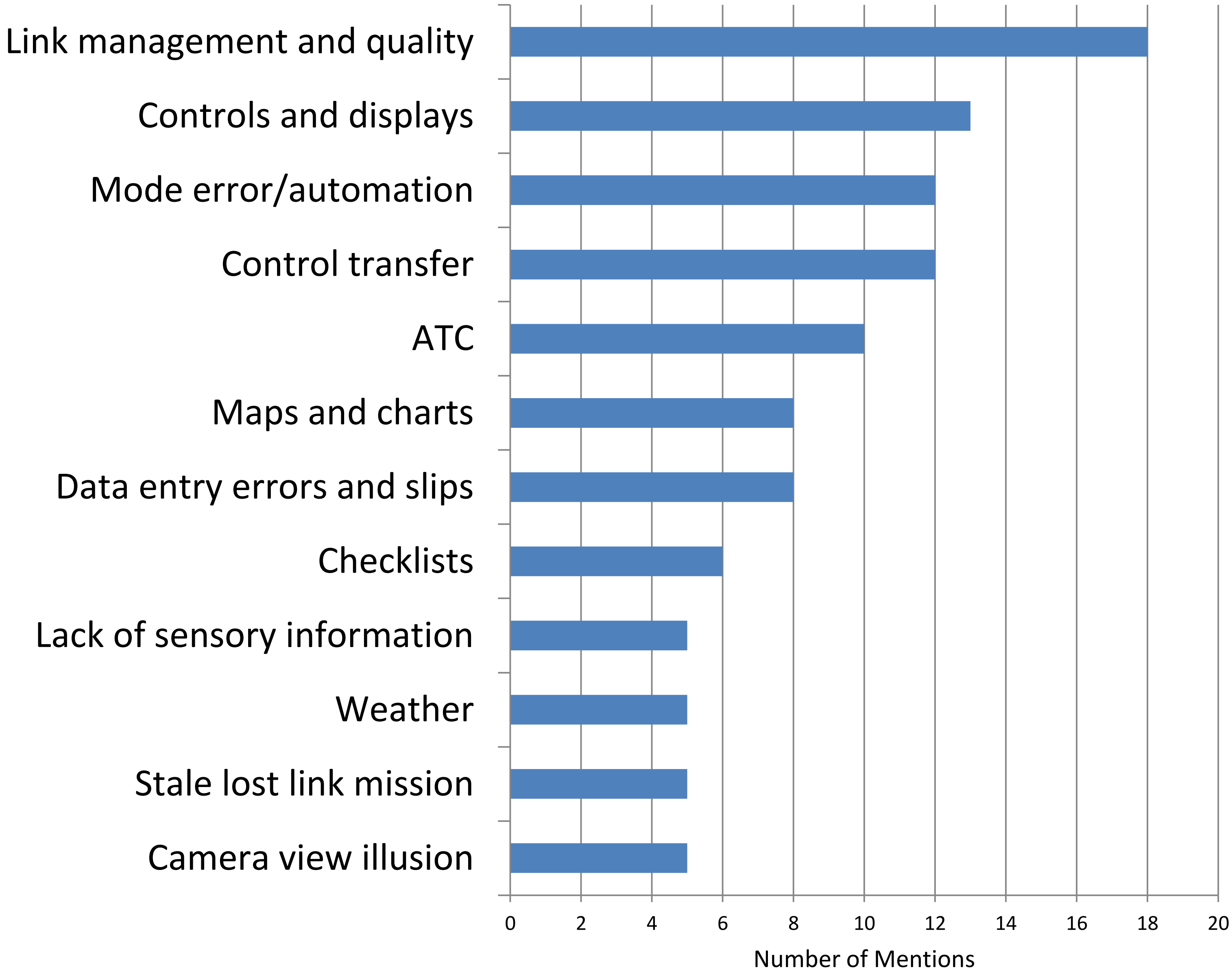


Preliminary Results

- 23 participants
- 90 incidents described
- Weight classes of the remotely piloted aircraft:

Aircraft max takeoff weight	*# of reports*
Less than 400 lbs	17
2000-15,000 lbs	60
Greater than 15,000 lbs	13

Problems Mentioned in Reports

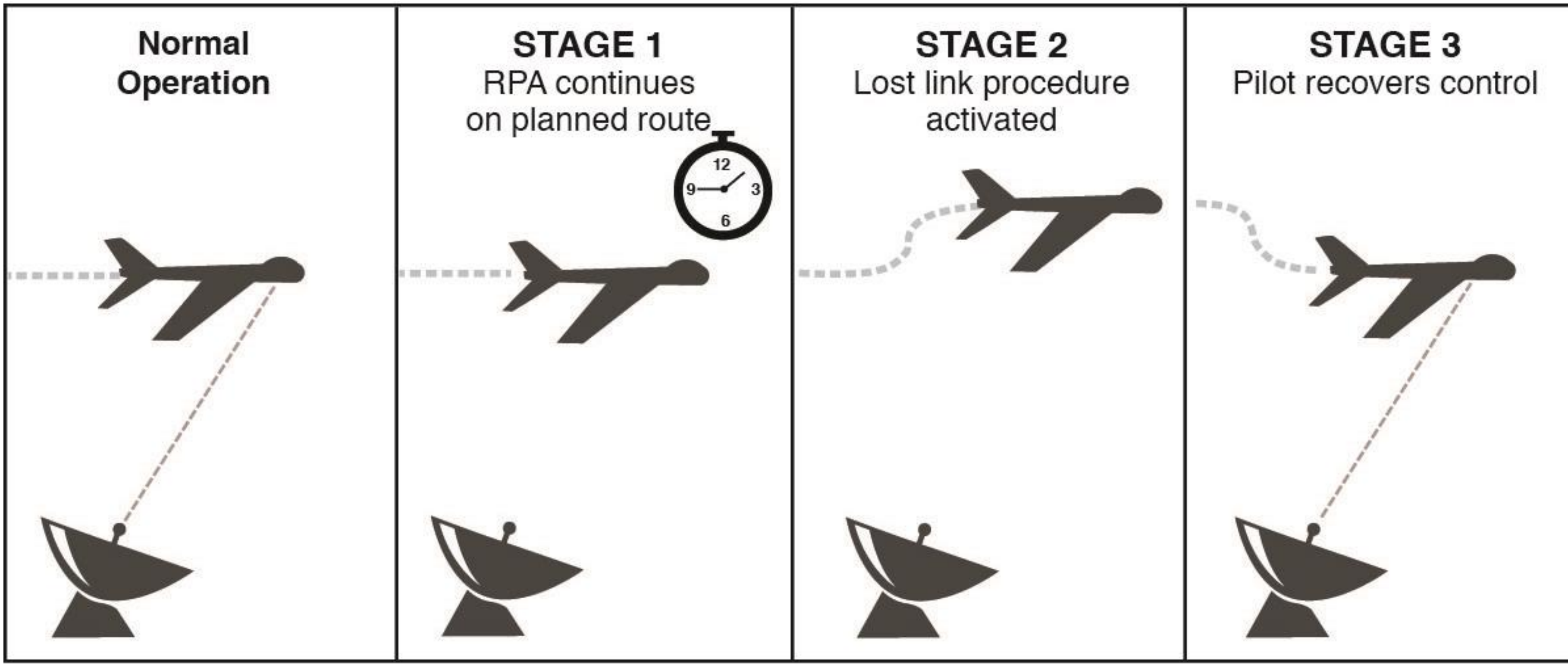


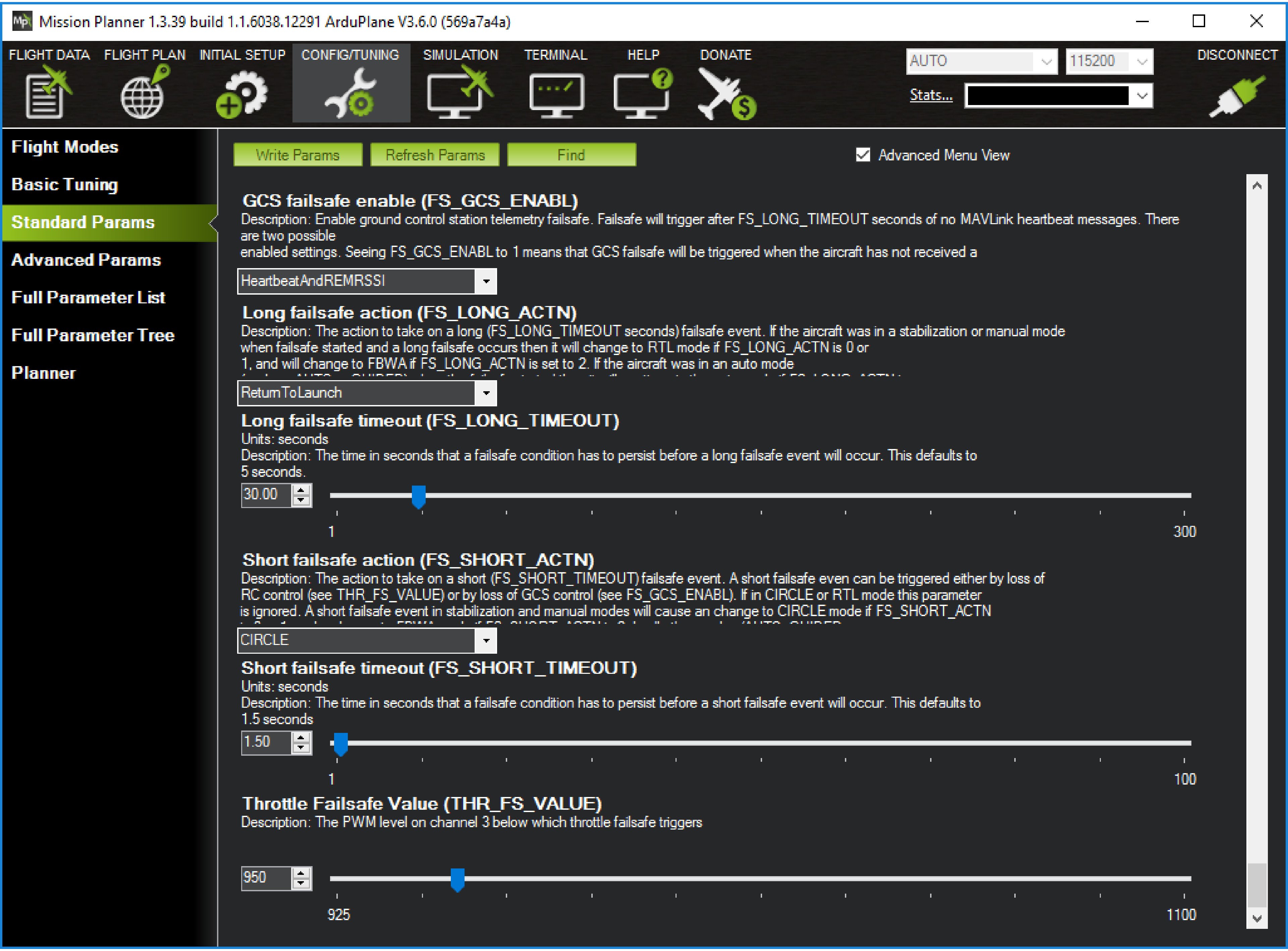
Example: Lost Link

“We were flying really far out … about 90 kilometers from the antenna. But I passed some random mountain peak for about one second and the aircraft went into emergency mode. Luckily I had the correct emergency mode programmed. If I didn't, I could've lost the aircraft.”

UAS Pilot Report

Stages of Lost Link




Mission Planner 1.3.39 build 1.1.6038.12291 ArduPlane V3.6.0 (569a7a4a)
FLIGHT DATA
FLIGHT PLAN
INITIAL SETUP
CONFIG/TUNING
SIMULATION
TERMINAL
HELP
DONATE
AUTO
115200
Stats...
DISCONNECT
Flight Modes
Basic Tuning
Standard Params
Advanced Params
Full Parameter List
Full Parameter Tree
Planner
Write Params
Refresh Params
Find
Advanced Menu View
GCS failsafe enable (FS_GCS_ENABL)
Description: Enable ground control station telemetry failsafe. Failsafe will trigger after FS_LONG_TIMEOUT seconds of no MAVLink heartbeat messages. There are two possible
enabled settings. Seeing FS_GCS_ENABL to 1 means that GCS failsafe will be triggered when the aircraft has not received a
HeartbeatAndREMRSSI
Long failsafe action (FS_LONG_ACTN)
Description: The action to take on a long (FS_LONG_TIMEOUT seconds) failsafe event. If the aircraft was in a stabilization or manual mode
when failsafe started and a long failsafe occurs then it will change to RTL mode if FS_LONG_ACTN is 0 or
1, and will change to FBWA if FS_LONG_ACTN is set to 2. If the aircraft was in an auto mode
ReturnToLaunch
Long failsafe timeout (FS_LONG_TIMEOUT)
Units: seconds
Description: The time in seconds that a failsafe condition has to persist before a long failsafe event will occur. This defaults to
5 seconds.
30.00
1
300
Short failsafe action (FS_SHORT_ACTN)
Description: The action to take on a short (FS_SHORT_TIMEOUT) failsafe event. A short failsafe even can be triggered either by loss of
RC control (see THR_FS_VALUE) or by loss of GCS control (see FS_GCS_ENABL). If in CIRCLE or RTL mode this parameter
is ignored. A short failsafe event in stabilization and manual modes will cause an change to CIRCLE mode if FS_SHORT_ACTN
CIRCLE
Short failsafe timeout (FS_SHORT_TIMEOUT)
Units: seconds
Description: The time in seconds that a failsafe condition has to persist before a short failsafe event will occur. This defaults to
1.5 seconds
1.50
1
100
Throttle Failsafe Value (THR_FS_VALUE)
Description: The PWM level on channel 3 below which throttle failsafe triggers
950
925
1100

Example: Lost Link Timer

“The airplane … made many turnarounds due to it being out of link then … it would reacquire and … return on mission. This affected fuel burn. [So I] set time-out feature just short of the actual mission duration.”

UAS Pilot Report

Example: Lack of Sensory Information

"We fly based on digital gauges. We don't hear or feel anything, like RPM changes …. The aircraft is supposed to level off, at say, 5,000 ft … As opposed to a real aircraft [where] you can feel the airplane leveling off, I couldn't determine if it was still climbing until I noticed it was 300 ft past its command altitude."

UAS Pilot Report

Stale Lost Link

- Pilot awareness of lost link mission
- Lost link mission needs regular updating
- Lost link mission can be a form of “automation surprise”

Example: Stale Lost Link

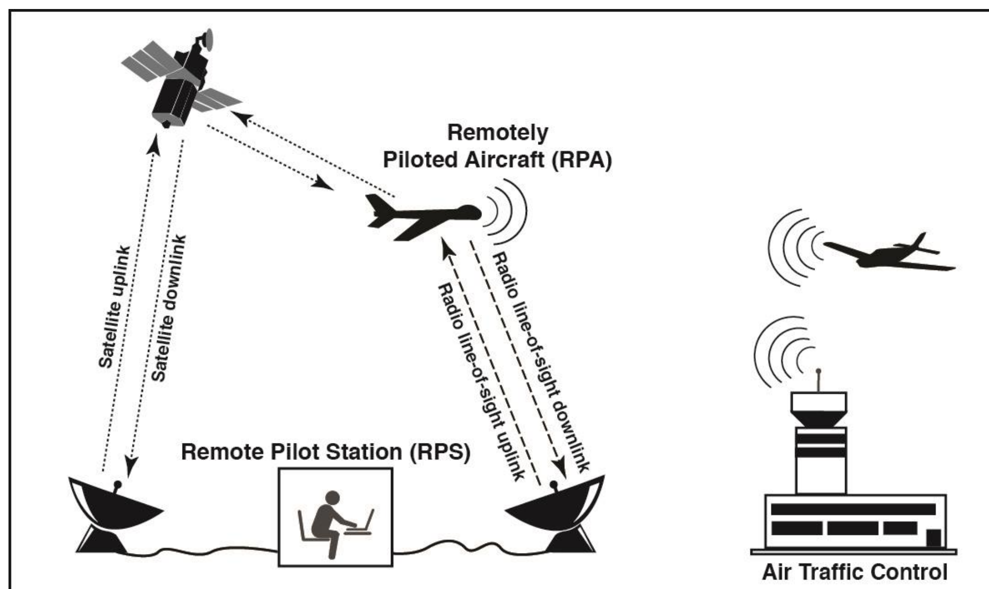
“At the beginning of the flight, the lost link procedure was valid, but the procedure was not updated later in the flight. At one point, had the lost link procedure been activated, it would’ve had the aircraft fly through terrain in an attempt to reach the next waypoint. However, the aircraft didn’t lose link and the error was caught in the handover to the next set of operators.”

UAS Pilot Report

Example: Voice Latency

"There is a delay between clicking the press-to-talk and talking. This is very difficult to manage when in very busy airspace, and listening for a gap to talk. Sometimes by the time we press the talk button, with the satellite delay, the gap is gone and we step on other aircraft."

UAS Pilot Report



Controls and Displays

- Some RPS interfaces appear to be particularly error-productive
- Shared payload and flight controls
- Keyboard and consumer interfaces

Example Narrative: Keyboards

"… an operator placed his manual on top of [the keyboard]. Accidently, this activated the GUI. Then more pressure was applied through handling the manual, on the space bar. As a result, it highlighted and armed, through several steps, the flight termination button. Luckily, the operator saw the countdown and caught it in time to deactivate this command."

UAS Pilot Report

Example: Data Entry Errors and Slips

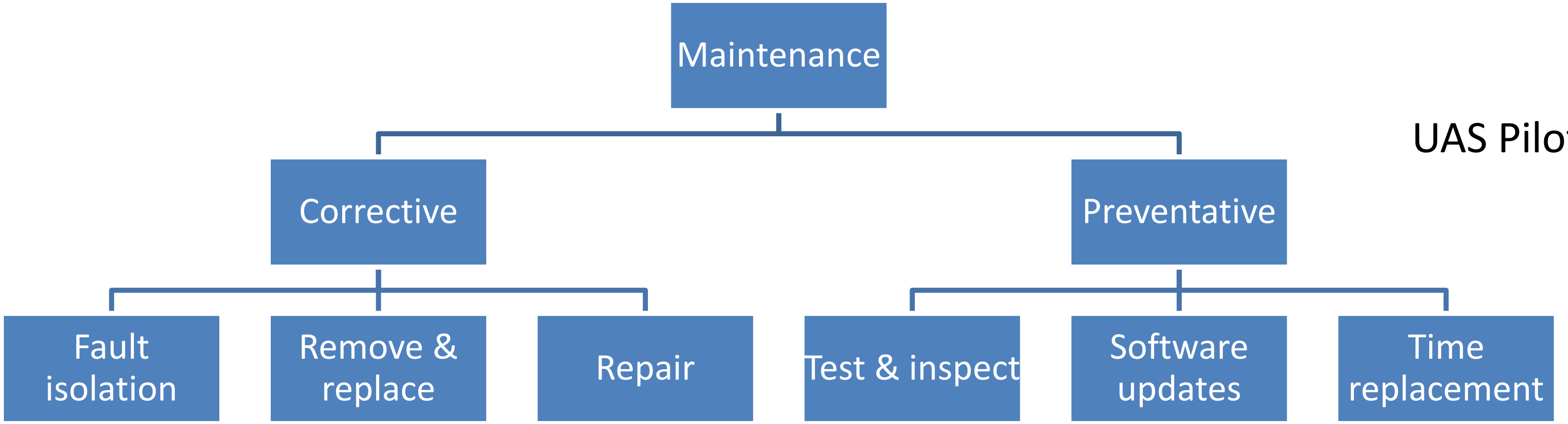
"I went to put the gear down, but instead I turned the SAS [Stability Augmentation System] off using the red emergency button. The aircraft went into a 20-degree bank and 5-degrees nose down. I was able to recover the airplane. I had developed muscle memory with the activation of the SAS disengagement button."

UAS Pilot Report

Accessibility of Control Station

"In manned aircraft it is clear who is in command, but with UAS operations, there are multiple people who have a sense of responsibility for the aircraft. So when there is something that needs attention many people run to the GCS [Ground Control Station]."

UAS Pilot Report



Example: Mode Error During Control Station Transfer

"During preflight, handover checks were being done … we had the aircraft engine at idle with the parking brake set, but when the radio handover switched to XXX, he didn't have the parking brake set and the power was set at 80% …. The result was the engine revving up, and the aircraft jumping its chocks."

UAS Pilot Report

Example: Unintended Transfer

"I was preparing to take control of the aircraft from [another pilot station]. The transmitters from my GCS were accidently left on. When I slewed the directional antenna to get the picture of the aircraft (the down link info), this automatically gave me control of the aircraft. I was not intending to take control of the aircraft at this time."

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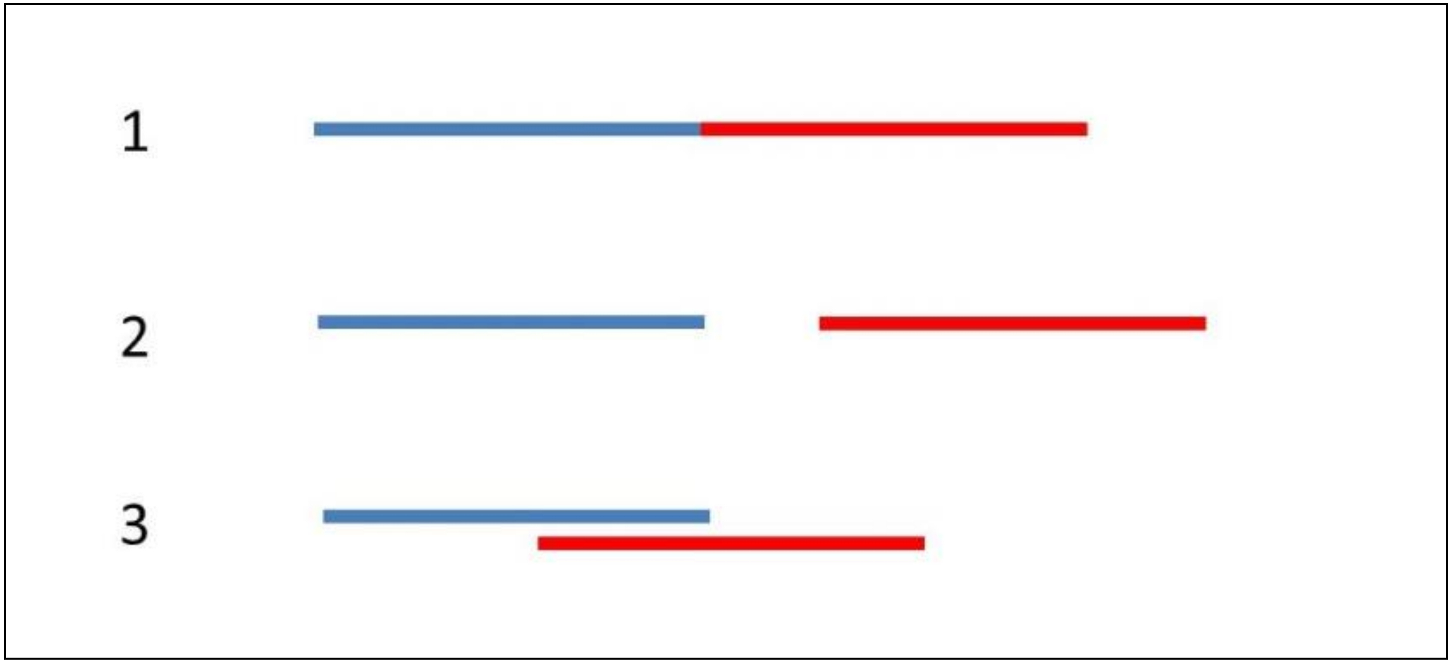
Three Styles of Control Transfer



Example: Camera View Illusion

"Depending on how I do the landing …. [the moveable sensor camera] …will be used to make sure that we clear the turns. But sometimes, the sensor operator will move the camera, which will make it look like I'm turning but I'm actually not turning. So I have to concentrate and make sure I don't respond to that erroneous camera view."

UAS Pilot Report

Next Steps

- Continuing to collect RPAS incidents
- Results are being used to inform design guidelines for RPAS control stations
- Incident reports are helping to identify under-examined topics

Applying the Lessons to RPAS Guidelines

Manage

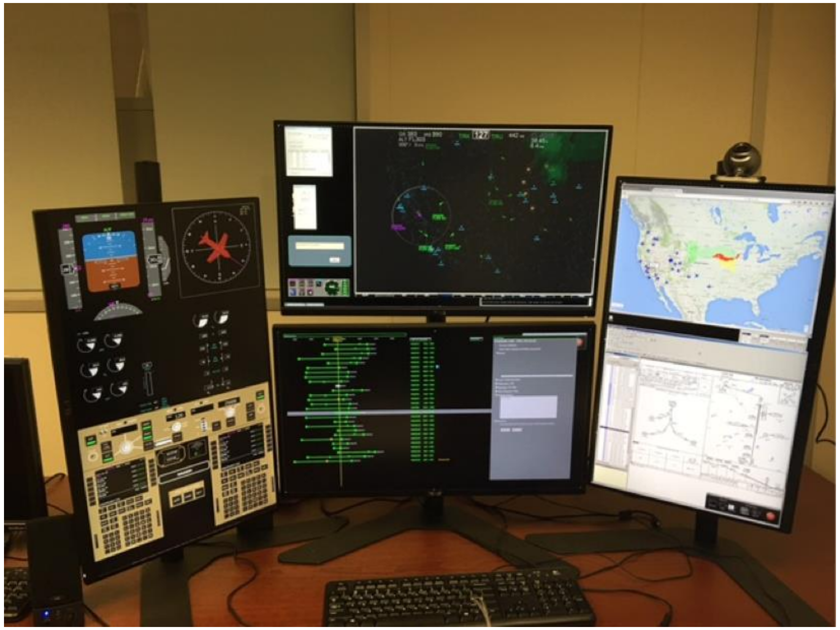
- **1. Aviate**
  - 1.1 Monitor and control aircraft systems, including automation
  - 1.2 Monitor consumable resources
  - 1.3 Monitor and configure control station
  - 1.4 Maneuver to avoid collisions with other aircraft or terrain
  - 1.5 Monitor and control status of links
  - 1.6 Transfer control
- **2. Navigate**
  - 2.1 Control and monitor location and flight path of aircraft
  - 2.2 Remain clear of terrain, airspace boundaries and weather
  - 2.3 Remain well-clear of other aircraft
  - 2.4 Review and refresh lost link mission as necessary.
  - 2.5 Terminate flight
- **3. Communicate**
  - 3.1 Communicate with ATC
  - 3.2 Communicate with other airspace users
  - 3.3 Communicate with other flight crew or ground support
  - 3.4 Communicate with ancillary services (e.g. weather)

Under-examined Topics

- How should control transfers be managed?
- What does ATC need to know about each RPAS flight?
  - e.g. Stages of lost link?
- How much voice delay is tolerable?
- How does teleoperation change threat & error management?
- How do we make the best use of human capabilities in teleoperated systems?
- What information is needed for flight termination decision making?
- How does the accessibility of the control station change CRM?
- What maintenance tasks should be permitted while a control station is linked to an aircraft?

A Final Thought

Will there be a convergence between conventional aircraft and RPAS?



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