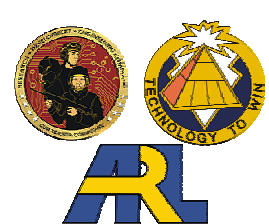




Determination of Mental Workload During Operation of Multiple Unmanned Systems

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HRI-ATO

Unmanned Aerial Vehicles

Micro Aerial Vehicle (MAV)

Human Research and Engineering Directorate



BACKGROUND

- The US Army Research Laboratory (ARL) Human Research and Engineering Directorate (HRED) began modeling Future Combat Systems (FCS) and Objective Force Warrior (OFW) mission environments in an effort to enhance human robotic interactions (HRI)
- Unmanned systems, specifically Unmanned Aerial Vehicles, are key assets within a commander's arsenal. The robotics NCO duties in FCS will include coordinating and/or operating multiple unmanned systems
- A modeling effort to understand the workload associated with operating multiple unmanned systems is needed

DESCRIPTION

- IMPRINT/MicroSaint workload model of multiple MAV operations
- Examine how many unmanned systems an operator effectively operate simultaneously and in what mode? Design looks at up to 3 MAVs in either Manual or Autonomous mode within 3 different scenarios (26 possible conditions)
- Simulation of workload associated with operating multiple MAVs in either Manual or Autonomous modes

OBJECTIVES & IMPACT

- Developed a workload model of multiple MAV Operations. Documented procedures and results of task analysis and model construction and analysis
- Determined the threshold for operating multiple unmanned systems.
- Further validate IMPRINT/MicroSaint as a workload modeling tool



Improved Performance Research Integration Tool (IMPRINT)

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Description

- ◆ A PC-based tool that
 - Incorporates embedded models of human performance
 - Advances a modeling approach to early manpower, personnel, & training (MPT) & human factors performance analyses
- ◆ A modeling environment that
 - Supports the Army design & acquisition process, experimental testing, & field evaluations
 - Is used to build models for application, research, & development



What Does *IMPRINT* Do?

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It helps you...

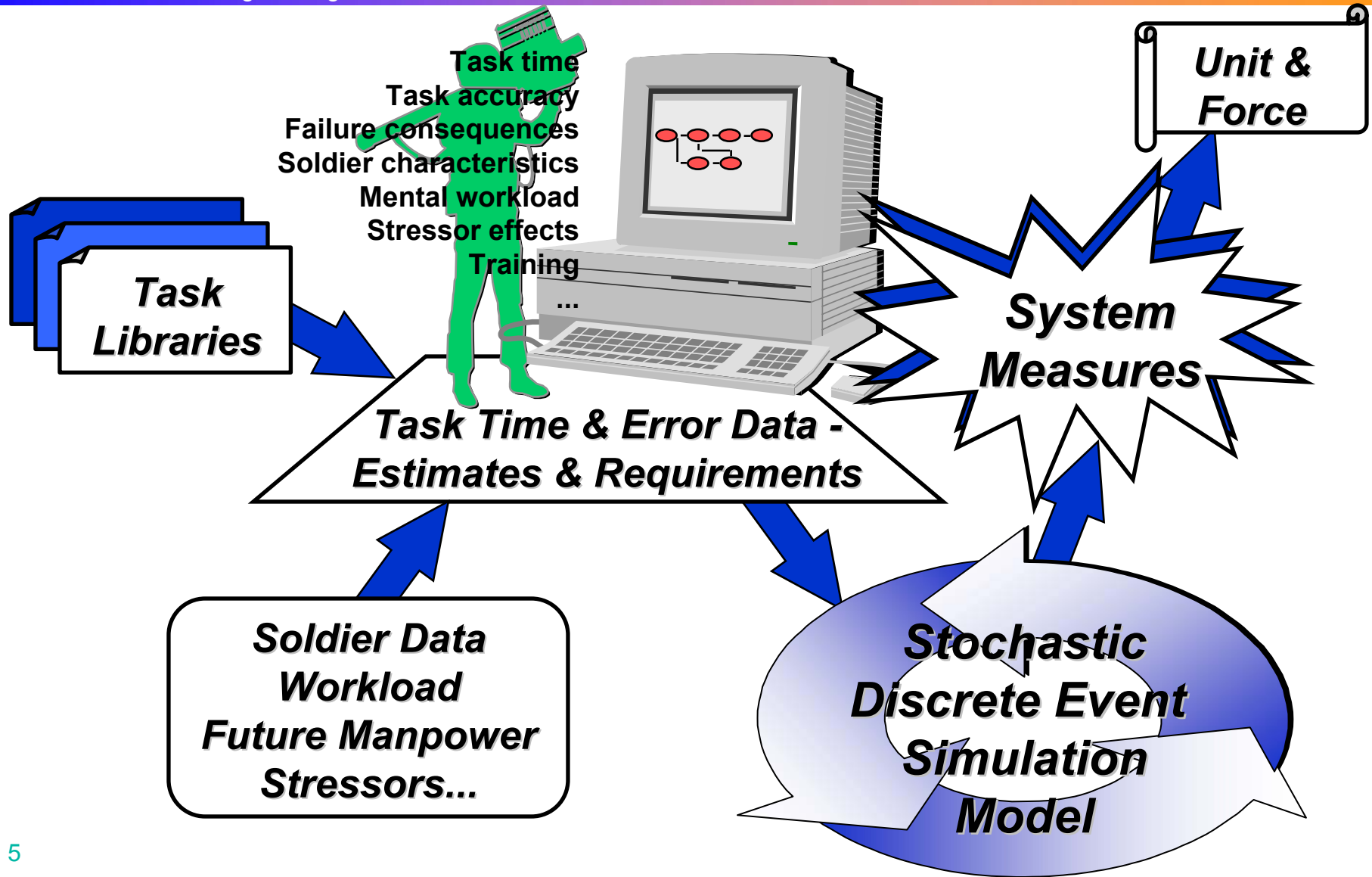
- ◆ Set realistic system requirements
- ◆ Identify future manpower & personnel constraints
- ◆ Evaluate operator & crew workload
- ◆ Test alternate system-crew function allocations
- ◆ Assess required maintenance manhours
- ◆ Assess performance under extreme conditions
- ◆ Examine performance as a function of personnel characteristics, training frequency & recency
- ◆ Identify areas to focus test and evaluation resources

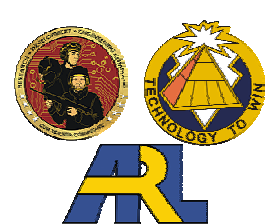
<http://www.arl.army.mil/ARL-Directorates/HRED/imb/imprint/Imprint7.htm>



IMPRINT Architecture

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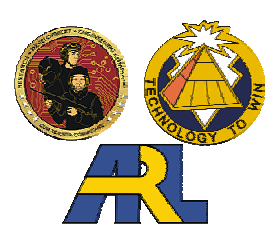




How many MAVs can an operator effectively operate and in what mode

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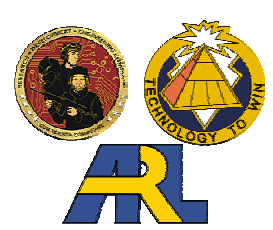




Missions

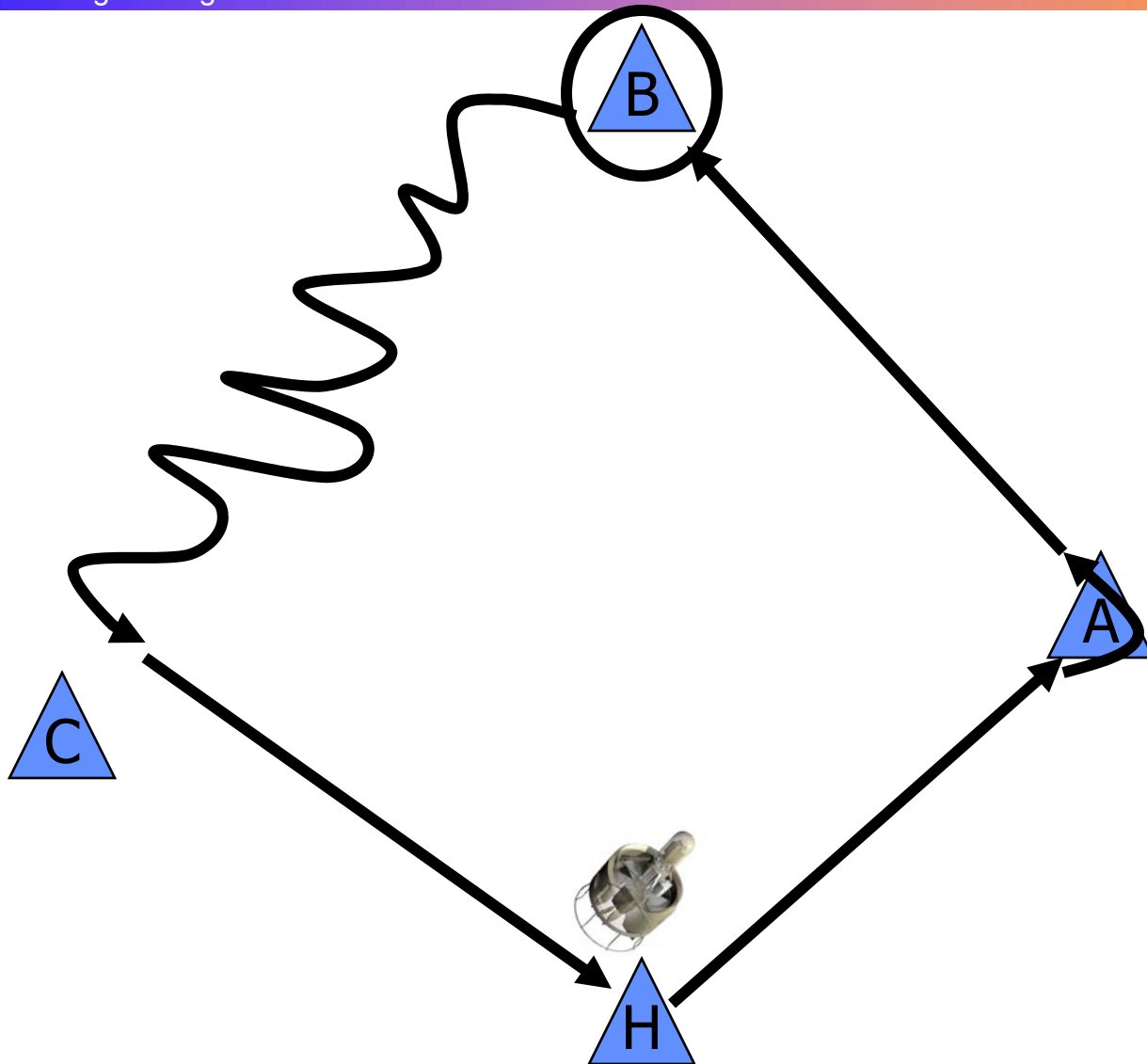
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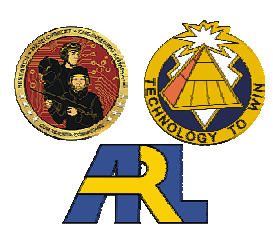
- 3 different missions were developed using a basic diamond configuration
 - Mission 1 (Route Recon) ($H \rightarrow A \rightarrow B \rightarrow C \rightarrow H$)
 - Mission 2 (Route Recon) ($H \rightarrow C \rightarrow B \rightarrow A \rightarrow H$)
 - Mission 3 (Hover of AO) ($H \rightarrow \text{Hover} \rightarrow A \rightarrow H$)



Mission 1

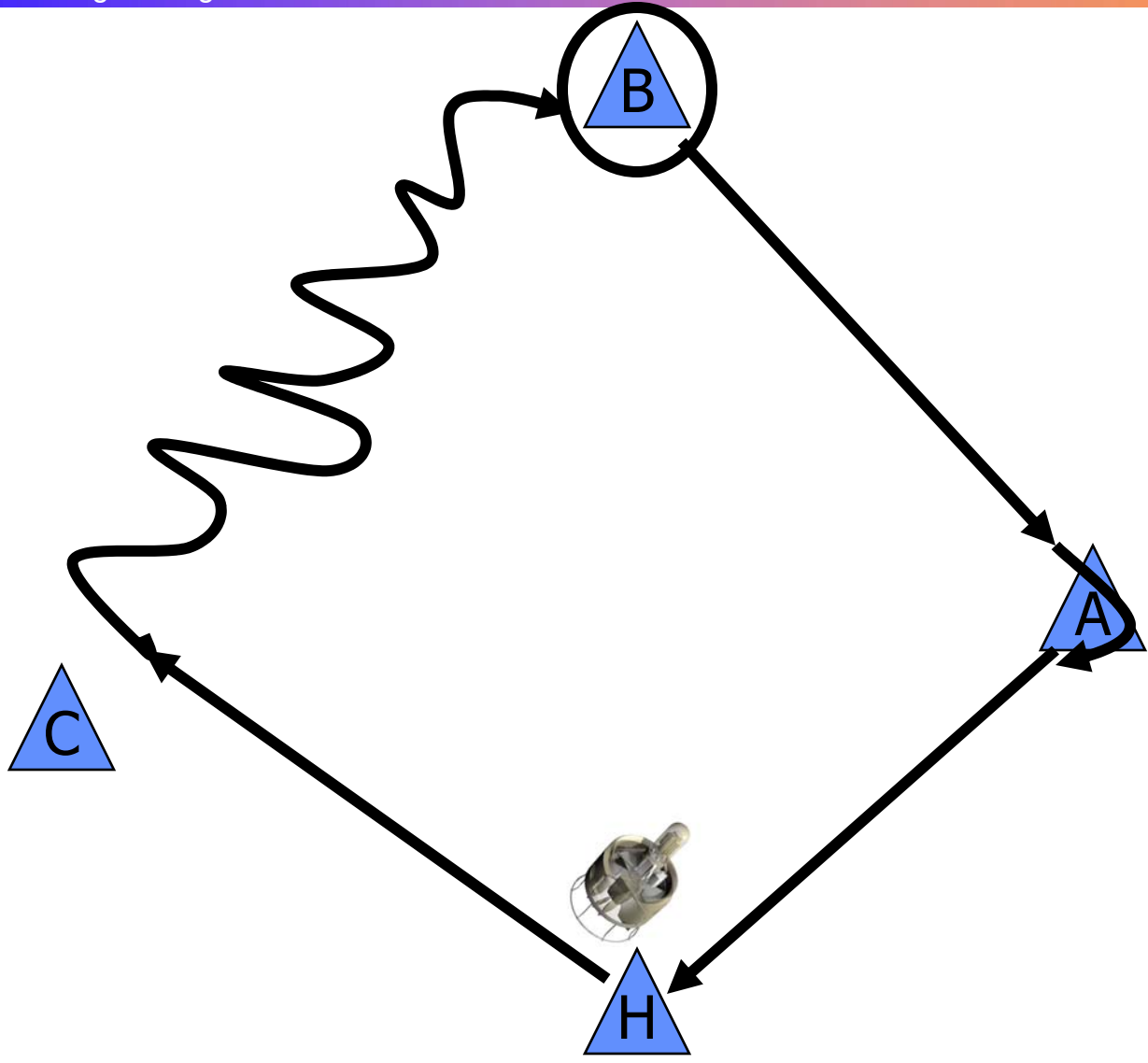
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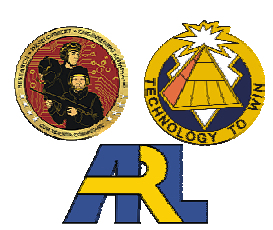




Mission 2

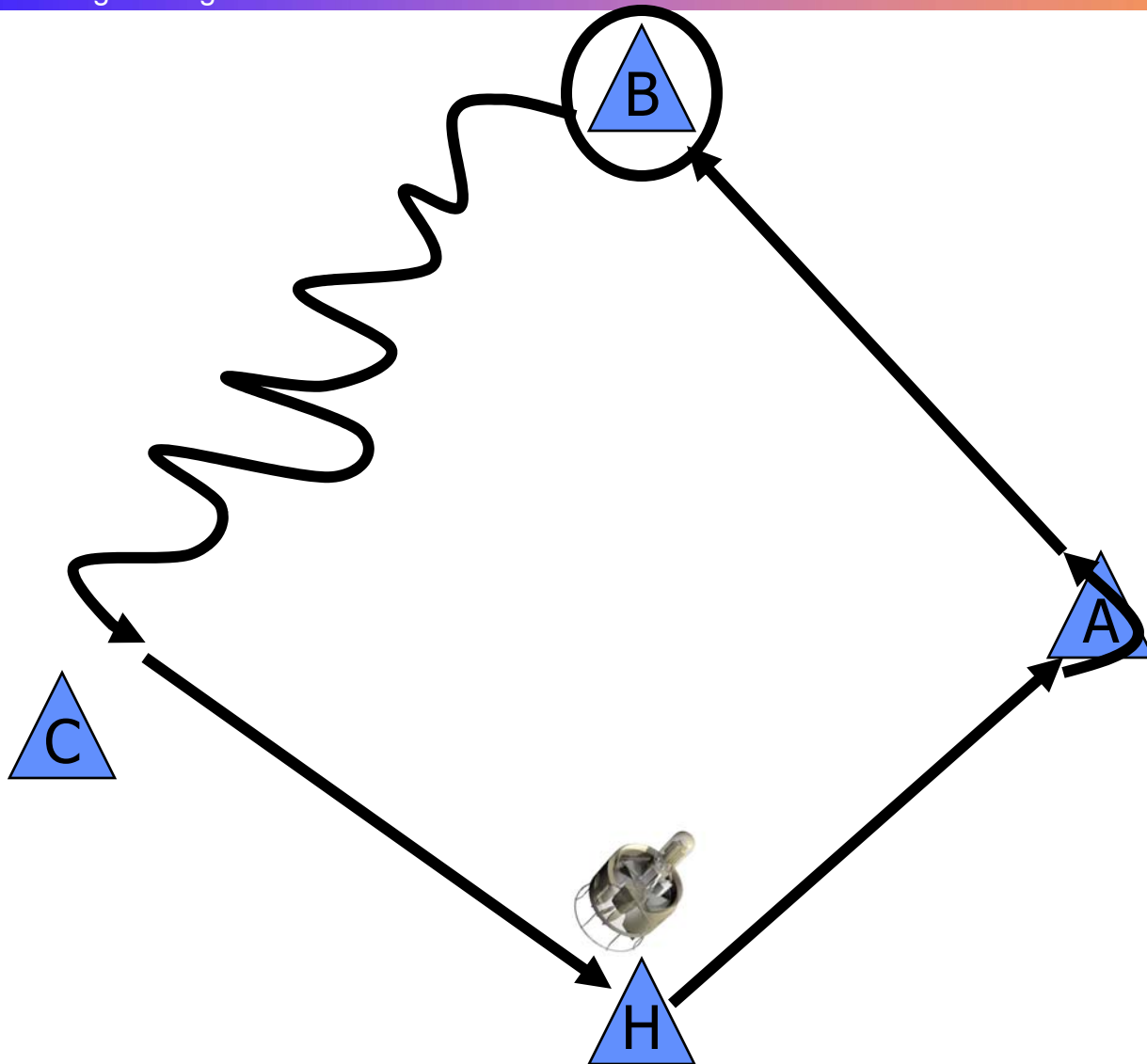
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Mission 3

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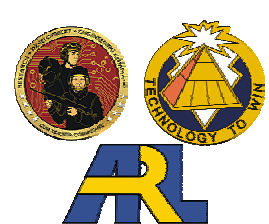




Scenarios

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- Each mission was tailored based on mode of flight (manual or autonomous) netting six scenarios.
 - 3 Manual Scenarios (MS1, MS2, MS3)
 - 3 Autonomous Scenarios (AS1, AS2, AS3)
- MAV conditions were tested with all possible combinations of the scenarios
 - 1 MAV in Manual
 - MS1
 - MS2
 - MS3

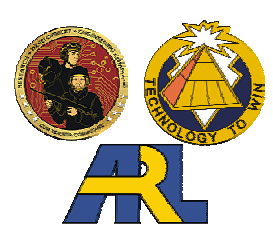


Conditions

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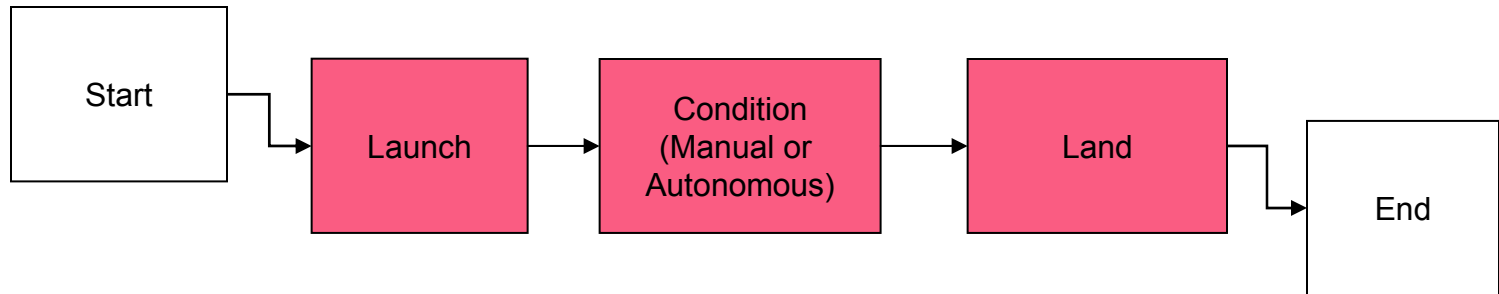
26 Conditions in all

# of MAVs in Manual Mode (M)	# of MAVs in Autonomous Mode (A)			
	0	1	2	3
0		AS1, AS2, AS3	AS1AS2, AS2AS3, AS1AS3	AS1AS2AS3
1	MS1, MS2, MS3	MS1AS2, MS1AS3, MS2AS1, MS2AS3, MS3AS2, MS3AS1	MS1AS2AS3, MS2AS1AS3, MS3AS1AS2	
2	MS1MS2, MS2MS3, MS1MS3	MS1MS2AS3, MS1MS3AS2, MS2MS3AS1		
3	MS1MS2MS3			



Base Model of MAV

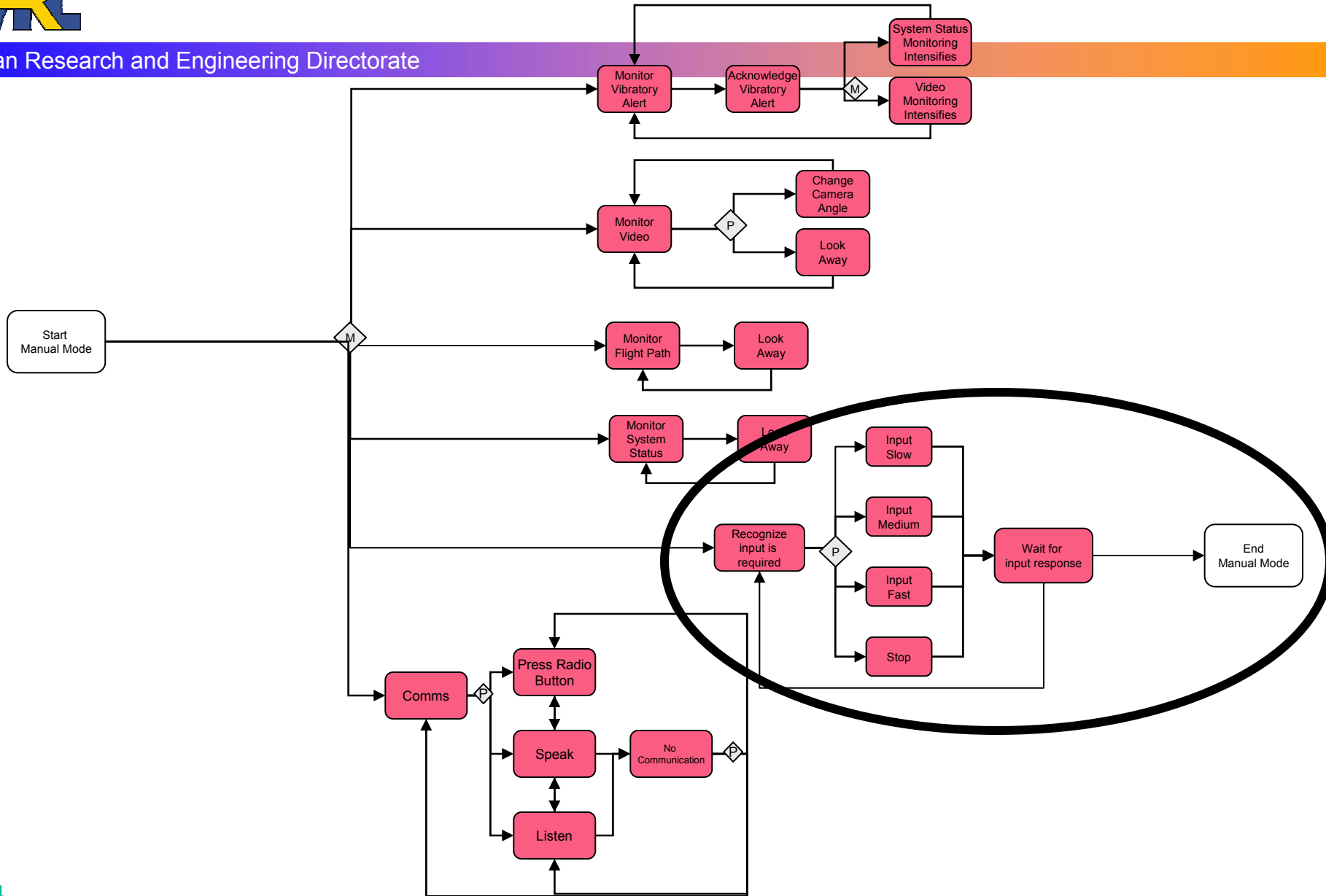
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Manual Mode

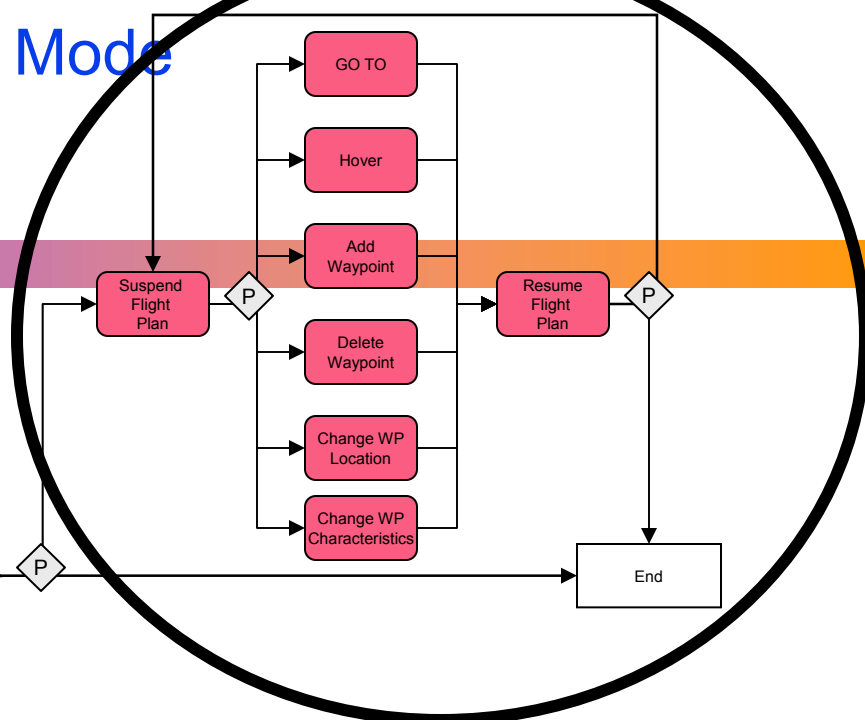
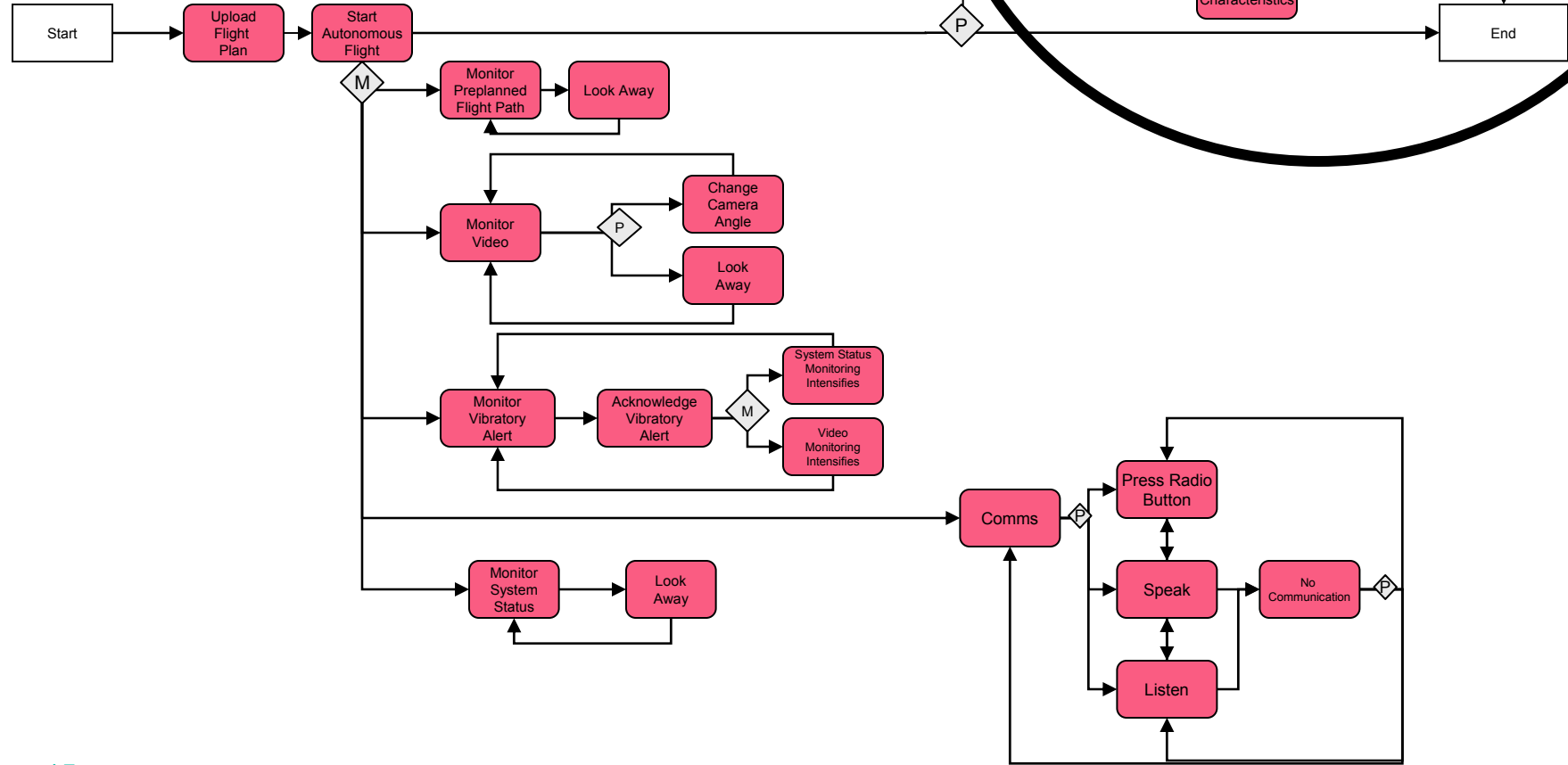
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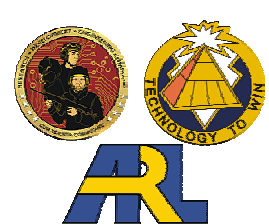




Autonomous Mode

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Workload

<ul style="list-style-type: none"> • V Visual 0.00 No Visual Activity 1.00 Visually Register/Detect (Detect Occurrence of Visual Stimulus) 3.70 Visually Discriminate (Detect Visual Stimulus) 4.00 Visually Inspect/Check (Discrete Visual Stimulus) 5.00 Visually Locate/Align (Selective Visual Stimulus) 5.40 Visually Track/Follow (Maintain Visual Stimulus) 5.90 Visually Read (Symbol) 7.00 Visually Scan/Search/Monitor (Complex Visual Stimulus) 	<ul style="list-style-type: none"> Auditory 0.00 No Auditory Activity 1.00 Detect/Register Sound (Detect Occurrence of Sound) 2.00 Orient to Sound (General Orientation/Attention) 4.20 Orient to Sound (Selective Orientation/Attention) 4.30 Verify Auditory Feedback (Detect Occurrence of Anticipated Sound) 4.90 Interpret Semantic Content (Speech) 6.60 Discriminate Sound Characteristics (Detect Auditory Difference) 7.00 Interpret Sound Patterns (Pulse Rates, etc.)
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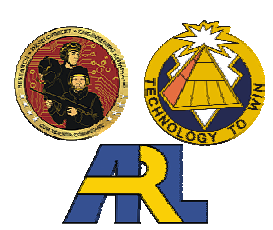
**Monitor
Video**

<ul style="list-style-type: none"> Psychomotor 0.00 No Psychomotor Activity 2.20 Discrete Actuation (Button, Toggle) 2.60 Continuous Adjustive (Flight Controls) 4.60 Manipulative 5.80 Discrete Adjustive (Rotary, Vertical) 6.50 Symbolic Production (Writing) 7.00 Serial Discrete Manipulation (Key) 	<ul style="list-style-type: none"> Cognitive 0.00 No Cognitive Activity 1.0 Automatic (Simple Association) 1.2 Alternative Selection 3.7 Sign/Signal Recognition 4.6 Evaluation/Judgment (Consider Single Aspect) 5.3 Encoding/Decoding, Recall 6.8 Evaluation/Judgment (Consider Several Aspects) 7.0 Estimation, Calculation, Conversion
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Overload

- Too many things happening at once

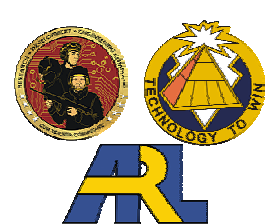




Overload

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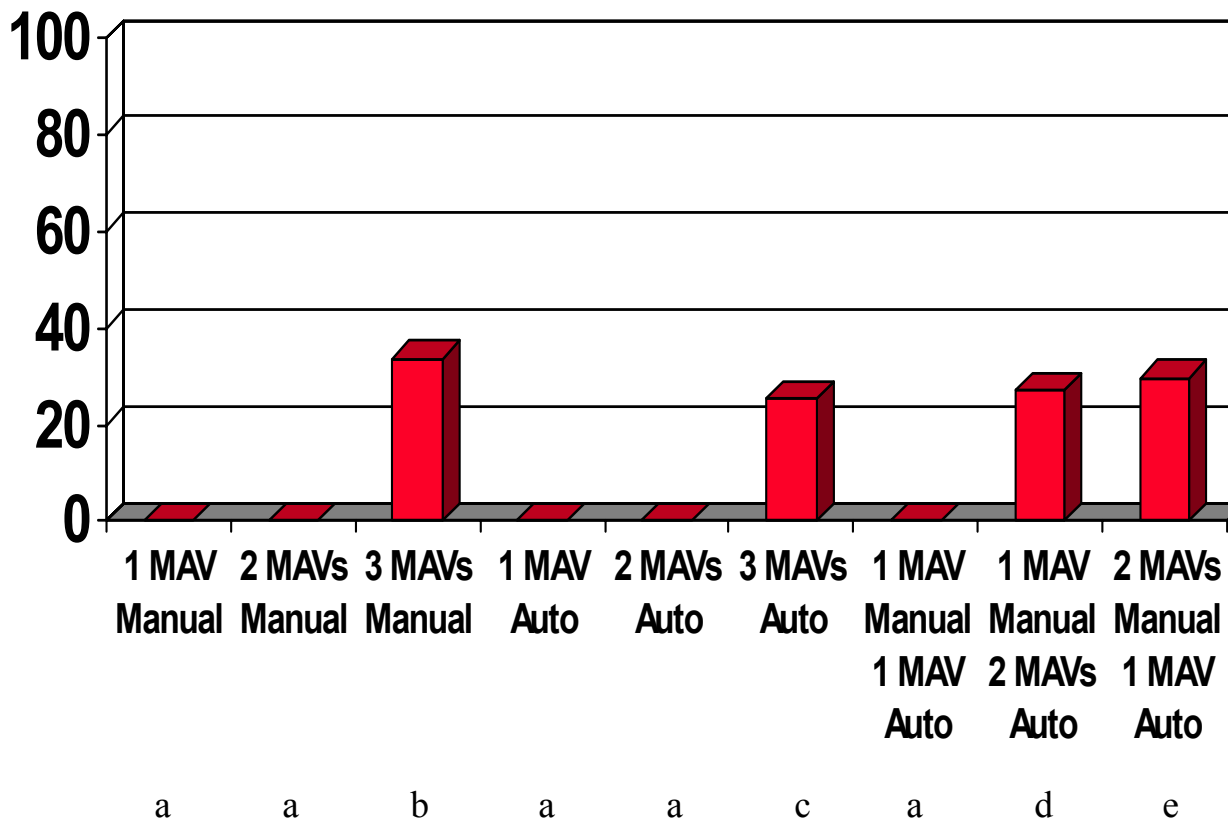
- Over 7 in any one channel (multiple tasks)
- The sum of all four channels is greater than 40
- Conditions of overload are areas when one would predict that performance errors would begin to appear

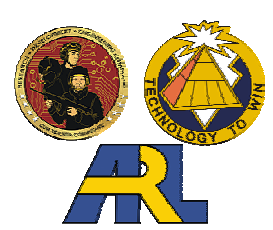


Overall Workload Results

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Percent of time in Overall Overload

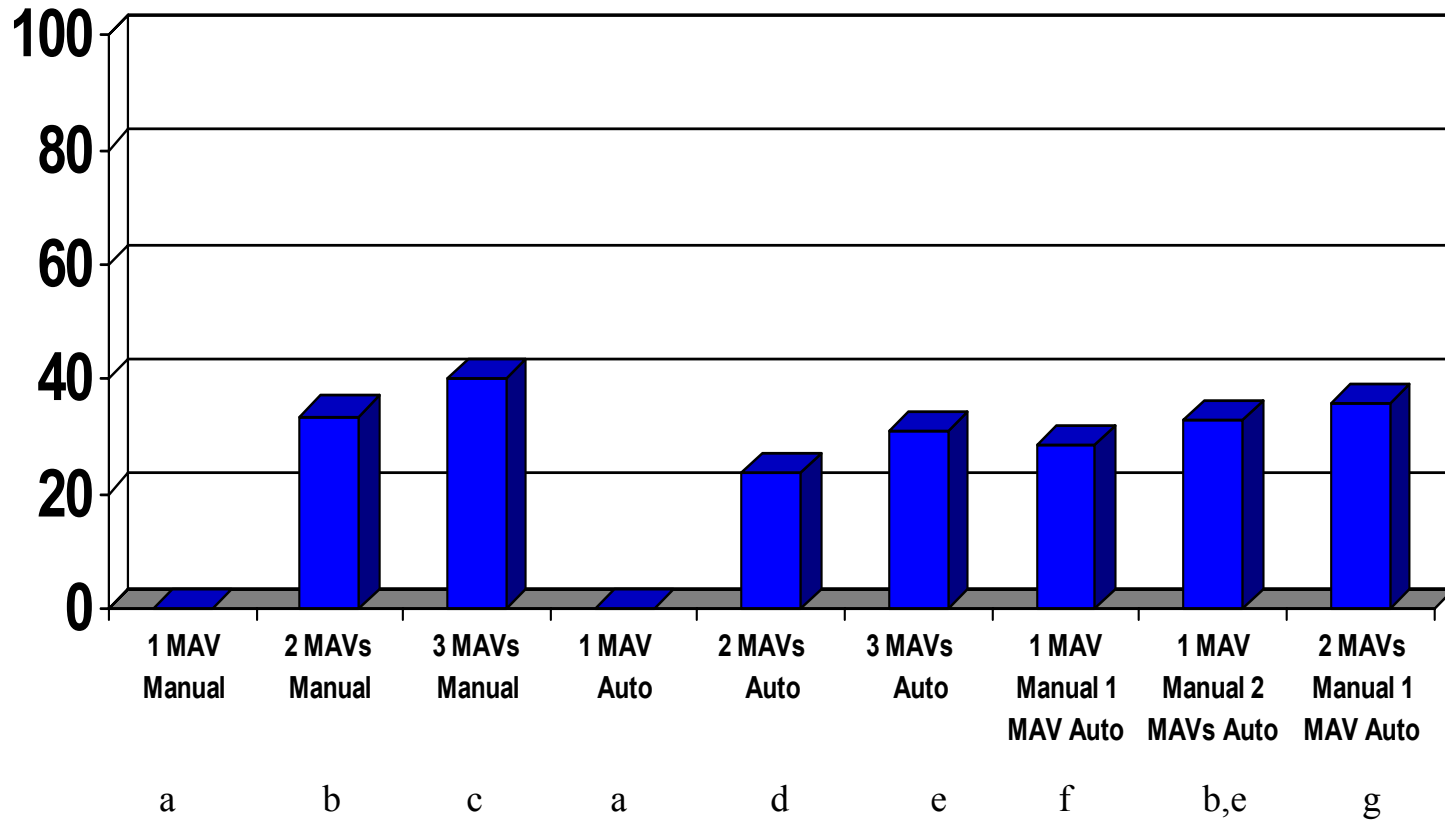




Visual Workload Results

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Percent of time in Visual Overload

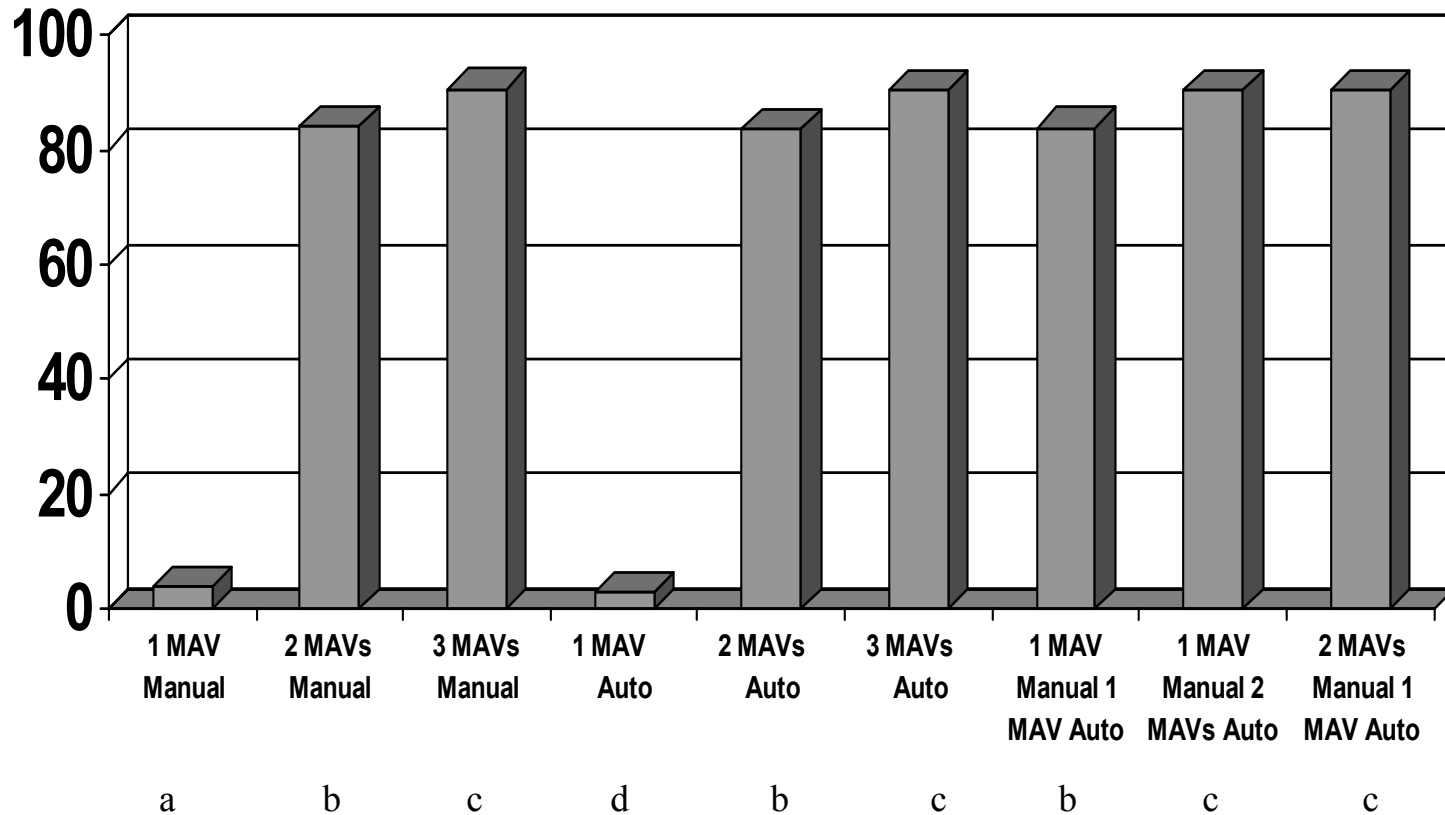


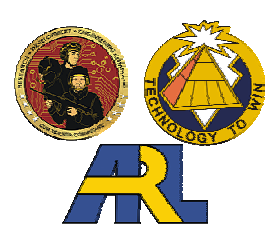


Cognitive Workload Results

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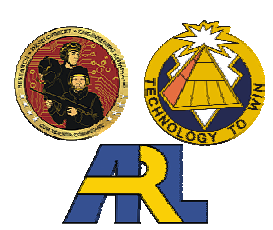
Percent of time in Cognitive Overload





Results

- 1 MAV regardless of mode
 - Well within the workload limits of a nominal soldier
- 2 MAVs
 - Overall workload indicates can be accomplished
 - Operator spends 20-40% of time in visual overload
 - Operator spends 80-90% of time in cognitive overload
- 3 MAVs
 - Operator's overall workload is in overload 20-40% of the time
 - Operator spends 20-40% of time in visual overload
 - Operator spends 80-90% of time in cognitive overload



Conclusions

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- This study indicates that workload levels are high for more than one MAV
- This investigation does not predict what performance changes would result from these levels of workload
- Validation of the workload numbers and the resulting performance impact would be required
- The study does not take into account any additional duties that a robotics operator may have to perform while attempting to operate the MAV. Future research should include the examination of mission related tasks while operating multiple unmanned systems
- Utilize same methods with additional unmanned platforms (UAVs, UGVs)