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

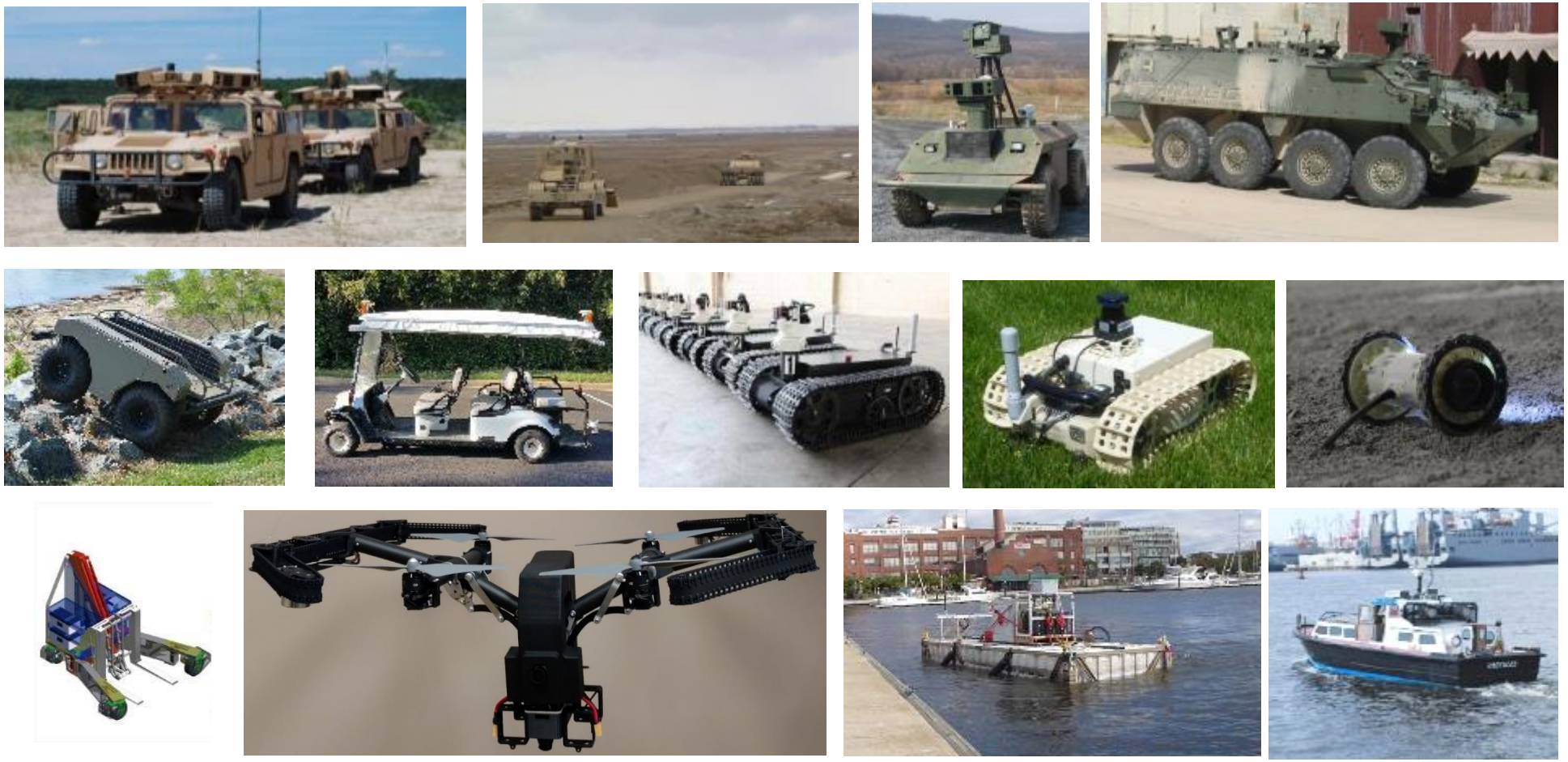
- Robotic Research, LLC was founded in 2002
  - Founders Alberto Lacaze and Karl Murphy were integral parts of DEMO I, II, and III development at the National Institute for Standards and Technology (NIST)
- Years of UxS expertise
  - Low-level Platform Control
  - Sensor Processing
  - Localization
  - 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

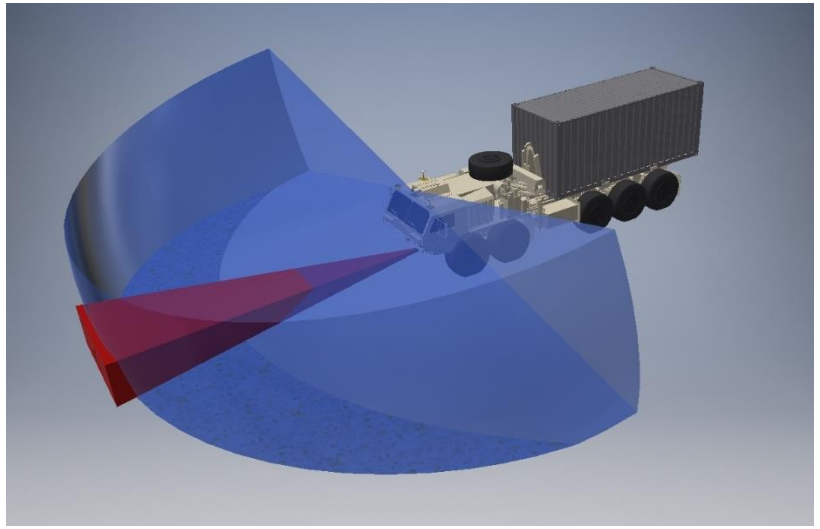


Across various domains, sizes, and types

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

Large Vehicle Platforms

Manned Platforms

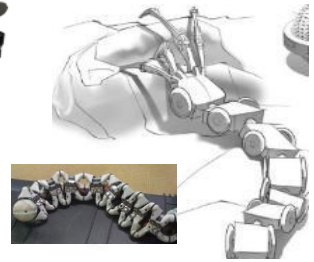
Small Robotic Platforms

Proven product for localization amongst a team of heterogeneous assets

Vehicle Convoys

MINATUAR

UAV



Biologically inspired

Dismounts

MUTT

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ARIBO Overview

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

ARIBO Approach

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

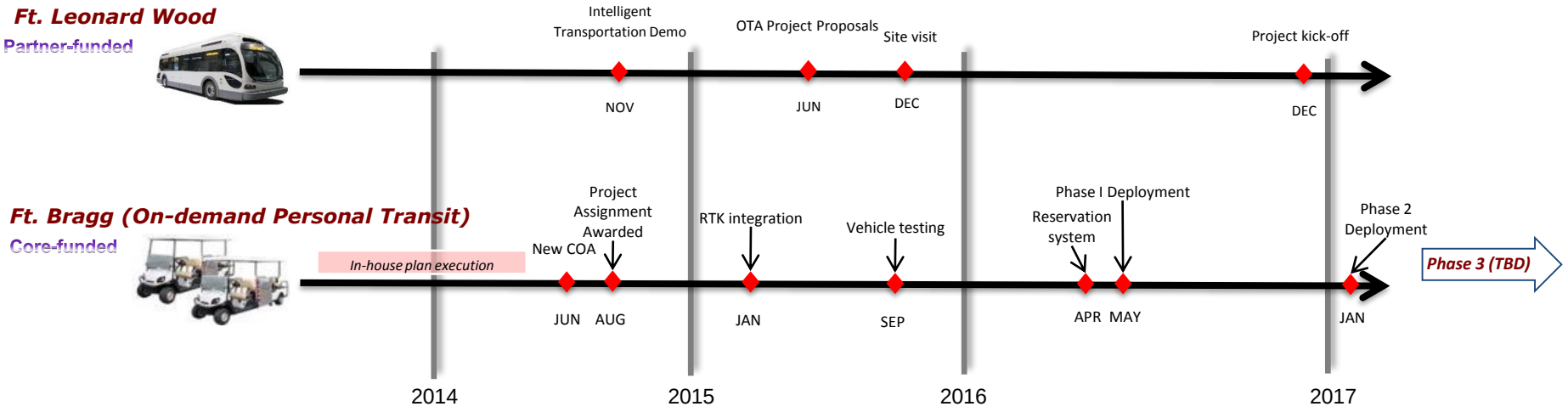
KEY PROGRAM EFFORTS

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

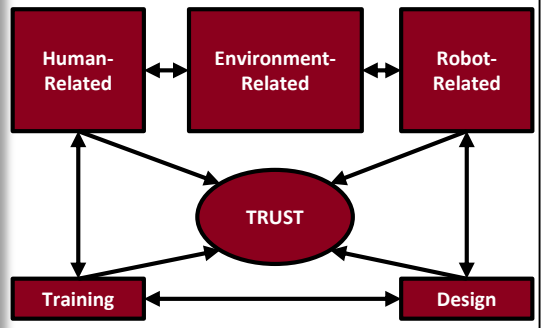
Current ARIBO Research Efforts

User Interface Design

Human Factors Research

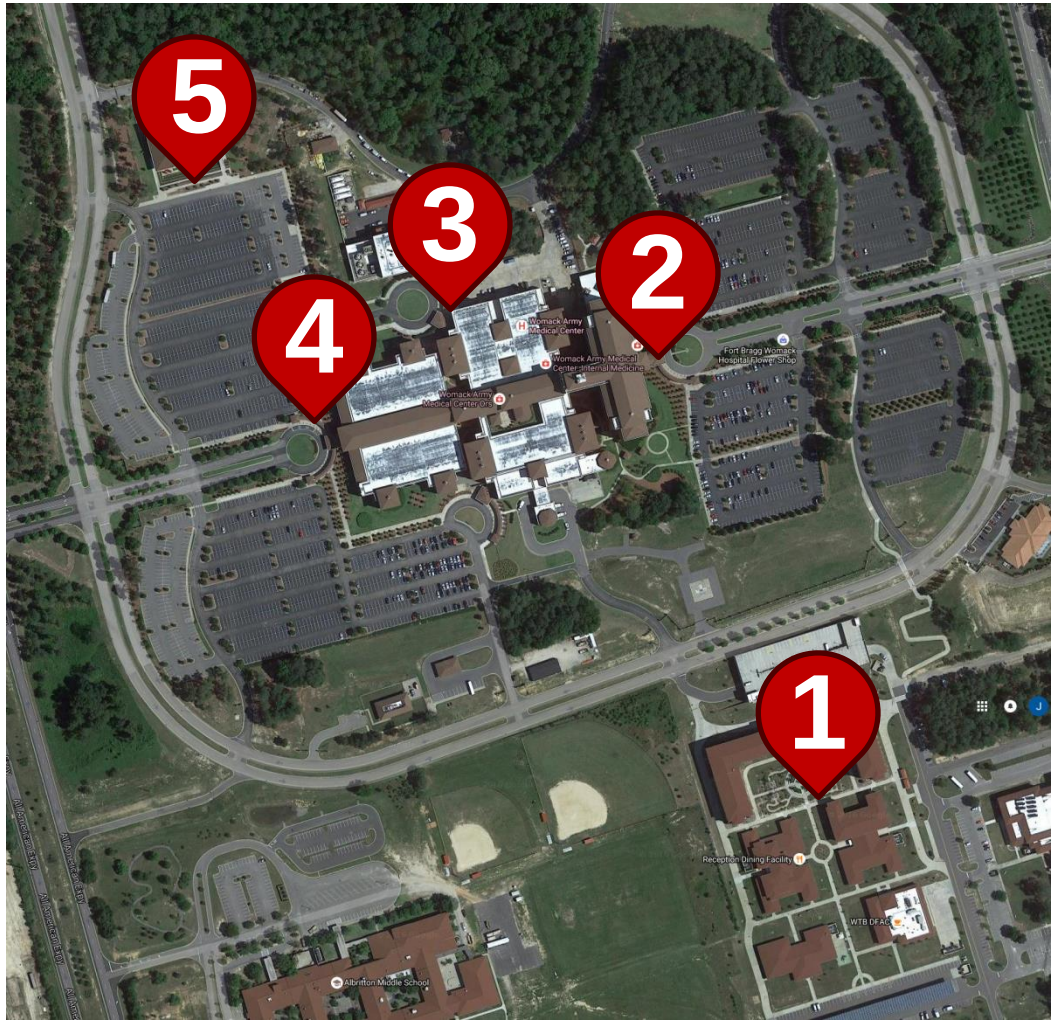
Impact on Non-Users

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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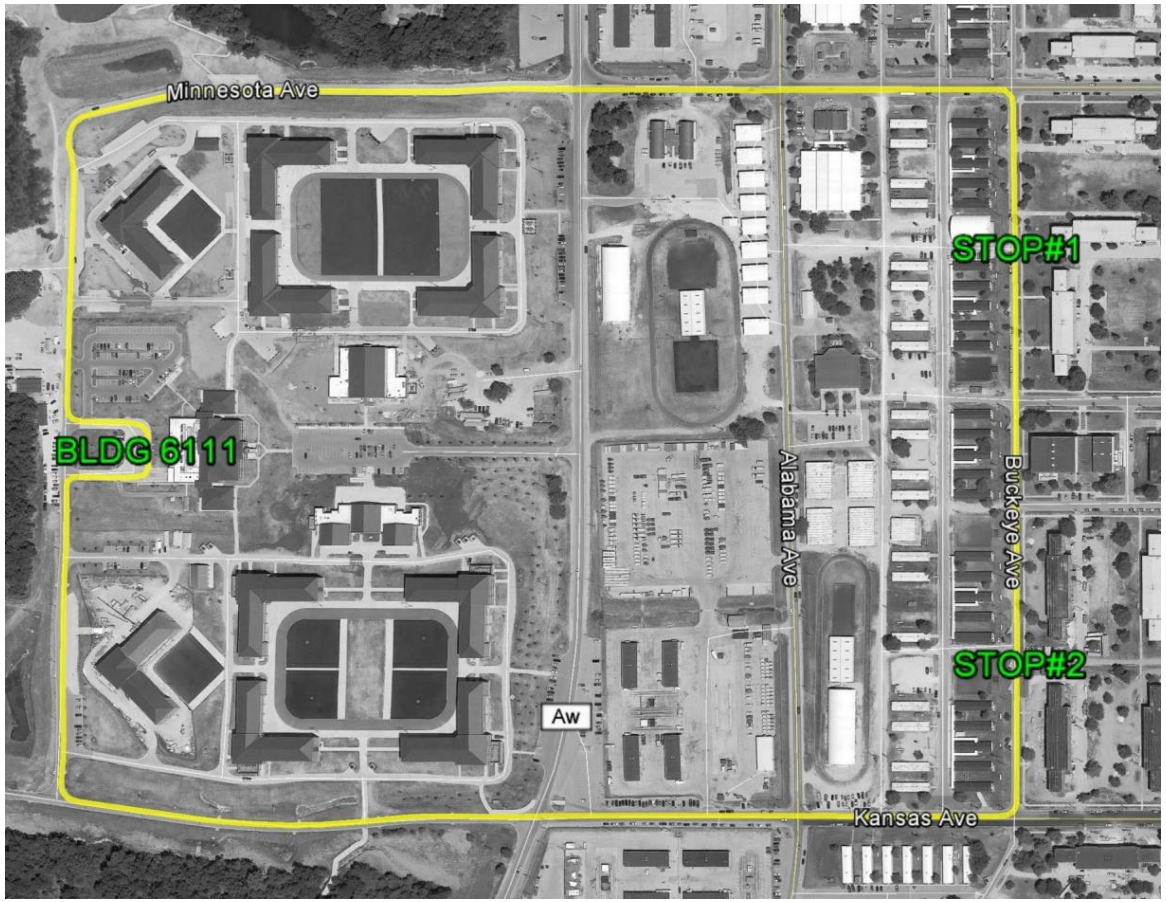
AT- CONOPS

- 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 obeys 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.

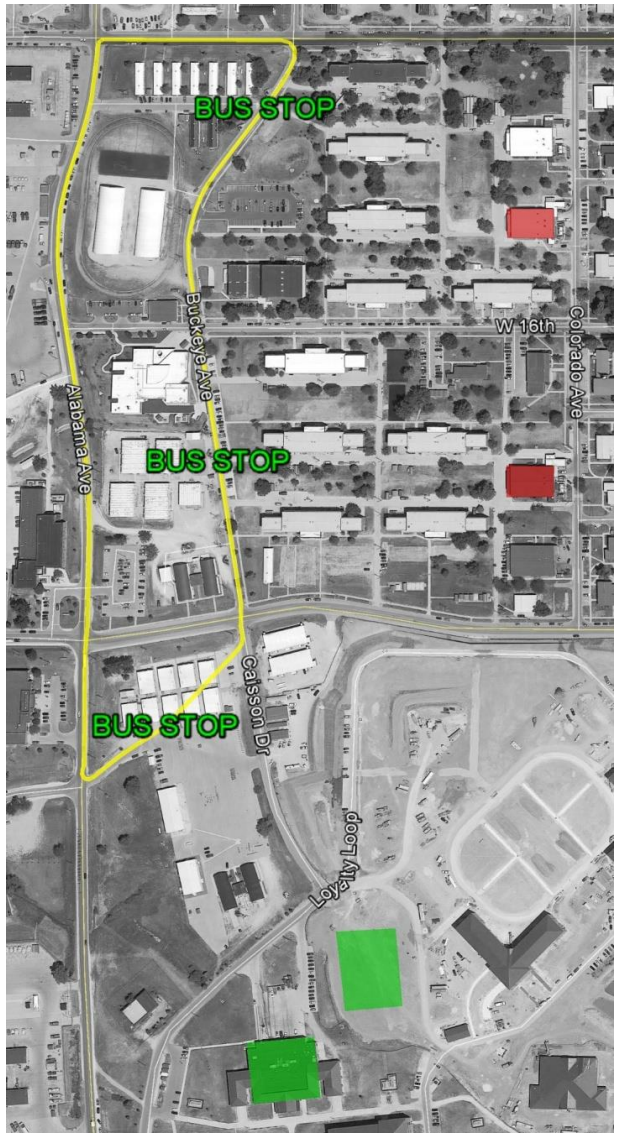
Routing, Route #1

- 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 of 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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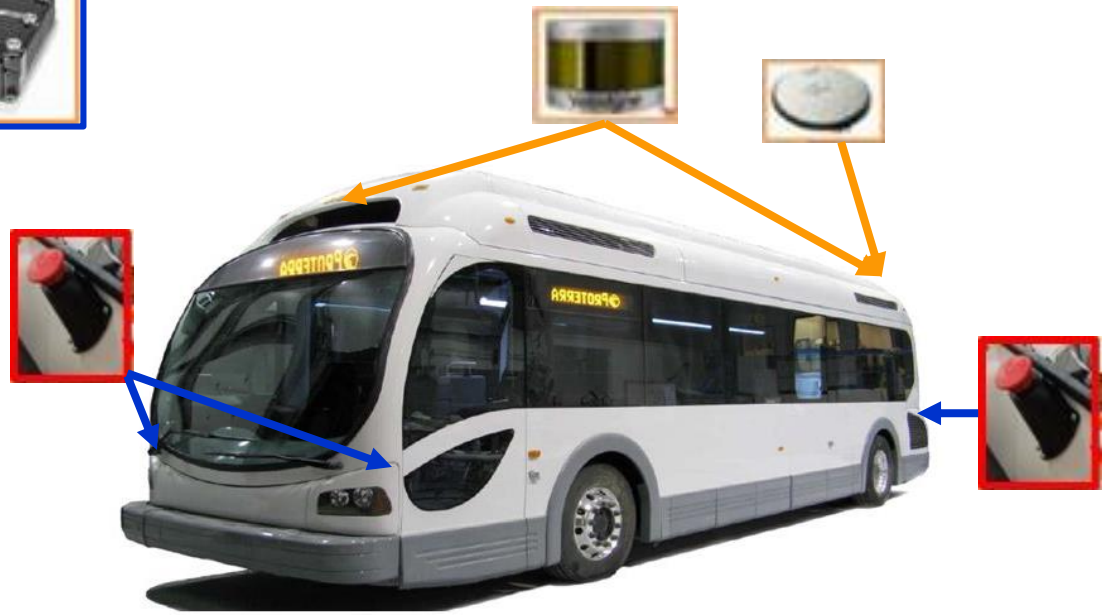
- Project Team (Ft. Leonard Wood)
- Issues/Questions

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