ROBOTICS

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Ft. Bliss TARDEC VTI Demonstration

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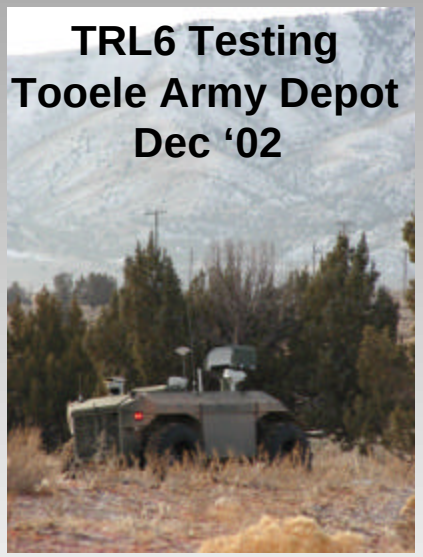
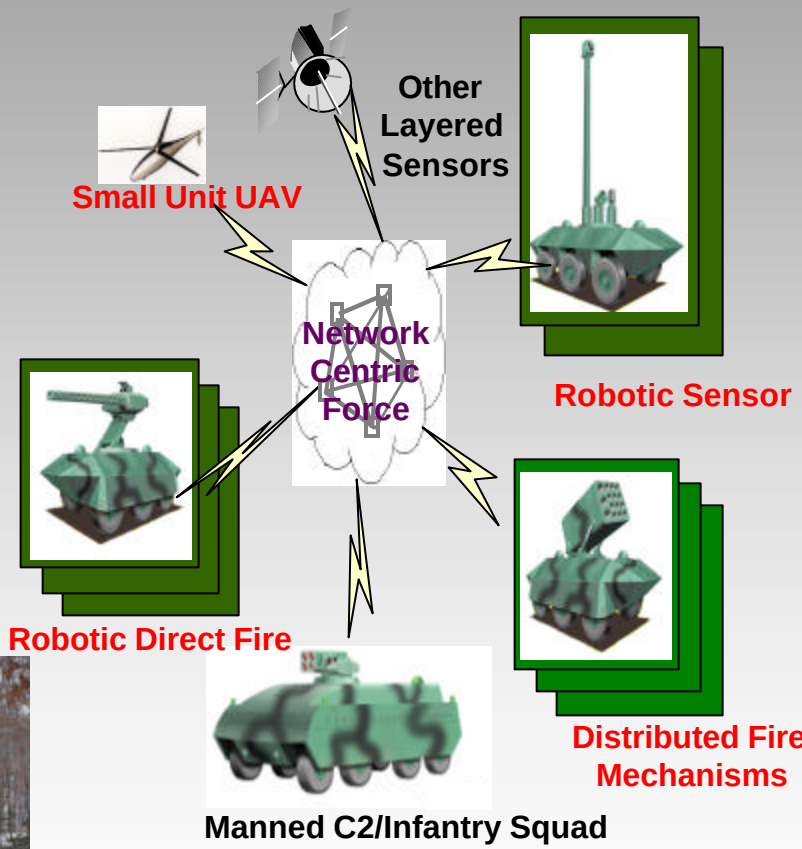
Robotics
Vision

Develop & demonstrate critical robotics technology required to enable formation of the Objective Force

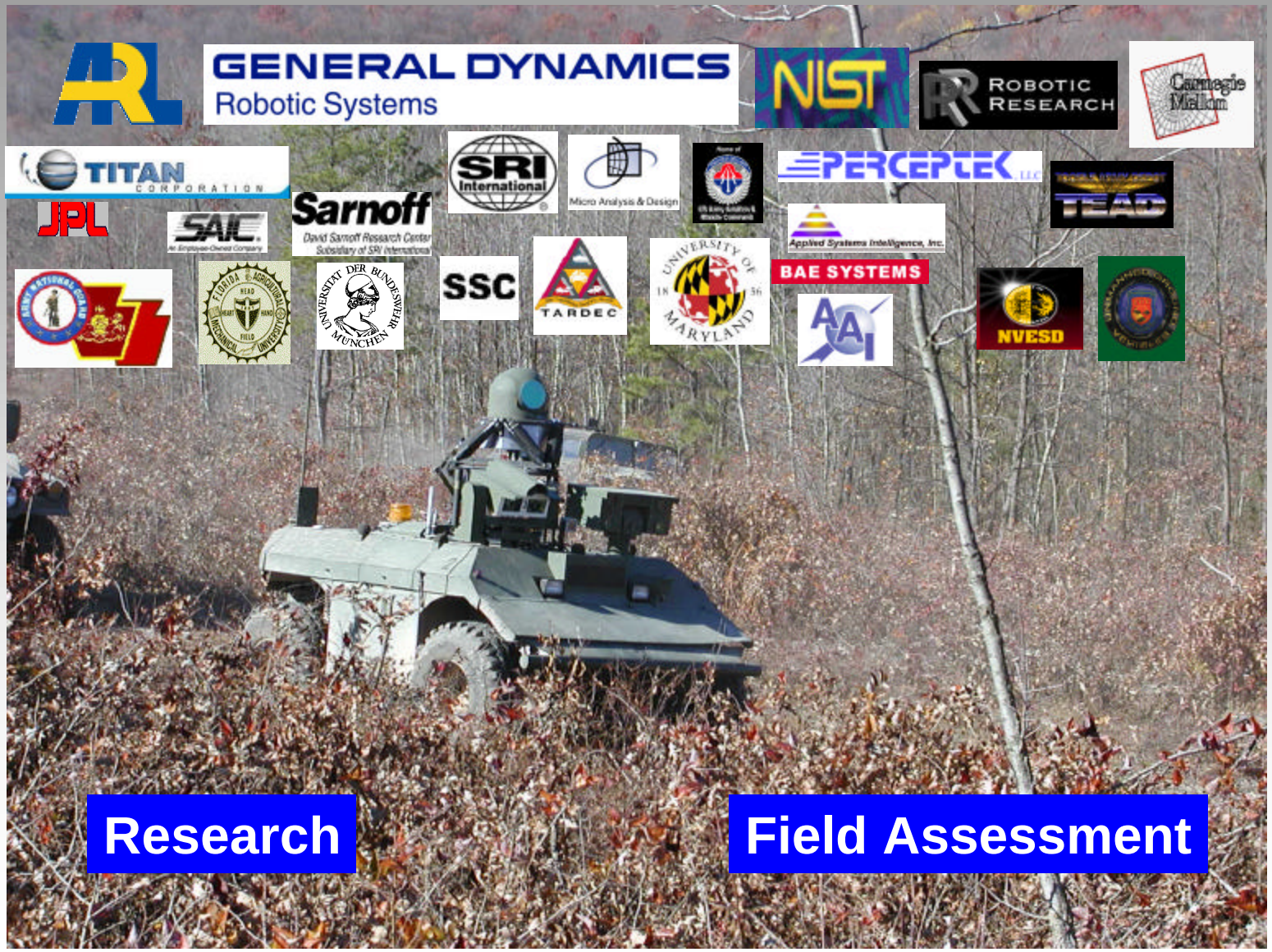




Autonomous mobility is key to multiple future military missions

Integrated Team Effort

Supporting Technology Development



Robotics Technology Development

Robotics Collaborative Technology Alliance

Consortium Partners

- GD Robotic Systems (Lead)
- JPL
- BAE Systems
- ASI
- Micro Analysis & Design
- Carnegie Mellon U
- U of Maryland
- Florida A&M
- SRI International
- Sarnoff
- Science & Engr Sys
- PercepTek
- Signal Systems
- AAI

Objectives

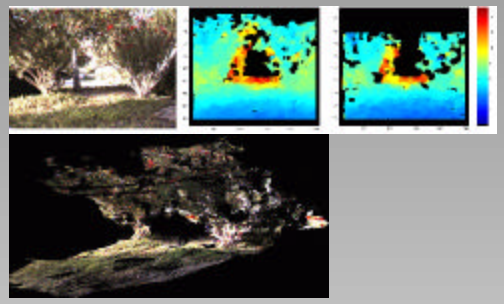
Develop and evaluate:

- Perception technologies enabling semi-autonomous robotic vehicles to maneuver with speed and agility over a wide array of terrain types in varied weather conditions
- Intelligent control technology integrating “tactical behaviors” supporting complex sequences of activity appropriate to the tactical situation
- Human-machine interfaces enabling effective direction and control of robotic systems while minimizing operator workload
- Modeling and simulation technology providing robotics researchers unprecedented ability to design and evaluate new robotic vehicle perceptual capabilities and tactical behaviors responsive to evolving operational needs

Technical Areas

- Perception
- Intelligent Control & Behaviors
- Human-Machine Interface
- Modeling, Simulation & Experimentation

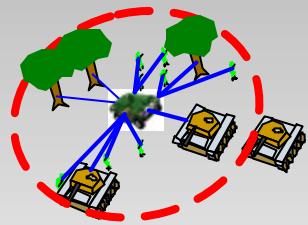
Advancing Perception Technology

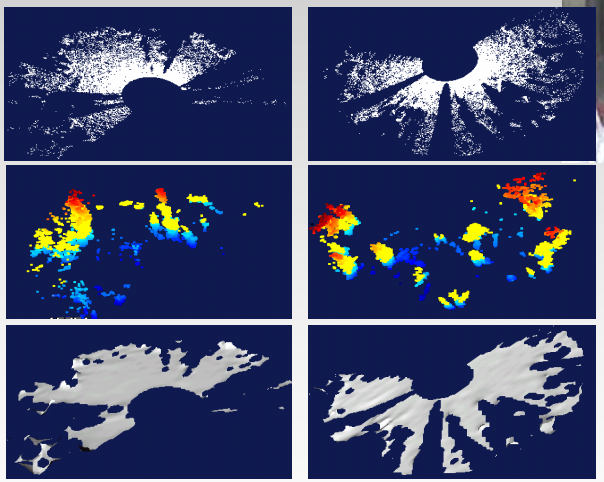


Stereo Imaging in complex environments

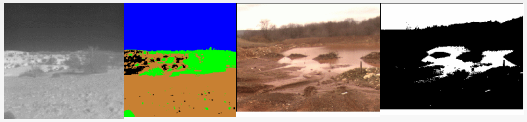
Tracking unstructured road networks

360° Safeguarding

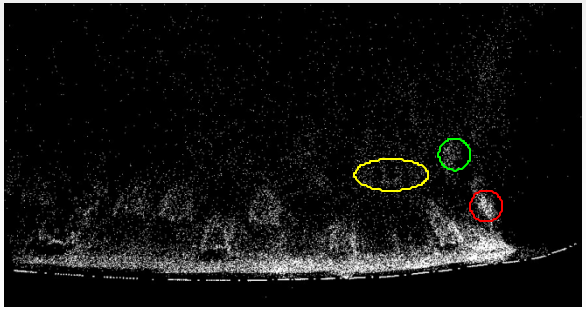




New Ladar processing algorithms recovering surface structure



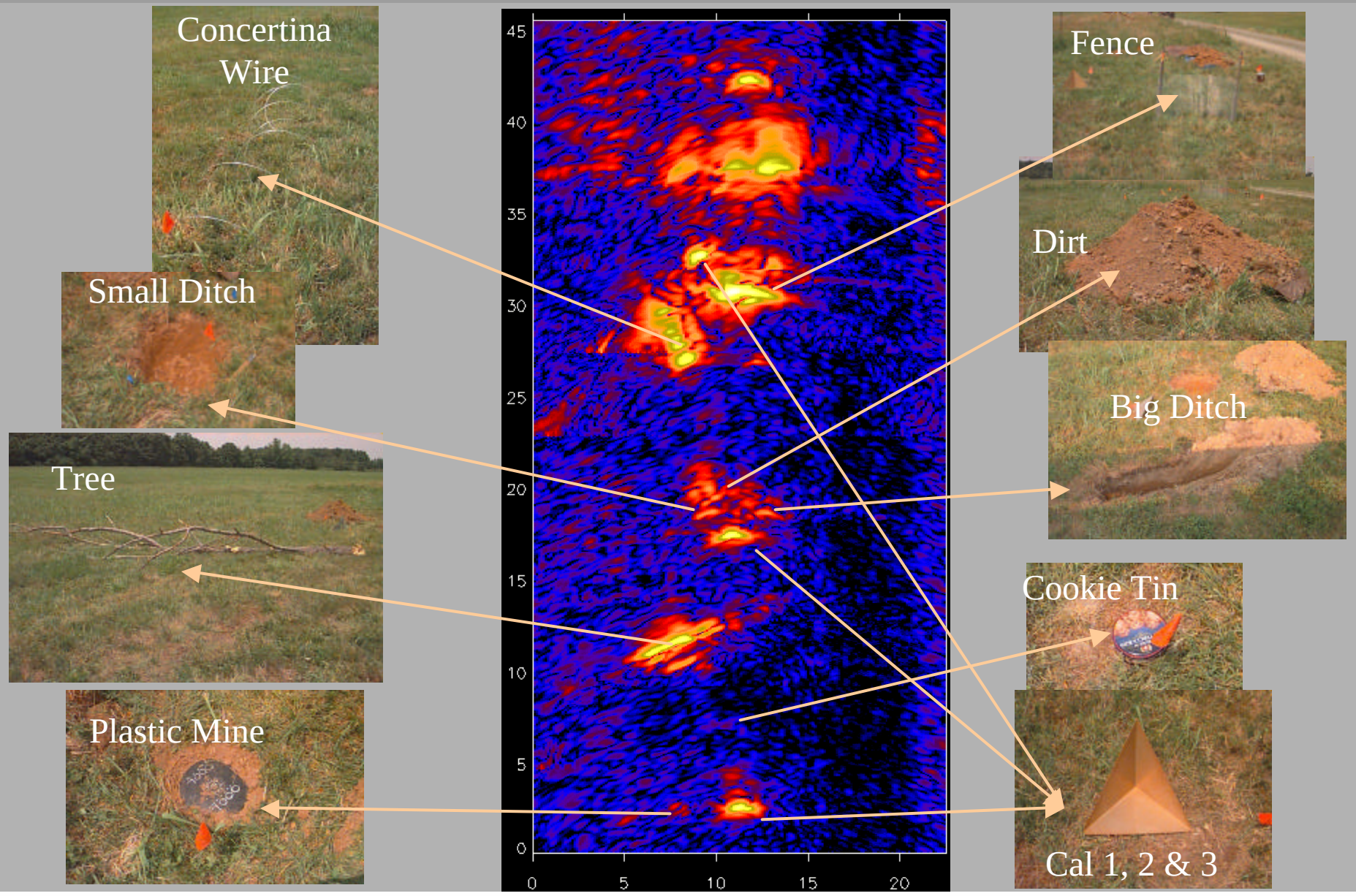
Object classification using thermal imagery



Mid-range perception motion stereo

Ultra-Wideband Synthetic Aperture Radar

Detecting objects hidden in vegetation

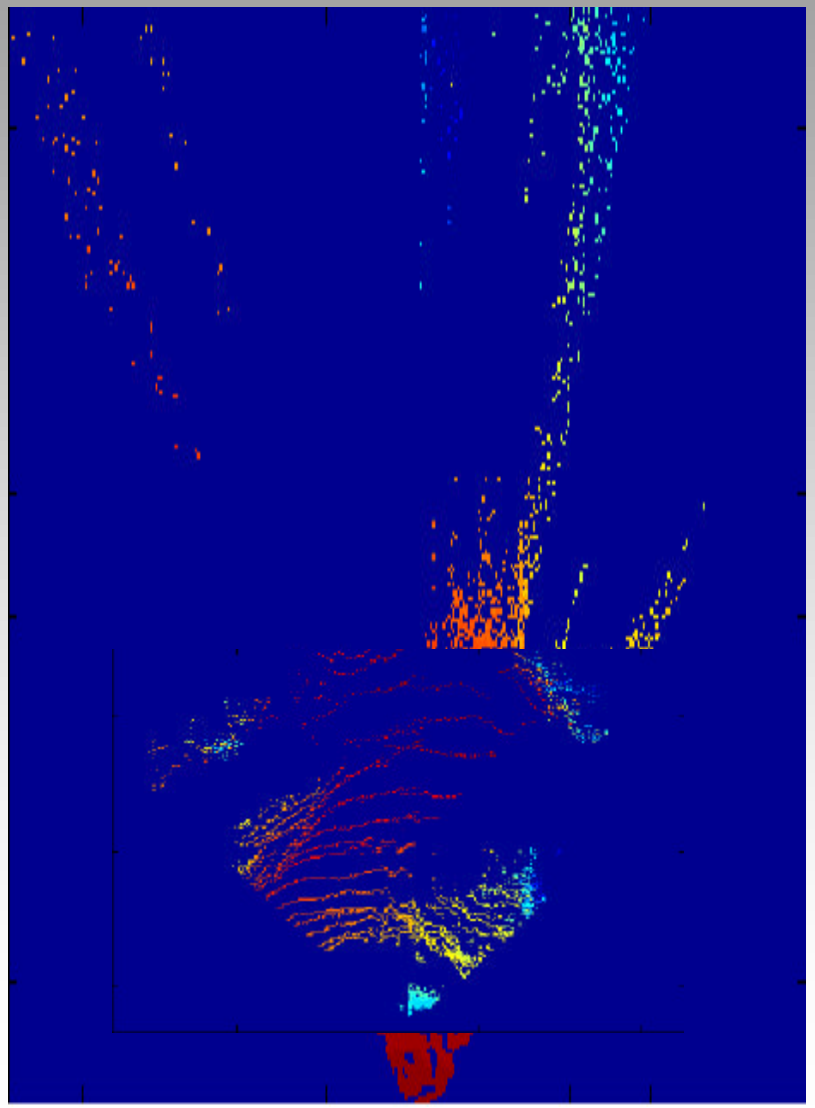


MMW Radar

Increased range for on-road operations or mid-range perception

Imagery Database

for Rapid Algorithm Development



Time-tagged sensor imagery sets

Tools for Visualization of Data Set

Developing tools and algorithms that integrate across time and sensor modality to improve estimates of terrain geometry and classification

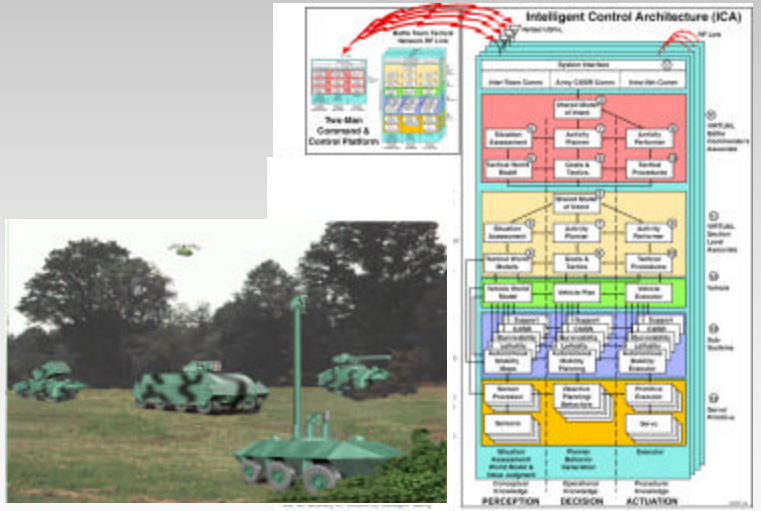
Intelligent Control Architectures

Robotics CTA

Objective: **Intelligent control technology integrating "tactical behaviors" supporting complex sequences of activity appropriate to the tactical situation**

Challenges:

- **Task definition and decomposition**
- **Multi-vehicle coordination and cooperation**
- **Symbolic & geometric planning**
- **Tactical behaviors**
- **Contingency handling**



Research Tasks:

- **Geometric & predictive planning algorithms**
- **Tactical behavior development**
- **Information management and data fusion**
- **Multi-asset cooperation**

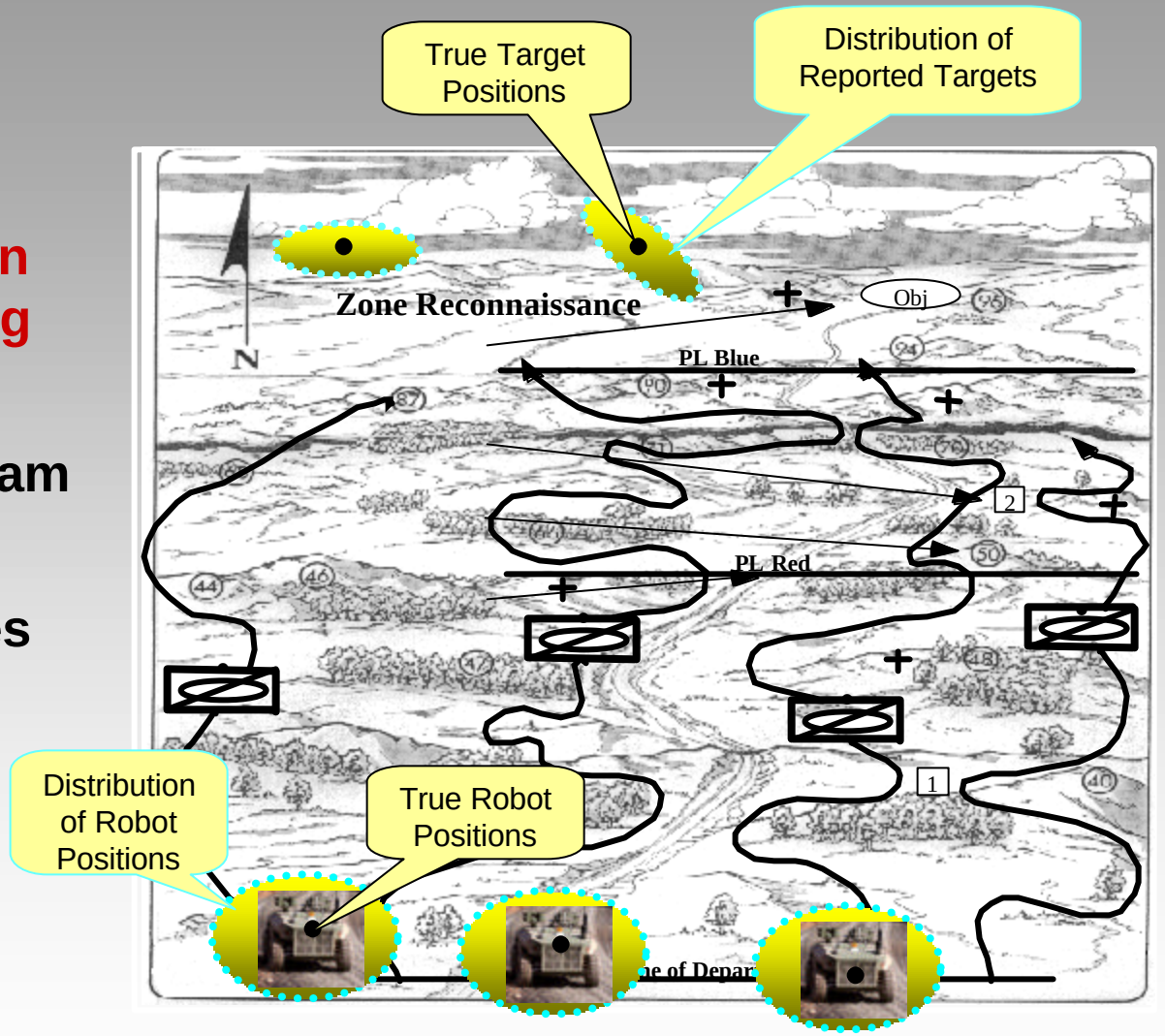
Tactical Behaviors

Improved Representation of Robot Team

Introduced uncertainty in localization and targeting

Modeled operator interaction with robot team

Modeled process and communication timelines



Building a Realistic Environment for Robotic Tactical Behavior Development

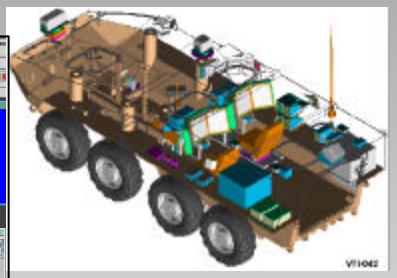
Human-Machine Interfaces

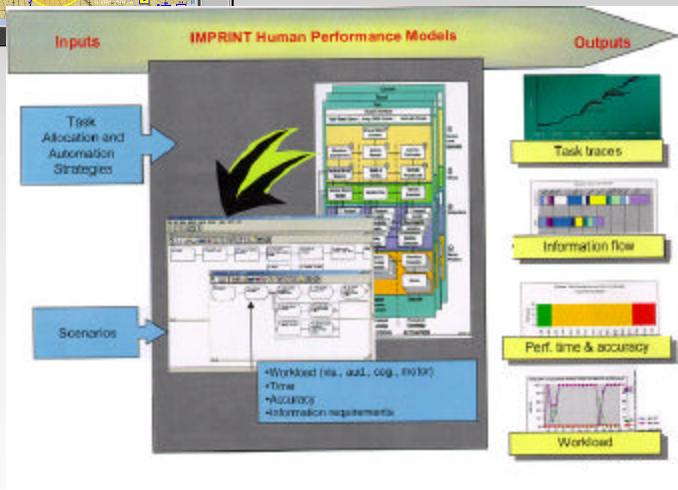
Robotics CTA

Objective: **Human-machine interfaces enabling effective direction and control of robotic systems while minimizing operator workload throughout the anticipated range of mission profiles, stressor conditions, soldier aptitude and battlefield intensity levels.**

Challenges:

- Optimal workload distribution between soldier and robot – prevention of cognitive overload
- Changes in HMI to support different operator roles, levels of autonomy, reliability of data
- Soldier trust





Research Tasks:

- Human Performance Assessment & Models
- Workload theory
- Trust in Automation
- Multi-modal soldier-machine interface
- Multi-modal interactions

ARL Robotics Technology

UGV Technology Gen 2 Capabilities

FCS Block I (Available May '03)

Perception

- Improved near field
- New sensors (e.g., MMW radar)
- Enhanced LADAR
- Local 360º awareness
- Day/night

Intelligent Control

- 4D/RCS – Vehicle level
- World model fusion
  - Two sensors
  - Map data
- Demo III mission planning
- Cooperative maneuver

Operator Interface

- Scalable core technology
- Implementations
  - 3 screen – VTI
  - 1½ screen – Demo III

Test Methodology

- Visualization, real-time data integration & display; rigorous experimental design

Gen 2 technology products

Perception

- Mid-range sensing tactical behaviors
- New sensors, e.g., Z-F
- Wider environmental capability
- Robust obstacle classification

Intelligent Control

- 4D/RCS – section level
- Large scale information fusion
- Complex behaviors

Operator Interface

- Soldier compatible command interface
  - Downward scalable
  - More intuitive, common interface style
- Adapt to new conditions

New Materials & structural science applied to platforms

- ***Rapid data feeds to FCS LSI & OFW***
- ***Transition to RDECs & PEO GCS***

FCS Increment I Autonomous Mobility

Technology Assessment

What's the current level of UGV autonomous mobility?

If intervention is required, what is the workload on the operator?

Autonomous Mobility

Technology Maturity Assessment

Assess ability of current autonomous mobility technology to meet FCS LSI concept for Increment I ARV operations in relevant environments – TRL 6

Experimental Conditions

- *Terrain types*
  - *Arid (completed 13 Dec 02)*
  - *Vegetated (completed 31 Jan 03)*
  - *Urban (April 03)*
- *Terrain difficulty*
  - *More complex*
  - *Less complex*
- *Maximum UGV speed*
  - *10 m/s (36 KPH)*
  - *3 m/s (10.8 KPH)*
- *UGV control mode - ARV*
  - *NLOS*
  - *LOS*
- *Range segments*
  - *500 m*
  - *1000 m*
  - *2000 m*

✓ **Excursions**
- **Manned HMMWV**
- **Night**
- **Military/civ operator**
- **Endurance**

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Technology Maturity Assessment

Tooele Army Depot/Ft. Indiantown Gap

Autonomous Mobility

Technology Maturity Assessment

Preliminary Insights

TRL Experiments at Tooele, UT and FTIG, PA

Analysis in Progress

Location	Complete runs	Total Runs	% Complete
FTIG	**155**	**181**	**85.6%**
Tooele	**171**	**177**	**96.6%**
Total	**326**	**358**	***91.1%***

XUV Autonomous Operation

	Distance (km)			Time (Hours)		
Location	Total	Autonomous	% Autonomous	Total	Autonomous	% Autonomous
FTIG	196.3	183.4	93.5%	37.8	32.0	**84.7%**
Tooele	205.5	202.1	98.3%	34.6	32.2	**93.1%**
Total	***401.8***	**385.5**	***95.9%***	**72.3**	**64.2**	***88.7%***

Operator Interventions Required During Autonomous Operation

Course	Freq	Mean distance between interventions (km)	Mean time between Interventions (Minutes)	Mean intervention duration (Minutes)	Mean intervention distance (m)
FTIG	177	1.1	12.8	1.9	67.2
Tooele	48	4.3	43.2	2.8	76.8
Total	**225**	***1.8***	**19.3**	***2.1***	**69.3**

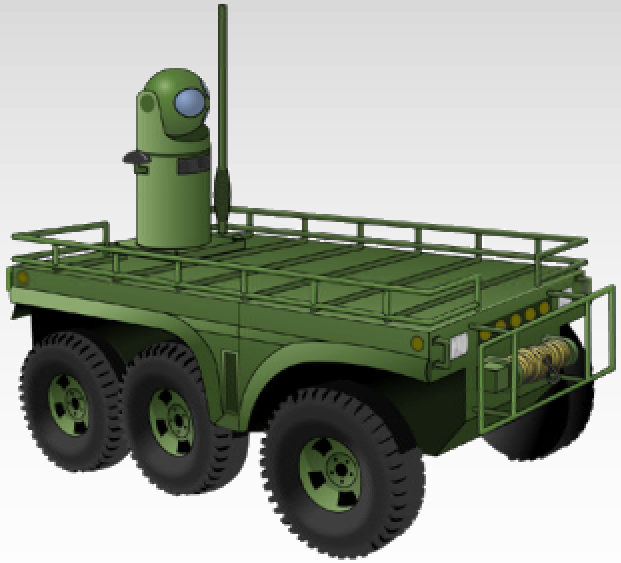
Technology Maturity Assessment

Urban Experiment - Ft. Indiantown Gap

Technology Transition

Force Protection

MDARS-E Physical Security UGV
(Currently in SDD; LRIP scheduled for FY04)



MULE

ARL/TARDEC Joint Robotic Follower ATD

2002-2003

ARV Surrogate

ARL Robotics Technology Program

Products

- *Develop & Evaluate Critical Technology for Military UGVs*
  - *Perception, Intelligent control, Soldier-machine interface*
  - *Core focus autonomous mobility*
- *Provide Autonomous Mobility Technology for Fieldable Systems*
  - *Block I FCS Armed Robotic Vehicle mixed initiative operation*
  - *Mule Objective Force Warrior*
  - *"Robotics for operations in confined spaces" – new initiative*
  - *Force Protection (PM-PSE), Countermine (NVESD/CECOM), Follower (TARDEC), Robotic Missile Platform (AMCOM)*
  - *Assessments technology maturity**
  - *New technology capabilities LSI, RDECs, Program Managers*
- *Provide Enhanced Technology for Integration into Future UGVs*
  - *Better perception 100m*
  - *New mid-range perception 50m – 500m*
  - *Core technology for scalable, common interface (OCU)*
  - *360° safeguarding*
  - *High speed road following*
  - *Information fusion into world model*
  - *Real-time data visualization, analysis products*

*** TRL 6 assessment**

Extending Soldiers' Reach

Future applications for unmanned systems will only be limited by imagination and ingenuity…