Overview of Army Robotic Convoy Technology Programs

Robobusiness 2007

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# Overview of Army Robotic Convey Technology Programs - Robobusiness 2007

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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

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.

[Map of Baghdad and other locations]
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.
**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.

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**Ruck Carrier**

**Supply Platoon**

**Rear Security**

**NLOS/BLOS Fire**

**Mature & Demonstrate Robotics Technology Required for Early Insertion into FCS**

**Autonomous Mobility Sensor Suite**
Robotic Follower Integration for FCS
Autonomous Navigation System

- 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

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

- **1990s**: Cruise Control
- **2000s**: Adaptive Cruise
- **2010s**: Collision Avoidance

- **Collision Warning**
- **Teleoperation**
- **Vehicle-to-Vehicle**
- **By-Wire**
- **Semi-Autonomy**
- **Full Autonomy**

Increasing Autonomy
Convoy Active Safety Technologies (CAST) Origins and Impacts

**Robotic Follower ATD**
- Transitions to FCS ANS
- Completed in 2006

**CAST**
- Develop a cost-effective solution for Current Force trucks
- Leverage S&T and commercial technologies
- Support FMTV system Development
  - Lay groundwork for robotics in outyears (08-13 Truck Buys)

**FCS Autonomous Navigation System**
- ANS provides leader follower for ARVs, MULEs and MGVs
- Fielded to FCS Experimental Element in 2012

**CAST**
- Demostrate Capability, which may lead to a requirement for Robotics with the Current Force

**CASCOM/TRADOC**
- Stimulate formal Requirements Generation
- Feed Requirements back into program to meet warfighter need

**PEO CS/CSS**
- FMTV-A1R, A2
- Outyear Funding (POM)

**Technology Transfer**
- Transition Technologies and Lessons Learned to FCS
- Generate support from PEO and meet needs of the soldier

**Requirements enable POM Cycle**
Vehicle Overview

- GPS
- Communications
- SICK LADAR
- Color Camera
- ACC RADARS
- Ground Speed Sensors
- SICK LADAR
Assumptions and Challenges

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
Improved Navigation

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
Perception-based Vehicle Following

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

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
Planned Technology Development

**Superior Technology for a Superior Army**

- 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

**TARDEC**

U.S. Army Tank-Automotive Research Development and Engineering Center
Planned Experiment

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
Questions?