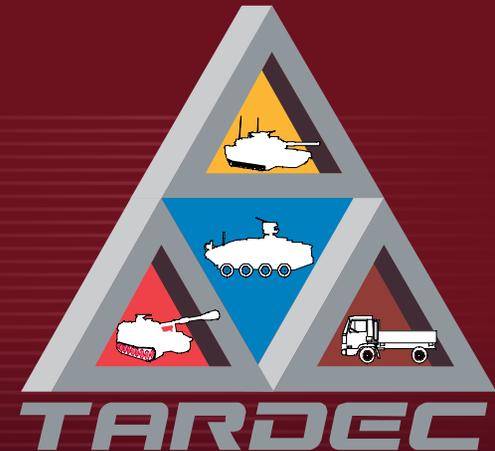




TARDEC Intelligent Ground Systems

UNCLAS: Dist A. Approved for public release



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

**AUVSI Unmanned Systems Interoperability Conference
San Diego, CA
31 Oct 07
Bill Smuda, Ph.D.**

Report Documentation Page

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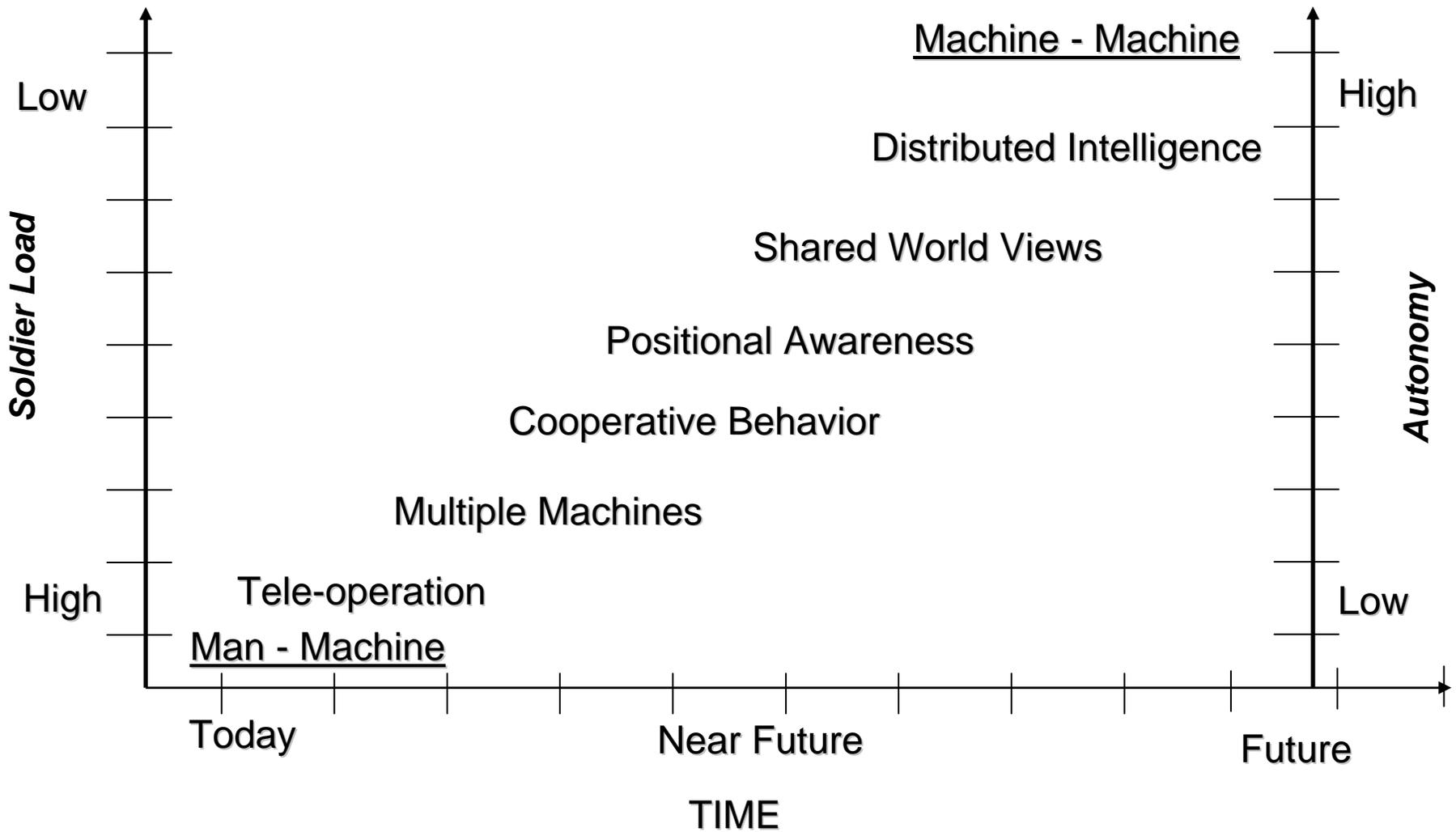
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IGS Has a Dual Role:

- **Furthering Unmanned Systems Autonomy**
 - Unmanned Ground Vehicle Platforms
 - Vehicle Intelligence and Control
 - Mission Payload Integration
 - Embedded Simulation
- **Increasing Soldier-Robot Interaction**
 - Human-Robot Interaction
 - Soldier Machine Interface
 - Embedded Simulation





•Intelligent Systems Overview

•Highlight

- Multi Robot Control – Sentinel SBIR
- Convoy
- Near Autonomous Unmanned System

Maturing UGV Safe Operations Technology through Integration and Test



Detect, track, and avoid humans



Dismounted forces safety



Maintain lane among civilian traffic



Integrating FCS representative technologies

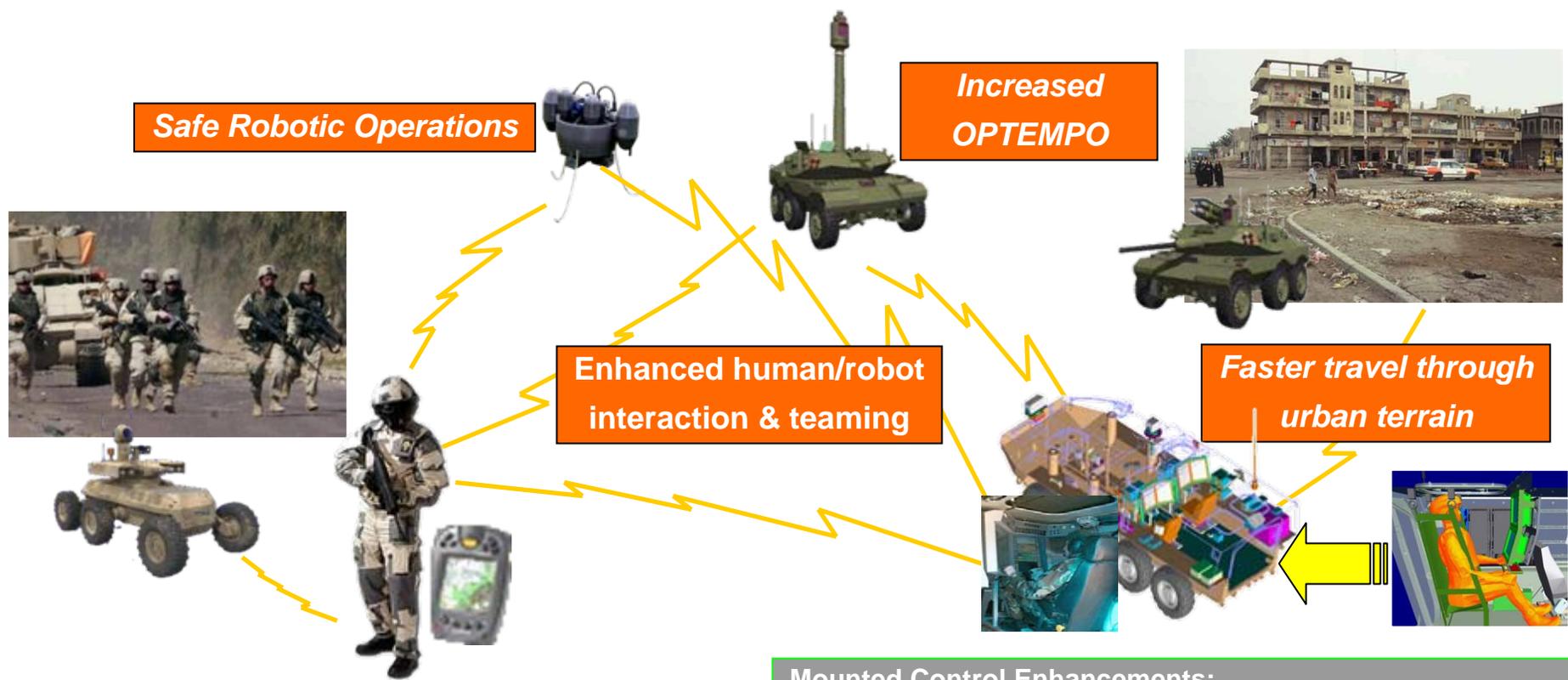
Integration:

- Gen 5 Autonomous Navigation System (ANS)
- Tactical Autonomous Combat – Chassis (TAC-C)
- ARL R-CTA developed algorithms

Test & Experimentation:

- Address FCS Risk UGV0213
- MULE & ARV relevant scenarios

- Directly address risks associated with employing UGVs in dynamic environments.
- Identify additional risk areas of operating UGVs around moving traffic, pedestrians, and dismounted forces.



Safe Robotic Operations

Increased OPTEMPO

Enhanced human/robot interaction & teaming

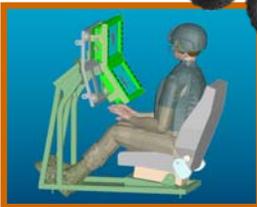
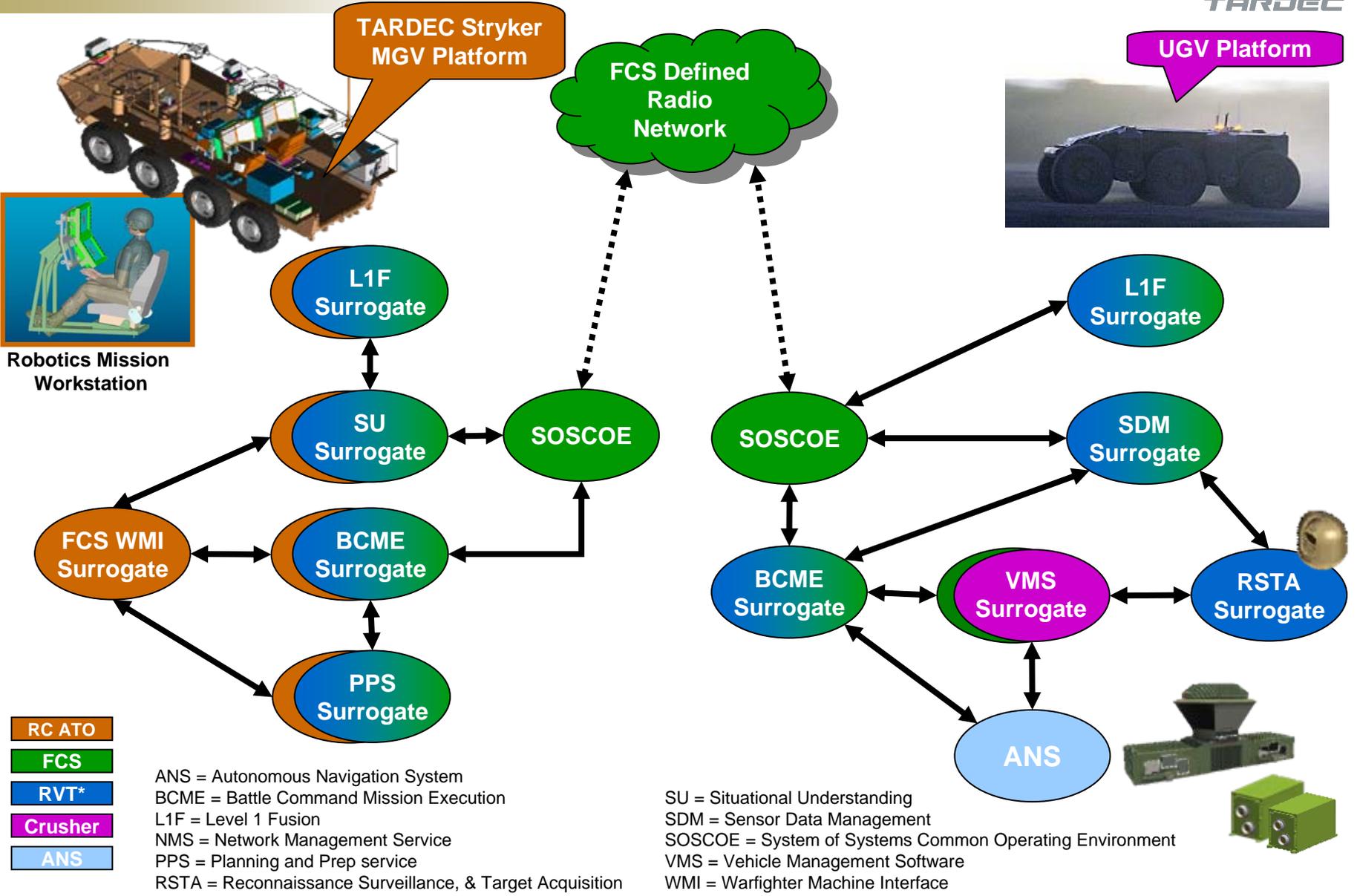
Faster travel through urban terrain

Dismount Development and Integration:

- Dismounted UGV following
- Increased planning capability
- Enhanced robotic understanding through non-visual cues (tactile)

Mounted Control Enhancements:

- Increased planning capability (replan and formations)
- Coordinated UAV/UGV operations for increased SA
- Soldier assists to autonomous capability during slow-downs and stoppages
- Better UV understanding for enhanced tele-operations



Robotics Mission Workstation



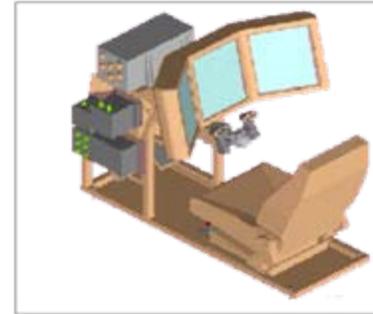
UGV Platform





Primary Efforts:

- Manned and Unmanned System Control
- Scalable Mounted and Dismounted
- Soldier-Machine Interfaces
- Intelligent Agents and Adaptive Automation
- Improved Local Situational Awareness and
- Mobility/Navigation
- 3D Map Visualization
- Indirect Vision Driving



Customers: PM FCS (BCT), PEO GCS, PM MSI

Existing Actions/Contracts for FY08:

- Human Robot Control
- Intelligent Systems Simulation & Technology
- Colorized Ranging

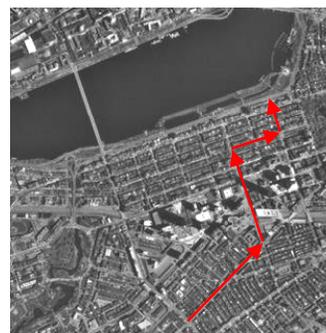


Potential Competitive Solicitations for FY08/09:
Secure Mobility

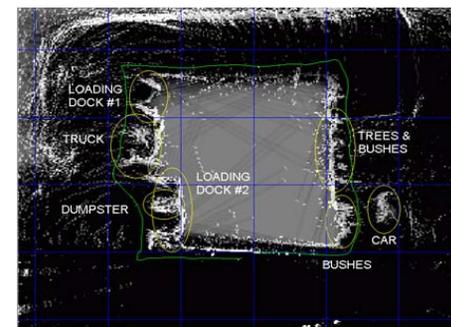
Intrinsic Mobility



Intelligent Mobility



Autonomous street following

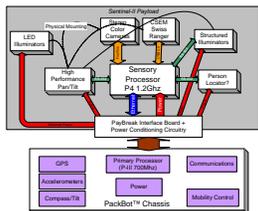


Autonomous perimeter following demonstration

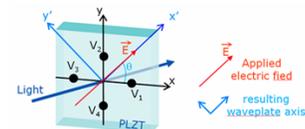
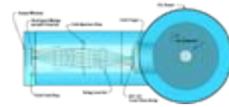
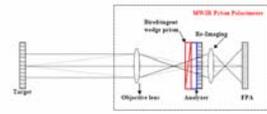
Innovative Control



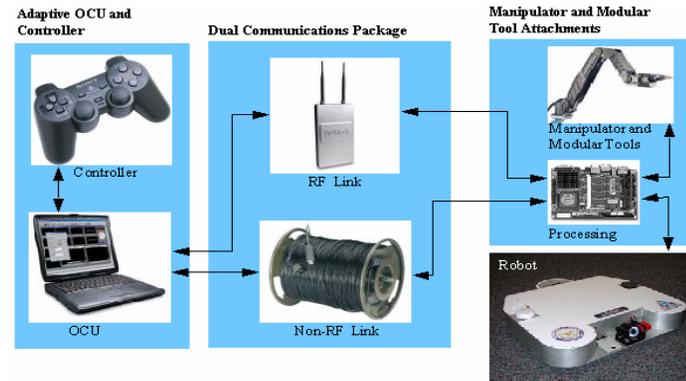
Sensor positioning for sub-vocal speech detection



Advanced Sensors



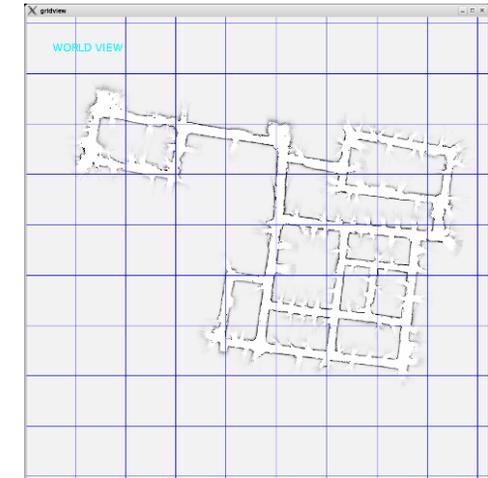
Adaptive Payloads



Sentinel: A System for Command and Control of Small Tele-operated Robots

iRobot

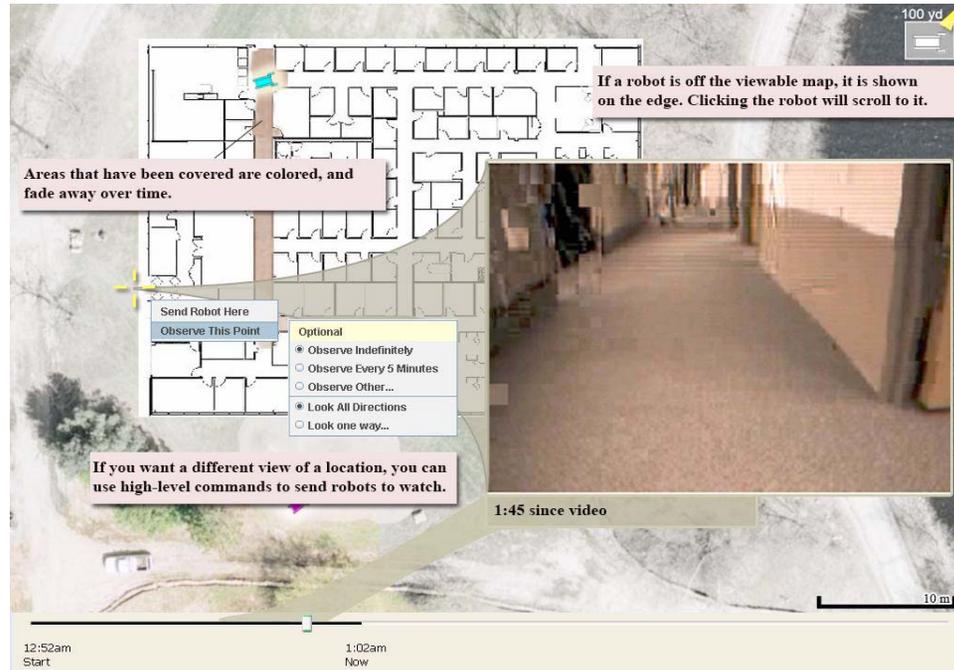
POC: Robert Karlсен



- Dynamic camera selection
- Tele-operated control of robot teams
- Semi-autonomous control of robot teams including local waypoints and leader-follower behaviors
- Fully-autonomous control of robot teams including navigate to waypoint

- Variable autonomy levels based on current situational demands
- Mobile robot self-localization and mapping in indoor environments
- Path planning
- Obstacle avoidance and understanding

- Building breaching operation
- One operator & team of robots
 - Two or three robots scout corridors, around corners and in rooms
 - One follows to guard the area behind
- Autonomy allows control via a high-level map interface.
- Tele-operate any of the vehicles when necessary.



- Sentinel builds on the Wayfarer program
 - Autonomous travel down communications-denied urban streets
 - Gather video and map data and return to the operator
- Sentinel project is expanding to allow control of an R-Gator



Sentinel applied to control a USN 7-meter RHIB

- Joint ground/water operations
 - Remote transport of ground platforms via water
 - Landing on a beach
 - Deploying the ground systems for reconnaissance
- Harbor patrol with multiple USV platforms
 - Harbor mapping
 - Change detection
 - Ship security radius



Robotic Convoy Concept

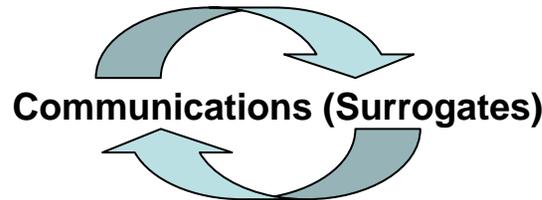


Armored-C2 Leader Vehicle



- Manned or Unmanned Vehicle
- Single Crew Station (ANS Operator Can Teleop Follower; Initiate, Monitor, Terminate Ops)
- Leader or Follower Capability
- ANS Components
 - Perception Sensors
 - Computer System
 - GPS / INS

25m – 2000m
Vehicle Spacing



- Leader Follower behavior
 - Lead Vehicle Provides GPS / INS Waypoints for Follower
 - Captures Sensor Data
 - Records vehicle status
- Teleoperation
 - Operator Provides Velocity / Steering Commands
 - Uses Compressed Video
- Surrogate Communication Network to Address Initial Bandwidth and Latency Considerations

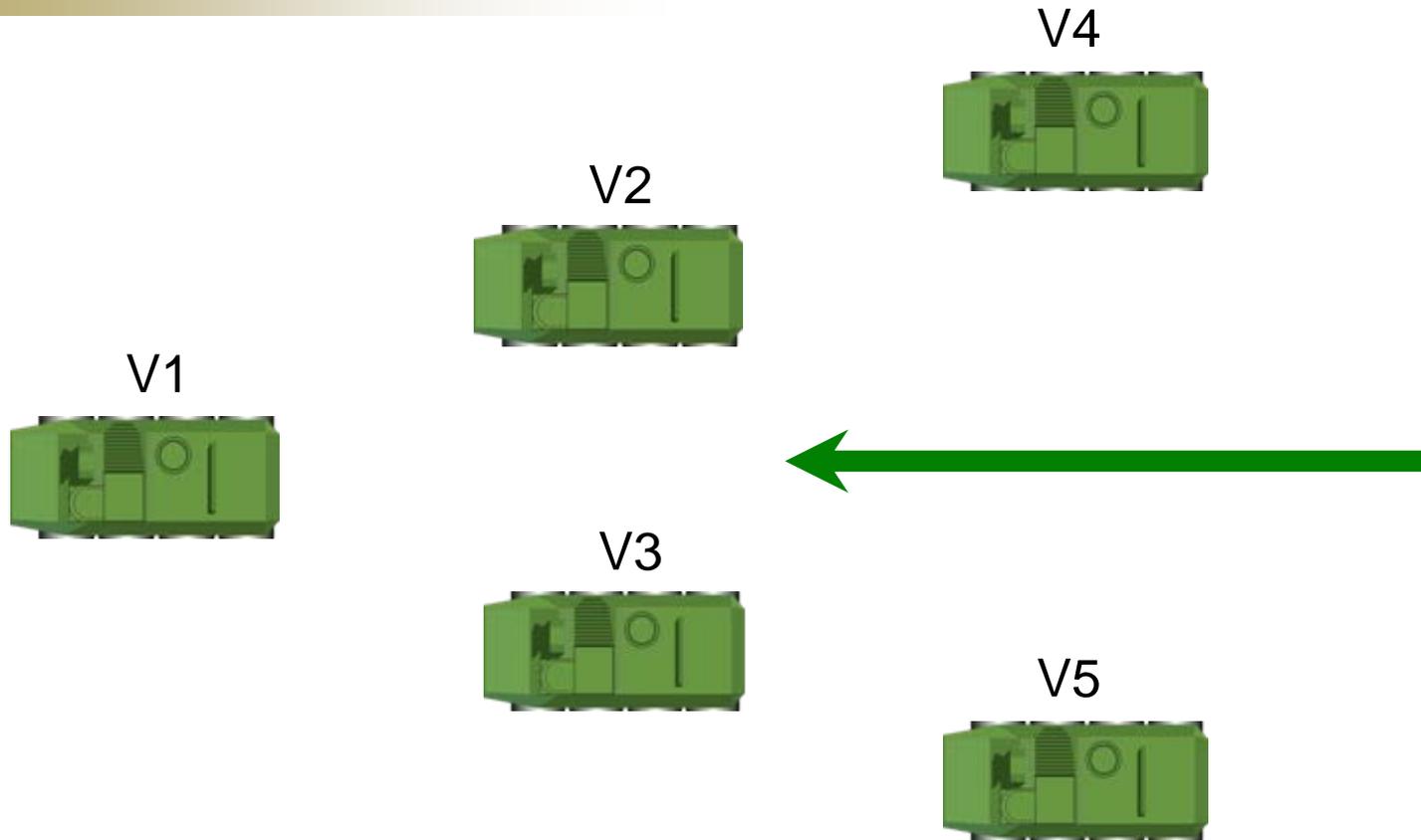
Military Tactical Vehicles – Followers (FMTV 5.0 & 2.5 Ton)



- Autonomous Navigation
 - Safety Operator in Each Vehicle
 - 2 to 4 Vehicles Follow the Lead Vehicle in Various “Formations”
- ANS System Navigates
- Communication System
- Leader Follower Capability
- ANS Components
 - Perception sensors
 - Computer system
 - GPS / INS



- Automate two 5 ton FMTV trucks to perform autonomous vehicle following
- Joint Project with PM CS/CSS
- Goal is low cost robotic convoy capability
- Supports manned driver automation for manned convoys
- On- and off- road operations
- Field Testing in November 06



- Echelon Formation Used in Open Terrain
- Operator Control Unit Located in Any Vehicle or on the Ground
- Formations Will Vary With Terrain and Experimentation Needs
- A Formation is Defined by Following Distance, Lateral Offset, and Speed

Near Autonomous Unmanned Systems (NAUS)



Autonomous Mobility



Tactical Behaviors

Purpose:

Develop and demonstrate key robotics technologies to reduce risk for PM FCS (BCT) and increase the utility of future unmanned systems.

Product:

- **Near-autonomous maneuver in environments relevant to FCS**
- **Validated tactical behavior methodology and integrated tactical behaviors**
- **System self security – fundamental technology for detection & tracking, and integration of weapon station**

Payoff:

- **Unmanned systems able to meet FCS threshold operational requirements**
- **Reduced burden on soldier & network**
- **Unmanned systems with greater survivability**

MILESTONE	FY06	FY07	FY08	FY09
Longer range, higher resolution perception (ARL)	[Progress bar]			
Personnel & vehicle detection & avoidance (ARL)	[Progress bar]			
Tactical Behaviors (ARL/TARDEC)	[Progress bar]			
System self security (TARDEC)	[Progress bar]			
Remote weapon station (ARDEC)	[Progress bar]			
Integrated reduced workload human interface (ARL)	[Progress bar]			
Autonomous unmanned vehicle field exercises (ARL)	▲	▲	▲	▲
Conduct development trials (TARDEC)			5	6

- * Vehicle
- ** Squad
- *** Platoon

Past

Leveraged Core Behaviors *
from CAT ATD

Fixed Formations **

System Self Security *

- Detect / Classify threat tracks
- Recommend Response
- User executes the response

Current

Dynamic Formations **

- Enter/Exit Formation
- Contact Drills
- *GPS based localization*

System Self Security *

- Autonomous Response
- Rules of Engagement
- Threat Pre-emption
- Response Resource Mgmt.
- Threat Track Consolidation

Future

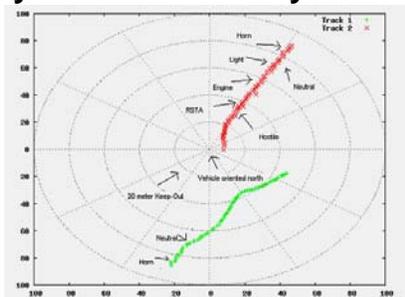
Reactive Formations ***

- “Beyond GPS” based localization
- Action Drills (*Action left/right*)
- Manage COM Loss

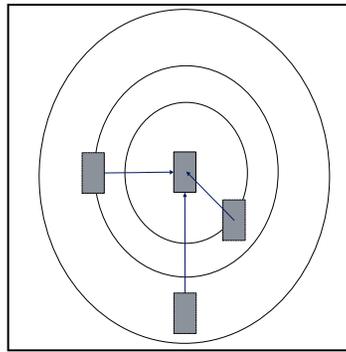
System Self Security *

- Vision based Intent Classification
- Threat cluster detection
- Multi-system tracks consolidation
- Intrusion detection on-the-move
- On-the-move detection and response

System Self Security

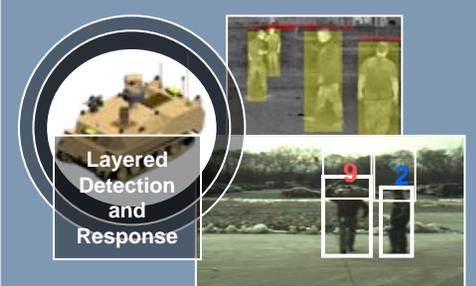
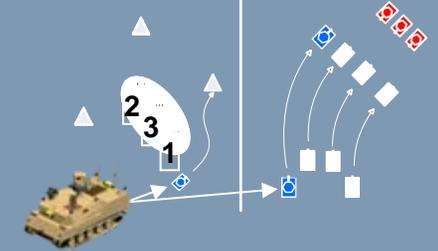


Tactical Formations



CAPSTONE DEMO w/ USERS

September 2008



Layered Detection and Response

Program Exit Criteria Elements



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<u>Move in Formation (<i>Flat terrain</i>)</u>
Max Deviation Separation Distance (<i>heading rate is +/- 3 deg/sec</i>)
Average Speed (<i>Meters/Seconds</i>)
Interventions (<i>Qty.</i>)
<u>System Self Security (<i>sTarget/mTarget</i>)</u>
Probability of true positive detection (<i>% of time</i>)
Probability of false positive detection (<i>% of time</i>)
Avg ID Time (<i>Seconds</i>)
Range (<i>Meters</i>)

sTarget = Static Target
 mTarget = Moving Target

Funding Increment Nov 2007

Formations

Self Security

Demonstrate multi-vehicle formation behavior using GPS/NAV
Manned (2)
Unmanned (1)

Demonstrate multi-vehicle formation behavior using "Beyond GPS" sensor solution
Manned (2)
Unmanned (1)

Demonstrate multi-vehicle formation behavior "Beyond GPS" sensor solution based formation behavior.
Manned (1)
Unmanned (2)

Integrate Additional Sensors (UWB, EO, RSTA, Stereo, IR, etc...as required)

Integrate VIS and establish new ROE for VIS hostility level and crowd behaviors

Develop response capability to retreat or advance as ROE requires for self security

Demonstrate SSS on the move*

Capstone Demo /w User



* Depends on UWB and VIS success

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