Automation in Unmanned Aerial Vehicles (UAS)

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NASA-UAS Integration into the NAS
Outline

• Historical Review (On the shoulders of Giants)
  – Fitts
  – Sheridan & Verplank
  – Parasuraman, Sheridan & Wickens

• “Vision” of the (very near) future

• Reality of today
  – Reaper GCS
  – Global Hawk

• Issues with UAS Automation

• Multiple UAS Control
  – Delegation
  – PB
  – Teaming
Humans appear to surpass present-day machines with respect to the following:
1. Ability to detect small amounts of visual or acoustic energy
2. Ability to perceive patterns of light or sound
3. Ability to improvise and use flexible procedures
4. Ability to store very large amounts of information for long periods and to recall relevant facts at the appropriate time
5. Ability to reason inductively
6. Ability to exercise judgment

Present day machines appear to surpass humans with respect to the following:
1. Ability to respond quickly to control signals, and to apply great force smoothly and precisely
2. Ability to perform repetitive, routine tasks
3. Ability to store information briefly and then to erase it completely
4. Ability to reason deductively, including computational ability
5. Ability to handle complex operations, i.e. to do many different things at once
Tom Sheridan (1951 - )

- Supervisory Control
- Levels of Automation (Sheridan and Verplank, 1978)

**Scale of Human-Machine Interaction**

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Whole task done by human except for actual operation by machine</td>
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<tr>
<td></td>
<td>Human asks computer to suggest options and selects from the options</td>
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<tr>
<td></td>
<td>Computer suggests options to human</td>
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<tr>
<td></td>
<td>Computer suggests options and proposes one of them</td>
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<tr>
<td></td>
<td>Computer chooses an action and performs it if human approves</td>
</tr>
<tr>
<td></td>
<td>Computer chooses an action and performs it unless the human disapproves</td>
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<tr>
<td></td>
<td>Computer chooses an action, performs it, and informs human</td>
</tr>
<tr>
<td>High</td>
<td>Computer does everything autonomously</td>
</tr>
</tbody>
</table>

8. Computer does everything autonomously
Vision of Autonomy
MQ – 9 Ground Control Station

Two Pilot Stations
Current UAV Operator Interface Issues

- Lengthy process to handoff vehicle control
- Too many inputs required to implement commands (e.g., 22 key strokes to turn on the auto pilot)
- Visualization is poor and perpetuates mistakes
- Multiple screens require significant mental integration to obtain mission/battlespace awareness
- Varying methods to input data
- Add-on systems (i.e., Falconview) provide needed functionality but cannot interface directly with core GCS
- Lack of system feedback regarding task completion
- Narrow visual field of view
- Limited alert cues to warnings where messages can be hidden
- Extra workspace required
- Non-intuitive multilayered menus
- Lack of system feedback regarding task completion
- Multiple separate comm devices
- No decision aiding/support technology
- Poor ergonomics
- Multiple keyboard/input devices required
- Numerious alphanumeric status displays
- Highly loaded visual channel

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How can we replace the information?

- You **can’t hear** the engine rpm fluctuating
- You **can’t feel** vibrations, accelerations or motion
- You **can’t smell** the fuel leak
- You **can’t taste** the electrical fire smoke
- AND, you **lose vision** in one eye, 30° FOV!
- WELCOME to UAS flying!
Global Hawk cockpit: Autonomous operations. Mouse and keyboard controls.
**Main results/conclusions:**

- Waypoint-to-waypoint control mode demonstrated significant deficits in all of the pilot measured response components compared to AP and M.
- AP and M had significantly shorter compliance times overall than WP.
- These results provide the initial database of expected pilot response time distributions, which will be critical to determining the Minimum Operational Performance Standards for UAS in the NAS.
  - Acceptability of C2 interfaces depends on the allowable response times given equipment performance specifications (i.e., sensors, aircraft performance, etc.).
Issues with UAS Automation

- Inflexible
- Brittle
- OOLP/ Left over principle

- TEAMING
A Playbook® Approach to Delegation

- A means of Delegation
- Plays contain an implicit goal
- Plays define a “template” of plan/behavior alternatives—a “space” of delegated planning authority
  - “pre-compiled” with convenient label
  - Supervisor can further constrain/stipulate as desired—by reference to play structure
  - Monitoring and information reporting facilitated by shared intent structure
  - Dynamic, real time revision and tuning = “calling signals”
- Subordinates responsible for best-effort attempts within play constraints
Flexible Levels of Execution - Interface Technologies (FLEX-IT)

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Adding Automation – 2 Options

Follow the “Leftover” Principle

• Automate as much as possible
• Automate based on feasibility versus utility
• Design philosophy: automation will be always work as planned
• The human will take care of all ‘leftover’ tasks

Follow the User-Centered Approach

• Enable automation that supports human intent
• Flexible & adjustable automation
• Design for automation transparency & intuitive control
• Design philosophy: Human flexibly employs automation as needed
Multi-level Framework with Extended Playbook & Intermediate Candidate Control Modes


“Noodle”: Pilot’s inputs on stick & throttle defines RPA’s near future path.

Lower Level Plays: Pilot’s verbal command initiates short, simple maneuver.

Higher Level Plays: Pilot’s verbal commands initiates a planning interaction with automation & then automates execution steps.

LOW  LEVEL OF AUTOMATION  HIGH
• Time to build on the foundation started in 1951
• Human-Autonomy TEAMING is the key
• Flexible, robust automation
• Transparent transition as mission/pilot requires