Intelligent Autonomy Update

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Intelligent Autonomy

- Mission management of 5-10 heterogeneous unmanned vehicles of 3-5 types from a common control station
  - Support Littoral ISR
- Highly automated retasking & fully autonomous dynamic replanning based on high-level mission goals, priorities, and ROE’s/constraints
- Multi-UxV mixed-initiative interface & tactical monitoring relative to team/vehicle goals
- Maritime Image Understanding

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IA Major Demo Roadmap

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<td>UAV Replanning &amp; Alert Management IWDL Sim Demo</td>
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<td>MRD Path Planning/Mapping</td>
<td>Single UUV Covert Harbor Surveillance Sim</td>
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<td>GCCS ASCM Int. In-Water USV Demo</td>
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<td>GDRS (fomerly Northrop/CMU)</td>
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<td>Scene Segment &amp; Object Detect</td>
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Risk-Aware Mixed-Initiative Dynamic Replanning
Draper Laboratory/Charles River Analytics

- Completed Integrated Simulation Demo
  - 4 UUV’s (high-fidelity sim) & 2 UAV’s
  - Improved search optimization and comms tasking
  - Increased ability of operator to provide guidance on risk management to autonomous system and to automate risk assessment and mitigation
  - Increased ability to deal with weather, contingencies, environmental data
  - Improved visualization of plans/execution
  - Integration with external sources, sensor fusion, and GDRS Image Understanding Software
  - Integration with NAVAIR Virtual Warfare Environment (JIMM)

- Planning Integration and In-Water Testing on USSV platform with GDRS Image Understanding software and participation in final IA demonstrations & naval operator evaluation with mix of live and simulated assets
Naval Operator Evaluations

- Developed set of 20 human system performance metrics that can be tailored for each of the IA demonstrations and related programs
  - Not human performance metrics
  - Measuring human-in-the-loop system performance

- Conducted naval operator evaluation of IA software with 7 operators
  - 4 UUV & 3 UAV
  - 5 Enlisted (2 chiefs) and 2 Officers
  - Key Metrics
    - SAGAT (situation awareness)
    - Mental models (maps)
    - NASA TLX (workload)
    - Reaction Time
    - System Usability Scale
    - User Satisfaction Ratings
  - 2 Day Experiment
  - Operators worked individually

- Planning additional naval operator evaluations for FY07
Metrics Assessment

• SAGAT provided useful data
  – Must be focused on mission relevant information as defined by SMEs
• TLX is multi-dimensional based on operator performance task (includes frustration)
  – Cooper-Harper better measure of the system influence on workload.
  – C-H is more general measure, but more quantifiable (know what a rating of a “3” is)
  – Try both next time and compare findings
• RT events measured not very useful in isolation
  – Need to be sure they are time critical tasks (SME defined)
  – Useful relative to other similar designs or to measure improvements
Metrics Assessment

- System Usability Scale
  - Should not use individual question scores
  - Limited meaning to composite score
- User Satisfaction shows general issues, but not cause
- Attempt to draw mental models, but that did not show any differences. Need to find a good way to measure mental model.
  - One suggestions included providing stickers with objects and asking operators to place them on a map and draw circles of certainty around the objects
- Operator comments and discussion are still most valuable tool for refining design.
- Other metrics good for comparing designs.
Intelligent Control & Autonomous Replanning of Unmanned Systems
Lockheed-Martin, Georgia Tech., Univ. of Penn.

- Developed design to integrate Lockheed, Draper, CRA, Aptima, UPenn, and Georgia Tech components into the ICARUS system via the publish/subscribe component to enable team planning for UAVs, USVs, and UUVs.
- Revised software to incorporate operator feedback & demo lessons learned
- Limited capability baseline demonstrated
- Initial integration testing done at NAVAIR w/
  - Publish/Subscribe Information Management
  - Operator Interface/Alert Management
  - Georgia Tech. Case-Based Reasoning to Support Rapid Mission Planning
  - Multi-Vehicle Planning and Arbitration of Assets
  - Individual Vehicle Dynamic Replanning
  - Replanning Assessment Component
  - UPenn. Secondary Task Optimization
  - Individual Autonomous Vehicle Control Systems
- Plans for increased integration w/ non-LM components from other IA efforts/STTRs, simulation demonstrations at NAVAIR & demonstration with mix of live and simulated assets
ICARUS Integration and Demonstration

LM Component Additions

Aptima & CRA
STTR Display Technology

Georgia Tech

Mission Specification

Operator Interface

UAV Controller

UAV Planning

Team Planning

Contingency Management

Secondary Objectives

Univ. of Penn

LM Modules Pub/Sub

UUV Planning

UUV Controller

Draper Labs

Univ. of Penn

Univ. of Penn

STTR Display Technology

Aptima & CRA
– Secondary Task Optimization Component
  • Developed and Tested with Receding Horizon & Sampling-Based Techniques
  • Initial integration w/ LM
– Verification and Validation of Multi-Vehicle Planning Software
  • Developed approach and implemented a software tool for testing of complex autonomous systems planning
Multi-Vehicle Cooperation
Georgia Tech./GTRI

• Design, development, and evaluation of Case-Based Reasoning/Contract Net Protocol approach for rapid tasking of unmanned systems
  – CNP allocates the tasks to appropriate unmanned systems based on the constraints
  – CBR retrieves only relevant tasks based on the user-specified constraints
• Integration with NAVAIR MURC (STANAG 4586) environment to be used in live asset demos
• Conducted simple usability study
• Initial integration w/LM arch.
UAV Flight Test
UC Berkeley

- Flight test at Camp Roberts of 4 UAV’s with distributed control despite limited communications
  - Communication range could be varied in software
  - User specifies high-level tasks, priority (mandatory or optional) & timing options (one-time, periodic, or continuous)
  - Task decomposition/allocation decided by agents in a decentralized manner
    - Number of agents assigned to task depends on number of available agents and relative priorities of other tasks
    - Task is divided into jobs for individual agents depending on # of agents assigned
    - Tasks can be re-divided
  - UAVs avoid no fly zones & report when it effects the feasibility of a task

- Currently refining algorithms based on lessons learned from flight demonstration
Phase II STTR
Charles River Analytics/MIT (Missy Cummings)

• Definition of limited operational scenario
• Detailed cognitive task analysis to define requirements for supporting human operators in both the development of mission plans and the monitoring of plan execution in mixed-initiative systems
• Application of analytical findings to the design of advanced mission monitoring and plan analysis visualization and interaction components
• Development of prototype implementations of system displays based on these components.
• Expanded the operational scenario to target unmanned assets across multiple C2 paradigms
• Plans for expanded Cognitive Task Analysis, HCI Design/Development, and integration and demonstration as part of Draper & LM demos
Phase II STTR
Aptima/University of Iowa (John Lee)

• Mapped out a Mission Planning Information-Control Space for unmanned vehicle-supported littoral ISR missions. This information-control space is a systematic map of the functions that must be performed in completing an ISR missions, decomposed down to the specific informational properties of the environment that support those functions.

• Developed the information layer between automated planning algorithms and the operator interface

• Translated the Mission Planning Control Space map into user interface designs using principles from Ecological Interface Design. The design phase maps the various levels of information (abstract vs. detailed) to appropriate visual forms for presentation on screen, based on context of use.

• Evaluate a storyboard concept of the interface using subject matter experts

• Plans to extend interface approach and perform software implementation & integrate display concepts in Lockheed architecture for evaluation at PAX
FY07 New Efforts

• MURI
  – Human-Robotic Interaction

• SBIR’s
  – Collaborative & Shared Control of Unmanned Systems
  – Affect-Based Computing and Cognitive Models for Unmanned Vehicle Systems
  – Peer-to-Peer HRI

• Large Tactical Sensor Network EC