



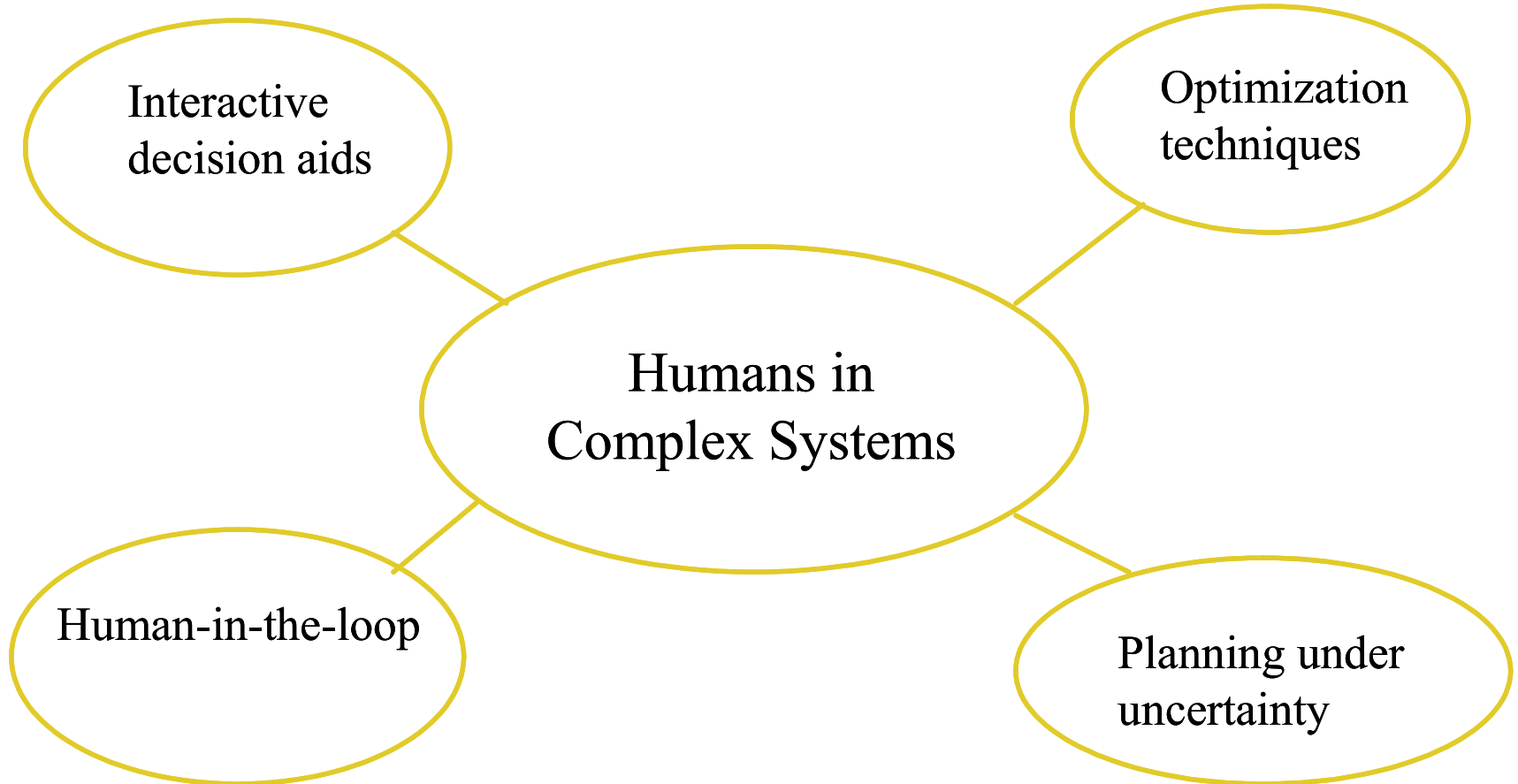
Human Centered Research Involving UAVs in Military- Focused Domains

Raymond Hill
S. Narayanan
Jennie Gallimore
Wright State University

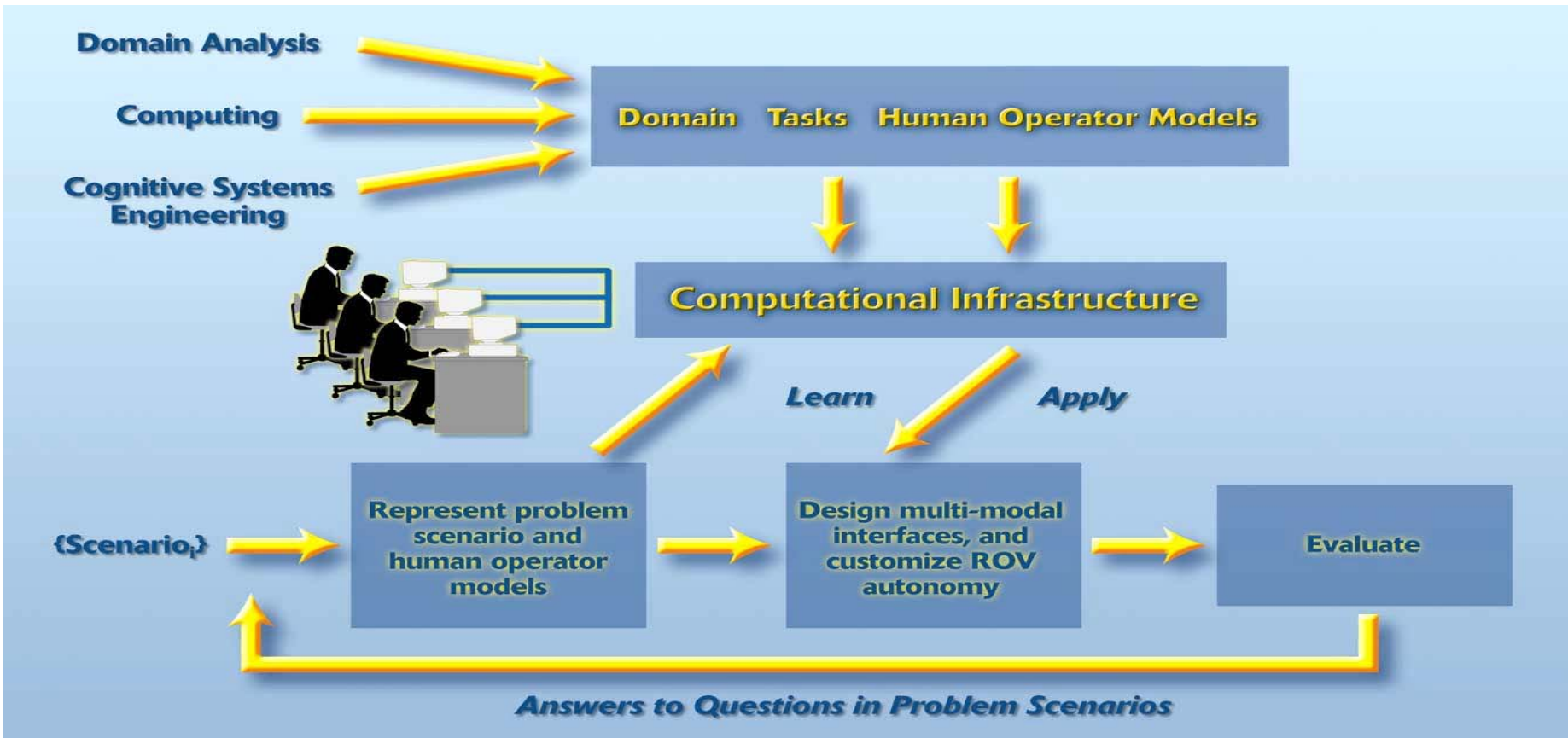
CERI Human Factors of UAVs Workshop

May 24, 2004

The WSU Research Approach



The Design Approach



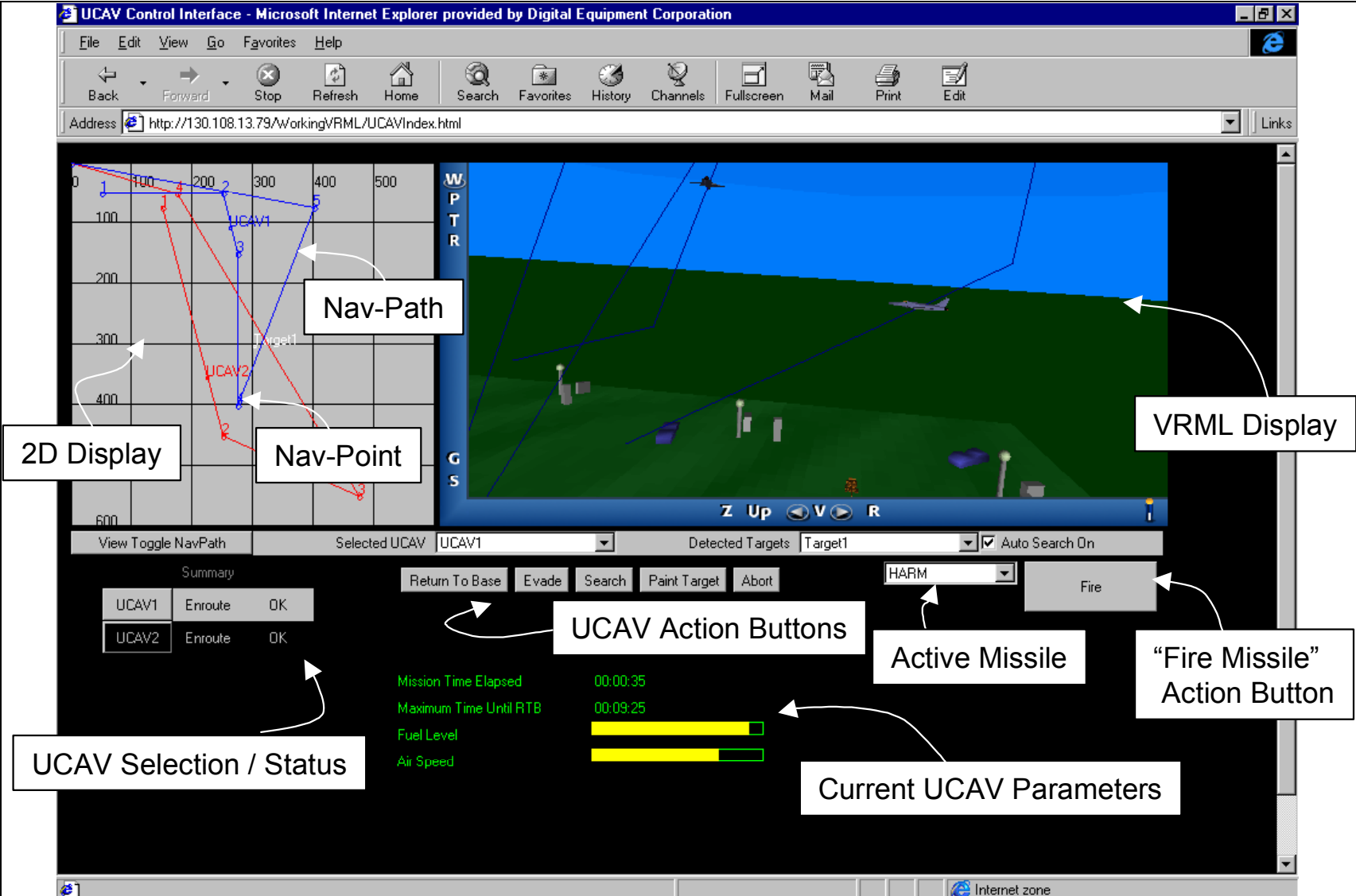
Human Operator Issues

- How to build reusable and modular software components for representing complex human behavior exhibited in ROV problem scenarios.
- What is the right number of human operators and system autonomy for certain realistic mission scenarios?
- How can modeling results be used to specify the content and form of multi-modal interfaces?
- For what situations are immersive technologies useful?
- What should the visualizations be to provide situational awareness to the operators?

Interface Capabilities

- Multiple UCAVs
- A realistic environment
 - √ Built using simulations to drive information
- Predictive feedback
- Protection from wrong decisions
- Provide direction for action
- Provide multiple perspectives
- Provide ability to override automation

Supervisory Control



The screenshot shows a web-based control interface for an Unmanned Combat Aerial Vehicle (UCAV). The browser window title is "UCAV Control Interface - Microsoft Internet Explorer provided by Digital Equipment Corporation". The address bar shows the URL: `http://130.108.13.79/WorkingVRML/UCAVIndex.html`.

The interface is divided into several key sections:

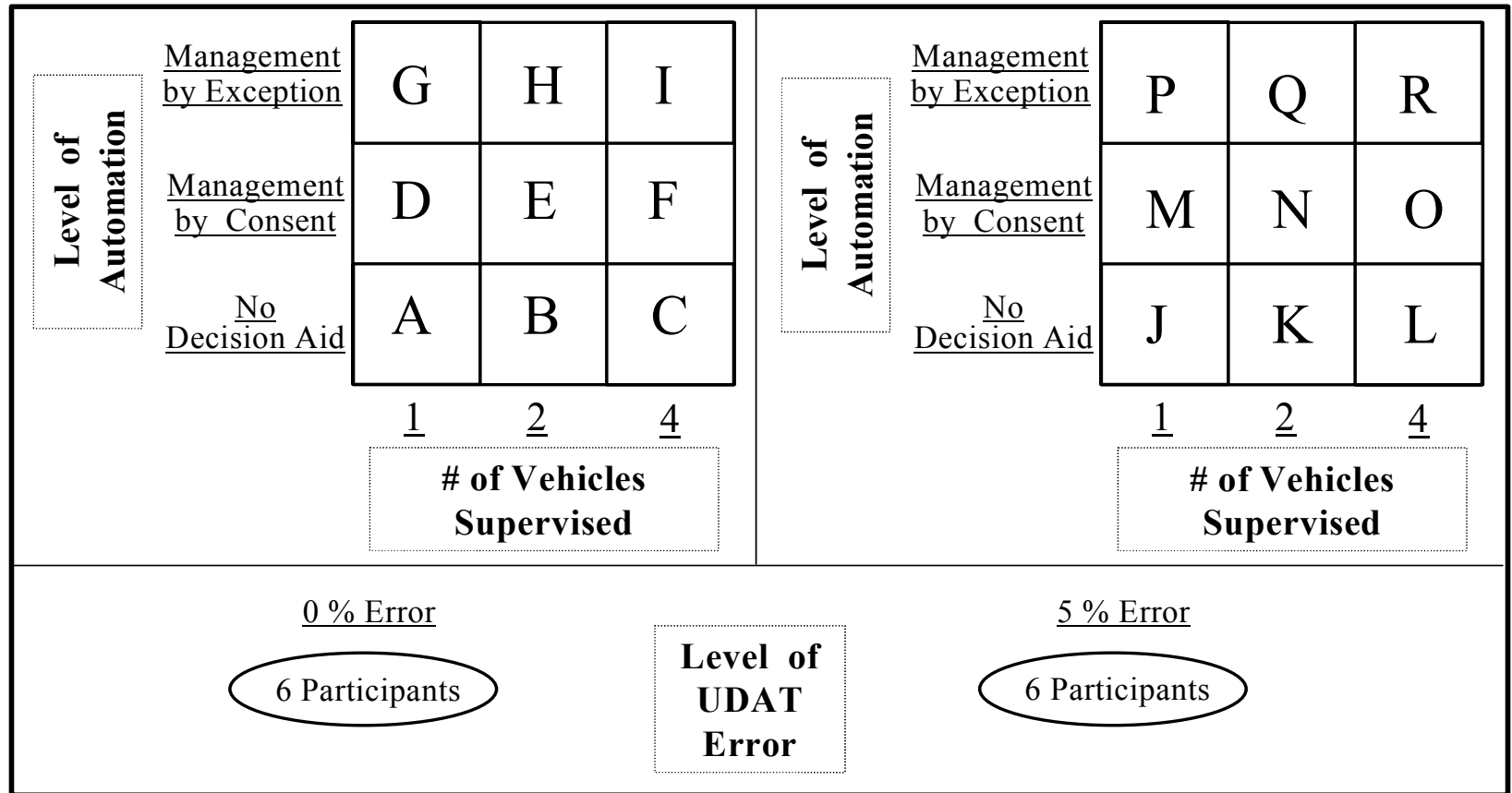
- 2D Display:** A grid-based map on the left showing flight paths for UCAV1 (blue) and UCAV2 (red). A specific point on the path is labeled "Nav-Point".
- VRML Display:** A 3D perspective view on the right showing the terrain, the UCAV's current position, and a target labeled "Target1".
- UCAV Selection / Status:** A table in the bottom left corner:

Summary		
UCAV1	Enroute	OK
UCAV2	Enroute	OK
- UCAV Action Buttons:** A row of buttons including "Return To Base", "Evade", "Search", "Paint Target", and "Abort".
- Active Missile:** A dropdown menu currently set to "HARM".
- "Fire Missile" Action Button:** A button labeled "Fire" that triggers the missile launch.
- Current UCAV Parameters:** A section showing mission progress:
 - Mission Time Elapsed: 00:00:35
 - Maximum Time Until RTB: 00:09:25
 - Fuel Level: A yellow progress bar.
 - Air Speed: A yellow progress bar.

Study by Ruff (1997)

ζ Experimental Design

ψ Mixed Design (2x3x3)



UCAV HIL Interface

UserInterface - Untitled

File View Option Help

View Option Automation

Flight View

60% 105

UCAV_03
60% 181

UCAV_04
60% 80

UCAV_02

UCAV_04

X	2417.0
Y	1314.4
Z	89.3

N	2.2
X	2417.0
Y	2263.0
Z	180.0

UCAV_01 | UCAV_02 | UCAV_03 | UCAV_04

Speed: Tasks

Time	TimeLeft	Ucav	Targ
<input type="checkbox"/> 0: 1: 9	0: 0: 0	UCAV_01	Tank

List Tree Unassign Fire

Actions: ReturnToBase Search Evade

Targets | WayPoint

Target Name: Tank_03

Target Type: Tank

Friend or Enemy: Unknown Enemy Friendly

Assigned to: UCAV_01

UCAV: UCAV_01 Assign

Munitions: Long_Range_Missile: 4 (A:70% R:200% K:25%)
 Short_Range_Missile: 3 (A:90% R:50% K:75%)
 None

Timer: 0: 1: 27

Map Selection: Satellite Camera Following

Viewer Position: Front Left Right Back

Camera: <-In Out->

Satellite Zoom: < 1x --- 2x --- 4x --- 6x --- 8x ---

Communication | Connection History

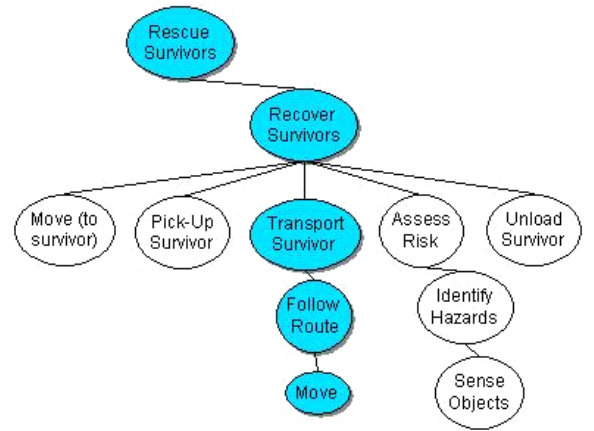
Send

Recent Ground UAV

Operator1021321212687

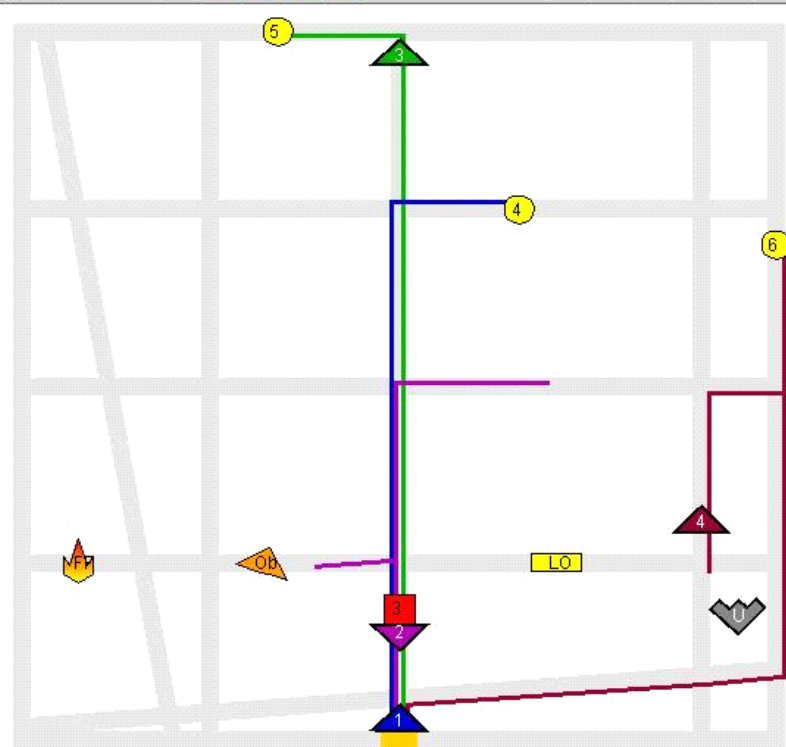
Paths: U G1 G2 G3 G4 Points: U G1 G2 G3 G4

U	G1	G2	G3	G4
Find	Recover	Recover	Recover	Recover



```

graph TD
    A(Rescue Survivors) --> B(Recover Survivors)
    B --> C(Move to survivor)
    B --> D(Pick-Up Survivor)
    B --> E(Transport Survivor)
    B --> F(Assess Risk)
    B --> G(Unload Survivor)
    E --> H(Follow Route)
    H --> I(Move)
    F --> J(Identify Hazards)
    J --> K(Sense Objects)
            
```



U	G1	G2	G3	G4
-	-	-	-	-
#	#	#	#	#

NO DATA

Name	G1	G2	G3	G4
4L	186	230	104	148
5L	235	280	54	262
6L	236	280	182	110

ACCEPT

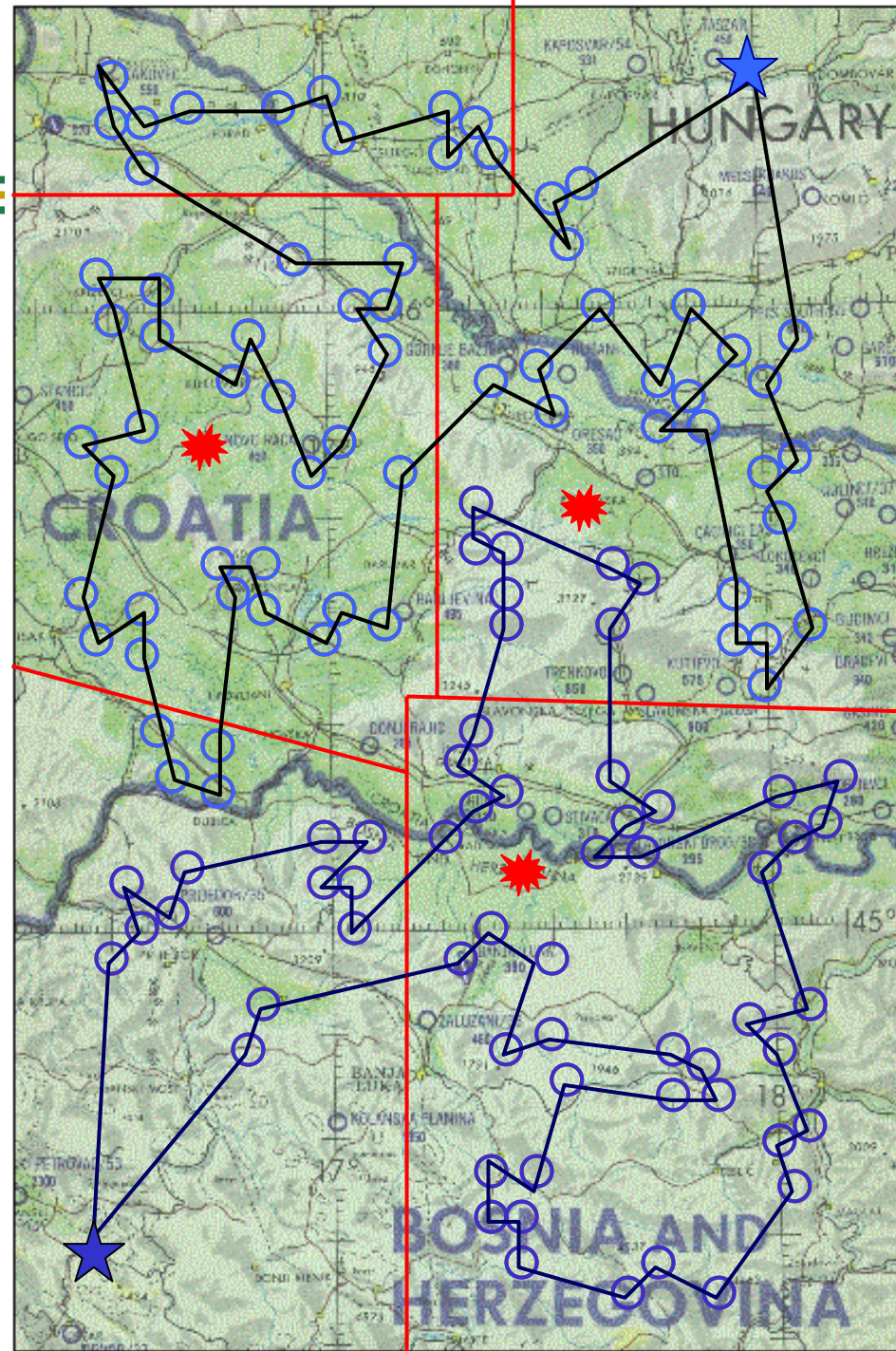
REJECT

FAULT

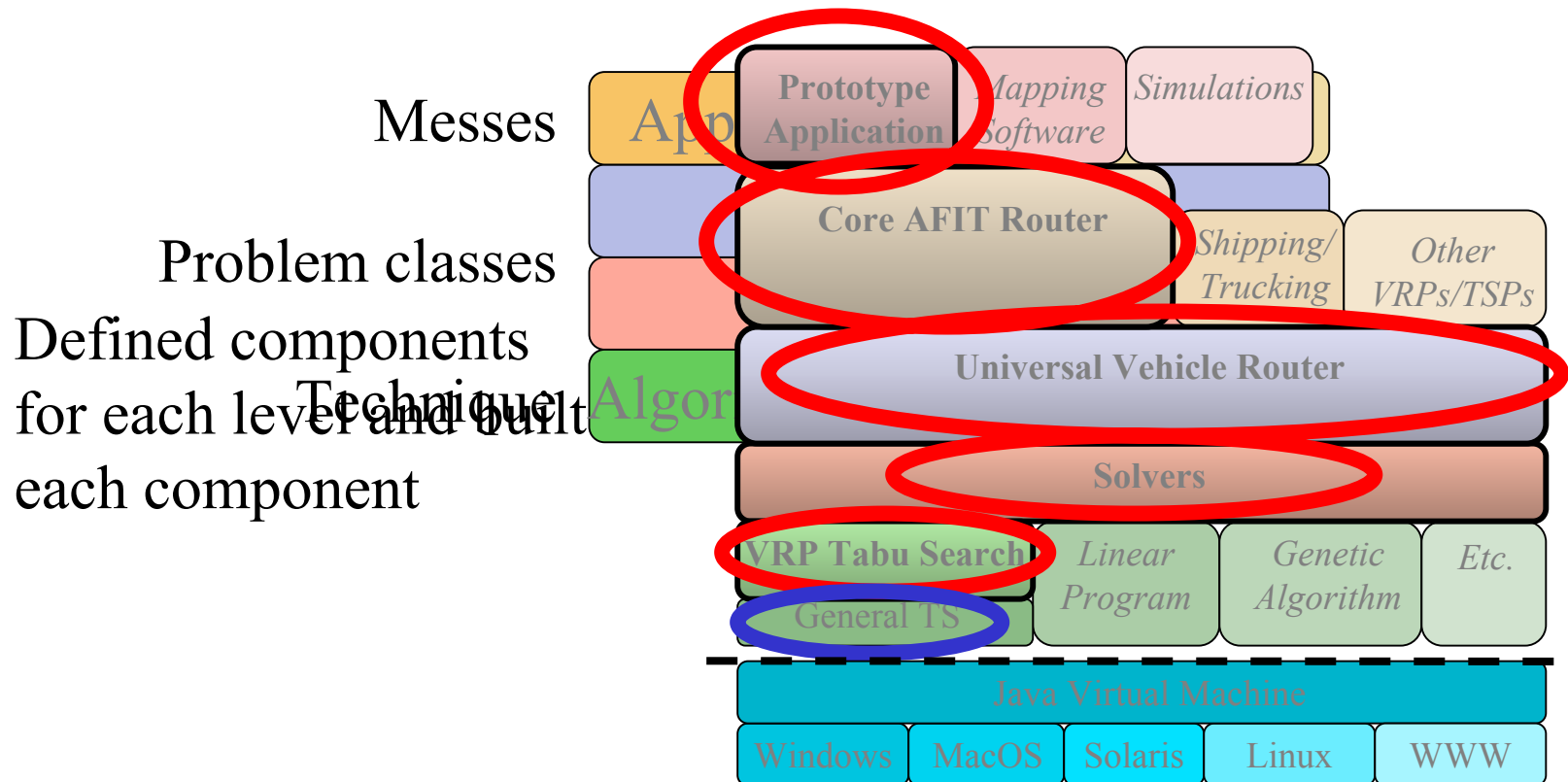


Optimization and Analysis Efforts

- Up to 500 targets daily
- Multiple assets with multiple depots
- Intelligence cell must allocate the targets to assets
- Operators must find route subject to
 - ✓ Time windows
 - ✓ Threats
 - ✓ Target priorities
 - ✓ Vehicle endurance



Defined an Architecture



Built an Application Level

AFIT Router

Sites	Vehicles	Other
Total: 100	Total: 4	Wind speed: 12
Enabled: 94	Enabled: 4	Wind from: West
Sites...	Vehicles...	Other...

Solutions

Shortest mission, length: 24 hrs. 18 min.
 Shortest mission, sites visited: 94

[Solve...](#) [More...](#) L&F

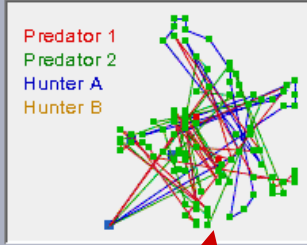
The application is the only portion of the AFIT router presented to the user. All other portions are hidden.

Solutions

Stats

Sites Visited: 95
 Sites Skipped: 2
 Vehicles Used: 4
 Highest Skipped Priority: 3

[Details...](#)
[Copy to clipboard...](#)

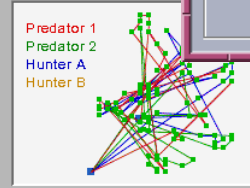


Solution

Stats

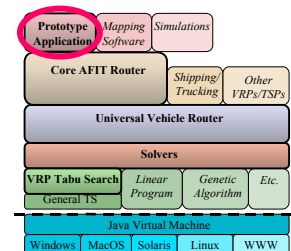
Sites Visited: 88
 Sites Skipped: 0
 Vehicles Used: 3
 Highest Skipped Priority: -2147483647

[Copy to clipboard...](#)



Vehicle	Name	Latitude	Longitude	Priority	Arrival Time	Departure Time	Original Order
Predator 1	Site_80	850000 N	250000 E	3	1835h +1 day	2005h +1 day	28
Predator 1	Site_9	280000 N	700000 E	3	2005h +1 day	2135h +1 day	29
Predator 1	Site_81	850000 N	350000 E	3	2135h +1 day	2305h +1 day	30
Predator 1	Site_78	780000 N	400000 E	3	2305h +1 day	0035h +2 days	31
Predator 1	Site_77	720000 N	450000 E	3	0037h +2 days	0207h +2 days	32
Predator 1	Site_96	620000 N	400000 E	3	0207h +2 days	0337h +2 days	33
Predator 1	Site_87	640000 N	460000 E	3	0337h +2 days	0507h +2 days	34
Predator 2	Site_63	500000 N	400000 E	3		0155h	35
Predator 2	Site_62	500000 N	350000 E	3	0155h	0330h	36
Predator 2	Site_74	530000 N	350000 E	3	0330h	0503h	37
Predator 2	Site_72	530000 N	300000 E	3	0503h	0638h	38
Predator 2	Site_61	500000 N	300000 E	3	0638h	0811h	39
Predator 2	Site_64	480000 N	300000 E	3	0811h	0943h	40

Users liked this feature



Details within Application Level

Sites

File Edit

Summary

Total: 100

Enabled: 96

Earliest time window:

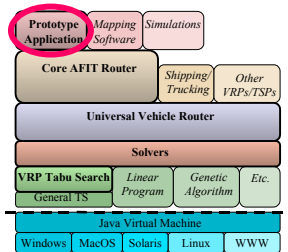
Latest time window: 0639h +2 days

Enabled	Name	Latitude	Longitude	Service Ti...	Priority	Require...	Earliest Al...	Latest All...	Earliest R...	Latest Re...
<input type="checkbox"/>	Site_1	520000 N	750000 E	90	3	EO/IR	0511h	0751h		
<input checked="" type="checkbox"/>	Site_2	450000 N	700000 E	90	3		0333h	0613h		
<input type="checkbox"/>	Site_3	620000 N	690000 E	90	3	SAR				
<input checked="" type="checkbox"/>	Site_4	600000 N	660000 E	90	3	Laser	2101h	2341h		
<input type="checkbox"/>	Site_5	420000 N	650000 E	90	3		0025h	0305h		
<input type="checkbox"/>	Site_6	160000 N	420000 E	90	3	SAR			1300h	1400h

Vehicles & Bases

Enabled	Name	Home	Capabi...	Speed ...	Range ...	Altitud...	Start Ti...	Use Al...	Alt. Lat...	Alt. Lo...
<input checked="" type="checkbox"/>	Predator 1	Rob AFB	EO/IR,...	70	30	12,000	0814h	<input checked="" type="checkbox"/>	23.4	10.4
<input checked="" type="checkbox"/>	Predator 2	Rob AFB	Laser,...	70	30	11,000	0900h	<input type="checkbox"/>	0	0
<input checked="" type="checkbox"/>	Hunter A	Rob AFB	EO/IR,...	65	24	11,500	0930h	<input type="checkbox"/>	0	0
<input checked="" type="checkbox"/>	Hunter B	Rob AFB	EO/IR,...	65	24	12,000	0930h	<input type="checkbox"/>	0	0
<input type="checkbox"/>			EO/IR,...	100	0	0		<input type="checkbox"/>	0	0

Name	Latitude	Longitude
Aviano	40.0	10.0
Other	32.5	29.4
Rob AFB	0.0	0.0
	0.0	0.0





Coordination and Control of Cooperative Swarms of Unmanned Aerial Combat Vehicles via a Virtual Testbed Environment

Themes of Effort

- Agent models and heterogeneous agents within the swarm
- Swarm limitations in terms of size, capability, cooperation, or loss of cohesiveness
- AOC control issues to include number of controllable agents, information presentation and influence on the swarm

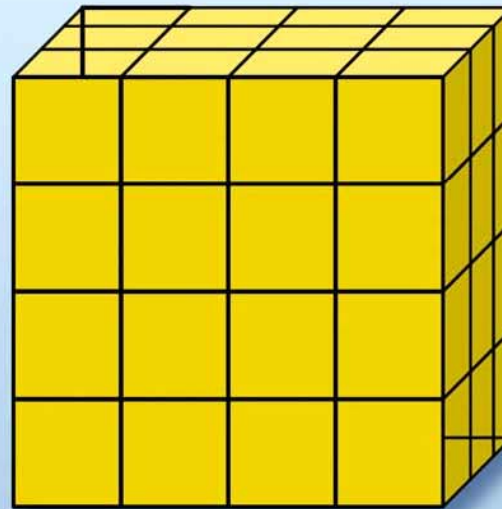
Research Questions

- What degree of cooperation is attainable?
- Can heterogeneous agent cooperation be accommodated?
- Can the swarm enlarge or constrict gracefully?
- Can emergent behavior be recognized and then beneficially controlled?

The “Control Cube”

Autonomous Control

- ◆ Fully Adaptive
- ◆ Constrained Flexibility
- ◆ Optimized End Game
- ◆ Fixed Objective & Strategy



- ◆ Pilot
- ◆ Mission Commander
- ◆ Battle Manager

Operator
Interaction



Multi-Vehicle Interaction

- ◆ Independent
- ◆ Common Sense
- ◆ Shared Strategies

Architecture Requirements

- Interactivity
- Multi-user connectivity
- Reconfigurable user interfaces
- Representation of information flow
- Analytical-based and controller-based information presentation
- Modularity and reusability of software architecture components

Activities Thus Far

- Project initiated in March 2004
- Establishing link with AFRL/MN for potential collaboration and technology transition
- Conducting the domain analysis and task analysis from which to define, design, and realize the software abstractions required to realize out virtual test environment

Research Challenges

- Models of agent cooperation
- Interfaces for human control of swarms of UCAVs
 - √ Protocol for human-computer interaction
 - √ Control cues for effective coordination
- Examine network-centric models involving swarms of UAVs
 - √ How to use emergent networks
 - √ How to guard against their attack



Questions?