
# An Adaptive Automation Approach for UAV UI Concept Development

Jeff O'Hara, Senior Research Scientist
Stuart Michelson, Research Engineer II
Georgia Tech Research Institute,
Human Systems Engineering Branch

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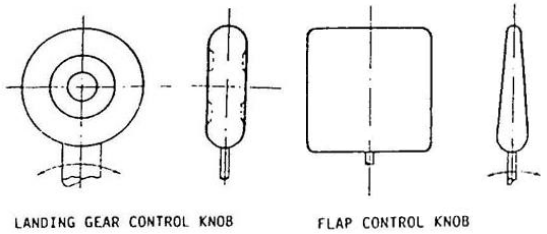
Problem. Solved.

# Background

- High loss rate of U.S. Military UAVs
- Numerous ergonomic / automation causal factors (Source: USAF SAB):
  - 80% of Predator mishaps involved human error due to fundamental design issues.
  - Warning/status messages buried layers deep.
  - Complex automation (22 steps to turn on the autopilot on the Predator).
  - $4.5M Predator lost due to pilot accidentally selected the engine kill switch instead of the landing gear switch.
- Analogous in terms of maturity to early manned cockpit design (systematic control shape coding analyses fixed a spate of B-17/B-25 crashes).
- Need a Systems Engineering approach to higher order human/automation system design.

B-17 Flap and Gear Handle




Modern Shape Coding

# Challenging Emergent Requirements Driving the Need for Automation

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- New UAV Combat Missions:
  - Airborne Electronic Attack (AEA)
  - Air to Ground (A/G)
  - Air to Air (A/A)
- New User Interface Goals:
  - Single Pilot for multiple UAVs
  - Multiple user interactions (ground troops, manned air).

UAV kill by Tactical High Energy Laser (THEL) 2011

- Derived Requirements Mandate the use of Automation:
  - Single pilot mismatch with available attention span over multiple vehicles and multiple users.
  - Human reaction time mismatch (reactive jamming of enemy radar pushes automated response requirements)
  - Human computational limit reached (pilot is overmatched trying to compute fuel burn vs. rerouting requirements for signature management, etc.).

# UAV Current Automated Capability

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UAV: "an aircraft or balloon that does not carry a human operator and is capable of flight under remote control or autonomous programming."

*(US DoD Definition: JP 1-02)*

- Current UAVs have very limited autonomy (e.g. preprogrammed flight to regain a lost link, auto land).
- Designers are struggling with adding more, incrementally.

MQ-1 Predator GCS

# What to Automate – and what to NOT.

- The appropriate Systems Engineering question is not “how to design man out”, but rather “which functions and tasks are appropriate to automate, and how?”.
- Factors include:
  - Tactically significant timelines
  - Latency in the control loop (Observe/Orient/Decide/Act – OODA)
  - Need for human oversight and control – with weapons releases.


- The next step is to recognize the need for automation to manage automation itself.

# Operator Role Theory of Automation
## (Folds, 1995)

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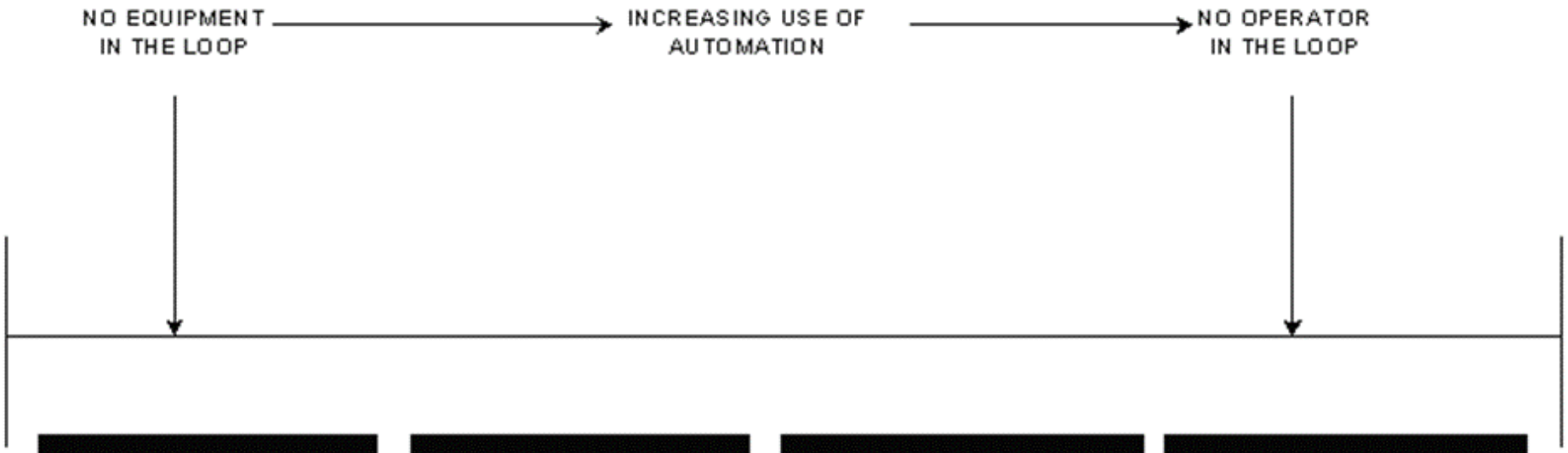


| "DIRECT PERFORMER" REGION | "MANUAL CONTROLLER" REGION | "SUPERVISORY CONTROLLER" REGION | "EXECUTIVE CONTROLLER" REGION |
|---|---|---|---|
| • HUMAN CLOSES LOOP<br>• CONTROL LOOP COMPONENTS PREDOMINANTLY HUMAN | • HUMAN CLOSES LOOP<br>• CONTROL LOOP COMPONENTS ARE A MIXTURE OF HUMAN AND MACHINE | • HUMAN OR MACHINE CLOSES LOOP<br>• CONTROL LOOP COMPONENTS ARE PREDOMINANTLY MACHINE | • MACHINE CLOSES LOOP<br>• CONTROL LOOP COMPONENTS ARE MACHINE ONLY<br>• HUMAN MAY START OR STOP FUNCTION |

# System of Systems Approach

- Need a system of systems engineering approach across applications - to adaptive automation.
- Perform MTA/Task Decomposition and apply Operator Role Theory to determine mission elements.
- Determine which elements will exceed human spans of capability.
- Determine the modes of interaction between automation, and the overarching control loop tasks.
- Determine where **Executive level automation** is best suited to arbitrate or interpolate or monitor, and where the tasks are best suited for humans.

# Executive Agent Example

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The Executive Agent

- Monitors automation managers within UAVs.
- Monitors coordinated tactics across UAV platforms.
- Compares weighted impacts of conflicting automation.
- Auto performs defined tasks / alerts pilot for other tasks.

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The Datalink Manager

- Monitors datalink latency and quality against calculated range.
- Multiple links (UAV/UAV, UAV/manned, UAV/GCS, etc.)
- Alerts when nearing lost link.
- Sets flight path to regain link.

The Signature Manager

- Monitors ownship multispectral vis against known threat sensors.
- Continuously computed during maneuvering.
- Alerts when near high Pd.
- Sets flight path to avoid.

# Executive Agent With the OODA Loop

- Monitor (“Observe/Orient”)
- Adjudicate (“Decide”).
- Recommend (or “Act”).
- Inform: elevate urgent advisories (would inform, then prompt, then warn).
- Perform specific-to-general reasoning related to induction, synthesis, and integration tasks.
- Perform general-to-specific reasoning related to deduction, analysis, and differentiation.
- Return the pilot to the role of a tactician.

# Summary

- The piecemeal use of automation may be worse than having none.
- By equipping proposed future multiple combat UAV control systems with agile, Executive level controllers which can rapidly perform multivariate, weighted arbitrations between systematically integrated automation, time critical combat tasks can be met within the multiple UAV control paradigm.