

Overview of Army Robotic Convoy Technology Programs

Robobusiness 2007



Justin Teems

justin.teems@us.army.mil

(586) 574-8989



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DoD Logistics and Convoy Challenges

DoD logistics personnel face inherent challenges daily

IEDs and other low tech attacks

Threat level places additional personnel in harm's way for convoy defense

Truck operators vulnerable to enemy ambush (lack of up-to-date situational awareness)

Long 18 hour days take a toll on truck operators



The Challenge:

Effectively utilize existing automation technology to enhance soldier performance/reduce threat exposure, increase OPTEMPO while conducting the 3 Ds:

Dull, Dirty, or Dangerous





Benefits of Robotic Convoy

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Offers tactical flexibility to convoy commanders.

Enables the convoy to move at precise speeds and spacing creating a more efficient convoy and reducing the risk of accidents.

Since the soldiers do not have to drive they can concentrate on communicating, planning and identifying enemies.

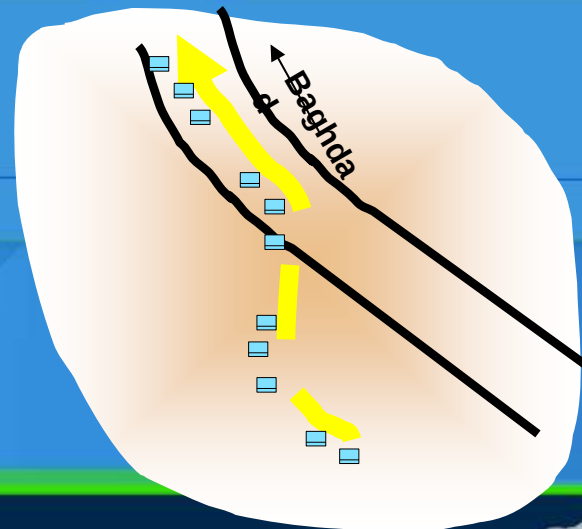
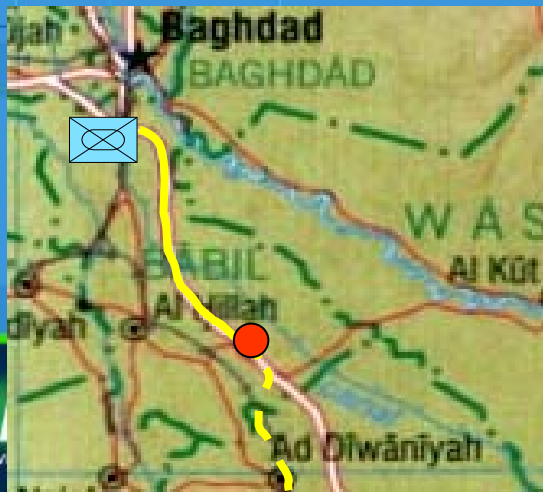
Driving workload of soldiers is reduced, allowing for increased force protection and situational awareness

Mission planning is automated .

Robotic perception identifies and avoids obstacles without soldier intervention.

Robotic vehicles automatically adjust spacing .

The vehicles automatically avoid both positive & negative obstacles while picking the most efficient path.





Marching Orders from the MILDEP

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Devise a focused effort to demonstrate convincing evidence of the viability of unmanned tactical wheeled vehicles performing convoy driving/maneuver functions in military relevant environment(s) using available/affordable robotic follower technologies within 1 year.

Conduct engineering and User evaluations necessary to determine whether there is basis for accelerating the insertion of robotic convoy capability into the Current Force tactical wheeled vehicle fleet.



Robotic Follower Challenge



Problem:

Current robotics technologies lack battlefield mobility, speed and robustness for Future Force applications.

Challenges:

Autonomous technology capability projections don't meet FCS requirements.

Unmanned systems following manned vehicles with significant physical or temporal separation.

Detecting/avoiding new obstacles in the follower's path.

Operation in live traffic.

What are the technical barriers to this problem?

Current sensor ranges and resolutions limit effective following speeds.

GPS availability and quality doesn't support follower accuracies.

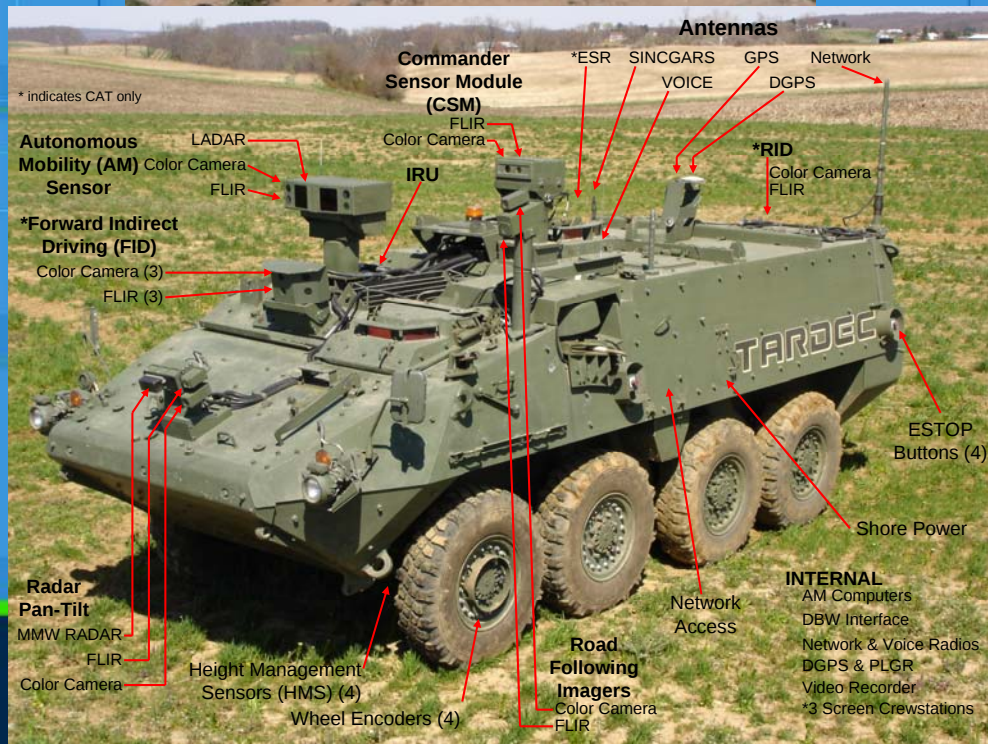
How will you overcome those technical barriers?

Rely upon a manned lead vehicle to "proof" terrain for following unmanned systems, taking advantage of human sensing and reasoning to reduce the burden on the unmanned systems.

Pass lead path to follower vehicles using "electronic breadcrumbs".

Employ a combination of sensors to look for obstacles, providing the best sensor for **multiple conditions** (day, night, vegetation).

Use feature data from lead vehicle's perception system and register that with the follower's perception system for improved accuracies





Robotic Follower Advanced Technology Demonstration



FOR A SUPERIOR ARMY



Autonomous
Mobility
Sensor Suite



Purpose:

- Provide mounted leader-follower capability to PM, FCS (BCT) for ANS and integration into ARV, MULE and MGV's for resupply, rear security and NLOS/BLOS Fire mission
- Provide dismounted leader-follower capability to PM, Soldier Warrior for integration into Land Warrior Advanced Capability for MULE application

Product:

- Ruck truck resupply & mule capability
- Follower algorithms, engineering test data, and tactical knowledge transfer to PM, FCS (BCT) and FCS LSI in FY03- FY06
 - [FCS UGV Risk Mgt Plan \(CT 18\)](#)
- H/W, S/W improvements and M&S results to FCS LSI through FY06

Milestones	(FY)	01	02	03	04	05	06
Obstacle Avoidance/Perception		■	■	■	■		
RF System '03 Design Objective System Design		■	■	■	■	■	
Leader-Follower Technologies		■	■	■	■	■	
Sensor/Map Registration		■	■	■	■	■	
Road Following		■	■	■	■	■	
System Integration Lab M&S				■	■	■	
Soldier-Robot Interface Integration CAT crewstation and Dismounted controller			■	■	■	■	
Systems Integration			■	■	■	■	
Conduct Warfighter Experiments, Demos, & Evaluations		4	6	6	6	6	6

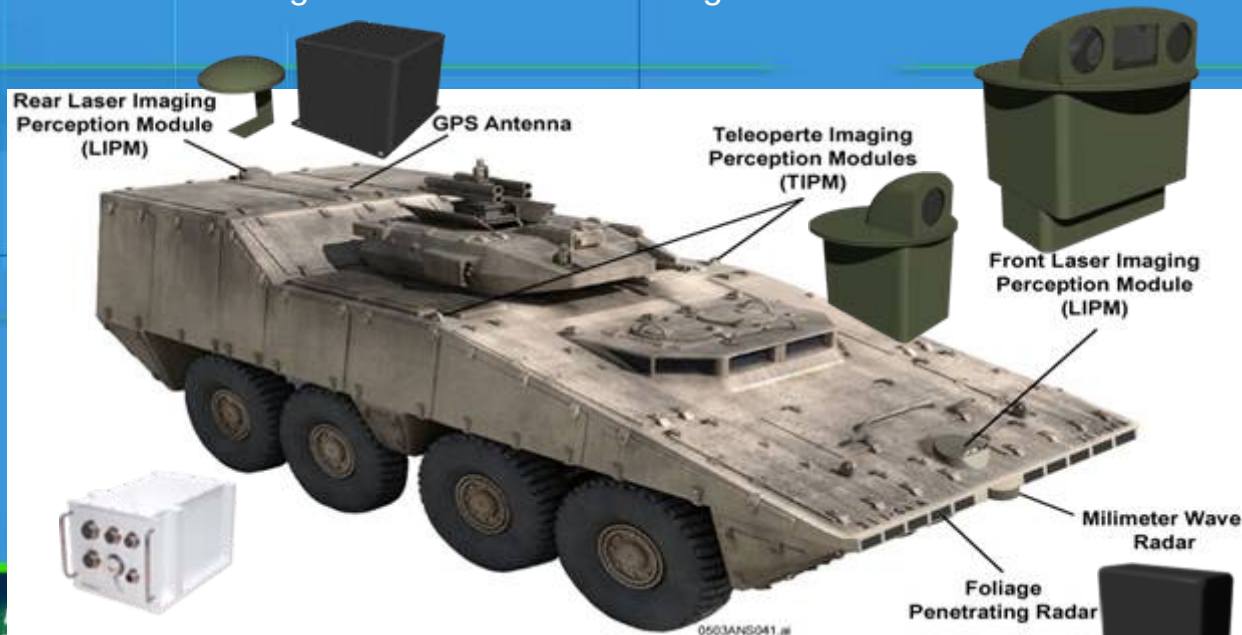
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Robotic Follower Integration for FCS Autonomous Navigation System

ANS is the heart of the robotic vehicle. ANS robustness bounds the mission capability of the FCS vehicles (ARV, MULE & MGVs) SUPERIOR ARMY

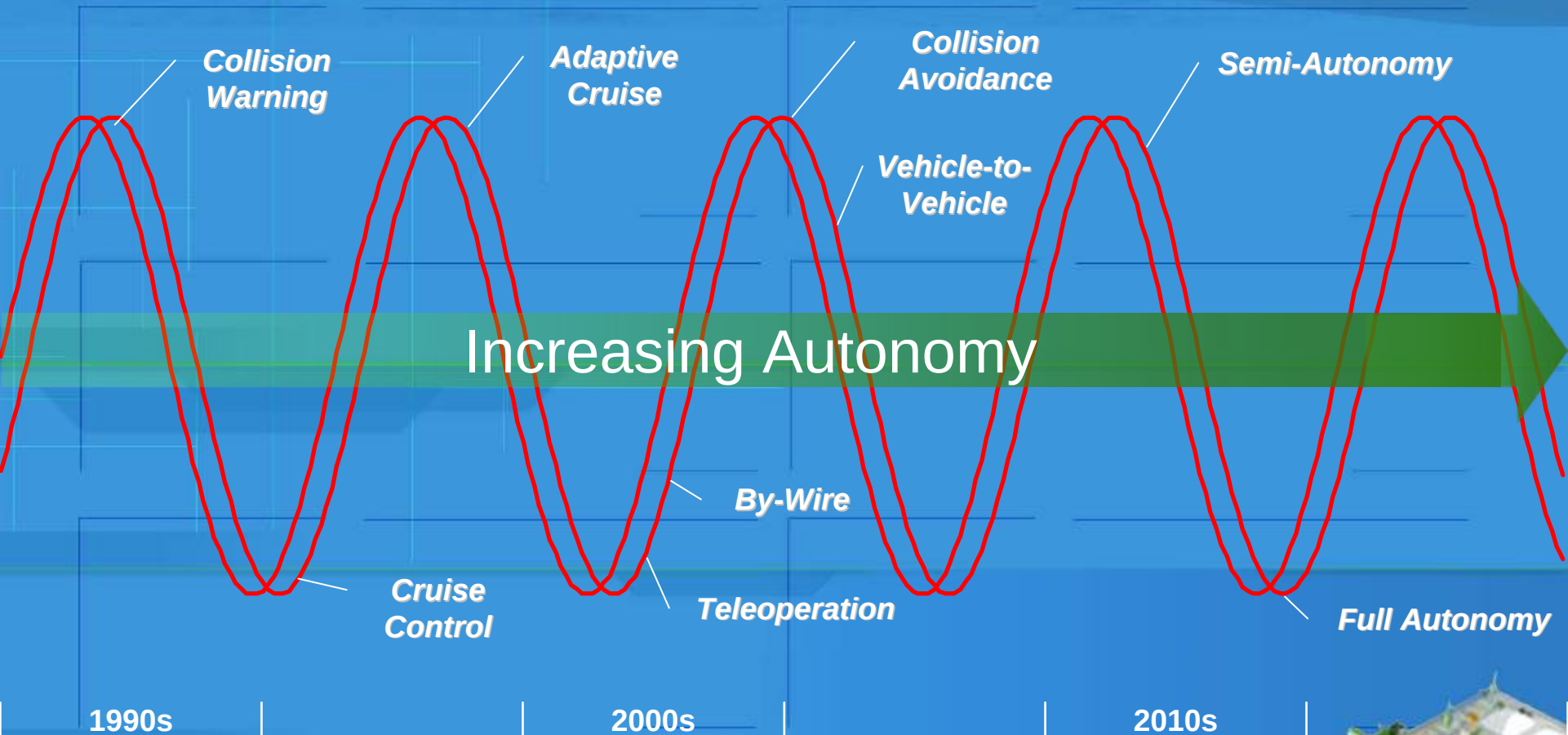
- Robotic Follower operational procedures and Unit of Action TTP development and refinement
- High speed autonomous convoy on narrow roads
- Feature based registration for Leader-Follower (non-GPS)
- Human odometry/dismounted follower
- Baseline convoy with live traffic
- Vehicle following behavior
- Baseline safety operational procedures
- Road/trail following
- Systems integration, testing and soldier evaluation
- Radar integration for vehicle tracking and collision avoidance



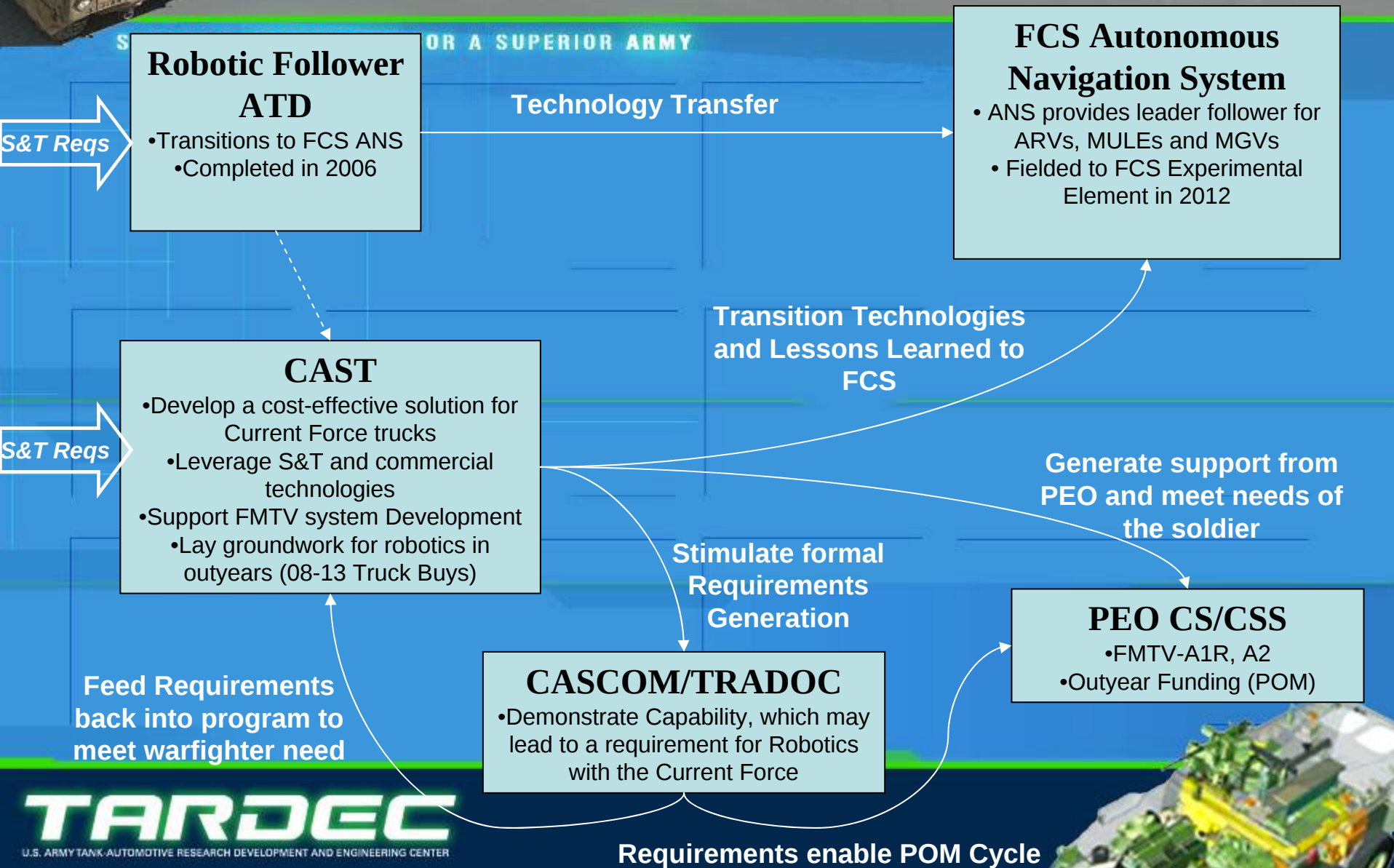


Progression of Autonomy

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Convoy Active Safety Technologies (CAST) Origins and Impacts





Vehicle Overview

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GPS

Communications

SICK LADAR

Color Camera

ACC RADARS

Ground Speed
Sensors

SICK LADAR



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Assumptions and Challenges

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Assumptions

WAAS GPS is reliable (7-10 m) and available

Navigation alone will be sufficient to get through large turns

Perception supplements navigation inaccuracies to decrease lateral offset

Challenges found during EETs

Navigation data is neither reliable nor available

300+ m jumps

Up to 4 minute outages

Navigation limitations require additional perception for tight angle turns

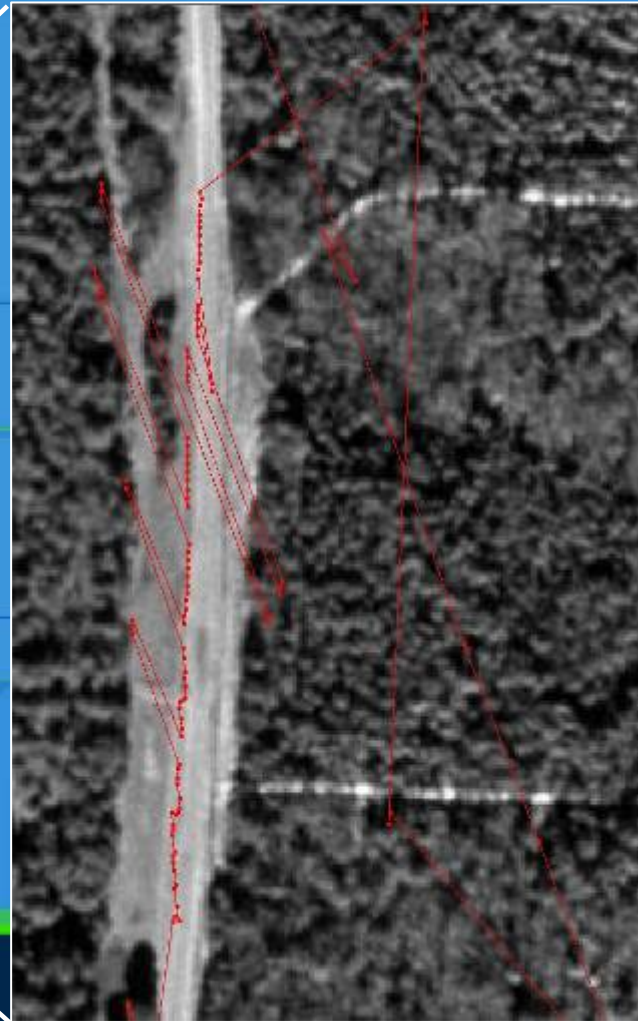
Conclusion: Requires additional investigation into GPS unit





Reliability and Availability of GPS

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Improved Navigation

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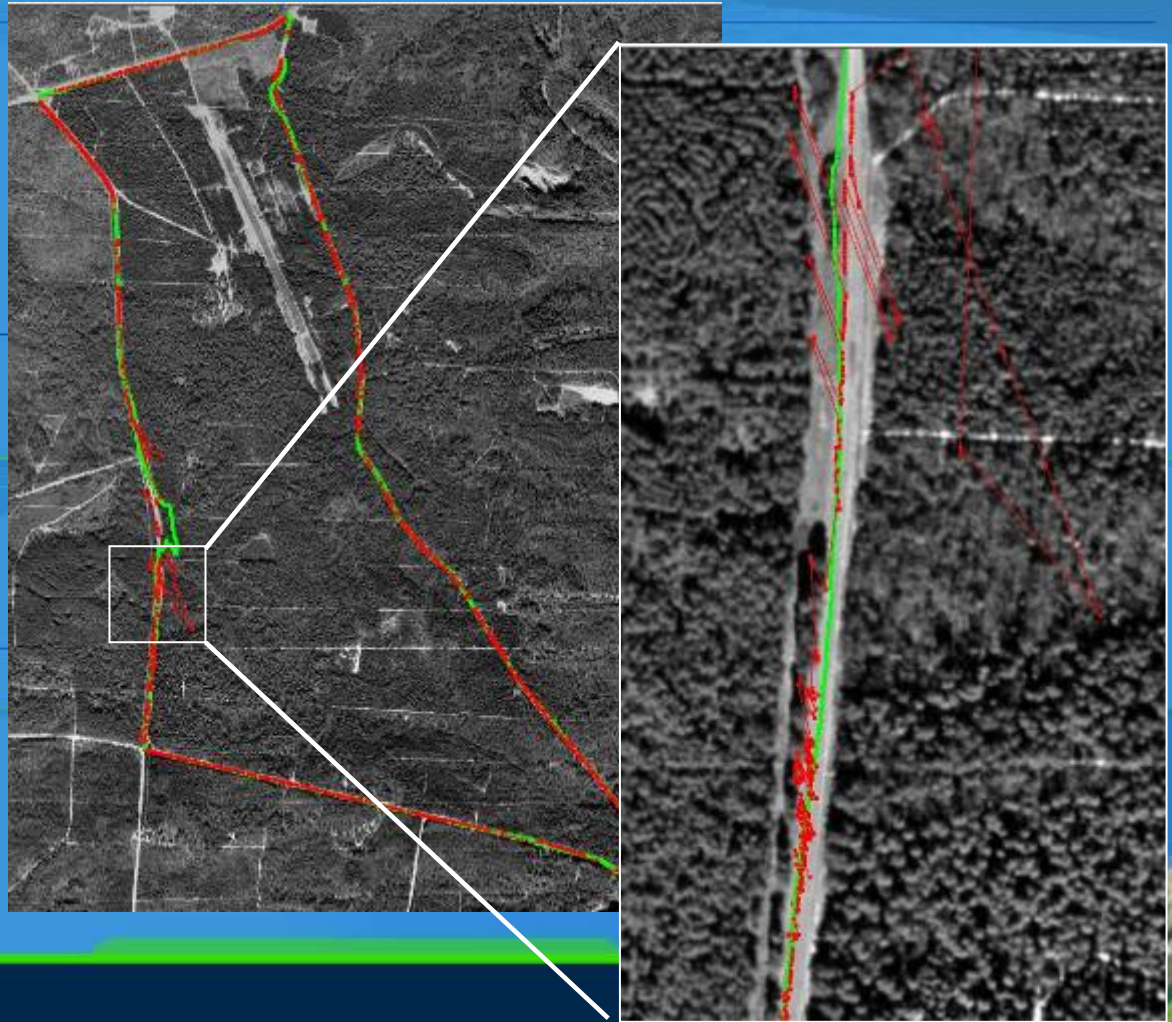
Uses distributed sensors on the vehicle

Loosely coupled Kalman Filter

Works with SGPS, WAAS or Single GPS coverage

Experienced outages of 4 minutes and pops of 300+ meters

In these conditions, stand alone geo-based following is untenable



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Perception-based Vehicle Following

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Uses Radar to detect vehicle

Uses Vision to aide in tracking vehicle

The radar and the camera have matching FOV

Model based expectation and localization

Performance

Detections throughout the range of the radar

Maintains a track throughout the FOV

Sends a steering vector to COMA for fusion with other behavioral inputs

Independent of Absolute Navigation Solution

Picture

Follower distance of 50 meters

Active Behaviors

- PVF
- Waypoint Following
- Gap Maintenance
- Radar Safe Distance





Obstacle Detection/ Avoidance

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Works with either Radar or Sick Ladar sensor

Acts as a “Negative Behavior” blocking steering directions that collide with hazards

Sends a steering and speed vector to COMA for fusion with other behavioral inputs

Independent of Absolute Navigation Solution

Test (video)

Follower distance of 60 meters

Obstacle placed in follower path after lead passes

Active Behaviors

- Obstacle Avoidance
- Waypoint Following
- Gap Maintenance
- Radar Safe Distance
- Perception-based Vehicle Following



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Planned Technology Development

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Turnkey Operation

Low-Cost User Interface

GPS Robustness Algorithms

Improved Perception Based Vehicle Following

Dynamic GPS States

Tight-Geometry Turns

Improved ODOA

Expanded/Selectable Gap Distance

Multi-follower Convoy Study

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Planned Experiment

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- Driving towards requirements generation
- TARDEC partnered with Combined Arms Support Command (CASCOM)
- Two scenarios
 - Safety
 - Situational Awareness
- Use feedback for improved technology development as well as requirements generation





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Questions?

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