The Development of Human Factor Guidelines for Unmanned Aircraft System Control Stations

Alan Hobbs
San Jose State University/NASA Ames Research Center
Moffett Field, CA, USA
Control Stations
Control Stations

• Inadequate feedback to crew on system state
• Multi-mode controls
• Difficult to read fonts and colors
• Placement of critical controls next to non-critical controls
• Unreachable controls
• Reliance on text displays
• Display proliferation
Human Factor Design Guidelines

A statement describing a characteristic of the engineered system with the intention of promoting safe and effective human use.
Human Factor Design Guidelines

A statement describing a characteristic of the engineered system with the intention of promoting safe and effective human use.
Examples of Existing Guidelines

• Unmanned Aircraft Systems
  – Draft NATO UAV Standardization Agreements
  – Draft Access 5 Guidelines
  – Draft CASA Design Standards for UAVs
  – US DoD UAS GCS Human Machine Interface Guide

• Conventional Cockpits
  – FAA & EASA regulations
  – FAA Human Factor Design Guidelines for Multifunction Displays
  – RTCA, SAE, ASTM, GAMA

• General Human Factors
  – MIL STD 1472 Human Engineering
  – ANSI/HFES Human Factors Engineering of Computer Workstations
  – ISO 9241 Ergonomic Requirements for Office Work with Visual Display Terminals
  – ISO 110641 Ergonomic Design of Control Centers
<table>
<thead>
<tr>
<th><strong>Guidelines for Guidelines</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consistent</strong></td>
</tr>
<tr>
<td><strong>Achievable</strong></td>
</tr>
<tr>
<td><strong>Assessable</strong></td>
</tr>
<tr>
<td><strong>Evidence-based</strong></td>
</tr>
<tr>
<td><strong>Organized</strong></td>
</tr>
<tr>
<td><strong>Not overly prescriptive</strong></td>
</tr>
<tr>
<td><strong>Not premature</strong></td>
</tr>
<tr>
<td><strong>Applicable to diverse systems</strong></td>
</tr>
</tbody>
</table>
Possible Topic Areas

• Displays
  – Replacements for lost sensory cues?
  – Signal strength, latency, approach to limit of signal
  – Other radio frequency users?
  – Status of ground station
  – Out-the-window view?
  – Obstruction of displays (by screen savers, pop-up windows)

• Controls
  – Number of mouse click or menu steps
  – Acceptable time to respond
  – Potential for wrong response

• Decision support & planning
  – Awareness of logic of automation
  – System behavior in event of lost link or system failure
  – Weather and traffic avoidance
  – Flight termination decision making
  – Control handover
**Principle**: A human factors concept that relates to whole-of-system functioning, or that has broad applicability across the engineered system.

**Property**: Desired physical or functional properties of controls or displays.

**Information requirement**: Information that must be provided by the engineered system to the human to enable a task to be performed.

**Control requirement**: Inputs that the engineered system must be capable of receiving from the human.

**Task**: A human activity that supports a system function.
Assumptions

- Each UAS will have a pilot in command
- Pilot can assume control at all times during normal operations
- Operations will not be autonomous during normal operations
Out of Scope

- Control of multiple aircraft
- Line-of-sight operations
- Payload
- Procedures
- Personnel qualifications
- Training
- Security
The Role of the UAS Pilot

Levels of human involvement
Direct human involvement, human supervises automation, human monitors automation
1. What tasks are expected to be performed by people?

2. What information must the engineered system provide to the human?

3. What control capabilities must the engineered system provide the human?

4. How should controls and displays look, feel & sound? How should they operate?

5. What broad or additional principles apply across the engineered system?
Manage

Plan for normal and non-normal conditions
Make decisions in normal conditions
Recognize and respond to non-normal conditions
Handoff control

Aviate
- Monitor and control aircraft systems, including automation
- Monitor consumable resources
- Monitor and configure control station
- Maneuver to avoid imminent hazard (e.g. aircraft or terrain)
- Monitor and control status of links
- Send aviate commands to aircraft

Navigate
- Control and monitor location and flight path of aircraft
- Remain clear of static hazards (e.g. terrain, airspace boundaries)
- Send navigation commands to aircraft
- Remain clear of dynamic hazards (e.g. weather, other aircraft)

Communicate
- Communicate with ATC
- Communicate with other airspace users
- Communicate with other flight crew or ground support
- Communicate with ancillary services (e.g. weather)
Manage

Plan for normal and non-normal conditions
Make decisions in normal conditions
Recognize and respond to non-normal conditions
Handoff control

Aviate
- Monitor and control aircraft systems, including automation
- Monitor consumable resources
- Monitor and configure control station
- Maneuver to avoid imminent hazard (e.g. aircraft or terrain)
- Monitor and control status of links
- Send aviate commands to aircraft

Navigate
- Control and monitor location and flight path of aircraft
- Remain clear of static hazards (e.g. terrain, airspace boundaries)
- Send navigation commands to aircraft
- Remain clear of dynamic hazards (e.g. weather, other aircraft)

Communicate
- Communicate with ATC
- Communicate with other airspace users
- Communicate with other flight crew or ground support
- Communicate with ancillary services (e.g. weather)
- Confirm spectrum availability before selecting link
- Select communication mode (e.g. terrestrial/satellite, frequency)
- Confirm that communication link is effective & established with correct UA
- Maintain awareness of link strength & quality
- Maintain awareness of geographic limits of link & potential obstructions to signal
- Change link in flight
- … … …
The control station will …
- provide the pilot with information on the quality of the control link before the link is actively used to control the UA.
- provide the pilot with the information necessary to identify which link settings are active (e.g. selected frequency, satellite vs terrestrial)
- alert the pilot when the link is lost or significantly degraded
- provide a means for the pilot to select communication mode (e.g. terrestrial/satellite, frequency)
- … … …
Principles

Properties of the engineered system

Information and control requirements

• Distinctiveness of aural or visual alerts
• Workload
• Consistency
• Feedback on control inputs
• Nuisance alerts
• Emergent properties

Tasks

Design-agnostic system performance requirements
Human factors engineering process

HFE processes

• Test and evaluation
• Task analysis
• Human failure modes and effects analysis
• Human factors probabilistic risk assessment
• Operational experience review and lessons learned
• ...

“Human errors occurring in the performance of critical tasks during test and evaluation should be analyzed to determine the reason for their occurrence”. (Department of Defense, 1999)
Conclusions

• Has been a failure to apply existing standards + lack of UAS-specific guidelines
• We can not wait for operational events to identify where UAS-specific guidelines are needed
• Guidelines will need to be regularly updated as experience accumulates
alan.hobbs@nasa.gov