Autonomous Control for Unmanned Surface Vehicles

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SIS Corporate Profile

- Small Business founded in 1997, focusing on Research, Development, Test and Evaluation (RDT&E) specializing in integration of complex software and hardware systems.
- SIS develops, implements, and deploys high-end technical solutions that incorporate technologies of Digital 3D Data Capture and Imaging, Robotics, Artificial Intelligence, Autonomy and PLM.

Office Locations

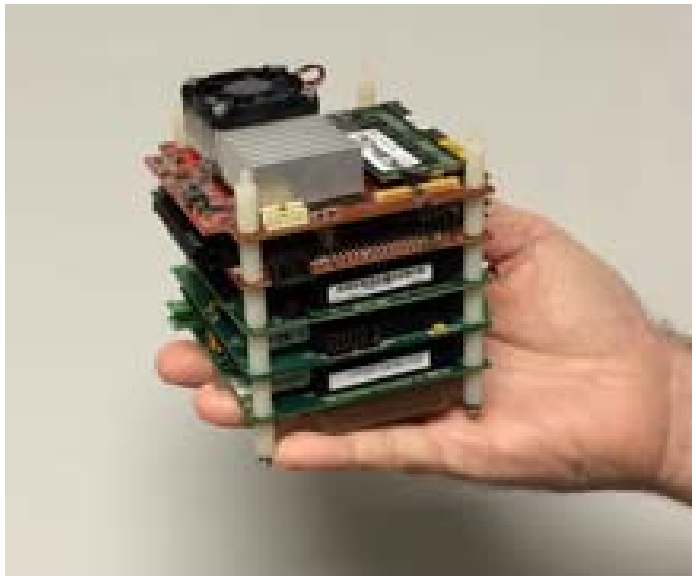
- Rockville, MD
- Virginia Beach, VA
- Kinston, NC
- Bremerton, WA (remote site)
- Training Center SVHEC South Boston, VA

Robotics Introduction

- Working with NASA Jet Propulsion Lab (JPL) supporting OSD, DARPA, NOAA and US Navy Projects since 2006
- SIS extended JPL technologies, including **CASPER & CARACaS,** to operate autonomous surface vessels
- SIS integrates CASPER & CARACaS into new environments, combining multiple platforms and communications links with new autonomy behaviors supporting a wide variety of missions
- SIS has worked to move from laboratory interfaces to tactically appropriate **Human ON the loop** operation in **limited bandwidth** environments

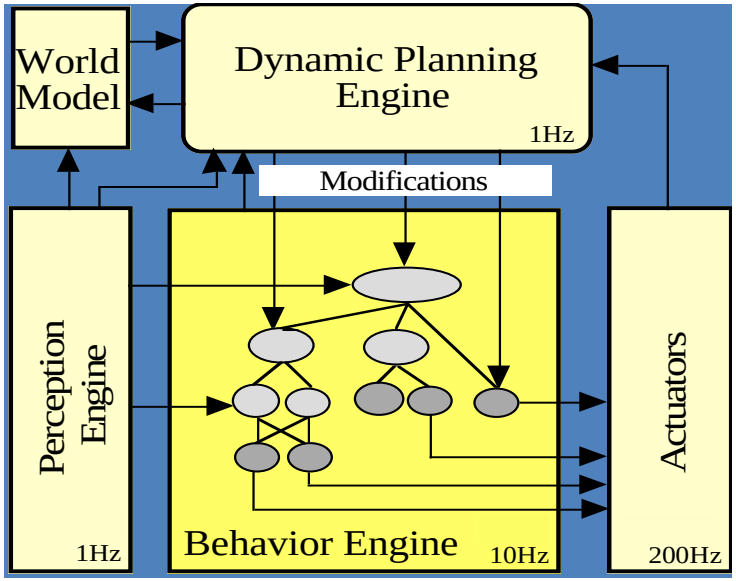
CARACaS = Autonomy

Autonomous Control - Control Architecture for Robotic Agent Command and Sensing (CARACaS)



Autonomy Framework: CARACaS

CARACaS



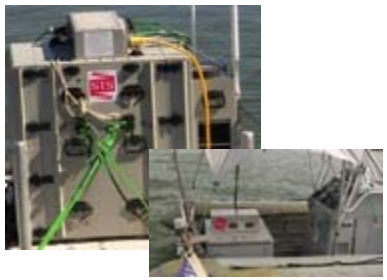
<u>Open Architecture</u> Autonomy Engine using JPL **flight-derived** technology with an integrated blend of hard real-time and periodic process control.

- Uses Industry standard Interface Control Document (ICD) communication protocols
  - TCP/IP, UDP, Pub/Sub/Open DDS
- **<u>Predictable</u>** performance of autonomous systems for PED analysis.
- Free for government use, SIS has commercial license

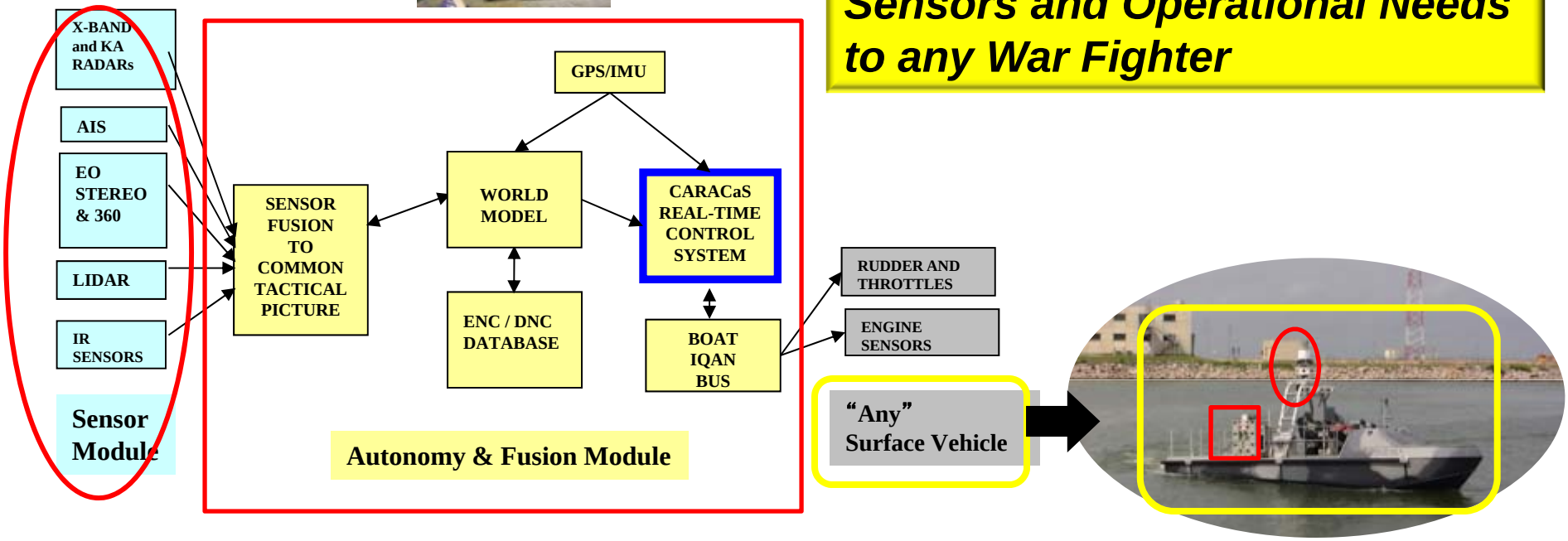
Continuous testing *using NAVY Unmanned Surface Vehicle (USV)* ***mission scenarios*** *since 2005*

"CARACaS" Enables Autonomy

- **Full autonomous capability for *ANY* Vehicle**
  - **Flexible modules: Optimal sensor mix with Fusion Module, "Plug – N – Play"**
  - **Ruggedized electronics enclosures, "Autonomy in a Suitcase"**



Mission Flexibility
Adapt Autonomous System to Sensors and Operational Needs to any War Fighter

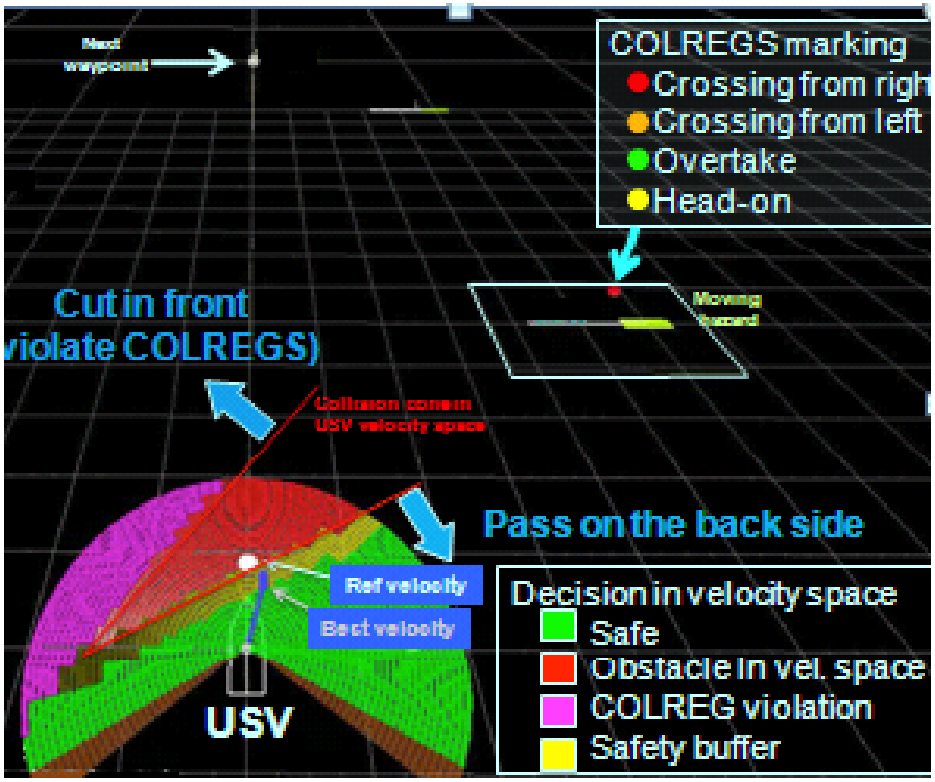


CARACaS: Behavior-Based Autonomy

Parallel Behavior Composition

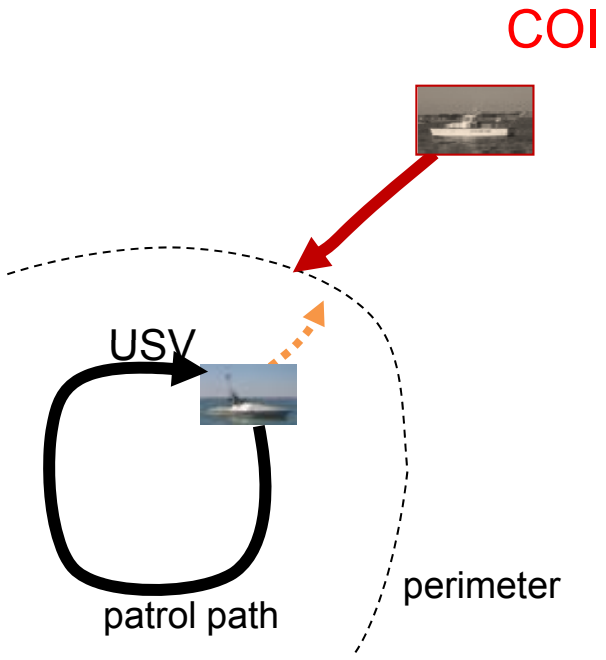
"Velocity Obstacles":

1. Go to destination
2. Avoid hazards
3. Obey COLREGs



Sequential Behavior Composition:

1. USV patrols until contact of interest (COI) detected
2. Discontinue patrol behavior and initiate intercept behavior to COI
3. Discontinue intercept behavior and initiate follow behavior



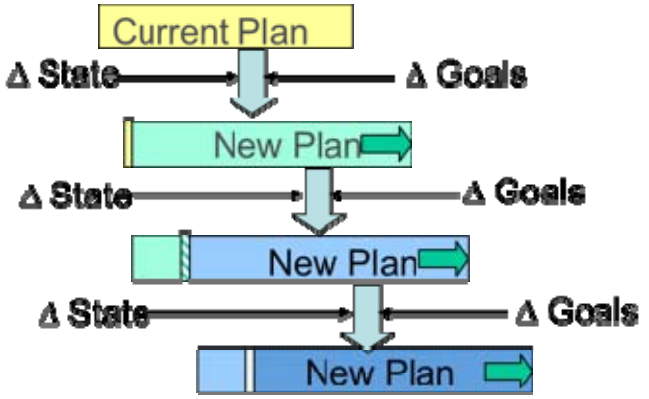
CASPER – Resource Planner

Continuous Activity Scheduling Planning Execution and Replanning

- Generates plans to meet mission goals for one or multiple cooperative swarms of robots
- Users specify mission goals, not robot actions
- Plans using available resources (robots, sensors) and known constraints (fuel, time, etc.)
- Uses plans to task robots to solve a problem
- Automatically adapts and re-plans when things change (equipment failure, new discoveries)
- Can work standalone with topic interfaces via RADS, or directly with the World Model database
- Can work directly with CARACaS
- JPL developed (free for government use, SIS has commercial license)

CASPER Planning System Features

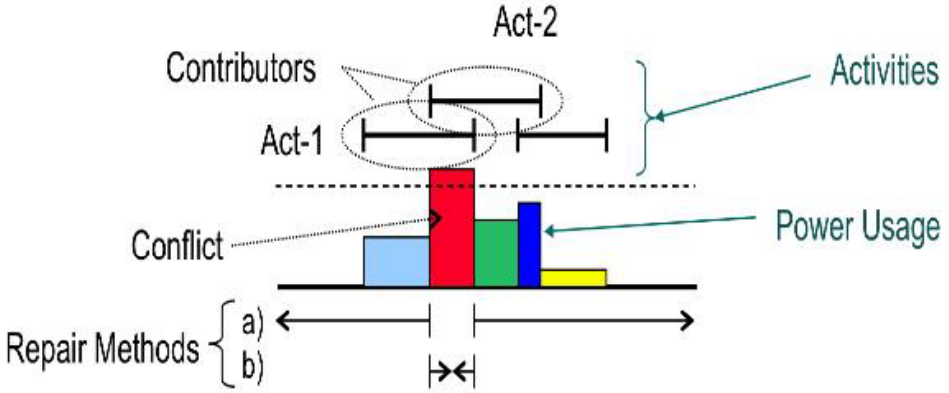
- Continual Planning Approach
  - Uses “iterative repair” to quickly repair plan conflicts and satisfy goals
  - As ground tool, can be used in fully autonomous or mixed-initiative mode
  - As onboard tool, provides rapid re-planning by continually monitoring plan execution



CASPER Continual Planning

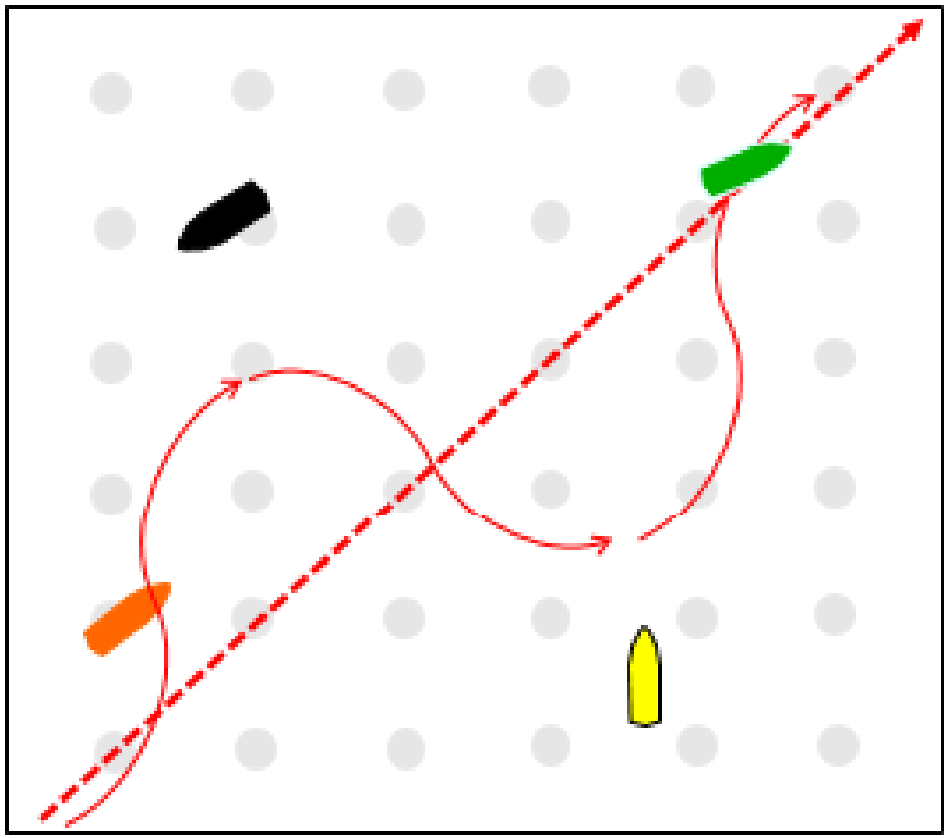
- Opportunistic
  - Respond to changing conditions
  - Different levels of reaction
  - Can be used to take advantage of unexpected resource availability

- Re-planning in response to problems
  - Handles resource or time over-subscription
  - Handles unexpected obstacles or path



Vignette Using Multi-Agent Robotic Control

Swarm Demonstration 9/16



COI enters first separated by second COI by 3000yds that enters 9 minutes later, both at 10kts, 1st COI on steady course and 2nd COI Zig Zag

Parameters

COI Contact Speed	10kts
COI Spacing	3000 yds (9 minutes)
Contact Maneuver	1st COI Straight, 2nd COI Zig Zag
Patrol Area entry point	Diagonal across Patrol Area
# UNK / # COIs	2 COI (Fountain)

USVs should be uniformly distributed across the Patrol Area (1 USV per quadrant) prior to starting each run

Potential Missions

- **Applicability:**
  - Fixed Asset Protection
  - High Value Unit Escort
  - Patrol/Search
  - Track/Trail of another vessel

- **Overcoming Challenges to Adoption (S&T Perspective):**
  - Key is human's trust in system
  - Focus on achievable autonomous functions such as perception and route-planning
    - Many others are needed as well
  - Use autonomous USVs for missions and in environments appropriate to the technical capability

USV Capabilities Available for UGV Adoption

- Autonomy software transferrable to other UxV platforms
  - Integrates with ROS & with ROS-M (when available)
- Multi-agent robotic control can support a variety of Army missions including:
  - Demonstrate control methodologies of unmanned ground assets from distant, remote locations to increase stand-off to reduce risk to Soldiers
  - Deploy/operate a long-range, multi-mission capable unmanned system to extend the Soldiers' reach
  - Demonstrate unmanned convoy operations to support global logistical resupply operations to reduce Soldiers' burdens
  - Develop autonomous systems with a high degree of inherent mobility to augment Soldiers' mission capability

The Future....??

We’re building Skynet.....

our job is to make sure the robots don’t kill us.