Development of Prototype Intelligent Adaptive Interfaces for Multiple UAV Control

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Recherche et développement pour la défense Canada

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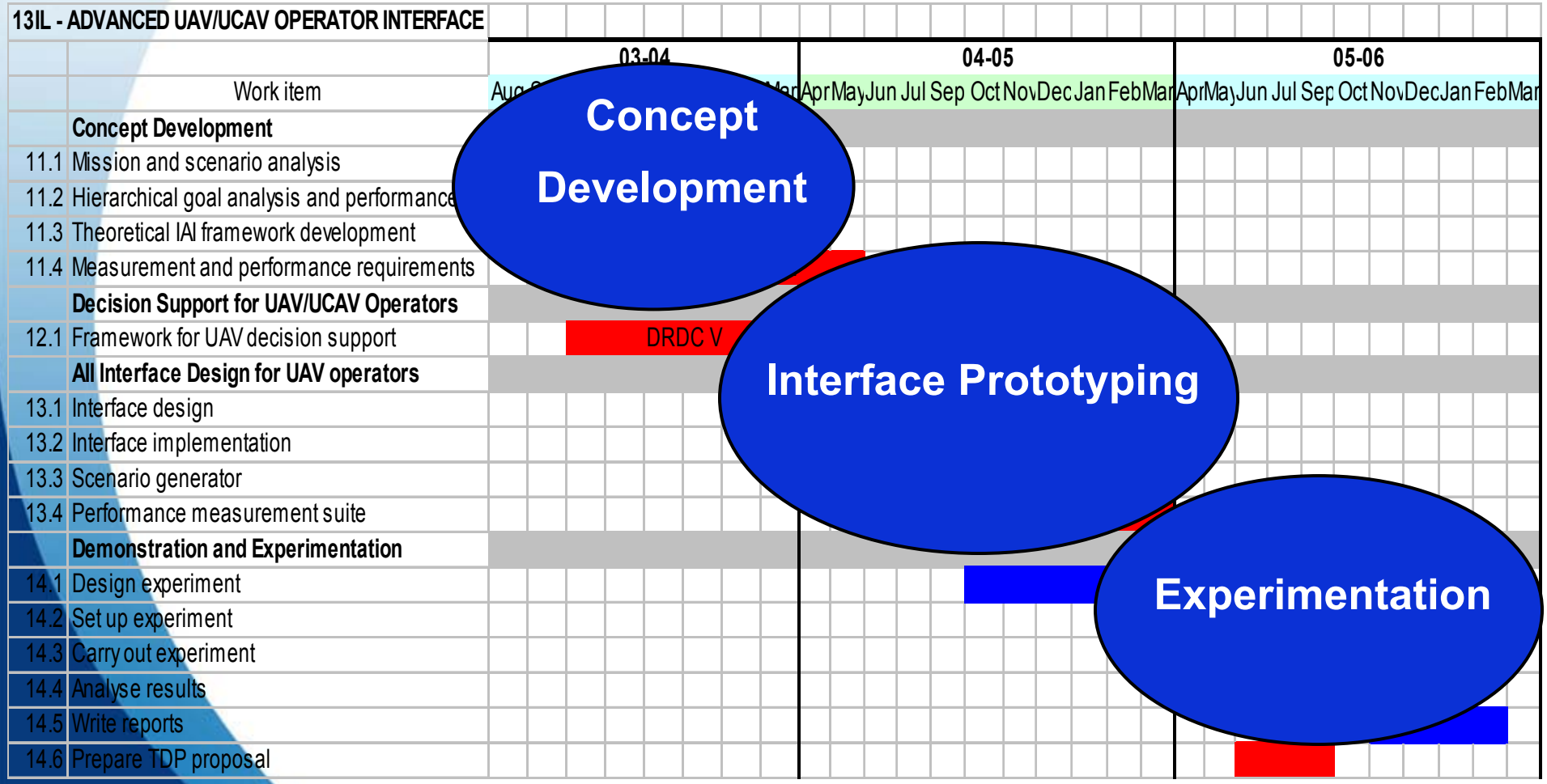
Canada

Future Joint Operations

Three Phases (2003 - 2006)



Intelligent/Adaptive Interfaces (IAIs)

Goal	Situation
•Improve: efficiency, effectiveness, and naturalness of human-machine interaction •Maximize overall performance	•Multi-task capabilities •Dynamic monitoring of task processes •Integrated system design •Improved distributed team collaboration task capabilities

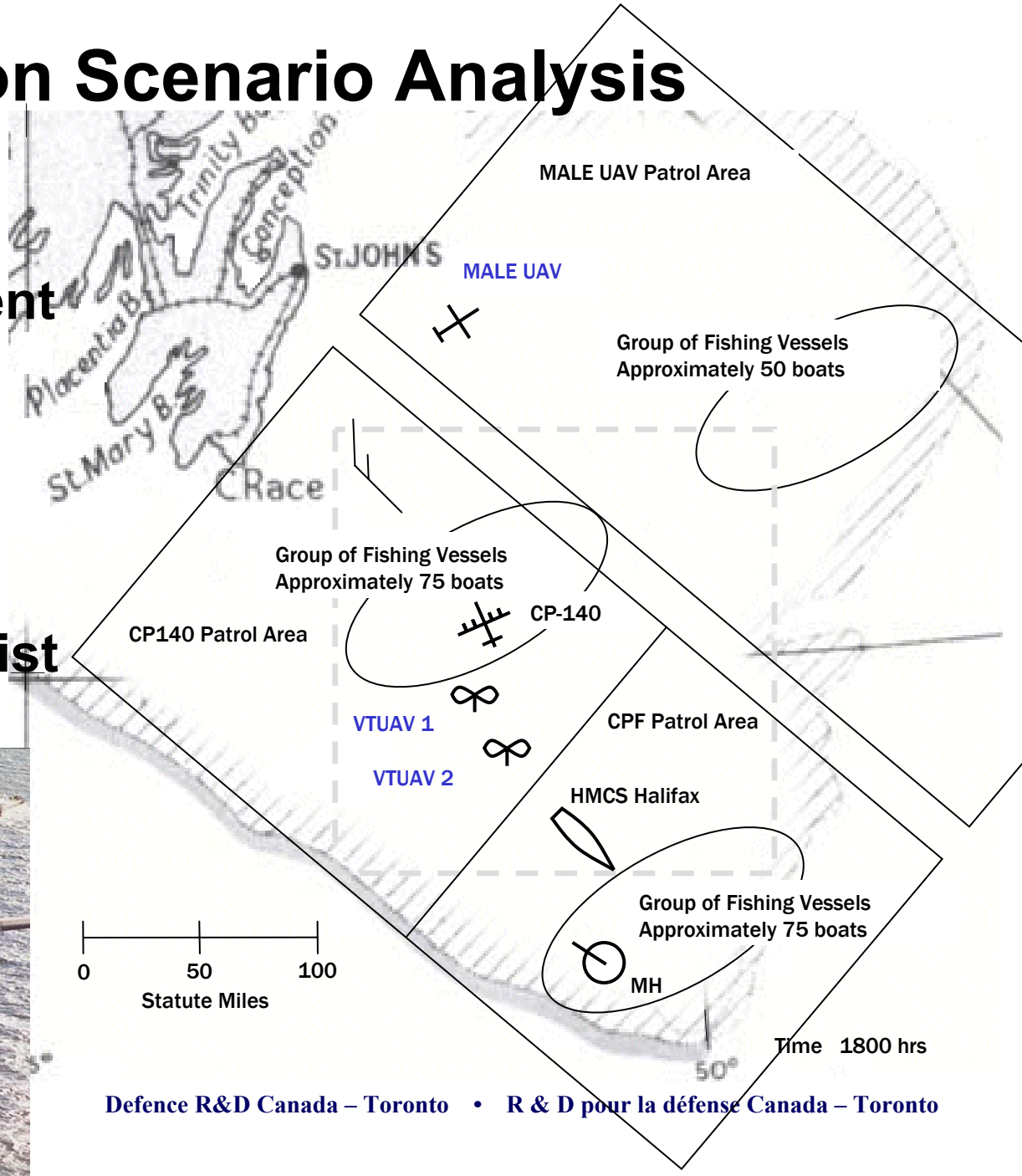
Method: Multi-Agent Technology

Phase I Work (2003 - 2004)

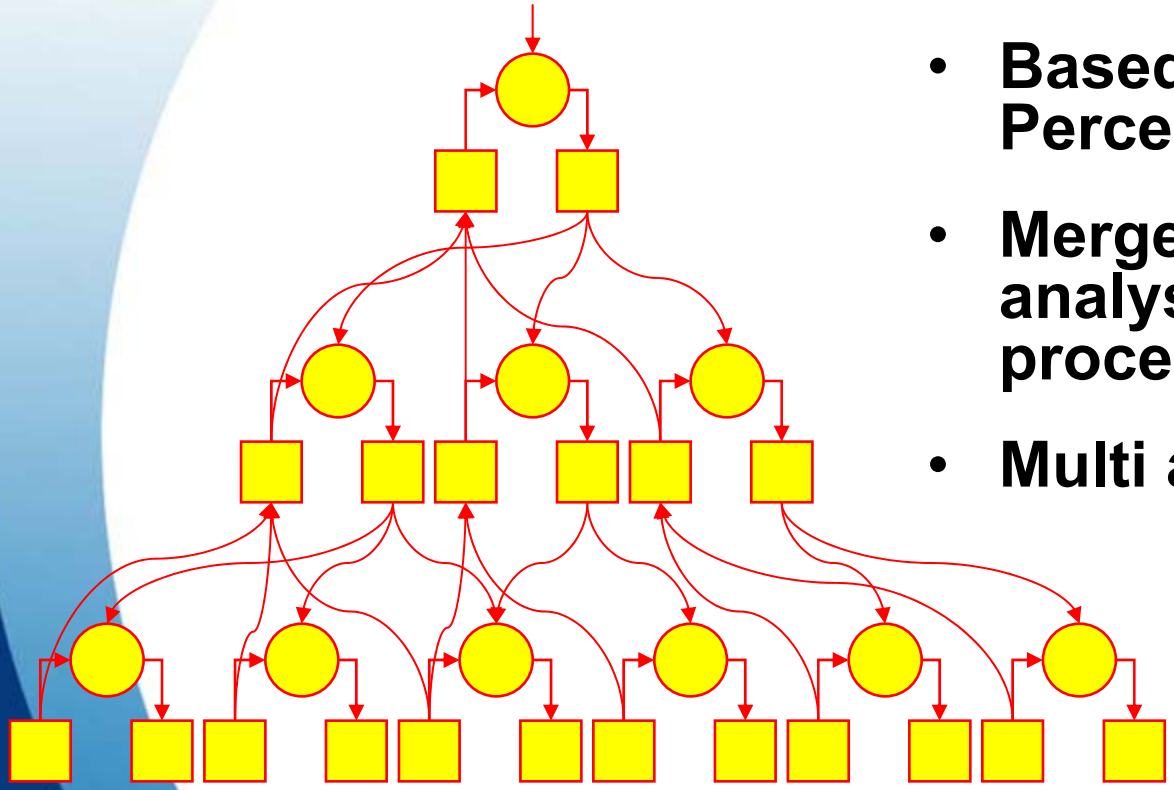
- Conceptual Design Framework for Optimising Operator-Agent Interaction
- Methodological Design Framework for Implementation of System Components
- Baseline Operational Scenario and Analysis of Anti-terrorism Mission
- Composite Scenario, Hierarchical Goal Analysis (HGA), & Performance Modeling

Mission Scenario Analysis

- Commonwealth Heads of Government Meeting Security Arrangements
- Multi-UAVs (Mini, MALE, VTUAVs) searching for terrorist vessel



Hierarchical Goal Analysis (HGA)



- Based on William T Powers' Perceptual Control Theory
- Merge Function and Task analysis into a single process
- Multi agent architecture

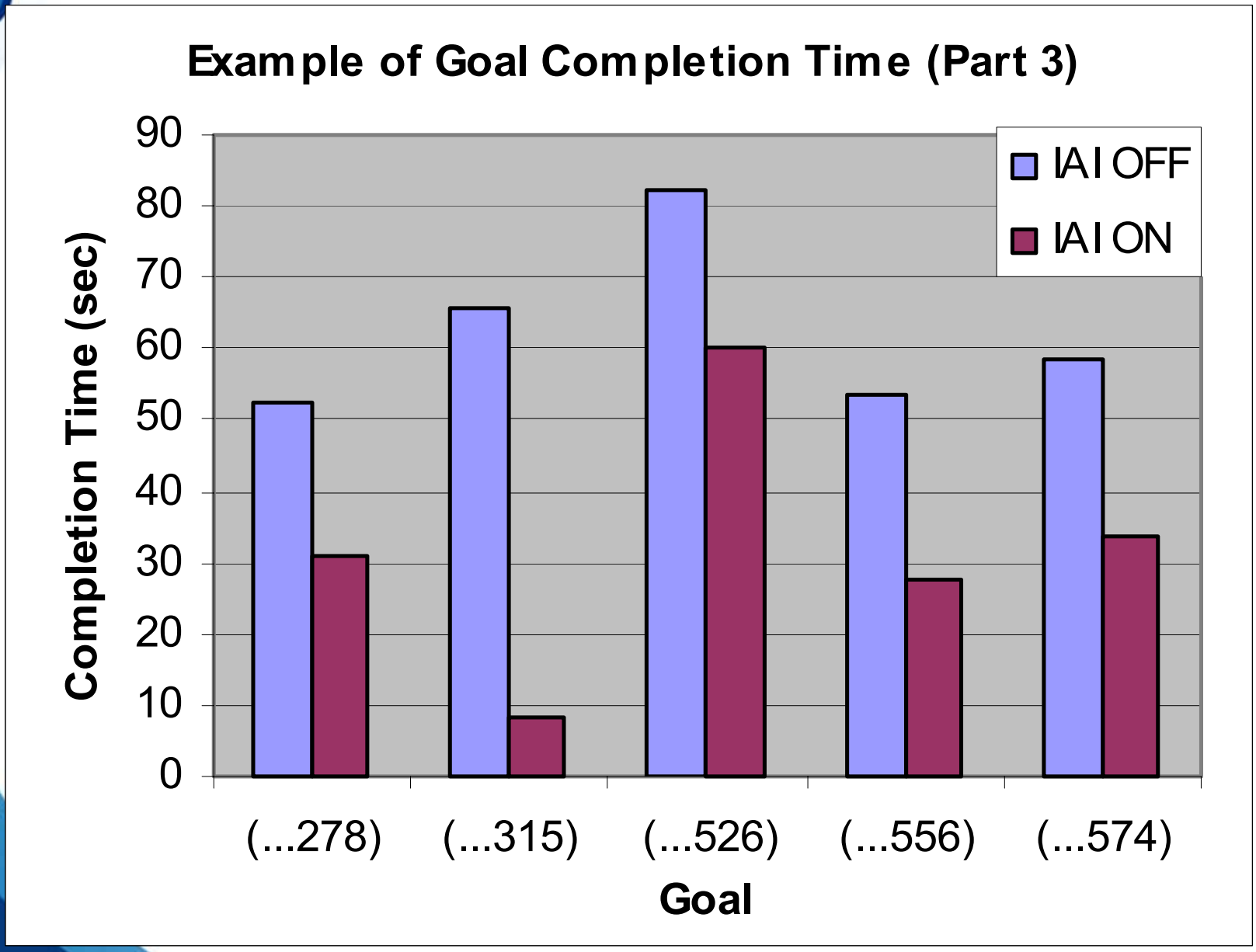
Integrated Performance Modelling Environment (IPME)

- IPME is a tool for front-end Human Factors analysis
  - Simulated timeline of human and machine activities
  - Predict operator workload, performance and error production
- Discrete event simulation
- Produced by MA&D

Measures of Performance and Effectiveness

- Percentage of time a crewmember is working with conflicting tasks
- Number of ongoing goals
- Instantaneous time pressure (workload)
- Completion time for critical tasks sequences

Goal Completion Time



Conclusions of Phase I Work

1. Improved performance was evident from IPME simulation results (with IAI ON)

2. Use of intelligent assistance (e.g., navigation and communication agents) should be considered as IAI functions in cognitively complex environments such as UAV control system

Phase II (2004 - 2005)

13IL - ADVANCED UAV/UCAV OPERATOR INTERFACE		03-04												04-05												05-06											
	Work item	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Sep	Oct	Nov	Dec	Jan	Feb	Mar
	Concept Development																																								
11.1	Mission and scenario analysis																																								
11.2	Hierarchical goal analysis and performance																																								
11.3	Theoretical IAI framework development																																								
11.4	Measurement and performance requirements																																								
	Decision Support for UAV/UCAV Operators																																								
12.1	Framework for UAV decision support																																								
	All Interface Design for UAV operators																																								
13.1	Interface design																																								
13.2	Interface implementation																																								
13.3	Scenario generator																																								
13.4	Performance measurement suite																																								
	Demonstration and Experimentation																																								
14.1	Design experiment																																								
14.2	Set up experiment																																								
14.3	Carry out experiment																																								
14.4	Analyse results																																								
14.5	Write reports																																								
14.6	Prepare TDP proposal																																								

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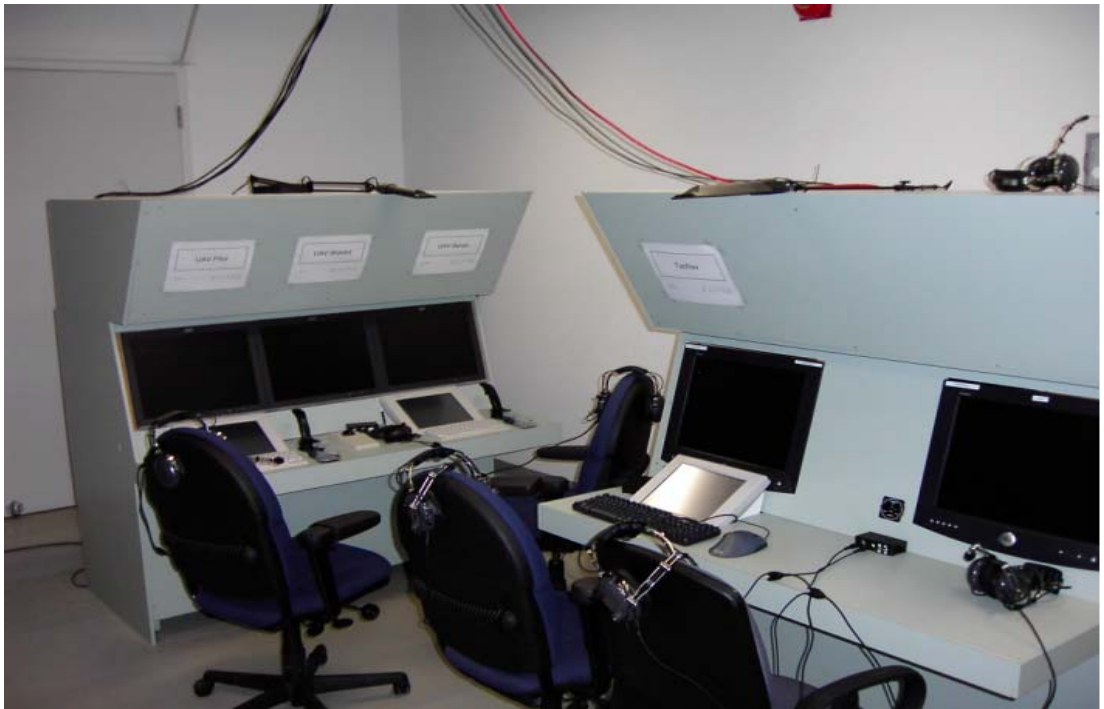
Prototype Interface Design and Development

Phase II Work

- Development of design concepts for both conventional and IAI-based interfaces
- Verification on design concepts with Subjective Matter Experts (SMEs)
- Implementation of prototype interfaces for UAV pilot (UP), payload controller/ UAV sensor operator (UO), and tactical navigator (TACNAV)
- Evaluation of interfaces with SMEs

Phase II

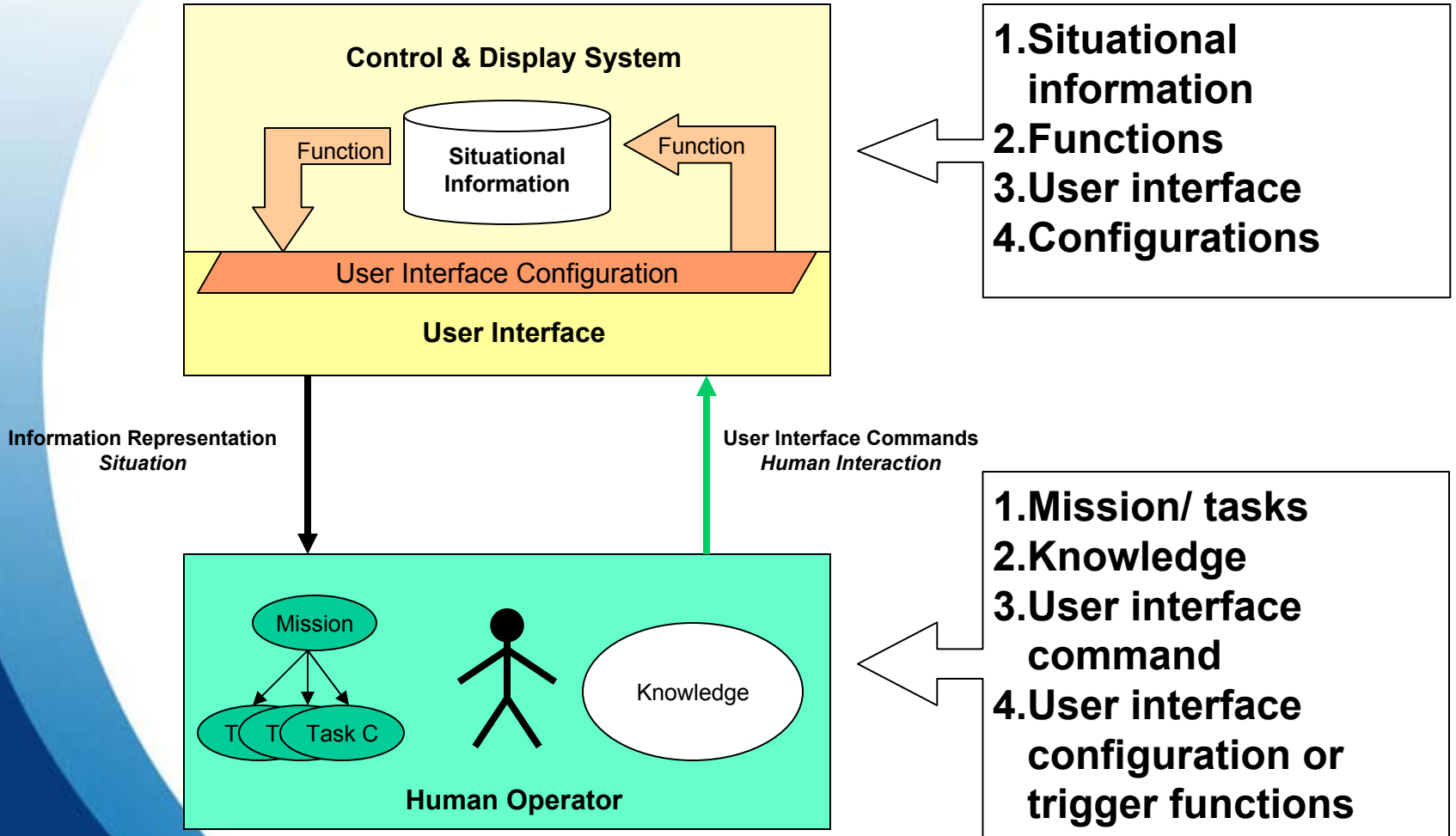
- Created an operational scenario and experimental environment that crews found both complex and realistic.
- Produced an experimental environment suitable for an assessment of IAI



Intelligent Adaptive Interface

- Comprehensive Investigation of IAI “State of the Art”
- Detailed IAI Interface Concept
- Produced Actual IAI Software (Agent JACK)
- IAI Software Development “Lessons Learned”
- IAI WoZ

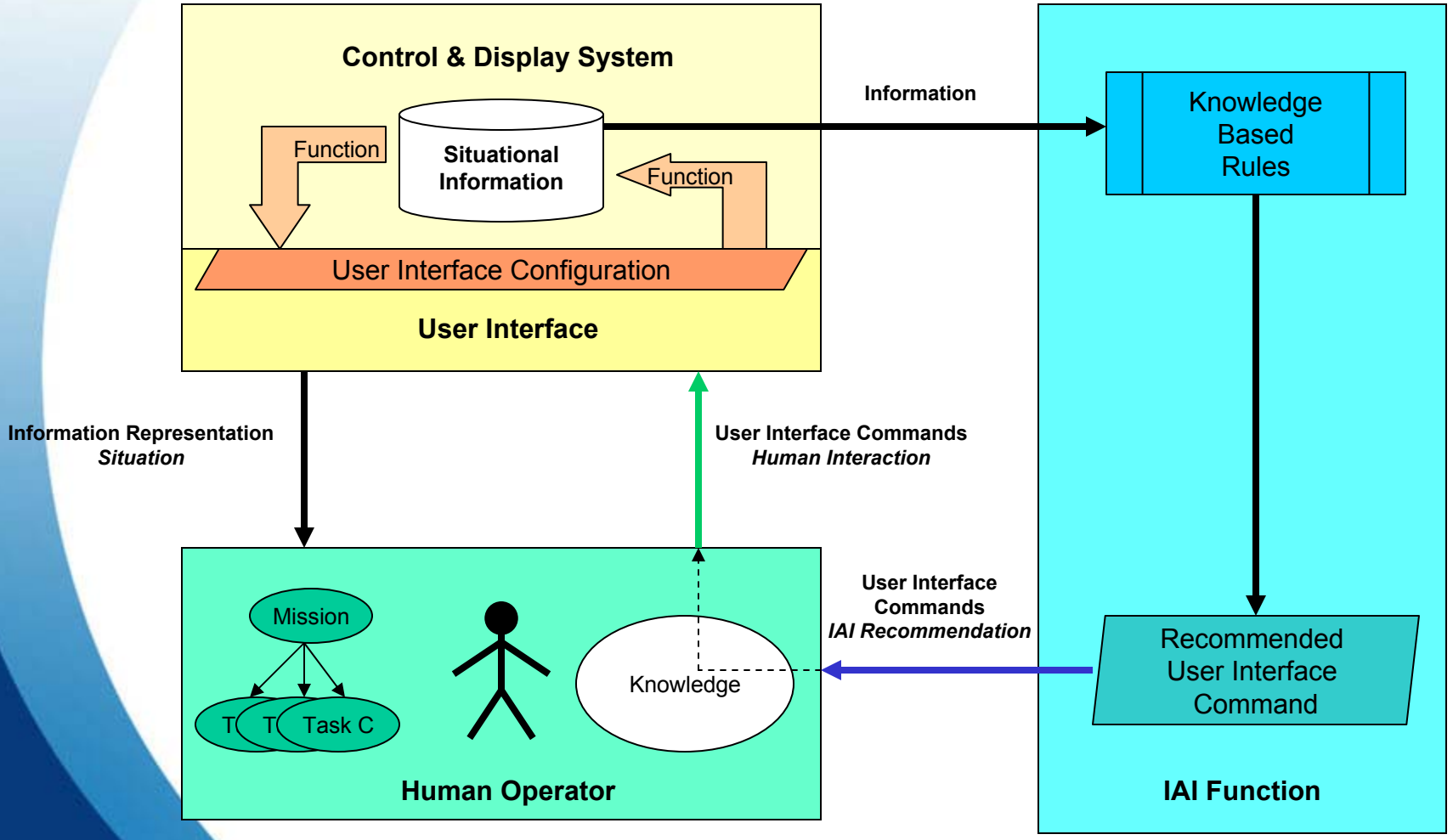
Human-Computer Interaction Model



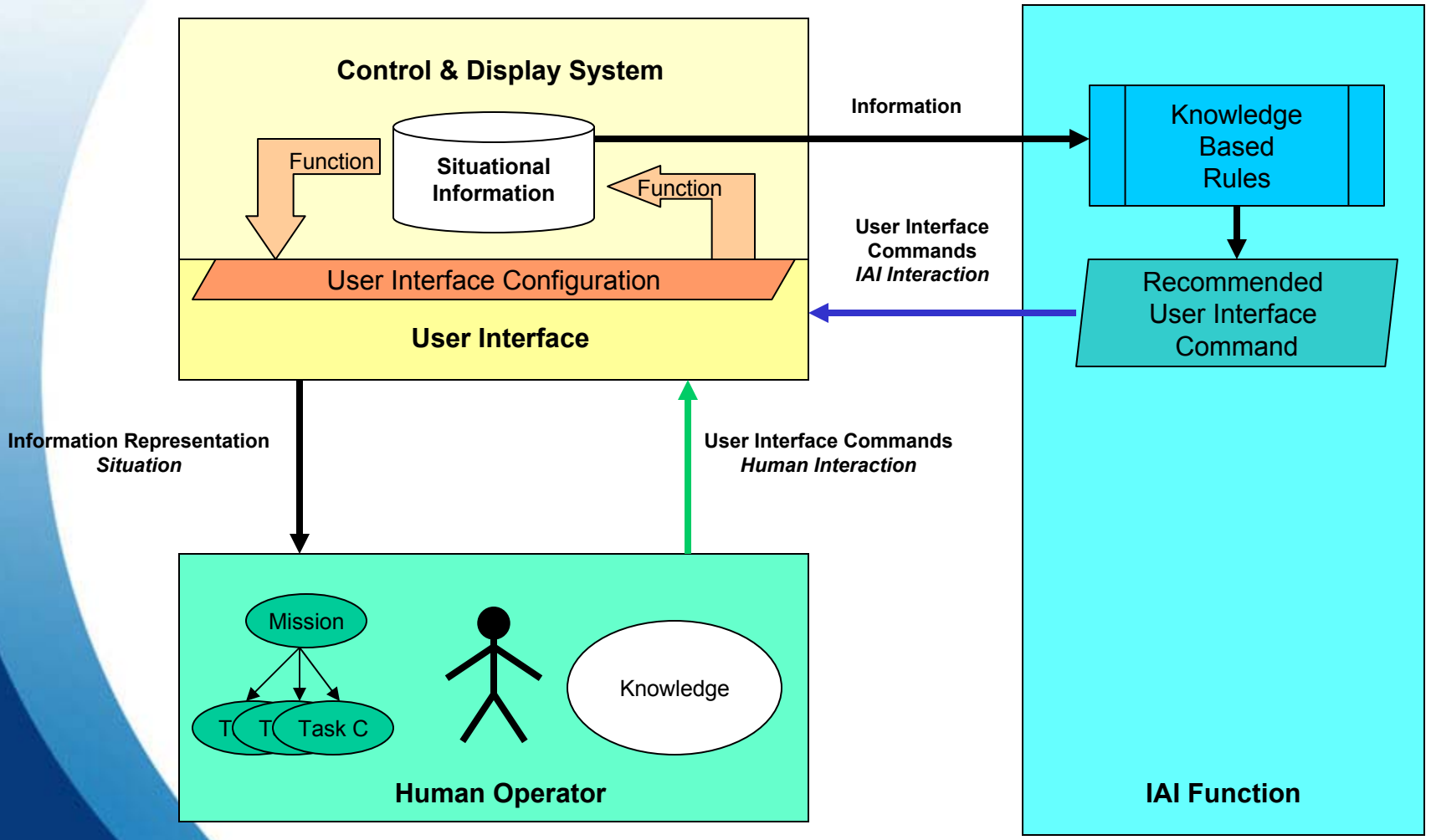
1. Situational information
2. Functions
3. User interface
4. Configurations

1. Mission/ tasks
2. Knowledge
3. User interface command
4. User interface configuration or trigger functions

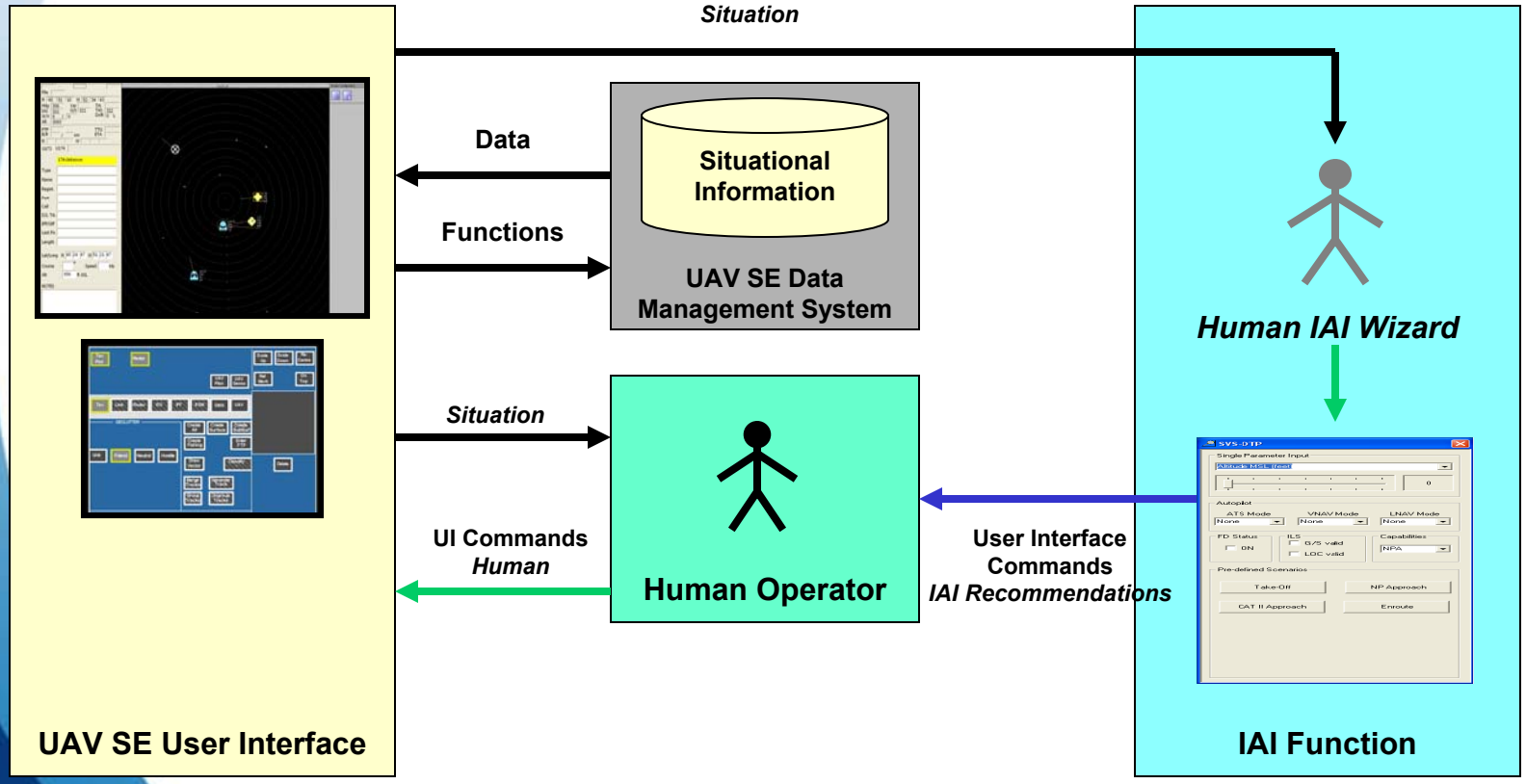
IAI Function (supporting)



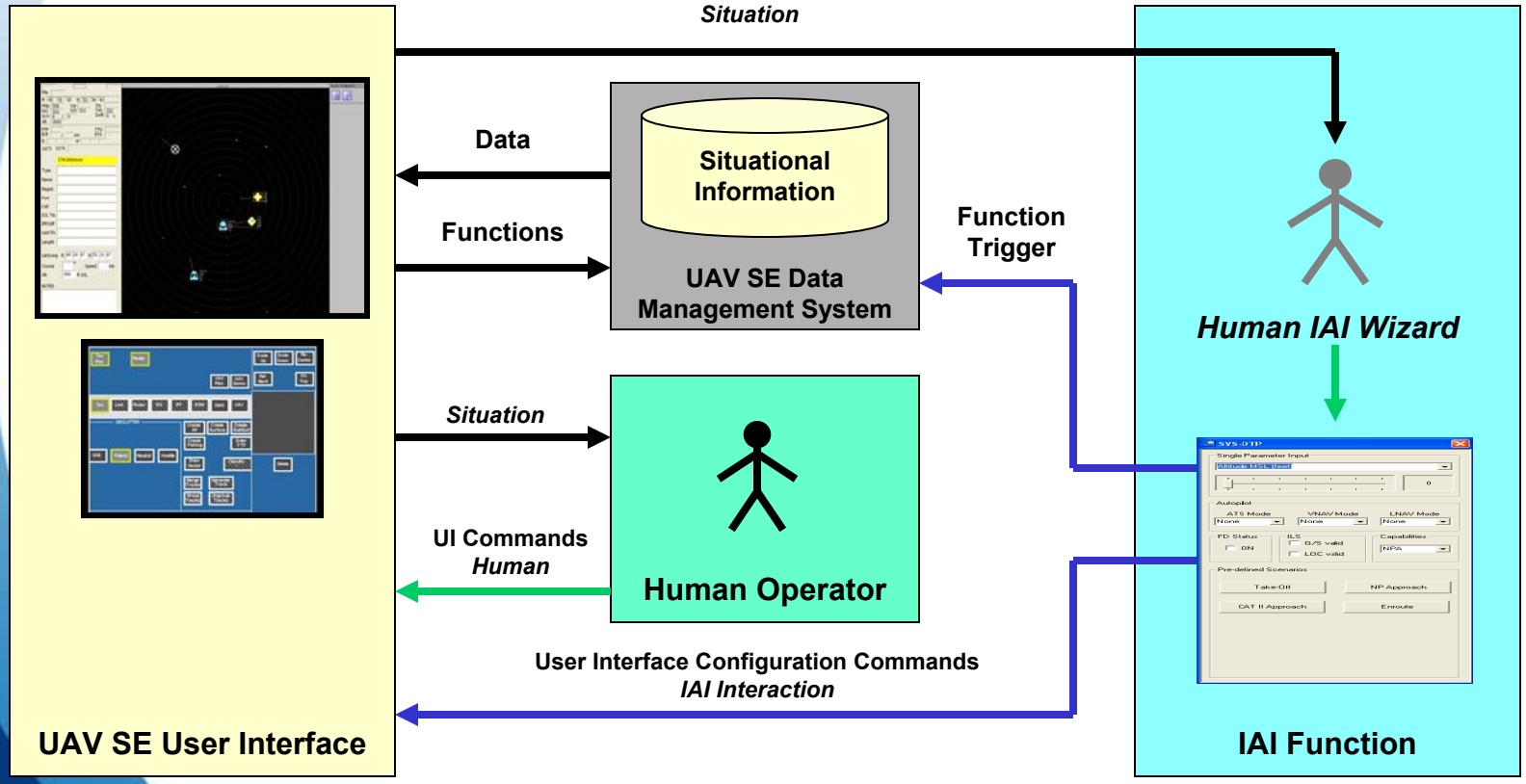
IAI Function (autonomous)



IAI Implementation Concept (Supporting IAI Wizard)



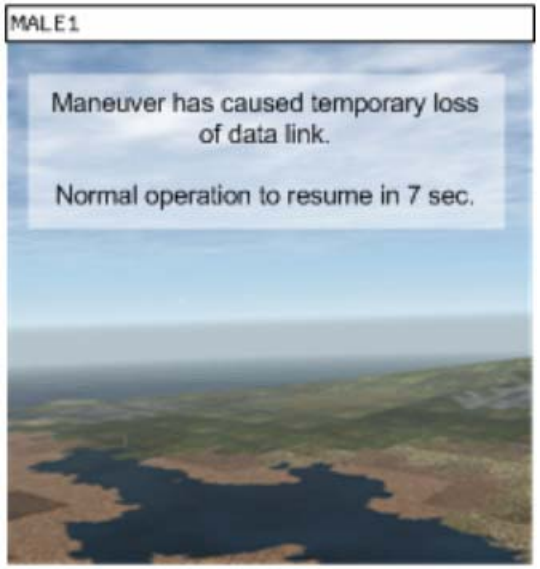
IAI Implementation Concept (Autonomous IAI Wizard)



IAI Trial Implementation

IAI functions implemented:

- Inter-crew communications
- Route planning
- Screen Management
- Data Link monitoring
- UAV Sensor Selection



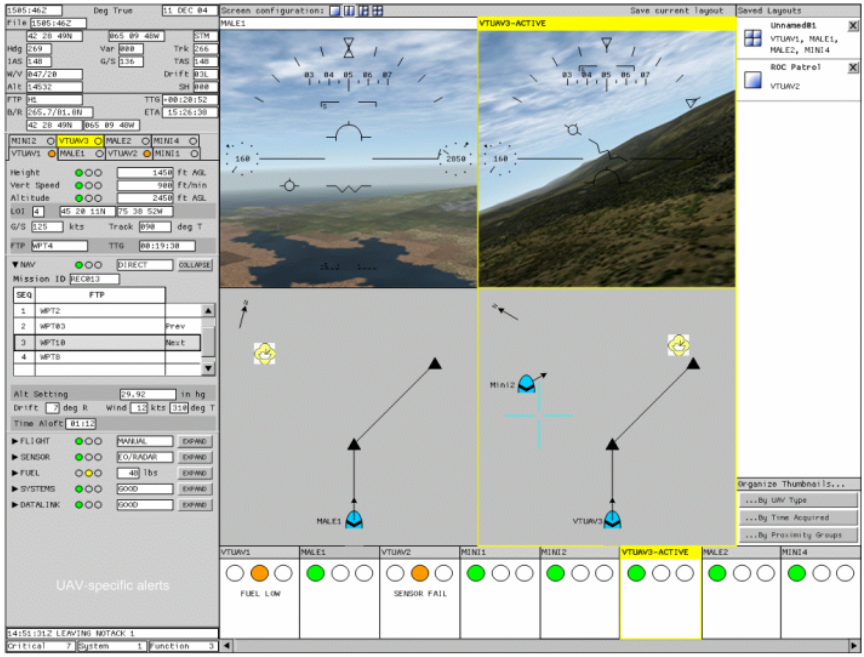


Figure 4-10 Primary Display for the UAV Pilot

Test Environment

- Free-play OI including GUI and PEP for 3 Operators
- Data, Video and Audio Experiment Data Collection
- Multiple UAV Version of STRIVE
- 4586 Interface Software
- Physical Mock-up
- User Intercom
- 3D World

Phase II Achievements

- Developed a full-dynamic simulation of three CP140 (P-3) workstations for multiple UAV control:
  - Comprehensive operational interface with 3D visuals for sensor image and pilot camera
  - Experimental functions allow intervention of all system functionality ("IAI Wizard of Oz")
  - Wide range of operational functions for UAV control, sensor operation and tactical management
  - Integrated with modern scenario and UAV simulation
  - Fully compliant with STANAG 4586

Prototype Readiness Review (March, 2005)

A Prototype Readiness Review (Pilot Test) was conducted so that an assessment could be made of the appropriateness of the synthetic environment to conduct IAI assessment trials.

Participants

Four SMEs from the MP&EU at CFB Greenwood visited to conduct the readiness review of the UAV control workstation prototypes and the associated experimental set-up.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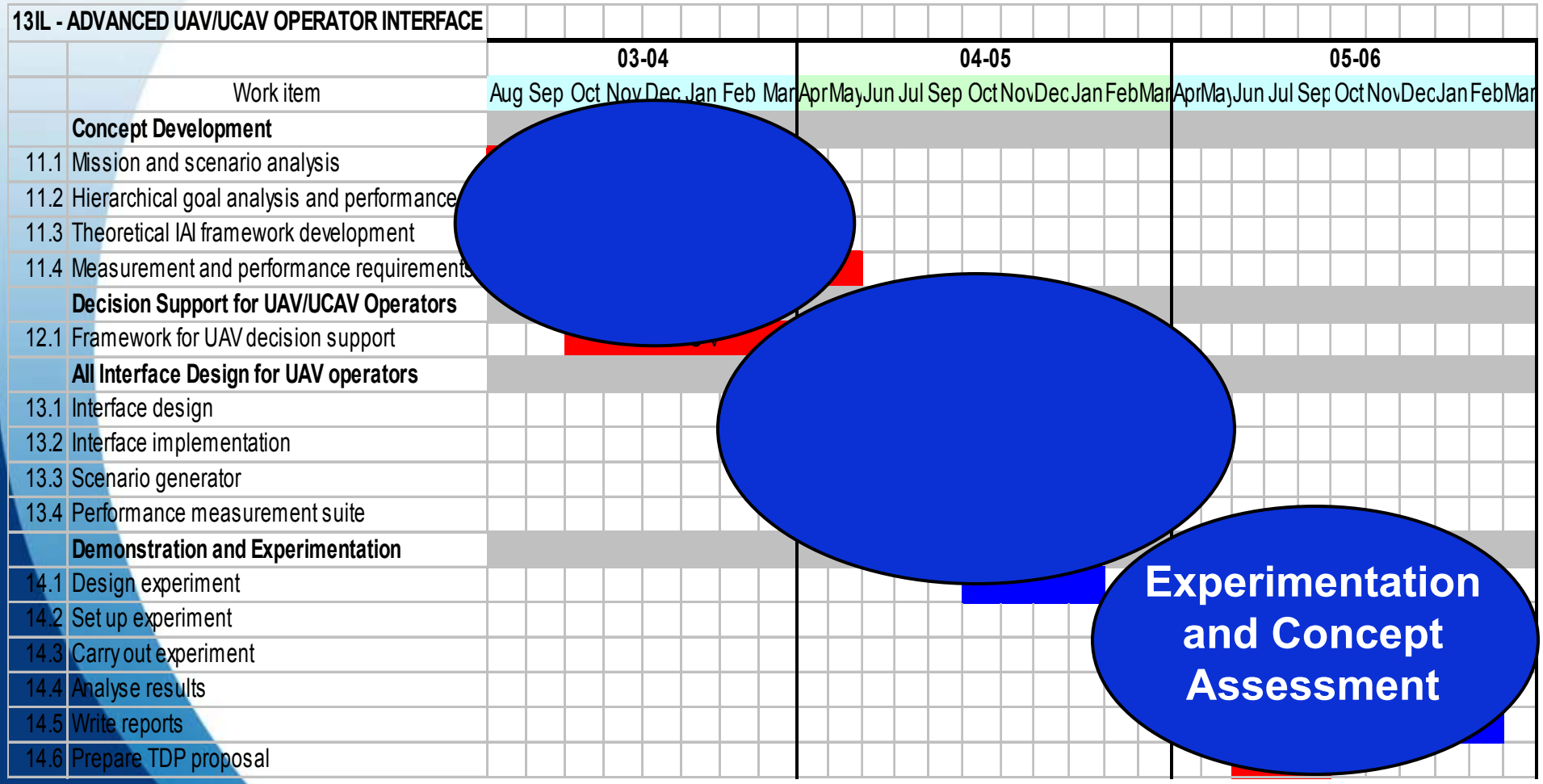
Conclusions

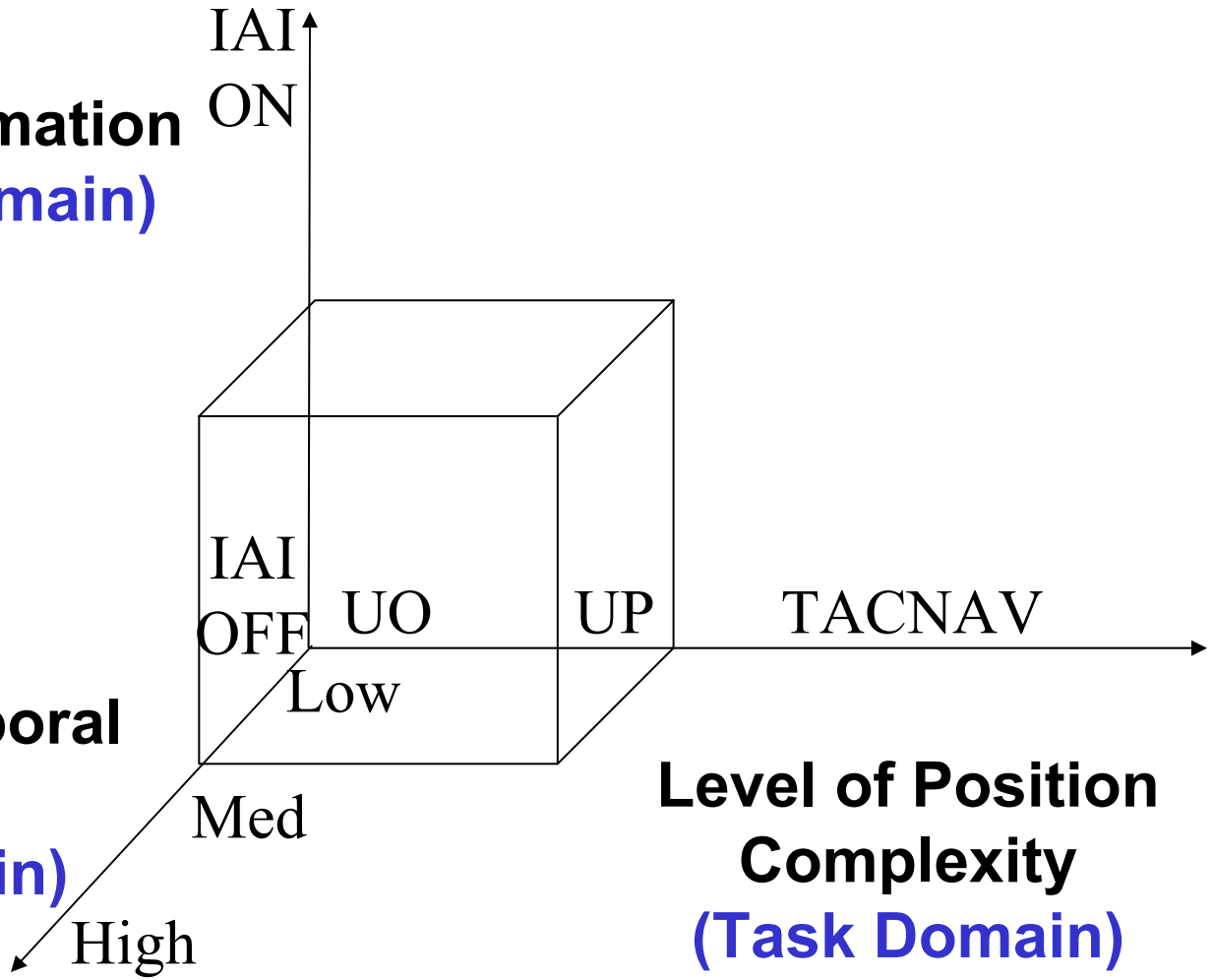
Designed an experiment that should have good power to uncover interface-related (e.g., IAI) performance effects

Phase III (2005 - 2006)



Phase III (2005 - 2006) Experimentation

Level of Automation
(Interface Domain)



Level of Temporal Workload
(User Domain)

Level of Position Complexity
(Task Domain)

Questions