

AIR FORCE RESEARCH LABORATORY

Uninhabited Systems and Operator Control

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**Human Effectiveness Directorate
Warfighter Interface Division
Wright-Patterson AFB OH 45433-7022**

December 2005



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Warfighter Interface Division
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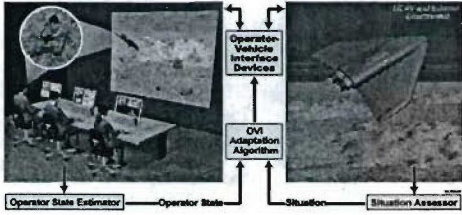
Air Force Research Laboratory Human Effectiveness Directorate



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Uninhabited Systems and Operator Control

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www.hec.afrl.af.mil
AFRL-WS-05-0408 18 Feb 2005



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Human and Machine Co-operate





Meet
Human Factors.

This is a
SAF/PAX doc

05-0477

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For pickup or return to
4A120

AFMC 05-342

AFRL/WS 05-2090



Human-electronic Crewmember Conferences

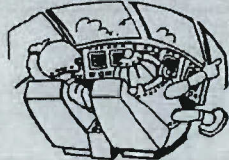


THE HUMAN-ELECTRONIC CREW: CAN THEY WORK TOGETHER ?
Conference Room at Stadttheater Ingolstadt
Ingolstadt, FRG, 19 - 22 Sept 1988



**THE HUMAN - ELECTRONIC CREW:
IS THE TEAM MATURING?**

The 2nd Joint GAF/RAF/USAF Workshop
on Human - Electronic Crew Teamwork
Stadttheater Conference Room, Ingolstadt, FRG
25-28 September 1990



**THE HUMAN-ELECTRONIC CREW:
CAN WE TRUST THE TEAM?**
Proceedings of the 3rd International Workshop on
Human-Computer Teamwork
Cambridge, United Kingdom, 27-30 September 1994



**THE HUMAN-ELECTRONIC CREW:
THE RIGHT STUFF?**

Proceedings of the 4th Joint GAF/RAF/USAF
Workshop on Human-Computer Teamwork
Hotel zur Post, Kreuth, Nr Tegernsee, Germany
23 - 26 September, 1997



THREE PILAS OF SUPPORT



Application Areas for Unmanned Vehicles



UAV's

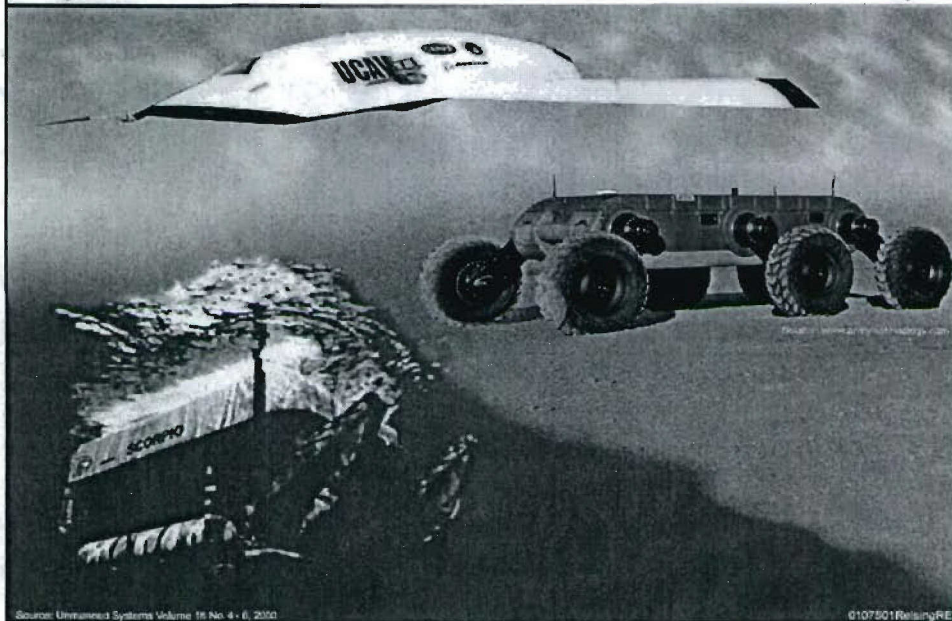
UGV's

UUV's





Air, Ground, and Undersea Examples



Source: Unmanned Systems Volume 16 No. 4 • 6, 2000

0107501RelingREV



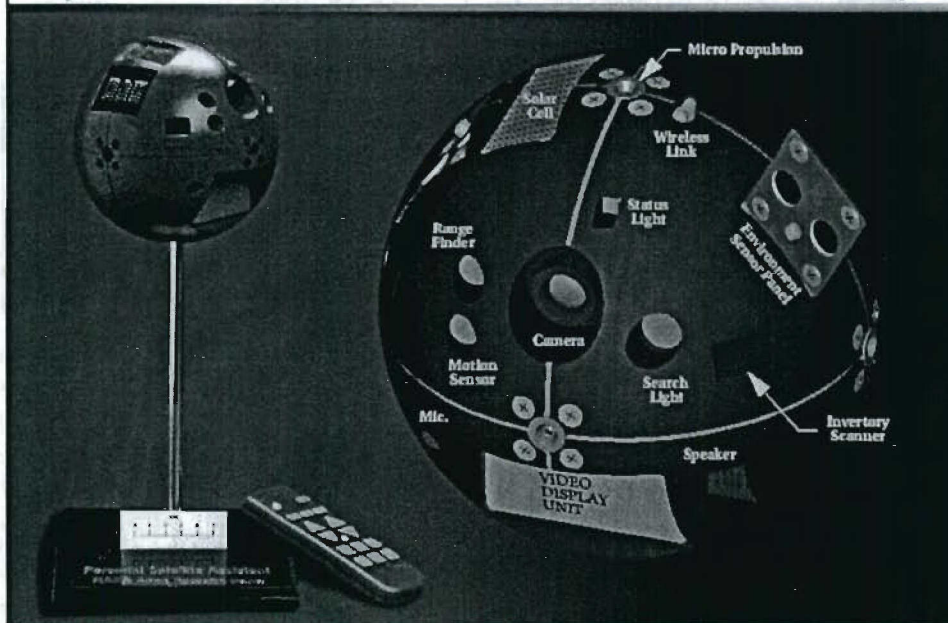
Supervisory Control



“ Specifically, supervisory control means that human **operators plan and teach** tasks to computers, and the **computers then implement** the tasks automatically through their own sensory inputs, memory and control actions”



Personal Satellite Assistant

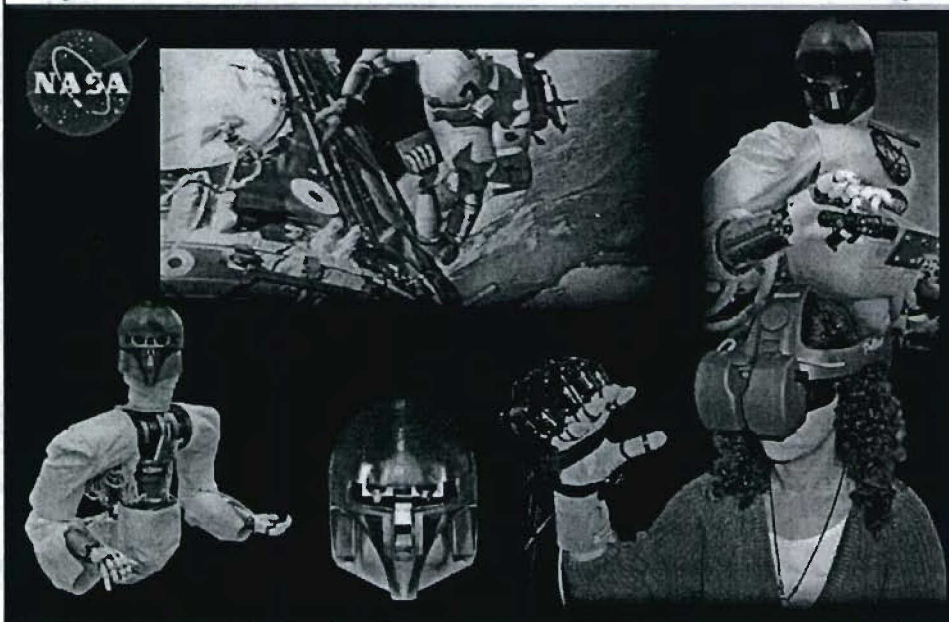


Personal Satellite Assistant Application

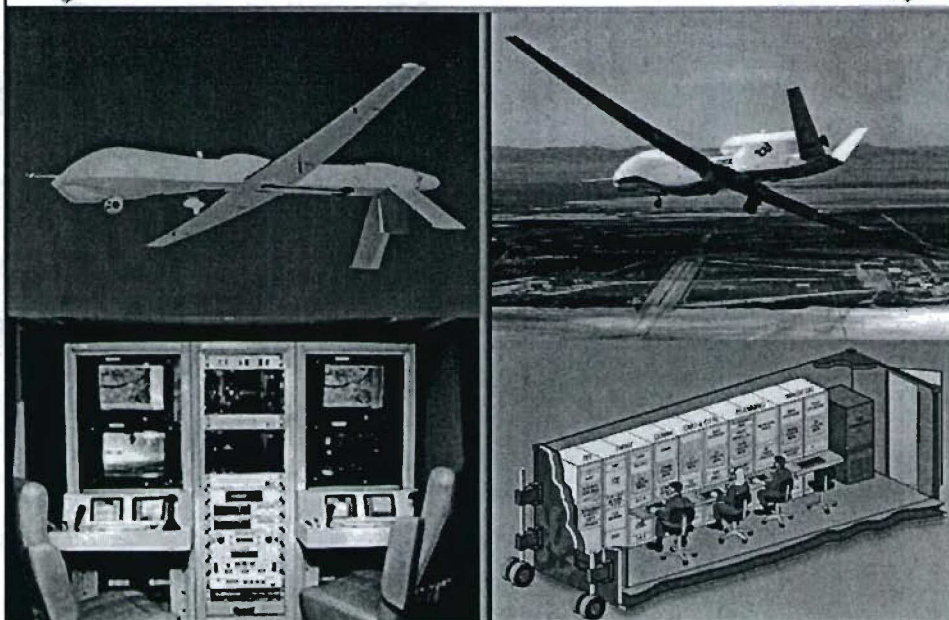




Robonaut

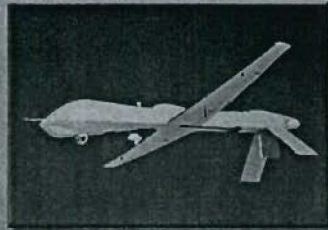


Current USAF UAVs





Predator and Ground Control Stations



Predator Ground Control Station

<http://www.ga.com/asi/photolib/photolib.html>

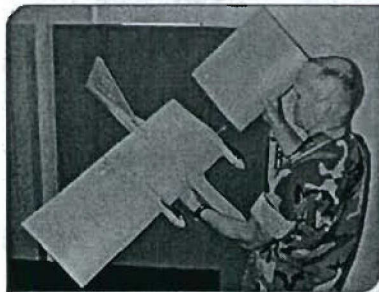


Tactical Control Station

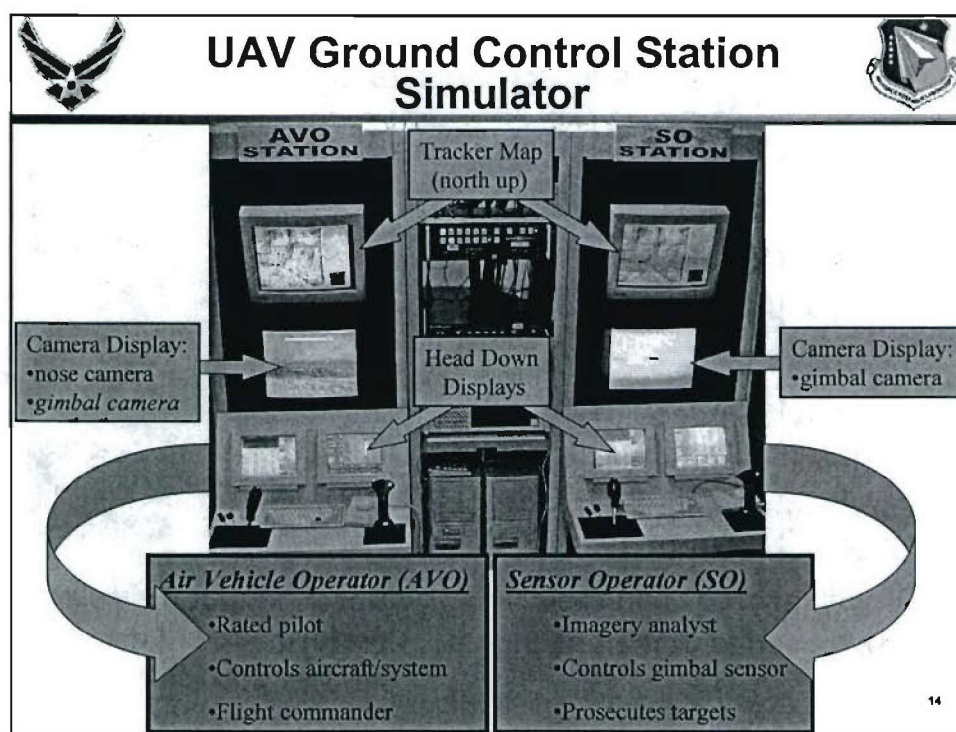
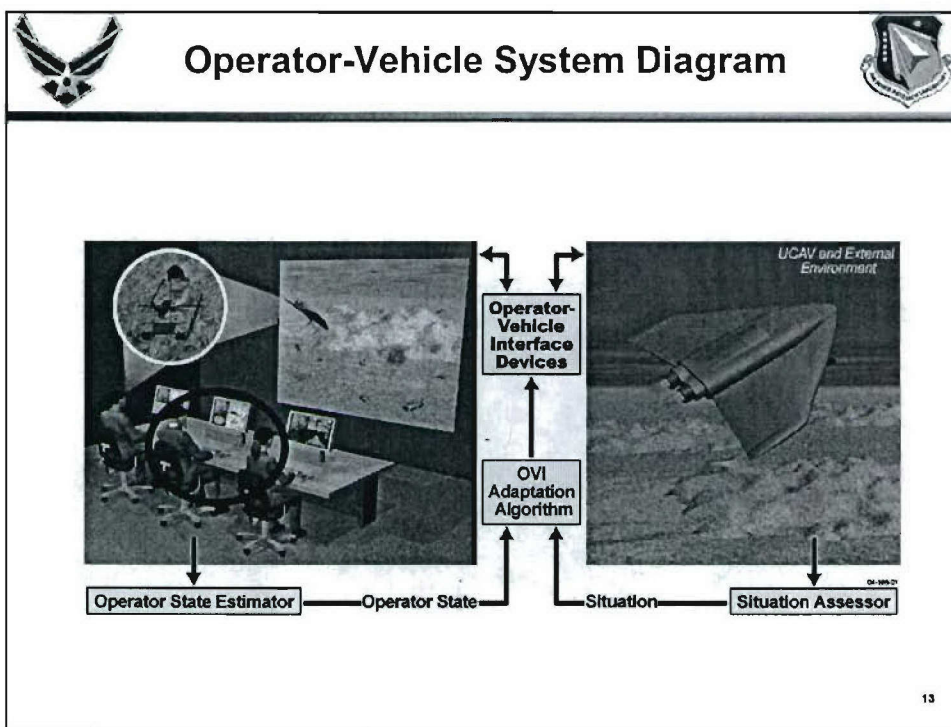
<http://home.navy.mil/tos/images/images.html>



Dragon Eye

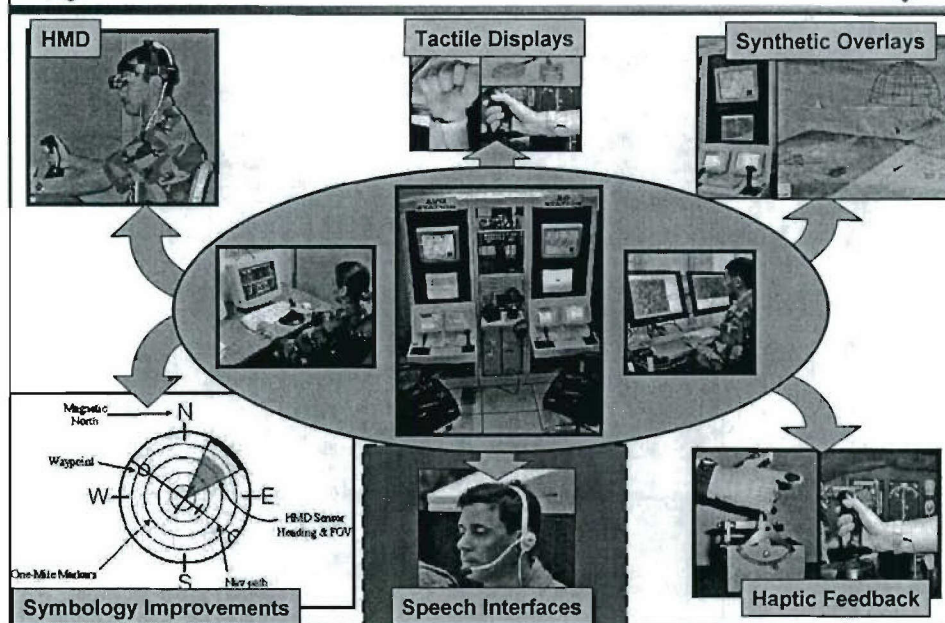


http://www.beyond2000.com/news/May_01/story_1134.html





Interface Technologies



Rationale for Speech Input in UAV Control Stations



- Natural and intuitive interface
- Mature technology
 - Real-time
 - Accurate
 - Speaker-independent
- Reduces resource competition
- Hands-free control
- Heads-up control
- “Voice macros” can replace complex series of manual inputs



Speech input improved performance in manned aircrew applications



Speech Input Implementation



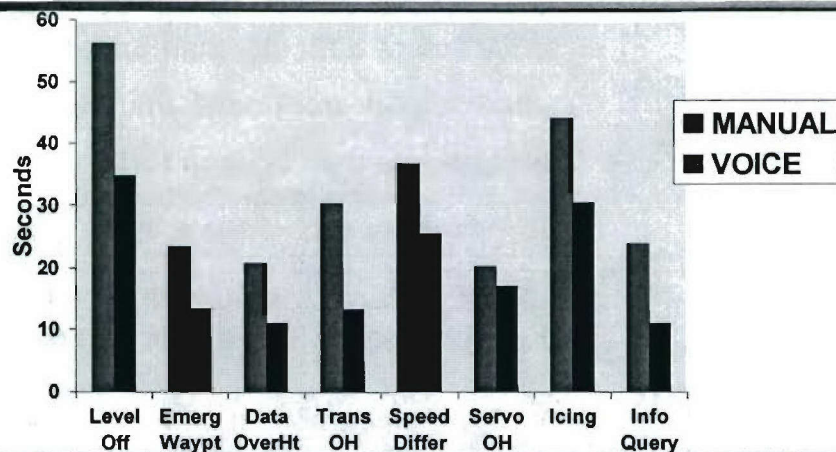
- Speech Recognizer:
 - Nuance v8.0
 - continuous, speaker-independent
- Vocabulary:
 - 70 commands
 - Total vocabulary: 160
- Push-to-Talk button (on joystick)
- Sennheiser 280-13 Pro headset/mic
- Visual feedback of commands on HUD
- Auditory environment: benign



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Results – Speech Better: Mean Task Completion Time



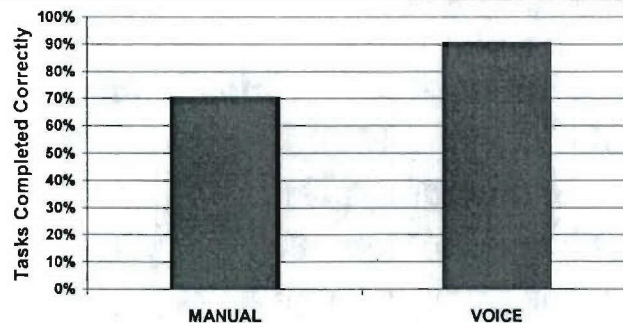
- Speech input significantly faster for all task types
- Average time savings range: 3.14 to 21.43 seconds
- Data entry time reduced by approx 40% with Speech Input



Results – Speech Better: Mean Task Completion Accuracy



Speech Input more Accurate than Manual



- More tasks completed *correctly* with Speech:
Voice macros are a factor
- Time outs less with Speech: Operators more frequently completed trials within the experimenter-specified time limit with Speech Input.

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Results – Speech Better Subjective Data



OPERATOR RATINGS

- Manual “more difficult” than Speech
- Manual “higher workload” than Speech
- Manual worse than Speech for:
 - Interference with flight/navigation task
 - Speed and accuracy of data entry

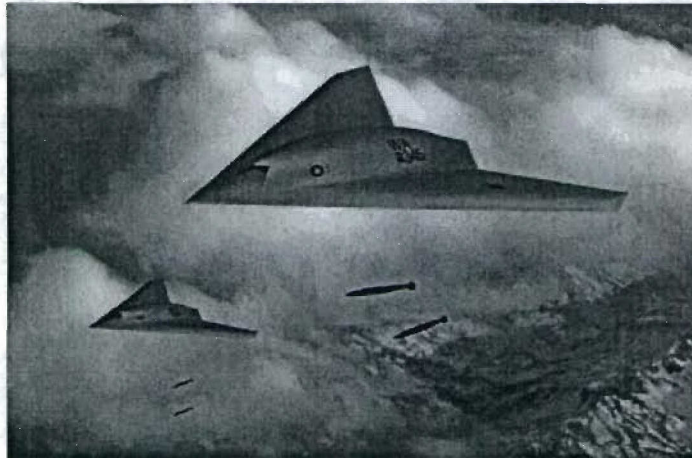
OPERATOR COMMENTS

MANUAL: “Menu...unintuitive.” “Info buried too deep.” “Have to be heads down.”

VOICE: “Voice was just so much easier.”
“You can stay heads-up.”
“Greatly reduced workload.”



UCAV

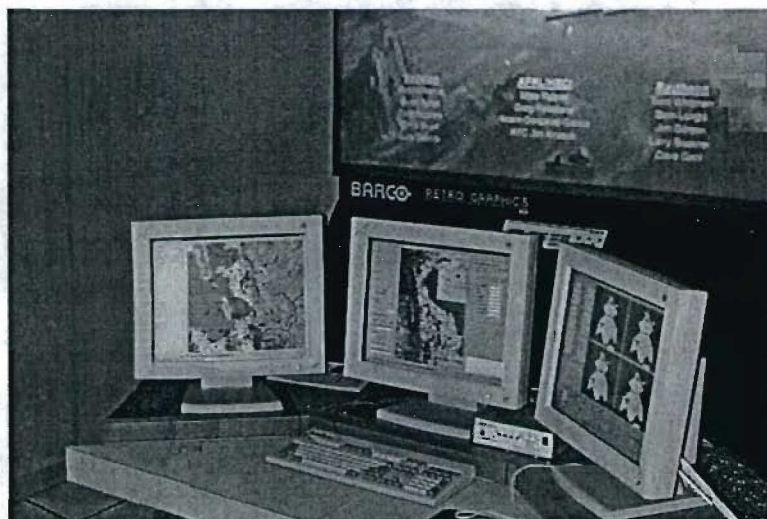


Col Michael Leggett, UCAV Conference, London 2003

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Operator's Console Example



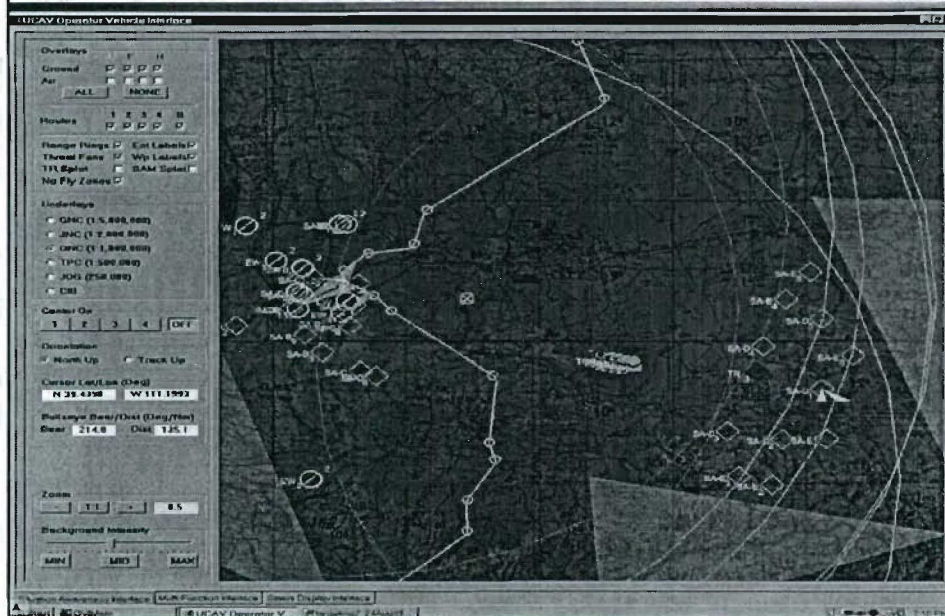
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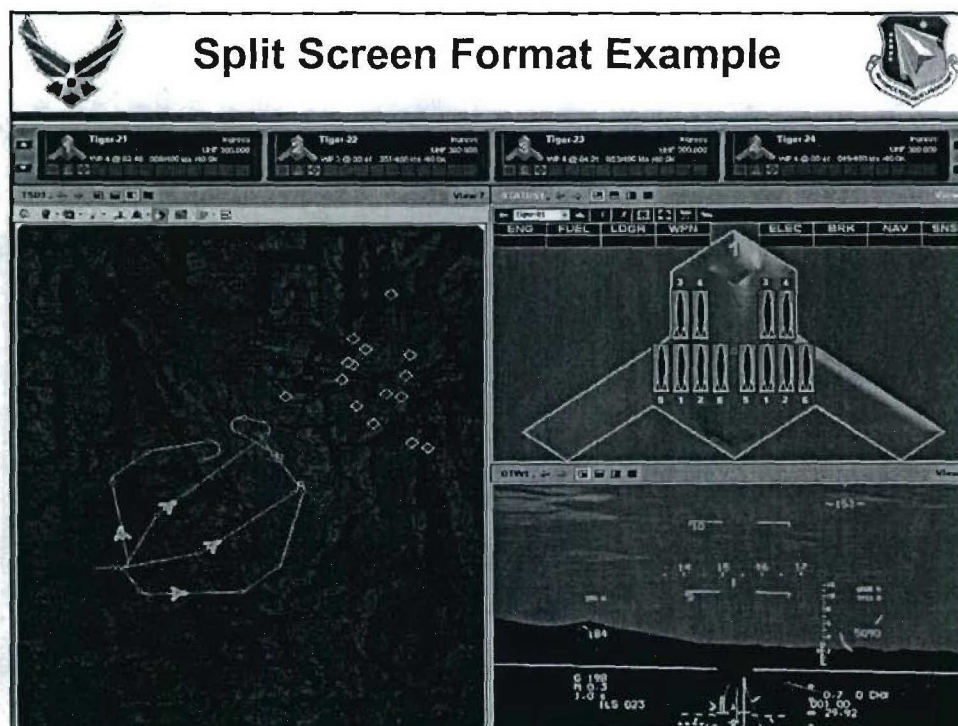
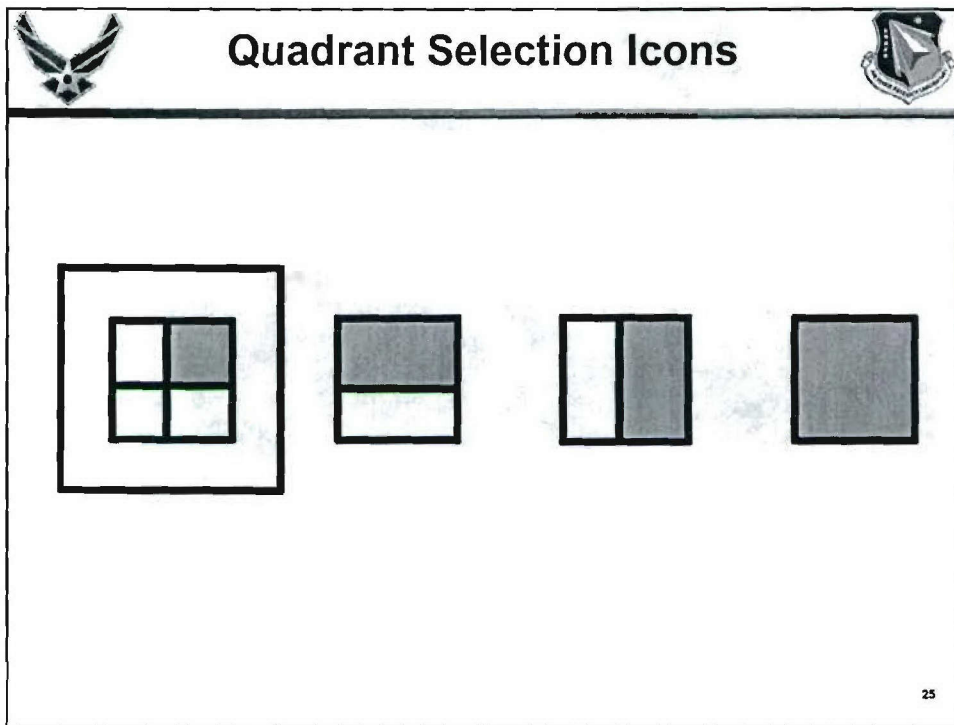


Operator Vehicle Interface Workstations



Situational Awareness Display Format







Mission Control Station Experimental Laboratory



Operator Console Development



Multi-Sensory Interface Technology Progression

UAV Reconnaissance - UCAV SEAD/Strike Effectiveness ↑



Current Technology
160 Inch² CRT Displays
HOTAS
Multi Layer Menus
No Virtual Technology



Multi-Sensory Displays
Visual Symbolology
Information Fusion
Haptic Displays
Spatial Auditory
Predator Application
10% Virtual Technology



Partial Immersion
3-D Multi-Sensory Displays
Synthetic Vision
Tactile Displays
Speech Control
Spatial Audio
Supervisory Control Interface
UAV + UCAV Application
50% Virtual Technology

1999

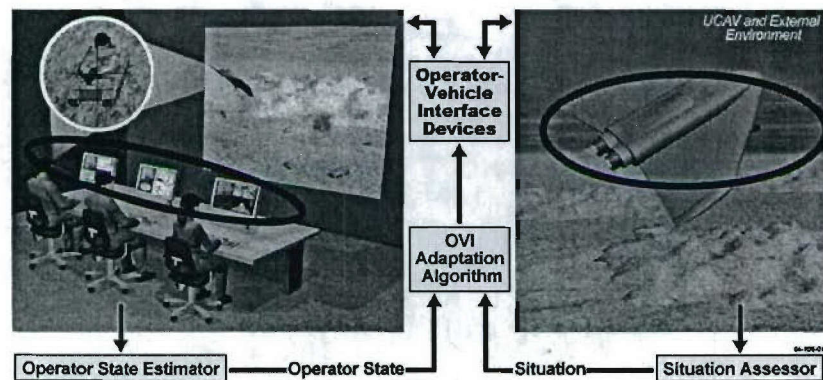
2003

2005

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Operator-Vehicle System Diagram



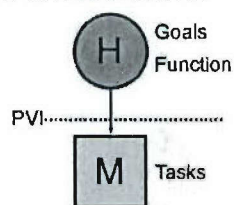
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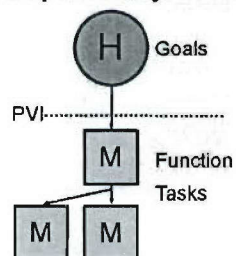
Human-machine Control Architectures



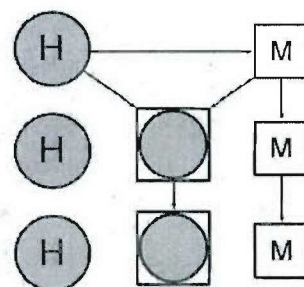
(a) Manual Control



(b) Supervisory Control



(c) Co-operative Functionings



Key: H= Human M= Machine
PVI= Pilot Vehicle Interface

Taylor 1902 AGARD LS 122

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Automation Concerns



**ACCIDENTS DIRECT FOCUS
ON COCKPIT AUTOMATION**

DAVID HUGHES/BOSTON and MICHAEL A. DORNHEIM/LOS ANGELES

**DRAMATIC INCIDENTS HIGHLIGHT
MODE PROBLEMS IN COCKPITS**

MICHAEL A. DORNHEIM/LOS ANGELES

**AIRBUS SEEKS TO KEEP PILOT,
NEW TECHNOLOGY IN HARMONY**

PIERRE SPARACOTTO/LOUISE, FRANCE

**INCIDENTS REVEAL
MODE CONFUSION**

DAVID HUGHES/BOSTON

**NTSB: MODE CONFUSION
POSES SAFETY THREAT**

EDWARD K. PHILLIPS/WASHINGTON

**CERTIFICATION OFFICIALS GRAPPLE
WITH FLIGHT DECK COMPLEXITY**

WILLIAM B. SCOTT/COLORADO SPRINGS

**STUDIES HIGHLIGHT
AUTOMATION 'SURPRISES'**

DAVID HUGHES/BOSTON

AW&ST January 30, 1995

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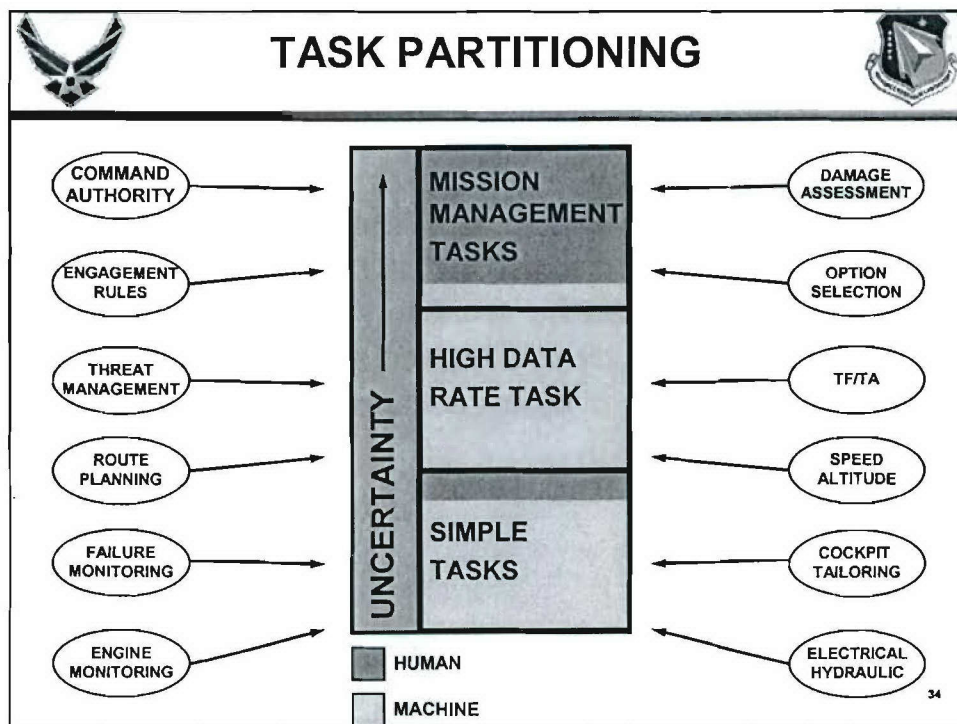
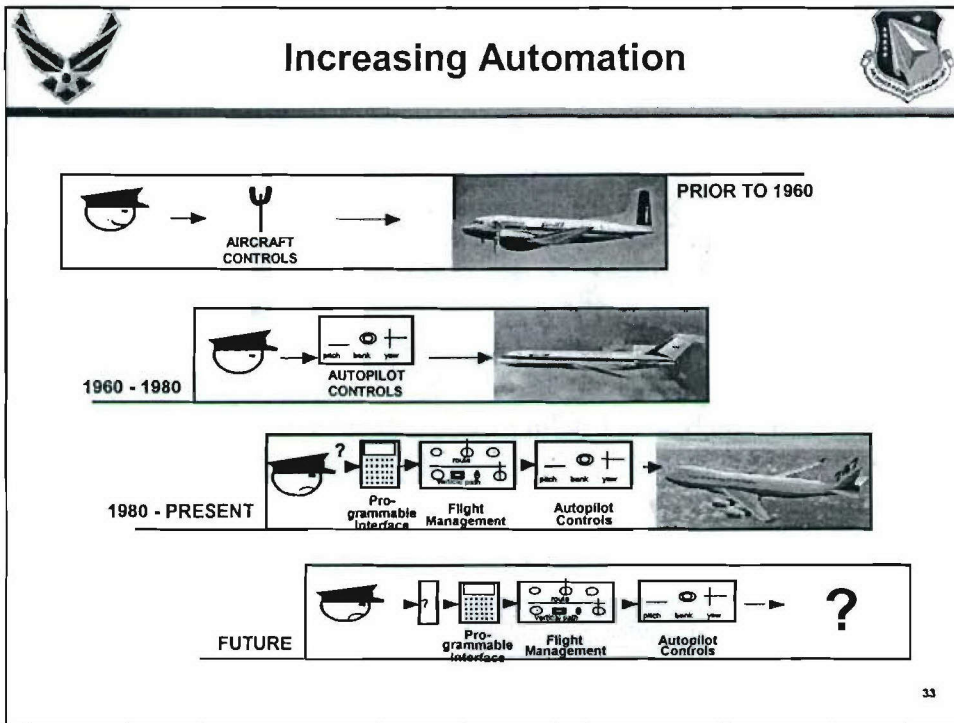


Human and Machine Co-operate



Meet
Human Factors.







Associate System



- Associate systems are computer-based aiding systems that are intended to operate as an **associate** to the human user. (Geddes, 1997, p.221)
- **A member without full status or privileges.**
(Webster's New World dictionary 1968, p. 89)

Mixed Initiative -- **both** human and decision aid can take action.

Bounded Discretion -- the human is in charge.

Domain Competency-- decision aid has broad competency, but may have less expertise than its human counterpart.

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Adaptive Automation

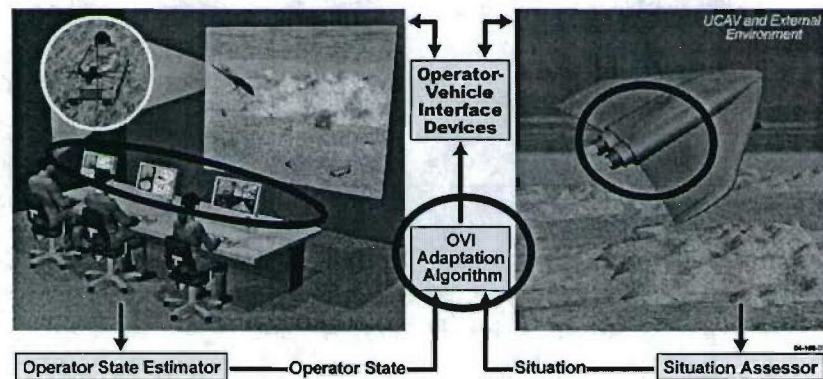


In adaptive automation, the **level or mode** of automation or the **number of systems** that are automated can be **modified in real-time**. Furthermore, **both** the human and the machine share control over changes and the state of automation.

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Operator-Vehicle System Diagram



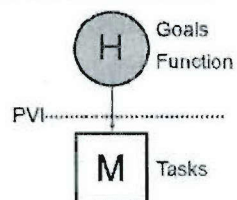
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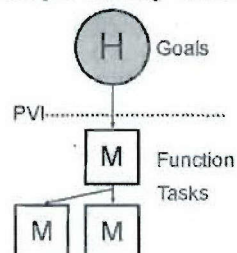
Human-machine Control Architectures



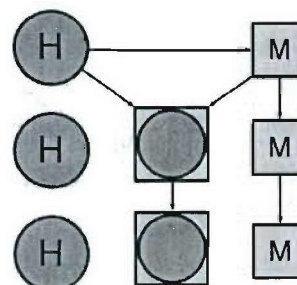
(a) Manual Control



(b) Supervisory Control



(c) Co-operative Functionings



Key: H= Human M= Machine
PVI= Pilot Vehicle Interface

Taylor 1992 AGARD LS 122

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Level of Automation and Human/System Roles



Level of Automation	Human Role	System Role
1. None	Decide, Act	-----
2. Decision Support	Decide, Act	Suggest
3. Consensual AI	Concur	Decide, Act
4. Monitored AI	Veto	Decide, Act
5. Full Automation	-----	Decide, Act

Endsley, Automation and Situation Awareness, p. 174, 1996.

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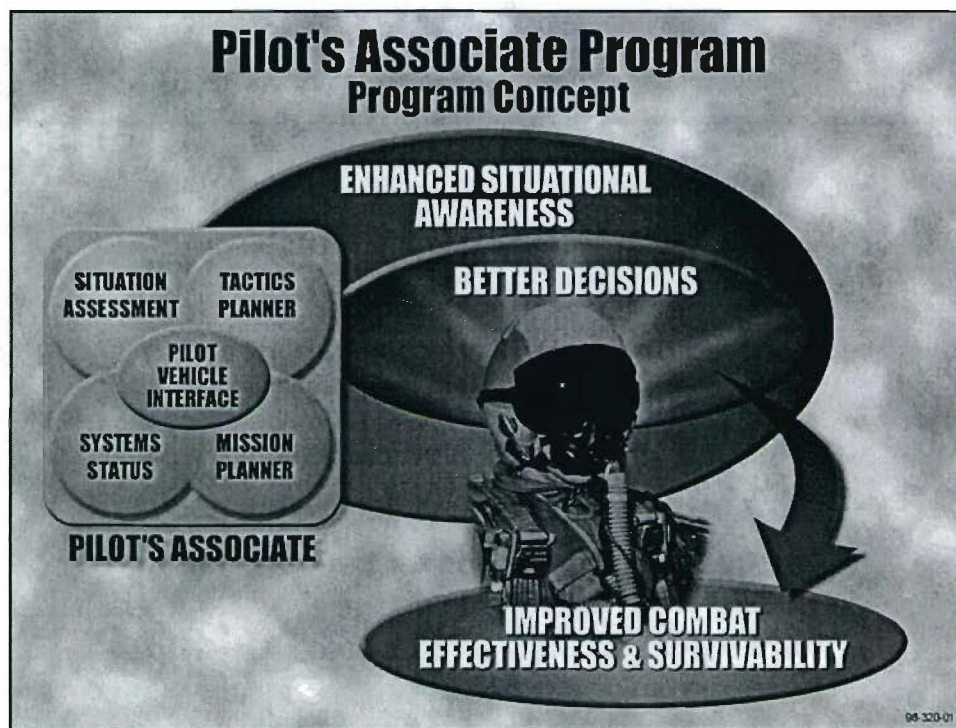


Three Phases of Trust Building



- Early Phase: Based upon the **predictability** of another's behaviors
- Intermediate Phase: Dependability -- "**Summary statistic** of an accumulation of behavioral evidence, which expresses the extent to which another person may be relied upon" (Muir, International Journal of Man-Machine Studies, 1987, 532.)
- Final Stage: **Faith** that a person will be dependable in the **future**.

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Prime Directives for Associate Systems: Example--Three Laws of Robotics



- A robot *may not harm* a human being, or, through in action, allow a human being to come to harm.
- A robot *must obey the orders* given to it by a human being except where such orders would conflict with the first law.
- A robot *must protect its own existence* as long as such protection does not conflict with the first or second law.



**The Effort Required of the Pilot to Control the PA
Must Be Less Than the Effort Saved by the PA.**



- Plans may be:
 - Approved or rejected explicitly
 - Approved or rejected pre-mission
 - Approved or rejected implicitly by pilot action
 - Ignored, with predictable results
- The PA must operate in a predictable manner.
- All PA actions must be tailorable by the pilot.
- The PA is required to monitor the pilot, not the other way around.
- The PA must follow the pilot's lead.

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RPA Rotorcraft Pilot's Associate



Focused Digital Battlefield Information

- Process Intel "real-time" from all available resources
- Gather Intel data to relay to higher echelons

Real-time Situational Assessment

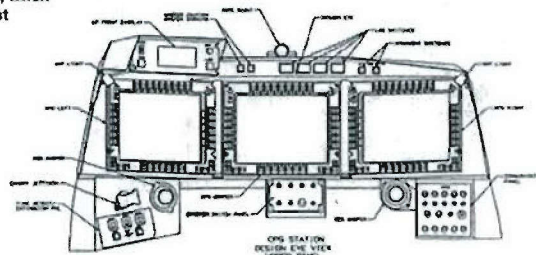
- Reasons on info to assess battlefield situation and aircraft/team members' conditions
- Infer the enemy's intent

Cockpit Information Management

- Provides pilot selectable task automation
- Monitor crew actions/reactions to predict information required for situation
- Present info to crew, when needed, in form most easily understood

Real-time Computer-Aided Decision Making

- Understands commander's intent; infers pilot's intent & plans accordingly
- Presents options for changing battlefield situations & pilot makes decisions
- Plans for Route, Recon, Attack, Com, Survivability, and Sensors



Sources: <http://eustis-aiddac.army.mil/rpa/about/rpav00.htm> &
<http://eustis-aiddac.army.mil/rpa/vision/rpan32.htm>

00-085-01/01R



Rotorcraft Pilot's Associate: Real-time Computer-aided Decision Making



- **Understands Commander's Intent;
Infers Pilots Intent and Plans
Accordingly**
- **Presents Options for Changing Battlefield
Situations, and Pilot Makes Decisions**
- **Plans for Route, Recon, Attack, Com,
Survivability, and Sensors**

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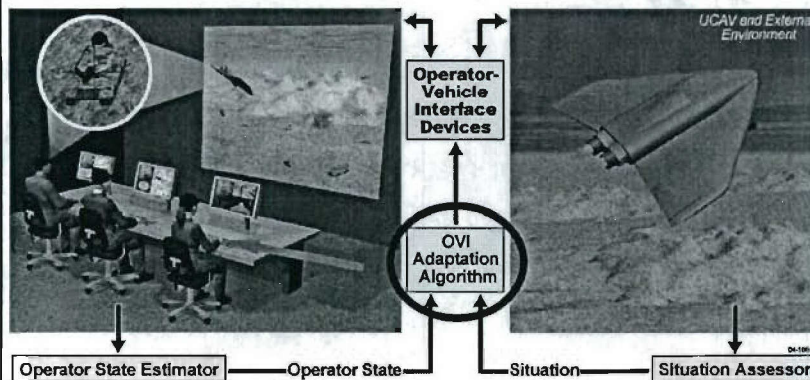


Longbow Apache





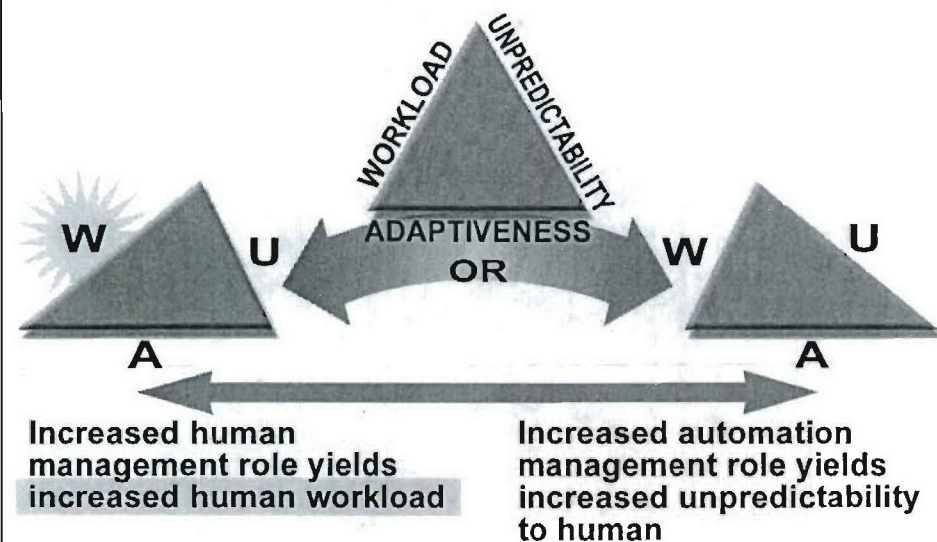
Operator-Vehicle System Diagram

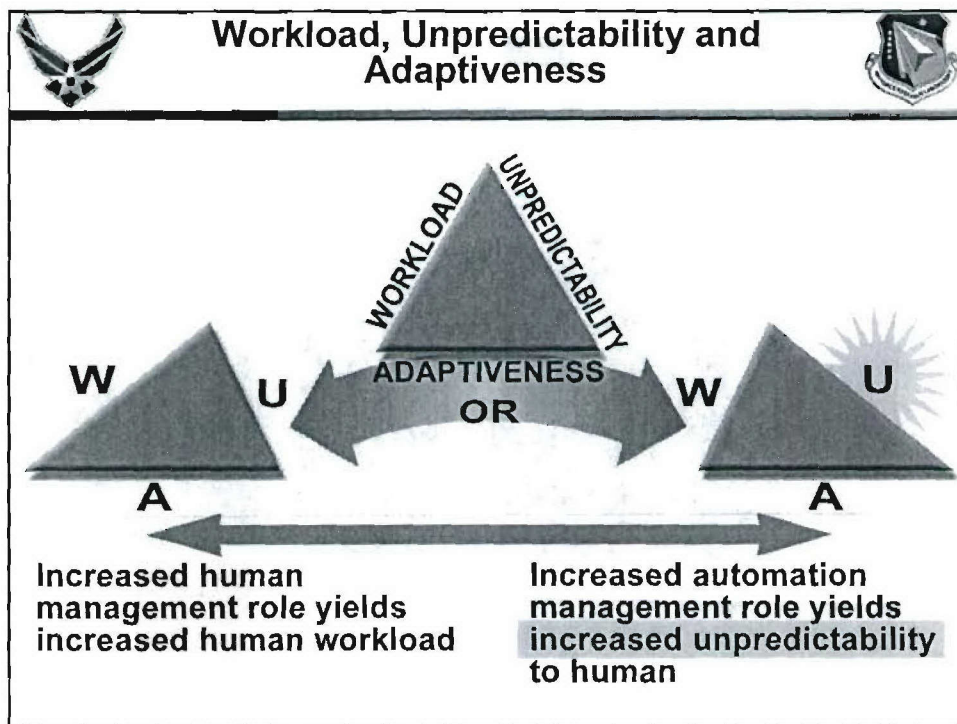
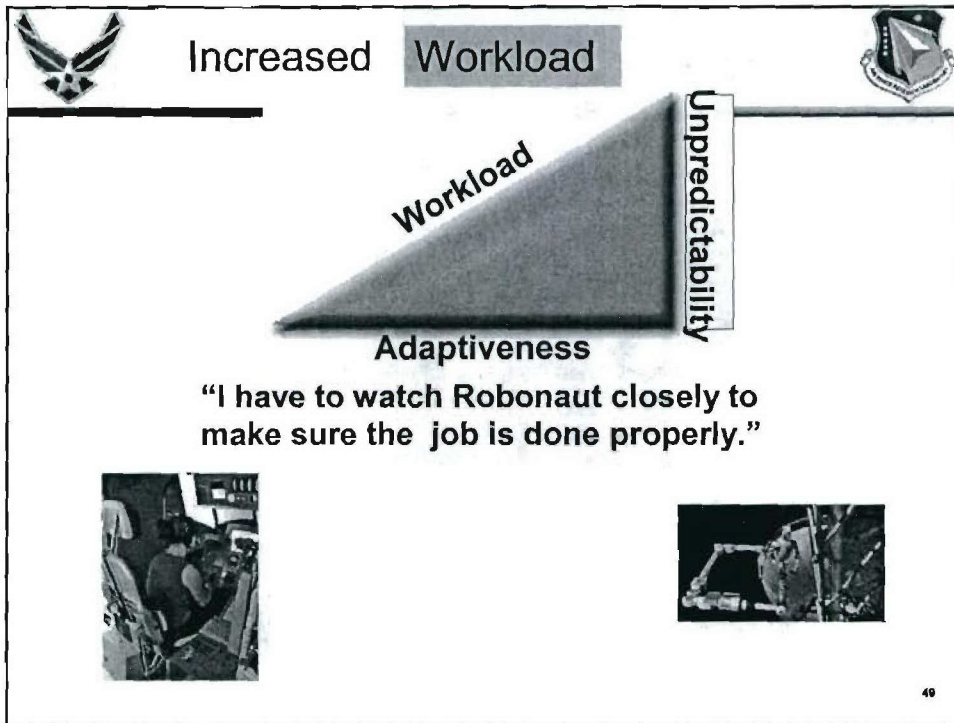


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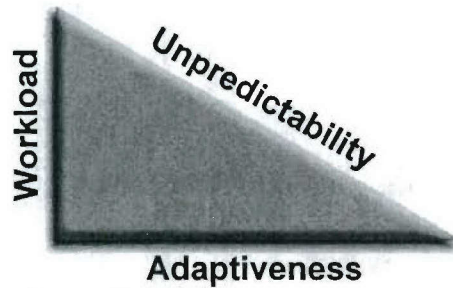
Workload, Unpredictability and Adaptiveness







Increased Unpredictability



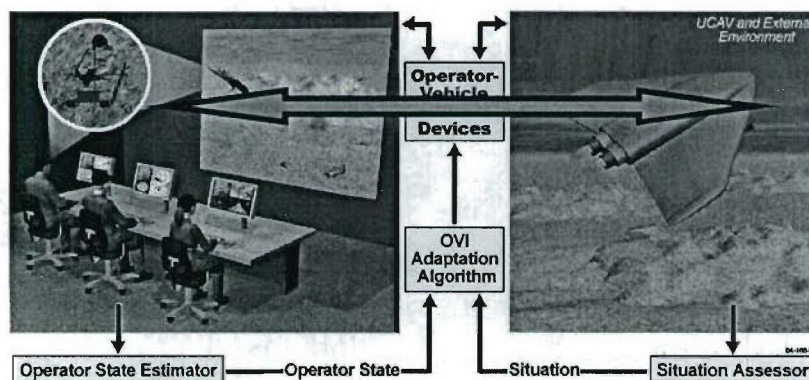
"What is PSA doing now?"



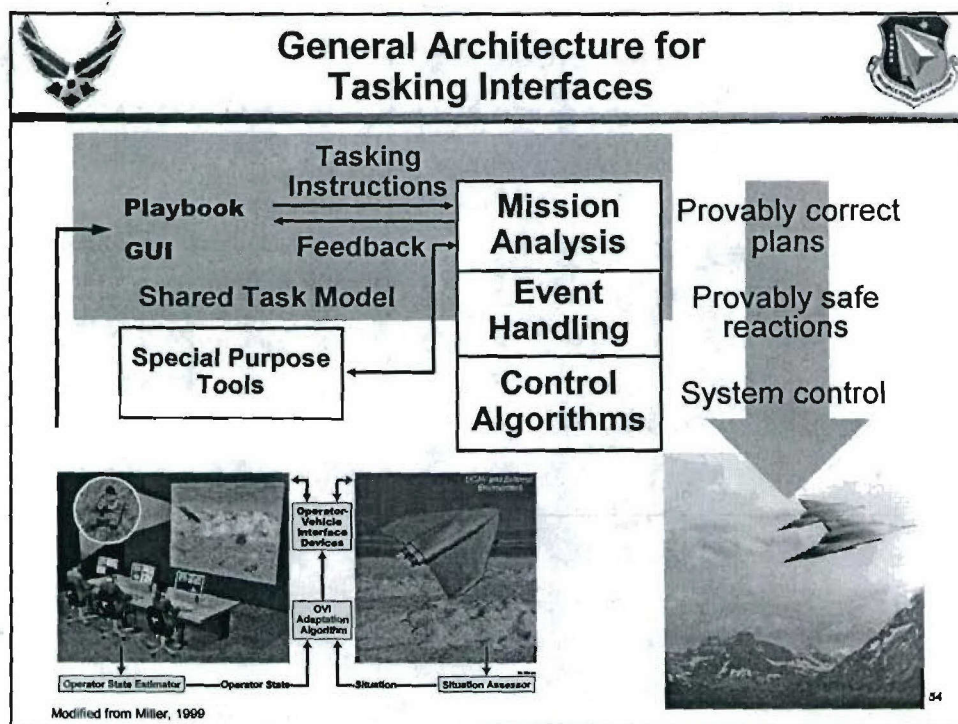
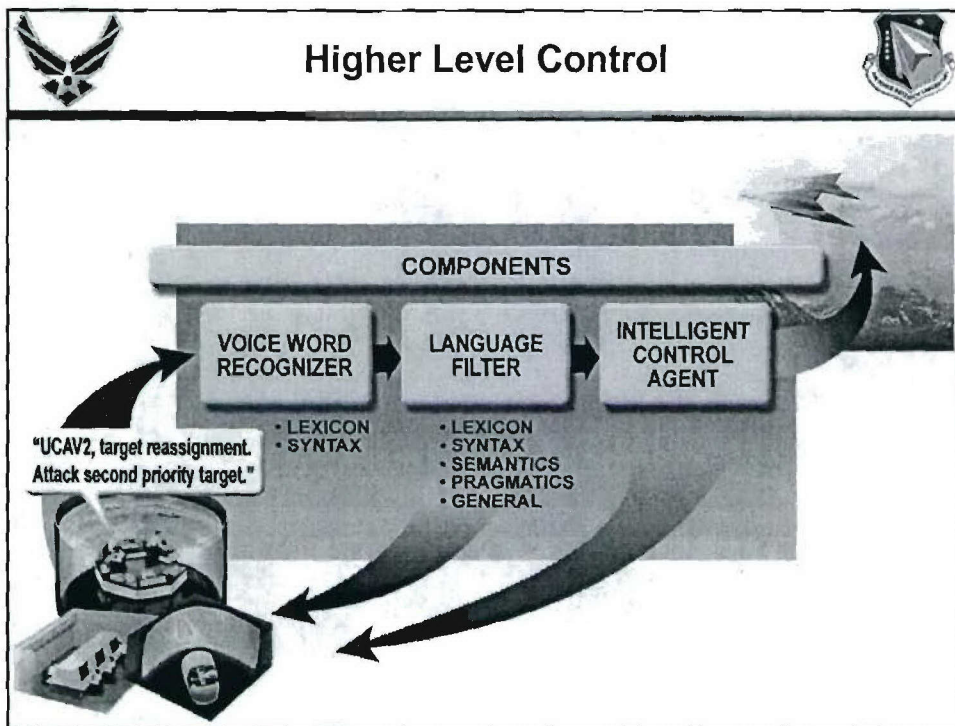
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Operator-Vehicle System Diagram



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Plan Generated From GUI Playbook

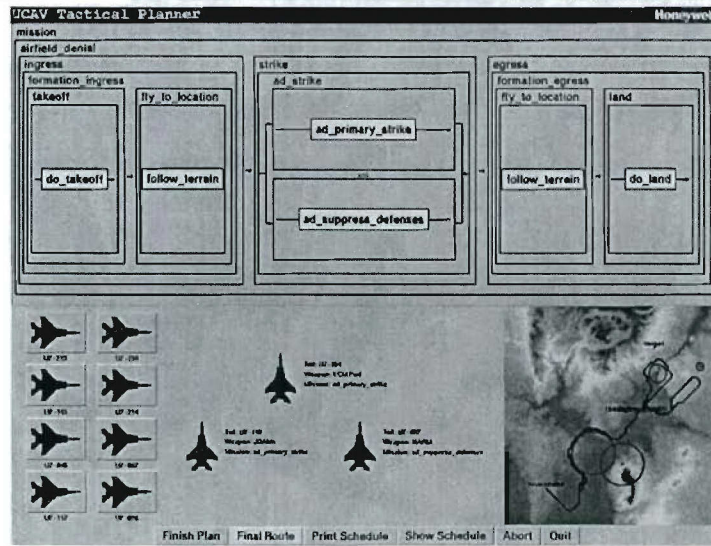


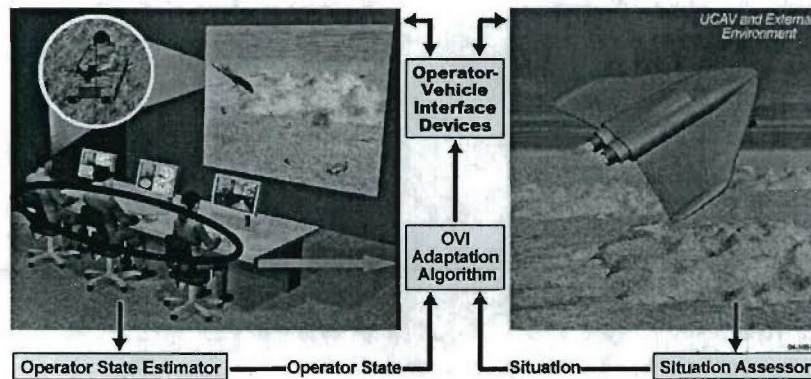
Figure 9. Finished plan returned by the MAC after User specification of the Ingress task.

Miller, Pelican and Goldman, 1999

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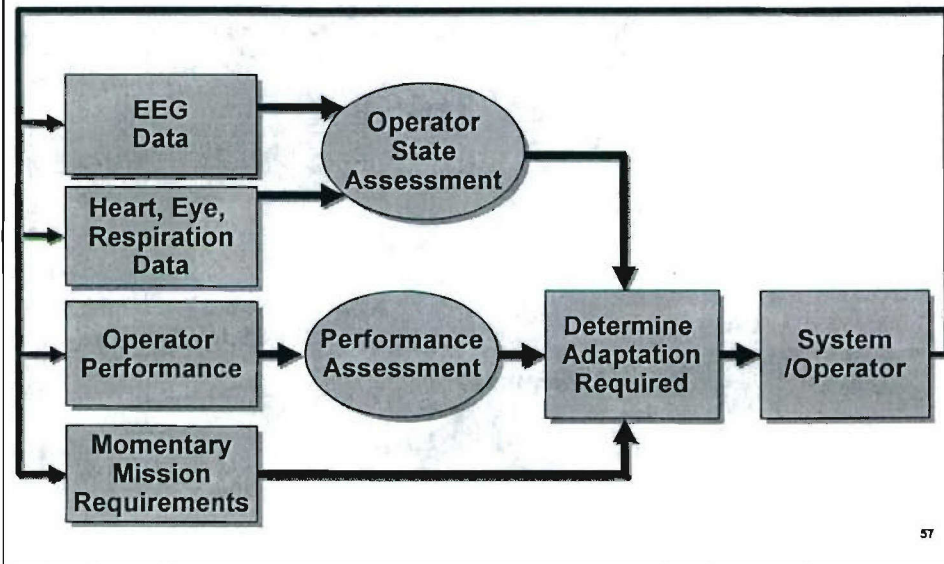
Operator-Vehicle System Diagram



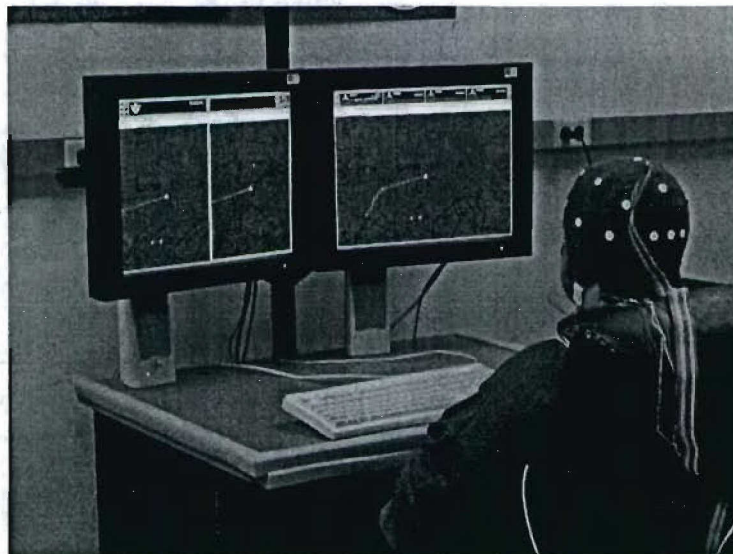
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Adaptive Automation System Diagram



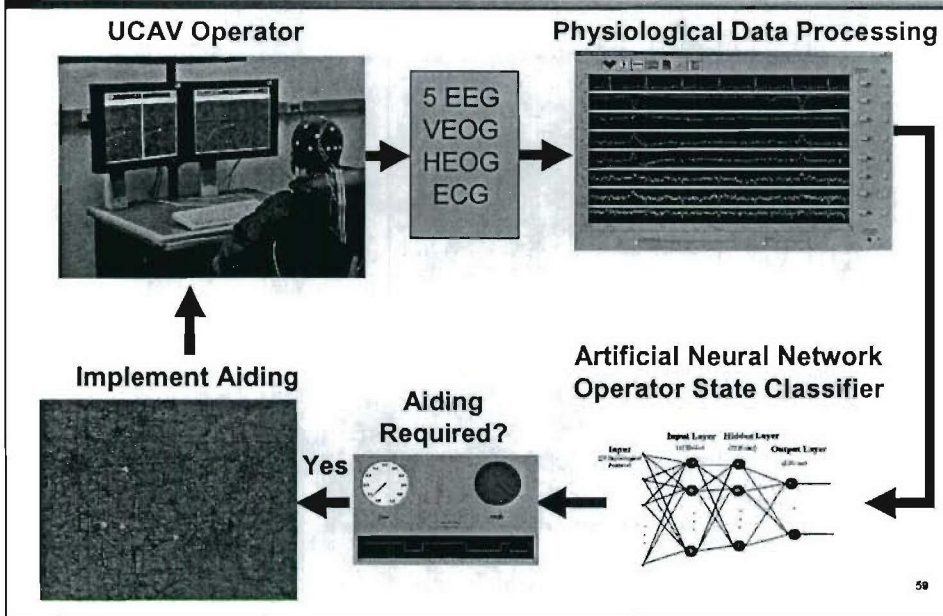
UCAV Adaptive Automation



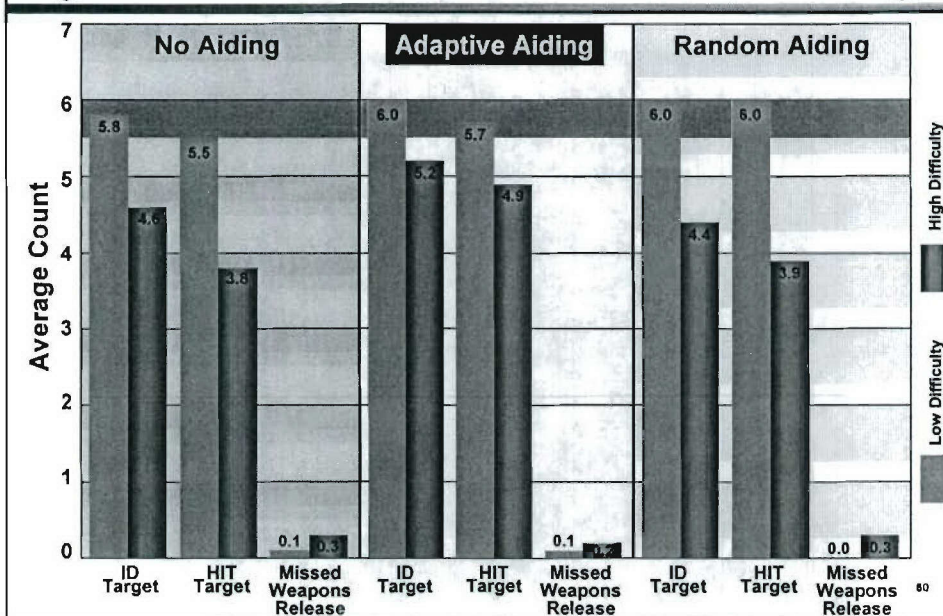


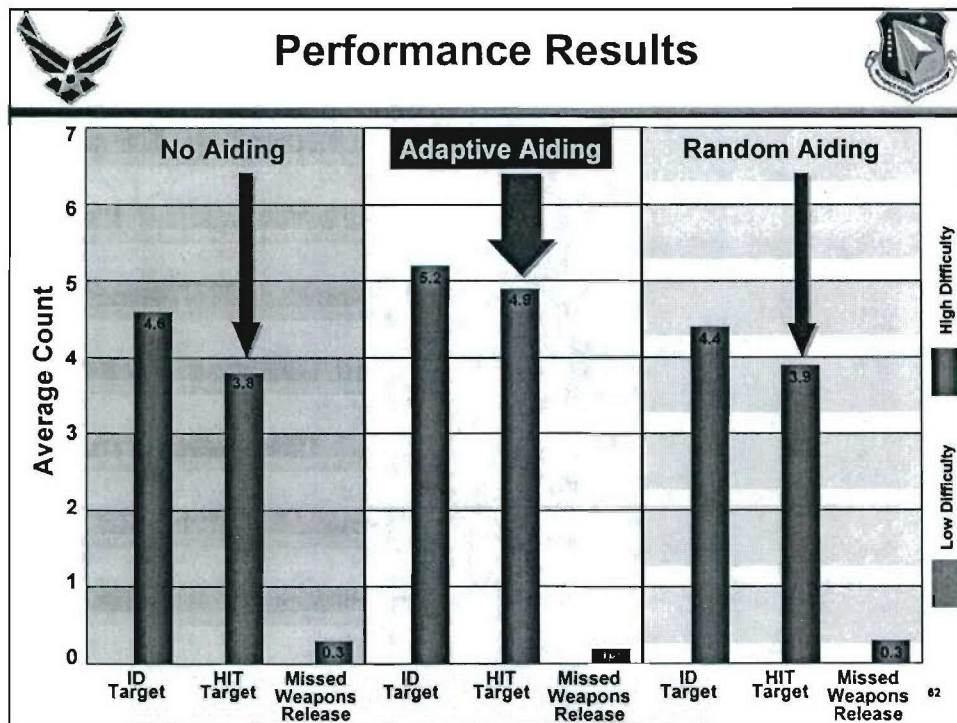
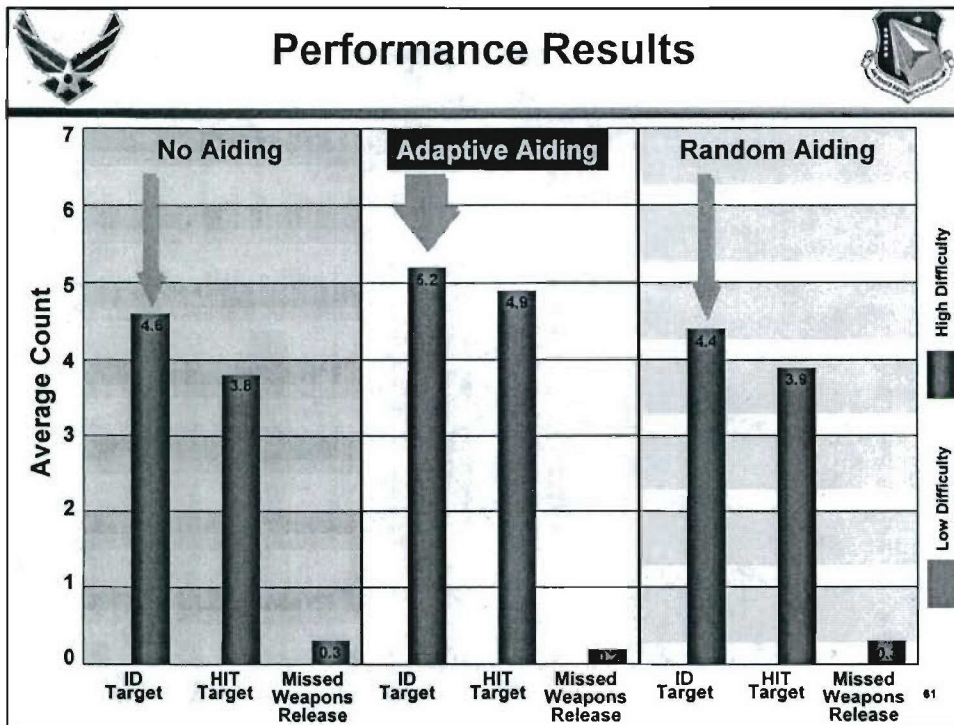
Current Research Program

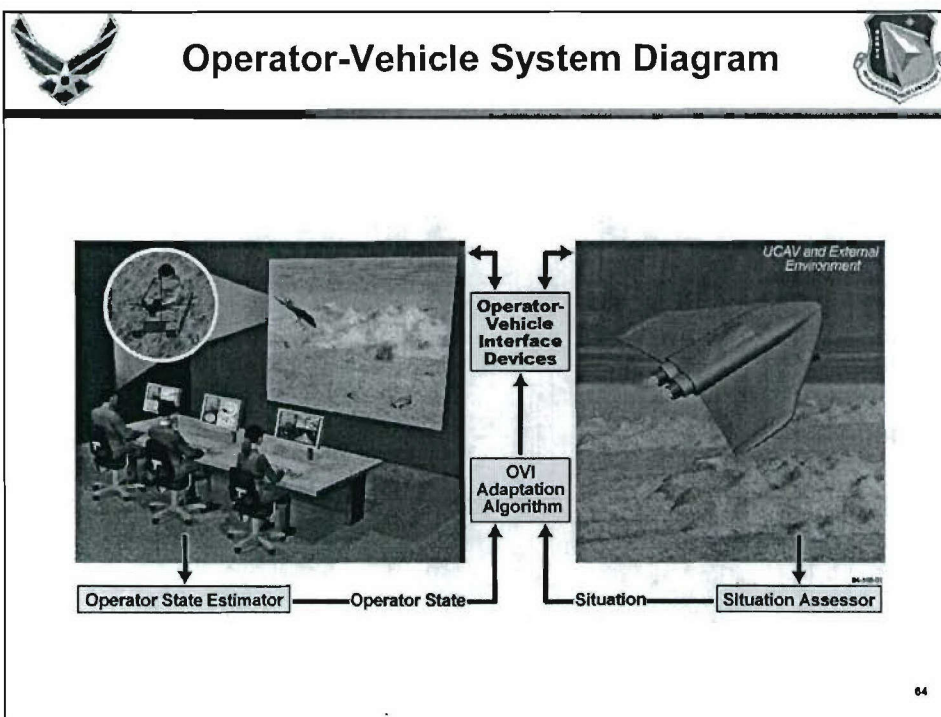
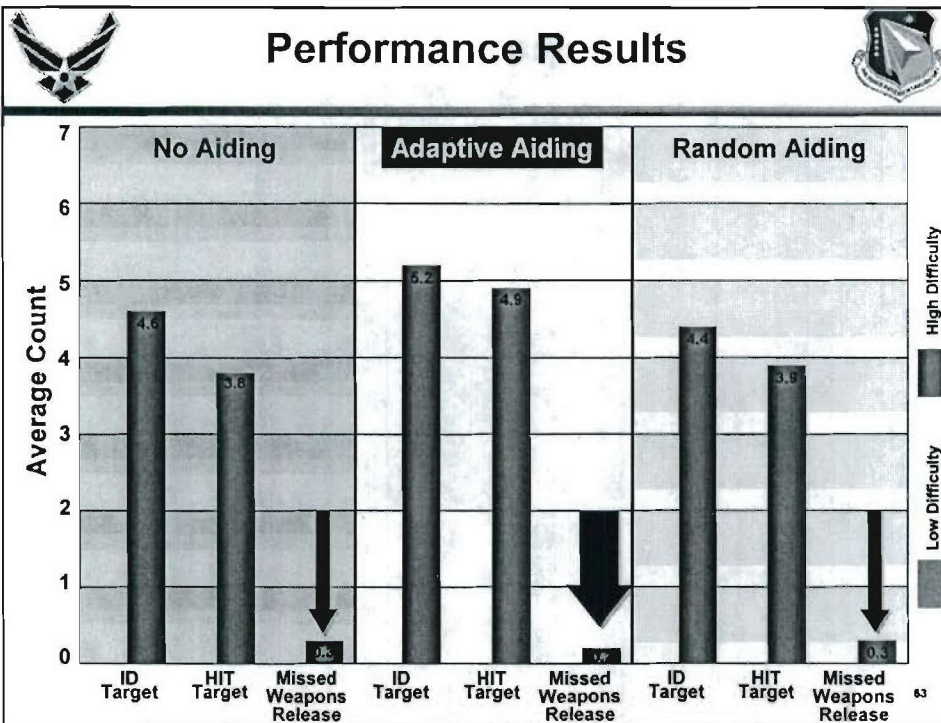
Closed Loop Adaptive Aiding - OVI UCAV Simulator



Performance Results









Summary

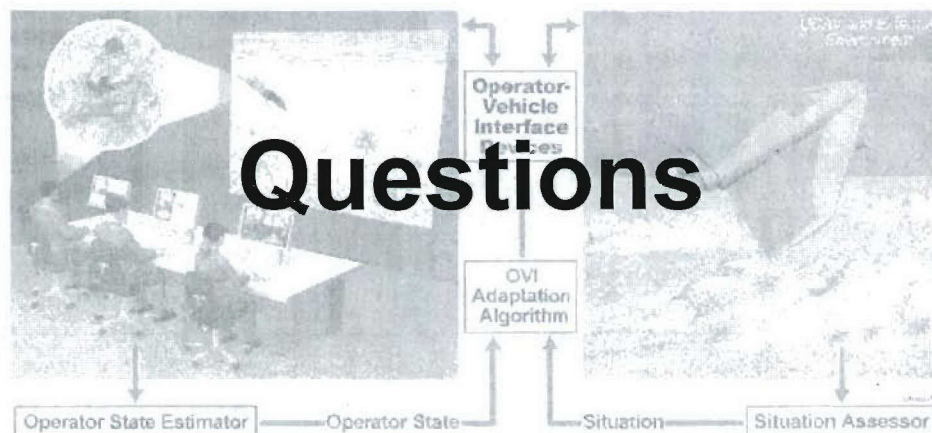


- Affordability will result in a **high degree of automation** in the UMV operator's console.
- Control of the UMV will be defined more in terms of **mission management** than manual control.
- Changes on the battlefield will require a very **flexible automation architecture**.
- Successful **team building** between the operator and the automation will require **trust** between the two.
- The UMV operator/console system is a **key feature** in achieving future mission success.

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Questions



66

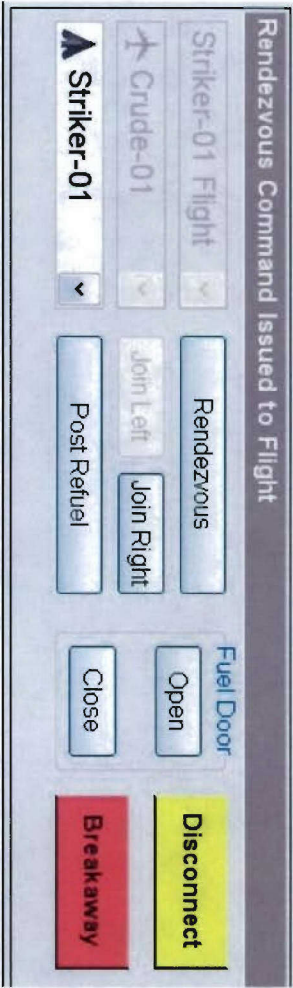
- **Slide 1** Contains four pictures: **A)** Across the top of the slide are the Summary Panels, one for each of the UAVs. The summary panels give the operator a quick view of the status of each of the UAVs. **B)** shows the command window. Two very important features are the yellow and red boxes. They enable the operator to disconnect from the boom after refueling and breakaway if an emergency occurs. **C)** The Fuel System display shows the total quantity and individual fuel tank quantities for the selected UAV. **D)** The refueling status display contains three lights. The lights are blue for ready (RDY), green to show contact with the boom (AR), and yellow to show the boom disconnect (DISC). The total fuel quantity of each UAV is shown below these three lights.
- **Slide 2** shows The Out-the-Window display which was a virtual display depicting the positional information of the UAVs and tanker.
- **Slide 3** shows position information about the UAVs, tanker, commanded positions. It is the primary mechanism for commanding the UAVs during the air refueling process.
- **Slide 4** shows that once the UAVs were positioned at the observation positions, and the UAV operator received permission from the boom operator to move, the operator used the mouse to drag the selected first UAV, Striker 01, to the precontact position.
- **Slide 5** shows that the Striker 01 is now in the contact position.
- **Slide 6** shows that all of the Strikers have been refueled are now in the post refueling position.

Slide 1 **NOTE: Slides printed on both sides**

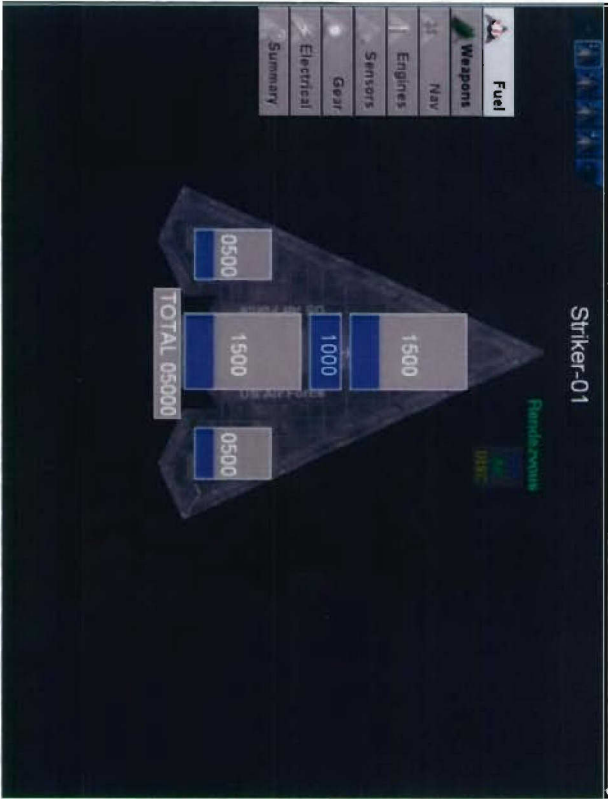
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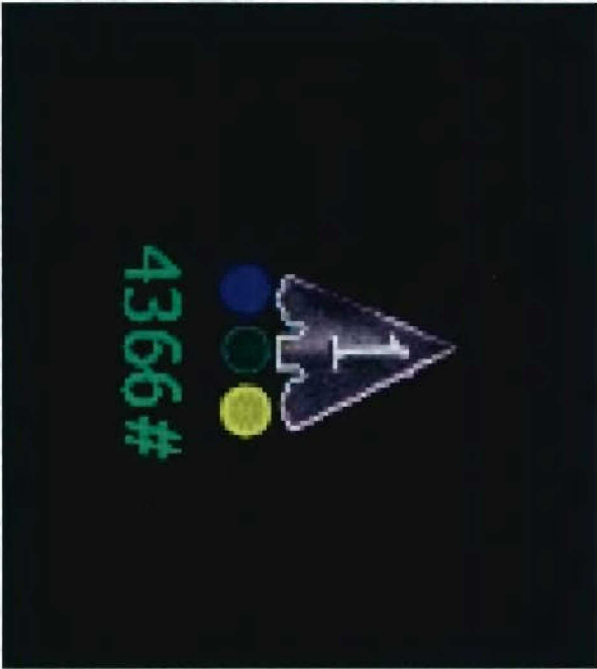
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C



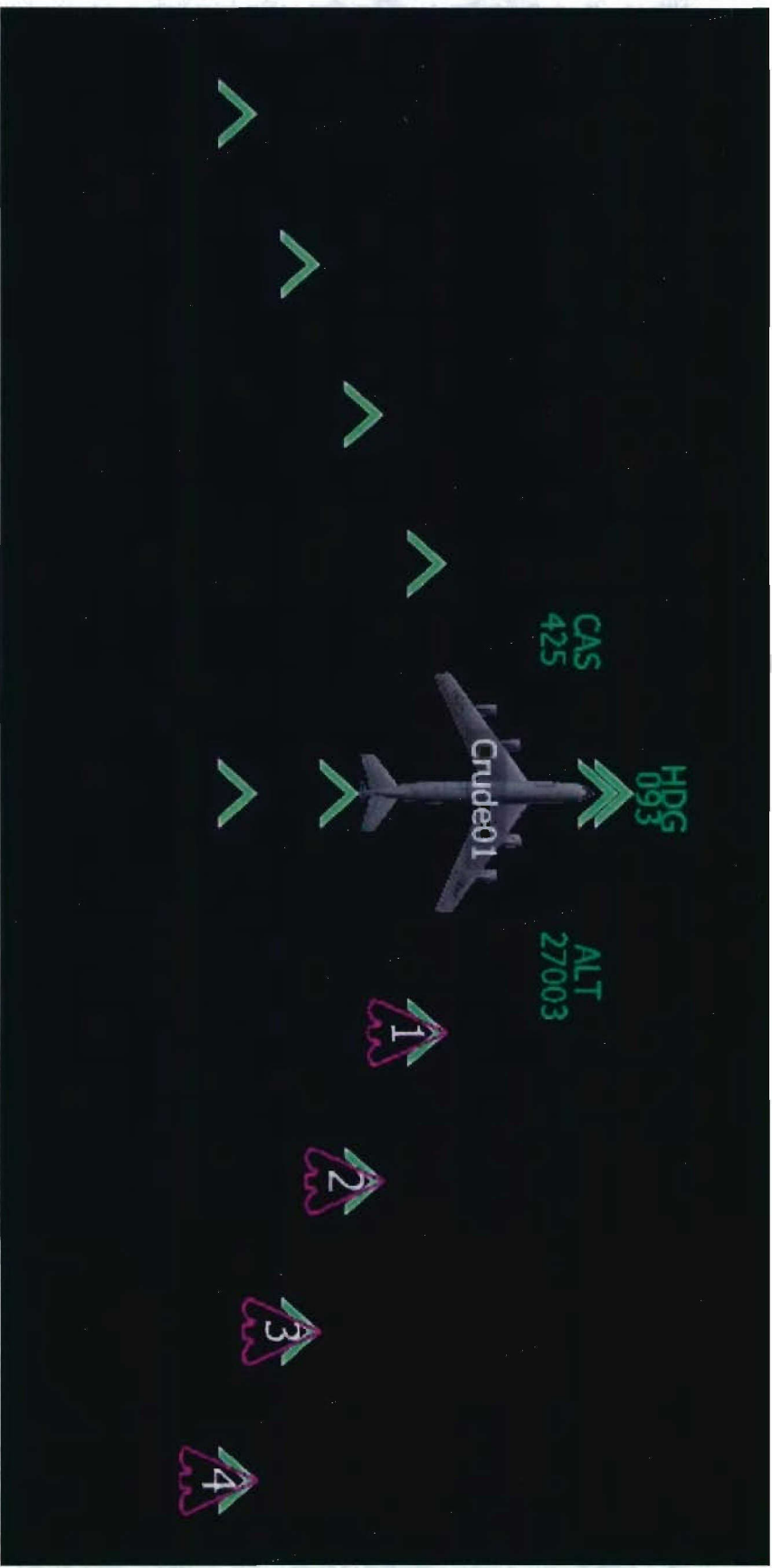
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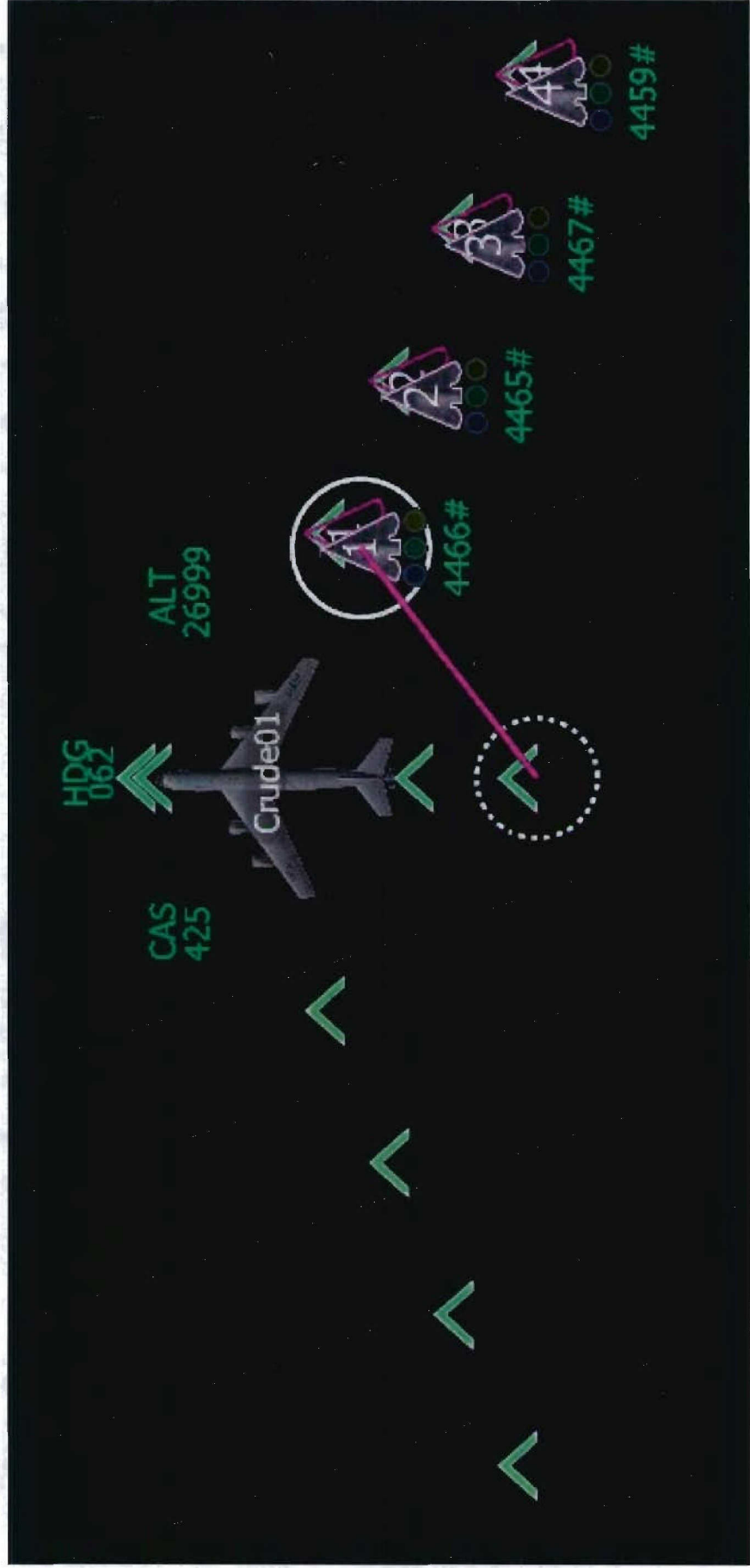
Slide 2



Slide 3



Slide 4



Slide 5



Slide 6

