Autonomous Transport

ARIBO

Ft. Leonard Wood

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(U/FOUO)
Agenda

• Robotic Research Background
• ARIBO Program Background
• Autonomous Transport CONOPS
• High-Level Requirements
• Robotic Kit
• Program Plan
• Questions
Robotic Research, LLC

• Robotic Research, LLC was founded in 2002
  – Founders Alberto Lacaze and Karl Murphy were integral parts of DEMO I, II, and III development at the National Institute for Standards and Technology (NIST)

• Years of UxS expertise
  – Low-level Platform Control
  – Sensor Processing
  – Localization
  – World Modeling
  – On-road and off-road path planning
  – Global and Tactical Planning
  – Task/Resource Allocation
  – Systems Integration
  – OCU and Situational Awareness Tools
Robotic Research: Expertise in Autonomous Mobility

Across various domains, sizes, and types

(U/FOUO)
Building on Autonomous Mobility Success
Autonomous Ground Resupply

- Design, develop, integrate, and test a robotic system that performs autonomous operations (robustly, and safely)
- Develop an open and modular architecture
- Address the requirements of the Autonomous Convoy Operations (ACO) Program of Record (PoR)
Architecture for Coordinated Localization

Proven product for localization amongst a team of heterogeneous assets

Large Vehicle Platforms
Manned Platforms
Small Robotic Platforms
Vehicle Convoys

Biologically inspired
Dismounts
MUTT

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The ARIBO effort aims to

1) provide a viable, cost-effective, and reliable service to meet local transportation needs

2) Accelerating the transition of advanced unmanned technology to military and government organizations
STRATEGIC OBJECTIVES

1. Socialize users and non-users with automated systems
2. Identify operational issues / develop mitigation strategies
3. Generate empirical data (e.g. performance, reliability, maintenance, etc.)

Summary: Progress toward these objectives will accelerate tech transition delivering better, less-expensive products to warfighters

KEY PROGRAM EFFORTS

Fort Bragg (underway)
- Personalized automated shuttle service between barracks and medical center to reduce missed appointments
- On-Demand Services, use only when needed

Fort Leonard Wood (underway)
- On demand bus service to close under-utilized DFACs and reduce operational costs through the efficient transportation of company-sized units
ARIBO Approach

For all of our ARIBO efforts, we follow a phased approach, where we build a body of evidence to determine it is safe to progress to the next phase.

Phase 1 (Chauffeured)
- Functionally, essentially no significant difference from normal shuttle operations
- Data collection and comparison (human:robot)

Phase 2 (Safety Operator)
- Driver becomes a safety operator
- Control shifted to robot and data collected

Phase 3 (Fully Automated – Driverless)
- Human removed from vehicle
- Lessons learned and findings applied
Current ARIBO Research Efforts

**User Interface Design**

**Human Factors Research**

Impact on Non-Users

Rider Trust: Simulation
Ft. Bragg Installation

- Continuous, automated electric vehicle that shuttles Soldiers between barracks and WAMC
- On-demand reservation system
Fort Leonard Wood Installation

- Continuous, automated electric buses that shuttle Soldiers between barracks and dining facilities (DFAC)
- Cost for buses and charging systems: ~$3.2M (4 vehicles)
- Cost for Automation: ~$4.0M
- Total cost: ~$7.2M
- Savings: ~$3M/yr
- Simple break-even 2-3 years through consolidation of two DFACs
Fort Leonard Wood Background

**PROJECT CONTEXT**

- Army operates 340 Dining Facilities (DFAC) System-wide
- Many are run by military personnel
- Cost to operate varies, contracted service is around $2.6M/yr for labor and energy
- Use autonomous vehicles to optimize DFAC capacity utilization and reduce number of DFACs required to meet mission

**FLW SPECIFICS**

- 10 DFACs deliver about 1M meals/month
- Autonomous buses could allow closure of up to three DFACs with trainees moved to other facilities
- Savings is about $1.2M in reduced labor and $300K in electricity/DFAC closed
- Total estimated savings would be $3M/yr (for 2 DFACs)
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AT- CONOPS

• Transport troops between barracks and a centralized dining facility.
• Capable of transporting company sized units on several buses.
• The system will be remotely scheduled and monitored.
• Vehicles will obey all traffic laws
• Vehicles will operate among other vehicles and pedestrian traffic
• Vehicles will be charged at a central maintenance facility when not in use.
• Charging schedule can be optimized to avoid peak electricity demand hours and avoid disruption to service.
Routing, Route #1

- First route to be implemented.
- Loop distance is about 1.75 miles
- Three bus stops including one at the DFAC and two near barracks.
- The highest speed limit on this route is 25mph
- 6 Stop Signs
Routing, Route #2

- Possible next route to be implemented.
- Loop distance is about 0.98 miles
- Three bus stops
- Highest speed limit is 35mph
- 2 Stop Signs
- NOTE: Will need to find a suitable turning location at last bus stop.
- NOTE: Routes 1 and 2 can be combined
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Operational Requirements

- Buses should pick up and drop off together.
- The host installation seeks to demonstrate 4 standing-only vehicles.
- Capable of carrying up to company size.
- The selected vehicle should allow for rapid boarding and egress.
- Loading/unloading should be possible within minutes of the bus doors opening.
- Vehicles should have some amount of climate control to provide a degree of comfort for all seasons.
Automation System Requirements

• Allows manual and autonomous operation
• Real-time monitoring of system performance
• System deployed and operated independent of Fort Leonard Wood computer networks
• System functions as intended in a closed system
• Hardware and software meets the program objectives
• Designed to be fail-safe
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Robotic Kit

• **Autonomy (A-kit)**
  - Sensors and Data Collection
  - Obstacle Detection/Tracking/Prediction
  - Route Planning
  - Announcements and Pickup Procedure

• **By-wire (B-kit)**
  - Drive-By-Wire control and safety mods
  - Human-Machine Interface
3D LIDAR Visualization
Project Team Participants

• NCMS
• TARDEC
• Robotic Research
• Missouri S&T