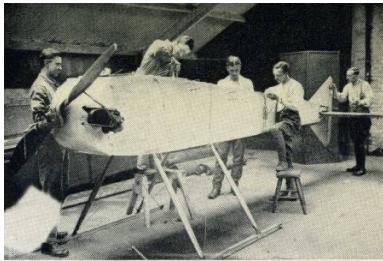


*Emerging Topics in Remotely Piloted Aircraft
Systems (RPAS) from the Human Factors
Workgroup of the International Civil Aviation
Organization (ICAO) Panel on RPAS*

Alan Hobbs
San Jose State University Research Foundation
Moffett Field, California, USA

1



Archibald Low's radio-controlled aircraft, 1917



Kettering Bug, 1918



Denny Radioplane, 1945

2

Convention on International Civil Aviation Chicago 1944



Convention on International Civil Aviation Chicago 1944, Article 8

“No aircraft of a contracting state capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting state without special authorization by that State and in accordance with the terms of such authorization. Each contracting state undertakes to insure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be so controlled as to obviate danger to civil aircraft”.

Amendment to the Paris Convention (1929)

“No aircraft of a contracting state capable of being flown without a pilot shall, except by special authorisation, fly without a pilot over the territory of a contracting state”

3

Annexes to the Chicago Convention

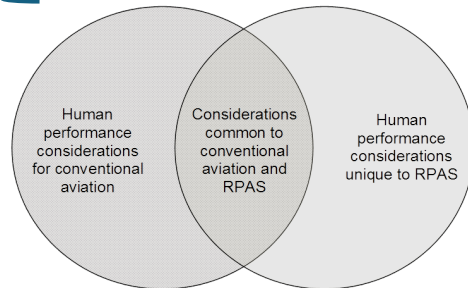
- Annex 1 Personnel licensing
- Annex 2 Rules of the air
- Annex 6 Operation of aircraft
- Annex 8 Airworthiness of aircraft
- Annex 10 Aeronautical telecommunications
- Annex 11 Air Traffic Services
- Annex 13 Aircraft accident and incident investigations
- Annex 14 Aerodromes
- Annex 19 Safety management

4

ICAO Technical Panels

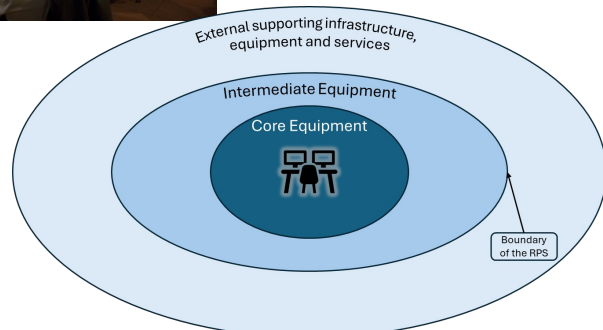
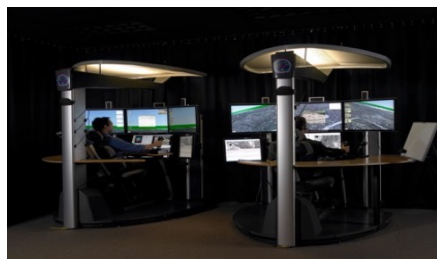
- Aerodrome Design and Operations
- Accident Investigation
- Airworthiness
- Air Traffic Management Operations
- Communications
- Flight Operations
- Meteorology
- Instrument Flight Procedures
- **Remotely Piloted Aircraft Systems**
- Separation and Airspace Safety
- Safety Management

- WG 1 Airworthiness
- WG 2 Command and Control (C2) Link
- WG 3 Detect and Avoid
- WG 4 Licensing
- WG 5 Operations
- WG 6 Air Traffic Management
- WG 7 Human in the System (HITS)



5

Airworthiness and remote pilot stations (RPS)



6

Command and Control (C2)

- Pilot actions can now disconnect “flight deck” from aircraft



7

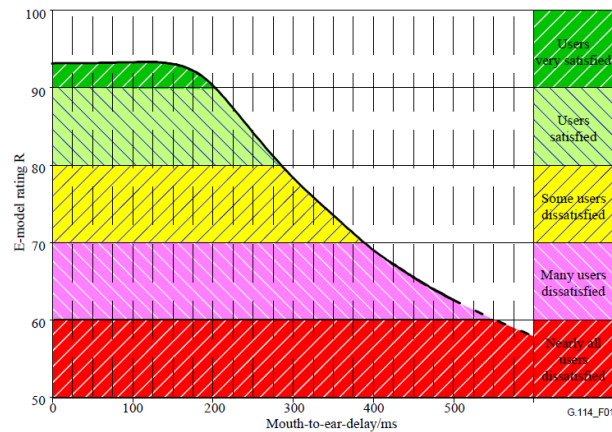
Command and Control (C2): Voice latency

“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.”

RPAS Pilot Report

8

Command and Control (C2): Voice latency



International Telecommunications Union. General recommendations on the transmission quality for an entire international telephone connection. One-way transmission time (2003)

9

Situational Awareness and loss of natural 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.”

RPAS Pilot Report

10

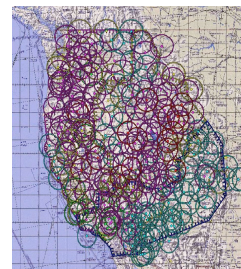
In-flight control transitions

- New ICAO terminology
 - Handover: The act of passing piloting control from one remote pilot station to another.
 - Transfer: The passing or exchange of control between pilots.
 - Switchover: A change of C2 link.

11

RPAS contingencies

- Link
- RPS
- RPA
- Flight termination



Over 280 emergency landing sites were identified for NASA's Ikhana wildfire monitoring missions in 2007. Image: NASA



Image: Author



Image: Author

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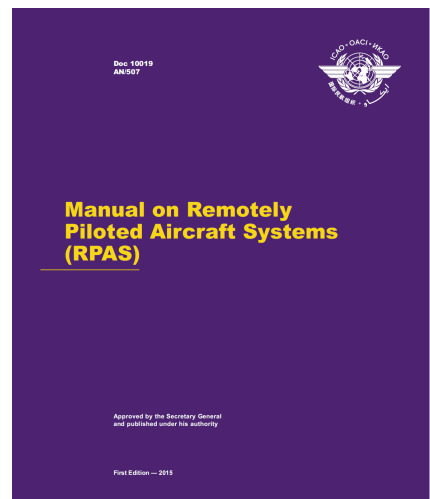
Air Traffic

- What does ATC need to know?
- Detect and Avoid
- Interceptions
- Aircraft behavior during lost link

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Human factors input to revised ICAO RPAS manual

- Human-centred design of RPS & automation
- In-flight maintenance
- Detect and avoid
- Behavior of RPA during lost link
- Pilot and ATC workload during lost C2 Link
- Voice latency
- Non-technical skills for crew
- Design for the positive contribution
- Safety management



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Non-technical skills for RPAS crew

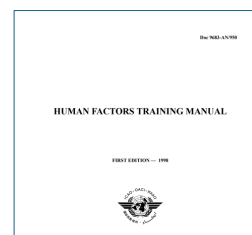
Examples from revised RPAS Manual Vol 2

Situational awareness	Maintain awareness of RPA position in relation to C2 Link service coverage area and anticipate changes in C2 Link Quality of Service.
Communication	Communicate effectively with dispersed team members in the absence of face-to-face communication and non-verbal cues.
Management of automation	Ensure that pre-programmed RPA responses in the event of a contingency (e.g., RPAS Lost C2 Link state) are appropriate at each stage of flight.
Leadership, teamwork and self-management	Perform in-flight briefings for RPS handovers and control transfers between remote pilots.
Threat and error management	Detect threats and errors in the absence of naturalistic cues.

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Future updates to ICAO human factors manual

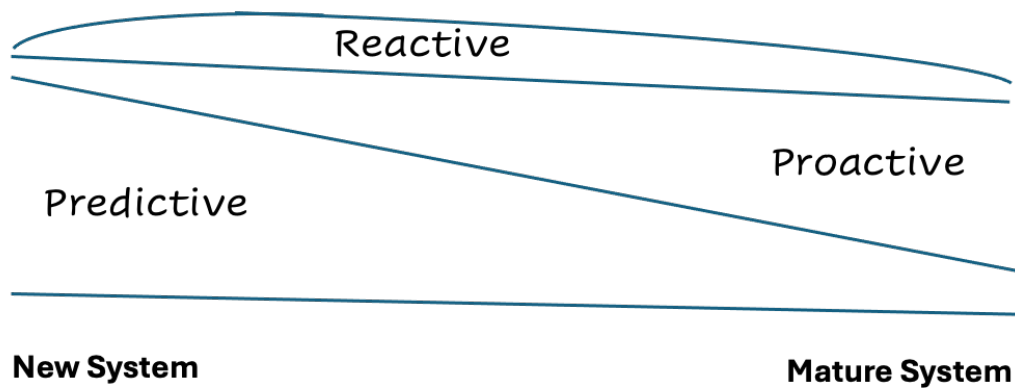
- Positive contribution of humans
- Remotely operated systems
- Advanced Aerial Mobility (AAM)
- Advanced automation
- Artificial intelligence?
- Multi-aircraft control



16

Safety Management Systems

Three Paths to Hazard Identification



17

Unanswered questions

- Is it too early to produce guidelines for control station design?
 - Should there be an RPAS equivalent of the “Basic T” flight instruments?
- How frequently do lost C2 Links occur, and why do they occur?
- How much voice delay is too much?
- Do remote pilots benefit from experience flying a conventional aircraft?
- What information is needed for flight termination decision making?
- What RPS maintenance tasks should be permitted while an aircraft is in-flight?
- How is TEM different for RPAS vs Conventional Aviation?
- How to design systems to make the best use of human capabilities?

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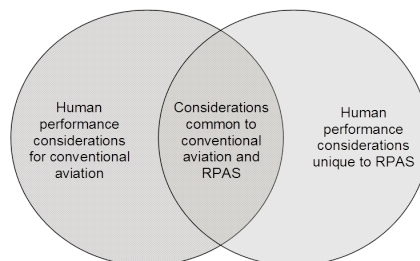
19

ICAO Technical Panels

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- Accident Investigation
- Airworthiness
- Air Traffic Management Operations
- Communications
- Flight Operations
- Meteorology
- Instrument Flight Procedures
- Remotely Piloted Aircraft Systems
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- Safety Management

- AAM Study Group

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