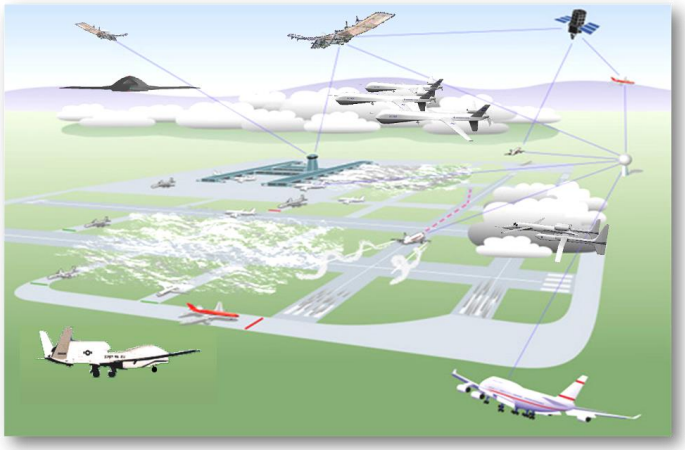
C2-Related Incidents Reported by UAS Pilots



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Presentation to RTCA Special Committee 228 Unmanned Aircraft Systems
Work Group 2, Command and Control

NASA

Agenda

- Human challenges of remote piloting
- Problem: Lack of available incident data
- Critical incident technique
- Preliminary results: under-examined issues
- Conclusions

Human Challenges of Remote Piloting

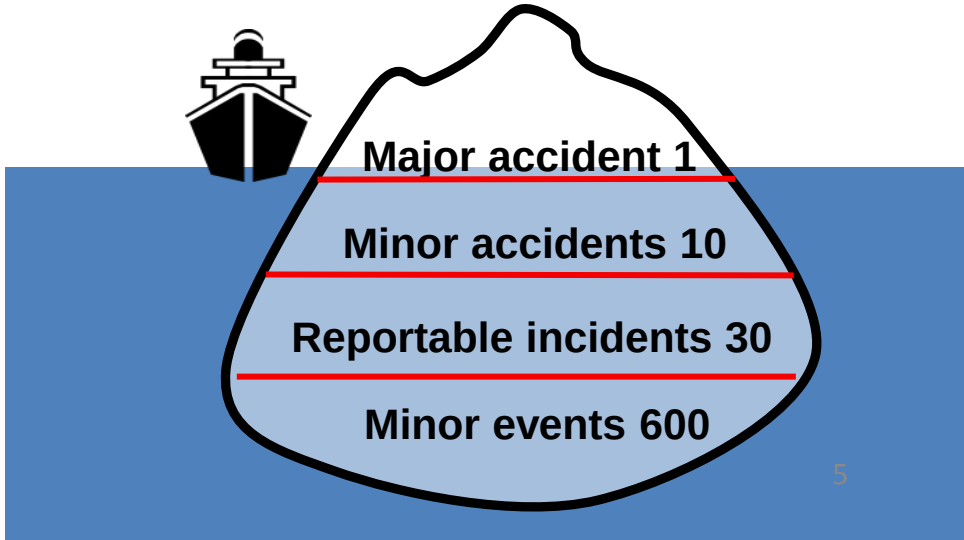
- Loss of natural sensing
- Control and communication via radio link
- Physical characteristics of control station
- In-flight transfer of control
- Reliance on automation
- Flight termination

The Problem

- Lack of data on Remotely Piloted Aircraft Systems (RPAS) incidents
- Relatively few RPAS reports have been submitted to NASA's ASRS by RPAS pilots

Critical Incident Technique

- In 1940's, researchers asked pilots to recall pilot error incidents
  - Many "errors" reflected poor cockpit design
  - Results led to standardized cockpit design in modern aircraft



The Current Study

- Goal: Examine the feasibility of a method to collect the operational experiences of RPAS pilots
  - Information will be used to identify needed improvements in control station design, procedures, training, etc
- Will provide independent and complementary data to supplement NASA simulations and flight tests

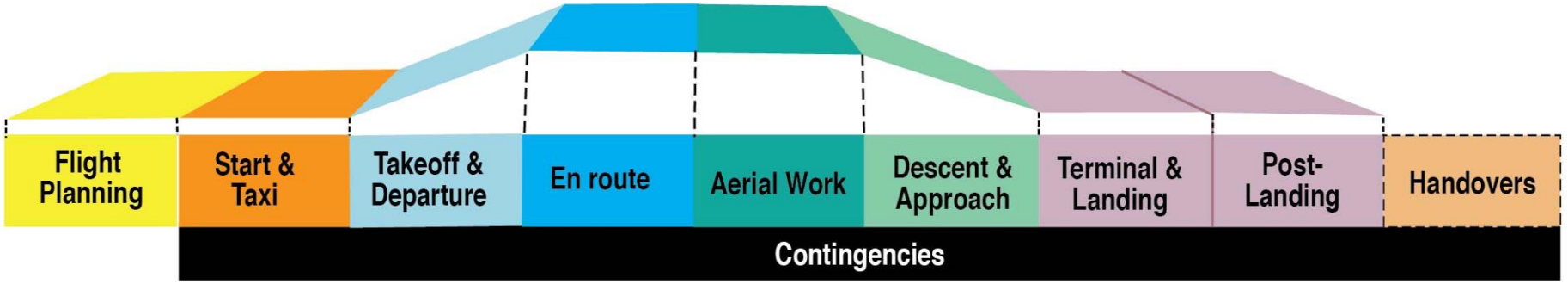
Approach

- Focus groups with 2-3 pilots at a time
- Participants asked to recall events that they have experienced while operating a remotely piloted aircraft
  1. A hazardous situation or error

     - Could involve the design of the system, procedures, communication, or other issue
  2. The rectification of a hazardous situation or error

Approach

- Participant identities remain confidential
- De-identified incident reports will be made public

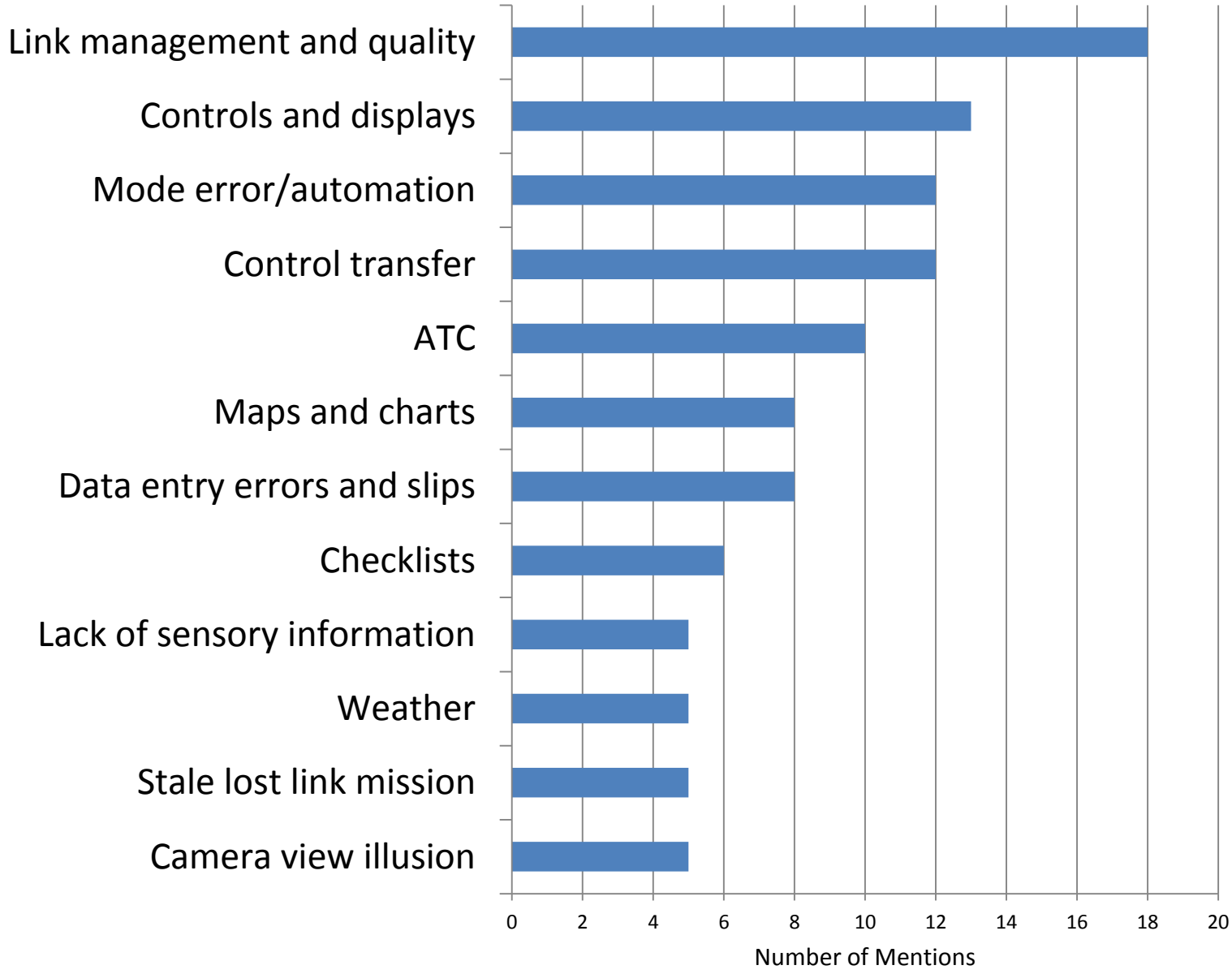


Preliminary Results

- 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 by UAS Pilots



Link issues

1. Lost link
2. Multiple losses of link
3. U/D
4. Voice latency
5. Accidental control transfer
6. Lost link timer and “lost link OK”
   - Entering areas with uncertain coverage
   - ATC certainty

Lost link (1)

“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”.

< 400 lbs

Lost link (2)

“A pilot programmed “lost link okay” for a 3-hour period while the aircraft was loitering on satellite control. While he had the aircraft it actually went into lost link and it was still lost link when I came in to take over. I didn’t want to take an aircraft that I have no idea where it’s at or what it is doing. I did eventually take over the aircraft and another GCS, who had line-of-sight control, finally took over the aircraft”.

>2000 lbs

Multiple lost link

“One day the power company severed a power line. We lost link to all UASs … The uninterrupted power system (UPS) in the GCS has a maximum of 18 minutes of power available until the generators are up and running, but power ran out before the back-up generators were up and running”.

> 2000 lbs

U/D

“Sometimes the signal to the aircraft is weak. And in the meantime, a maintenance guy … turns on the power to the aircraft that he is getting ready to work on, it can interfere with my aircraft’s signal and I end up getting the camera view from that other aircraft. …. Prior to putting on aircraft power, maintenance should make sure that no other unmanned aircraft are on final, but they don’t. This can also happen with other UAS GDT operations”.

> 2000 lbs

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. … This does not happen with [LOS] because they … transmit from the GCS direct to the tower”.

> 2000 lbs

Accidental control transfer (1)

“I’m LR and I was preparing to take control of the aircraft from the MCE. 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”.

>2000 lbs

Accidental control transfer (2)

“We were getting the aircraft ready for flight. A back-up GCS operator skipped a couple of steps on the check list and accidentally took full control of the aircraft while it was on the launcher. He was setting up the control station and was trying to be in the receive mode but inadvertently was in transmit mode. The aircraft went into full throttle and flight control surfaces started moving while there were a lot of people working around the launcher”.

< 400 lbs

Lost link timer

“Flight over the pole. Terrible Iridium connectivity problem. Data link problems … you are passed off and passed off …. Moisture in the air attenuates Iridium signals. If the airplane didn’t get a call in 30 minutes, it would return. It made many turnarounds due to it being out of link then coming back on mission time. This affected fuel burn due to time out features. It would reacquire and then return on mission. Set time-out feature just short of the actual mission duration”.

< 400 lbs

So what?

- Human actions can affect link.
  - In manned aviation pilot actions do not generally degrade operation of control cables and fly-by-wire systems.
  - In unmanned aviation flight crew actions can impact the C2 link.