U.S. Department of Transportation

Notice of Funding Opportunity Number 693JJ317NF0001

"Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Initiative"

VOLUME 1 – TECHNICAL APPLICATION

Project Name	Greenville Automated (A-Taxi) Shuttles
Eligible Entity Applying to Receive Federal Funds	Greenville County
Total Project Cost	$ 8,500,000
ATCMTD Request	$ 4,000,000
Total Federal Funding (including ATCMTD)	$ 4,000,000
Are matching funds restricted to a specific project component? If so, which one?	Yes: Restricted: GAVP $2M = Automated Vehicles/ equipment; Verdae $1M = Mobility Hubs
State(s) in which the project is located	South Carolina
Is the project currently programmed in the: • Transportation Improvement Program (TIP) • Statewide Transportation Improvement Program (STIP) • MPO Long Range Transportation Plan • State Long Range Transportation Plan	Yes/No – *please specify in which plans the project is currently programmed* No - currently for all items. Yes for MPO, if the GPATS Board approves the 2040 MPO Long Range Transportation Plan in October 2017 with documents supportingAutomated Connected Electric Shared (ACES) vehicles and technologies used in this proposal.
Technologies Proposed to be Deployed (briefly list)	• Automated Taxi (A-Taxi) shuttles using V2V and V2I technology • Infrastructure Enhancement (V2I) • nSight™ automated vehicle data collection and analysis system • Real-time traveler information system to support on-call service by A-Taxis

Submitted by:

Greenville County, SC

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PROJECT DESCRIPTION

1 INTRODUCTION

1.1 Background

Transportation is in the midst of a quiet but profound revolution. This includes technology advancements (automated vehicles) as well as new systems of travel (shared mobility), and new attitudes towards traditional automobile use. While focus in the popular press has been on fully automated vehicles (all roads, all the time), specialized vehicles already exist. Automated shuttle buses have been deployed in half a dozen European countries and have begun to be deployed in specialized locations in this country. Babcock Ranch in Florida and Bishop Ranch in California are examples of planned deployment on private real estate development.

These vehicles offer speeds up to 25 miles per hour and most can operate on local roads with mixed traffic. In sum, they do not require a driver and function as SAE Level 4 vehicles within specific geographies. Most expect the technology to improve over the next few years, with faster speeds and greater ability to handle mixed traffic.[1] This expected improvement makes them an ideal building block for a community that wants to build their transport system around vehicles that are Automated Connected Electric and Shared **(ACES**).

Greenville South Carolina will be the first community in America to deploy an integrated system of Automated Taxi-Shuttles (A-Taxis) on public roads in several demographically different districts. The ACES shuttles operated on public streets will be referred to as **A-Taxis**. These A-Taxis will improve mobility with expanded service, increased convenience (including on-call using smart phones and other devices), , and livability advantages that will attract broad public ridership. A-Taxis will improve last-mile connectivity and improve access for social disadvantaged and mobility impaired residents to services such as healthcare, education, jobs, and existing bus transit. The result will increase economic opportunities and reduce traffic congestion, accidents, costs, and pollution. A-Taxis will connect disadvantaged citizens with the services they need.

1.2 Program Overview

Greenville County's goals are ambitious – to be the national center for Automated, Connected, Electric, Shared vehicle deployment. Any practical and speedy deployment of leading-edge transport technology calls for public-private partnerships. In addition to public funds from the County and City, we have already attracted significant private sector financial and technical support. The County recently secured a $2 million matching challenge grant from the Global Automated Vehicle Partnership (GAVP)[2]; $1 million from Verdae Development, Inc. [3] for multi-modal stations; and $500,000 in in-kind resources from Robotic Research as part of their technology deployment. This means that almost all of our matching funds will be provided by our private partners. Revenues from user fees and County cost savings are estimated to total an additional $1 million.

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[1] "The Road Ahead" by John Zimmer (CEO of Lyft); (September 18, 2016, https://medium.com/@johnzimmer/the-third-transportation-revolution-27860f05fa91#.rk35qtx8u

[2] http://gavpartnership.org/ These funds can be used to purchase automated vehicles and related equipment.

[3] http://www.verdae.com/ These funds will provide a mobility center to link A-Taxi routes with existing transit.

Furthermore, we will leverage the manufacturing and academic resources in the region. The region is home to BMW's largest assembly plant and the US headquarters for Michelin Tire. Clemson University's International Center for Automotive Research (CU-ICAR) is located in Greenville and will be an active participant in our deployment of A-Taxis. The ATCMTD grant will be an essential building block to the near-term A-Taxis deployment and will help to stimulate the region's long-term investment in shared AV technology.

1.3 Phased Approach to A-Taxis Deployment

Any ambitious plan must start someplace, and Greenville is the place, and now is the time. The 3 phases of deployment are described below. As a sign of Greenville's commitment to ACES and to rapid generation of benefits for our residents, we will begin Phase 0 this summer and expect to have it fully deployed by the time DOT makes an award under the ATCMTD program.

1.3.1 Phase 0 – Proven Technology

Phase 0 starts this summer (2017) and will be operational by the end of 2017; all before FHWA makes a decision on the ATCMTD program,. Two electric automated vehicles (EAV) are currently used by Robotic Research at Fort Bragg under the Tank Automotive Research, Development and Engineering Center (TARDEC) ARIBO effort to transport "Wounded Warriors" autonomously. These EAVs will be repurposed as A-Taxis in Greenville at CU-ICAR, connecting with nearby academic and business collaborators (including BMW's research center) as well as shopping, dining, and living areas along Millennium Drive. See Map below.

Our team's nontraditional pre-award deployment demonstrates 1) a commitment by Greenville to be the national leader in Automated Vehicle development and deployment and 2) we have technical and financial resources as well as the necessary political commitment to begin operations prior to receiving funds from US DOT. Facilitation for Phase 0 comes through Robotic Research from an existing Department of Defense ARIBO program hosted by TARDEC. When combined with other public and private resources, this totals at least $500,000 in automated assets, support equipment and software, and a combination of local public and private resources.

Simultaneously, we will modify and make available the existing Robotic Research reservation and scheduling backend software that provides access to the A-Taxis service. CU-ICAR will provide a location for A-Taxi operations and services.

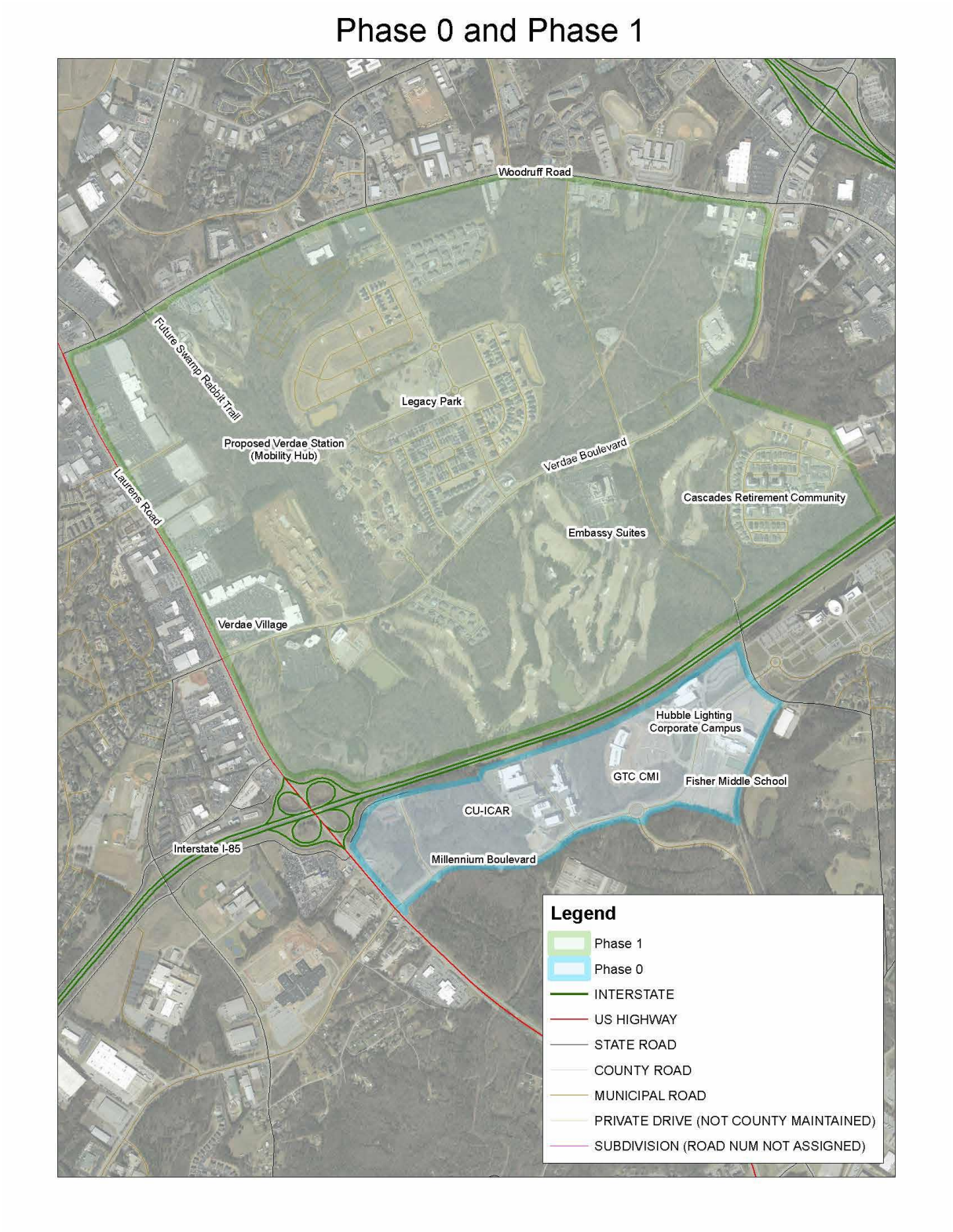
Phase 0 offers an opportunity to deploy the A-Taxis and provide proof of concept and the value of autonomous vehicles to the Greenville community. It will demonstrate that safe operations is priority one, stimulate community interest in the technology, and encourage further deployment.

1.3.2 Phase 1 – Initial Expansion

After a successful Phase 0 pilot, the A-Taxi service will expand across I-85 to serve the nearby Verdae development with its housing, office, retail, and commercial centers. At this stage, Verdae Development will build a mobility center to serve A-Taxi routes and link with existing transit services.

We expect deployment within 3-6 months following an ATCMTD award (ideally by mid 2018). This phase will involve an additional 4-6 A-Taxis. These additional A-Taxis will be built on a vehicle platform that is specifically designed for automation enhancements, interior climate controlled and more user-attractive than the two Robotic Research EAVs used during Phase 0.

Additionally, 1-2 of Phase 1 A-Taxis will be equipped with technologies to fully assist the mobility impaired. [4]

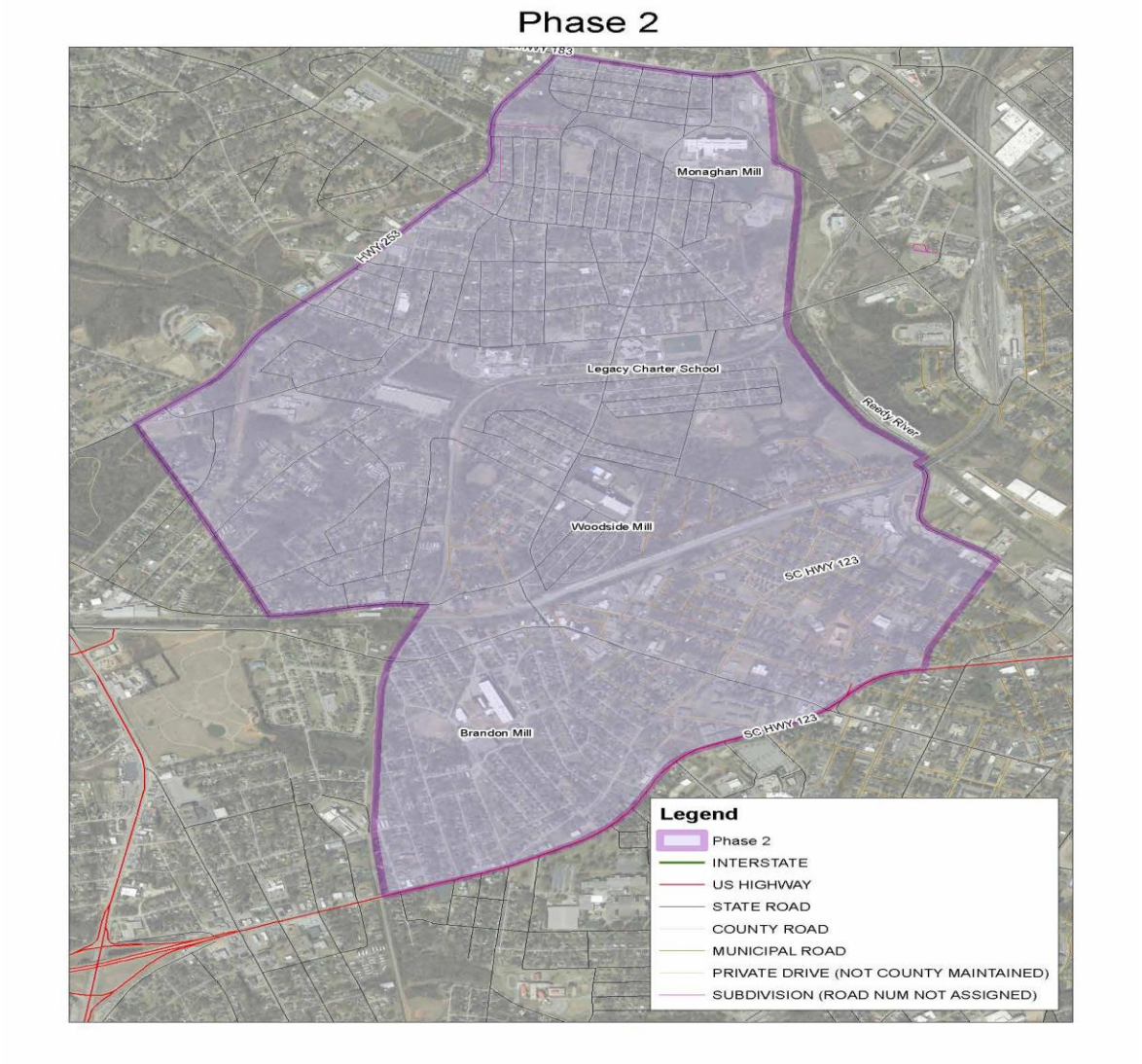


[4] This technology has been developed by Robotic Research and tested with Wounded Warriors at Fort Bragg.

1.3.3 Phase 2 – Expanded Service and Capability

Emergency Medical Services (EMS) deployment. This will provide non-emergency medical transportation (NEMT) to disabled, elderly, low-income, and other transportation disadvantaged people. The vehicles will be based near Legacy Early Middle College Charter High School and serve residents within the Parker zip code (among the lowest 10% of incomes in America). Citizens will be picked up at their residences and delivered to healthcare appointments, screenings, rehabilitation, exercise or other daily activity needs. Piedmont Health Foundation has found that lack of transportation is a key barrier to economic success in our community.[5]

We expect deployment by late 2018, with an additional 4-6 A-Taxis vehicles. In addition to important health benefits, the county will generate significant savings since this service currently costs the county an average of $450 for each trip. These savings provide an important justification for financial support from the County. A-Taxi service could also provide transportation to jobs, retail, recreation, and other locations.



[5] http://piedmonthealthfoundation.org/our-focus-transportation-mobility/mobility-study/

1.4 Outreach

This will be ongoing during the project. In addition to written material and webinars, we will invite interested parties from other communities and transportation organizations around the country to visit Greenville and observe the operational system first hand. The facilities, faculty and students at CU-ICAR provide a state-if-the-art resource for demonstrations, seminars, and workshops. An important part of this effort will be to develop business case options that will enable other communities to replicate a similar bankable plan. We will update our business plan to support a regional deployment of A-Taxis and related automated technologies.

1.5 Evaluation

Continuous evaluation of operational data from Phase 0 through Phase 2 allows improved operations throughout the grant period. Our private partner, Robotic Research will supply one of the most advance automated vehicle data collection and analysis systems (nSight™) for use during the life of this program. All captured data and lessons learned during this effort will be used to improve operations, and will be an integral part of our final report to DOT.

1.6 Key Characteristics of Proposal

The Greenville A-Taxi program stands out in several ways. This is a true public-private partnership. Greenville will leverage Robotic Research resources, experience, and lessons learned from their automated vehicle deployments around the world. Financial backing from GAVP, a private non-profit organization devoted to speeding deployment of autonomous vehicles. We leverage investment from Verdae Development Corporation, the technical knowledge at CU-ICAR, and the local automotive industry including BMW, Michelin and other nearby firms.

We emphasize low cost deployment and customer needs. Our technology approach uses a vetted retrofit system – this makes it possible to match the vehicle size and type to the specific needs of each location. This is not a research project since we will build on proven technology already developed and deployed by Robotic Research.

- This emphasis speeds up national deployment of A-Taxis and related automated vehicles.
- It stands in contrast with expensive ($250K and up) custom vehicles that may or may not meet customer demand, and locks you into a specific vendor.

Our focus is customer needs. – the only way to reduce congestion and provide economic and social benefits especially to those currently living in disadvantaged areas.

We will deploy A-Taxis in varying locations with diverse transportation needs: 1) new residential area with “last mile” links to office parks, traditional transit, and local amenities and 2) non-emergency medical transport access to local healthcare for residents of a low- income neighborhood.

We are not cherry-picking locations. Most current deployments focus on upscale locations alone (Babcock Ranch in Florida and Bishop Ranch in California are examples). We will deal in the real world, covering diverse types of communities. This approach offers tangible benefits to Greenville but also provides lessons learned and real data for other communities across the nation can benefit from.

We will refine our formal business plan during each Phase of the program and provide as guide to help other communities deploy A-Taxis. This will also assist Greenville in deploying a full regional network beyond this program.

2 GREENVILLE COUNTY QUALIFIED APPLICANT

Greenville County (County) is the qualified applicant entering into the Advanced Transportation and Congestion Management Technologies Deployment agreement with USDOT. The County is a political entity created and existing under the laws of the State of South Carolina. The County is responsible for the management, development, operation and maintenance of services for about 500,000 people and 790 square miles in Greenville County. A twelve (12) member elected Council provides policy guidance for the County. County Council employs an Administrator/ CEO. The Administrator is responsible for the implementation of County Council's policies and directs the development, operation, management, and promotion of all activities, which the County is charged with under the State laws.

2.1 County Partners in a Public Private Consortium for Management

Greenville County will manage finances and audits and engage a public private consortium to help manage the project. The consortium meets eligibility guidelines published in the NOFO:

1) "Partnership with the private sector or public agencies, including multimodal and multi-jurisdictional entities, research institutions, organizations representing transportation and technology leaders, or other transportation stakeholders."

2) "Meaningful arrangement with all members involved in planning the overall direction of the group's activities and participating in most aspects of the group;" and

3) "long-term relationship intended to last the full life of the grant."

A key partner leading the consortium is the Carolinas Alliance 4 Innovation (CA4I) that is organized as a private non-profit, 501.c.6 public benefit corporation serving to advance innovation and economic development goals. The 2017-18 Executive Committee of the CA4 Innovation includes five individuals representing a cross-section of the local community, including:

CA4I, Chair, and Green Ribbon Advisory Committee, Past Chairman, Doug Webster;
CA4I, Chair-Elect, and IEEE, Past Board Member, Lee Stogner;
Clemson University-Center for Automotive Research, Executive Director Fred Cartwright;
City of Greenville, Councilman and SCRA Board Member, George Fletcher;
Greenville County, Councilman and GPATS (MPO) Committee member, Fred Payne.

Greenville County has identified a public ad hoc Committee on Innovation for Economic Development (I4ED) to work with the Carolinas Alliance 4 Innovation (CA4I or CA4 Innovation), which will oversee the planning, management and fund-raising for this project. The I4ED Committee and the CA4I Executive Committee have the same members (current 5 members represent County Council, City Council, Green Ribbon Advisory Committee, IEEE professionals, and CU-ICAR). I4ED will hold public hearings and meetings, while CA4I will be oversee management of the Greenville A-Taxi project.

The CA4 Innovation Consortium is comprised of members and advisors from several entities:

- The CA4I Executive Committee will be responsible for managing plans and projects.
- Robotic Research will serve as Project Director for the "Prepare" and "Operate" portions and will provide technical automation expertise, user interface methods, intelligent route planning and data collection, analysis, and management.

- GAVP – a 501.c.3 is an Advisor providing a $2 million challenge grant and a Project Coordinator to develop a playbook template to replicate A-Taxi fleets in other areas.
- Compass Transportation and Technology will provide evaluation and business plan support
- Greenville County Administrator and staff provide financial and transport planning management
- Advisors representing EMS and local hospitals for NEMT programming
- Advisors representing local funding sources and deployment districts

These team members will work with CA4 Innovation on planning, funding, and management of the program, including phases underway prior to the ATCMTD grant.

To assist with data collection and analysis, the project will partner with Robotic Research and with Clemson University and its International Center for Automotive Research (CU-ICAR).

2.2 Funding Description

Funding sources include both public entities and private partners. CA4 Innovation represents a public private consortium that is a voluntary, meaningful, long-term planning and participation arrangement with members from governmental, academic, corporate, and non-profit sectors. Multiple letters of support document interest, intent, and funding support from all these sectors.

The proposed A-Taxi deployments are expected to take three years to complete so that a proposed 2018-2020 fiscal year service schedule is reasonable.

The proposed A-Taxi system implementation and testing is expected to cost $8.5 Million. The $8M in total project cost, is proposed to be split with $4 million from ATCMTD and $4.5 million from private and public matching funds.

- GAVP for AV deployment on local roads to collect data, attract riders, and develop a template for other metro communities across America- $2M Challenge.
- Verdae Development has pledged $1M for land and mobility hub facilities on their property
- The Spinx Corporation will provide $180,000 in resources to support EV charging locations.
- The A-Taxi system will generate revenues from both user fees and budget savings, estimated conservatively at between $1 and $2 million total. Greenville County EMS lost over $2M in 2016 on non-emergency medical transportation (NEMT) in Parker zip code area. We expect to receive a portion of these savings as part of an A-Taxi solution in Phase 2 as well as user fee income from the Phase 1 deployment in Verdae.
- Robotic Research is currently deploying a A-Taxi system developed for a military project. The value of their investment in Greenville will exceed $500,000.

3 GEOGRAPHIC AREA /JURISDICTION OF A-TAXI SERVICE

The project is confined to property in Greenville County, South Carolina. There is often severe congestion on I-85 that connects the region with Charlotte, North Carolina and Atlanta, Georgia. Congestion is routine along other major traffic corridors including Woodruff Road and Laurens Road adjacent to CU-ICAR and Verdae (Phase 0 and Phase 1 deployments). Initial deployment for testing, validation, and demonstration will be in the CU-ICAR and Millennium Drive area.

Greenville County has a 2016 population of about one-half million residents and expects to grow by 25 percent or more by 2040. Greenville has changed from the being the center of the nation's textile manufacturing last century to being in the middle of the I-85 automotive belt today.

Greenville has been actively seeking ways to improve public access and transportation for many years. In 2009-2010, a multi-modal transportation feasibility study was undertaken by TranSystems along the GCEDC former railroad corridor that compared five public transit options. It determined that Bus Rapid Transit (BRT) was least costly, but all existing systems lacked projected ridership thresholds and potential attraction to "choice riders."

Today, automated vehicles and shared rides offer an opportunity to provide better, lower cost services that match individual travel needs. As a result, in 2017, Greenville County is now ready to deploy automated (A-Taxi) shuttles with "crawl, walk, run" or "pilot, demonstration, deployment" phases beginning over the summer of 2017. These steps have specific goals:

- Pilot – limited area, operator on board, testing operational systems, collecting data, visual observers, surveys completed, no passengers
- Demonstration – pilot completed, voluntary passenger, and non-paying trial riders
- Deployment – everything above, with commercial service.

4 REAL WORLD ISSUES AND CHALLENGES

The Greenville A-Taxi shuttle program will demonstrate several new technologies and serve multiple mobility demands. We will need to address and resolve a series of practical issues. Where possible, we will draw on the experience of other regions. Examples include:

Human factor issues are a key topic of conversation regarding new technology. These will come in several shapes and sizes and we do not expect to find "cookie cutter" solutions. While there has been a steady stream of articles about automated vehicles, few people have seen them in person and even fewer have used them on a regular basis. How will the public react to a vehicle with no active operator? We will spend considerable time during the field test period using vehicles with an operator to answer questions. We are open to changing everything from routes to operating practices in response to reactions from our early stage customers.

The Greenville A-Taxi network will provide new forms of mobility. Service will be more personalized, with door-to-door type service rather than bus stop to bus stop with last mile/first mile connection issues. How will the public adapt to this – and how long might this take?

We plan to serve three quite different markets/communities: 1) *Phase 0* - CU-ICAR academic and office park. 2) *Phase 1* – Verdae, an upper income neighborhood where there will be competition with private transport; and 3) *Phase 2* – Parker zip code areas, a lower income neighborhood with more limited private and public Non-Emergency Medical transportation. While we expect important cost savings due to the larger scale of deployment, we recognize that each area represents an individual market. Most previous efforts to deploy automated shuttle vehicles have only tried to serve a homogenous market. Our approach makes it easier to provide community-wide service.

New performance measures and new ways to collect operating data. The nSight system developed by Robotic Research will help here, but the results will need to be formatted to fit performance measures more commonly used to evaluate traditional transit service.

The A-Taxi network will use electric-powered vehicles. These will need to be integrated with the Smart Grid and other energy distribution and charging systems. This should be done with an eye to a growing fleet of public and private electric vehicles. That is, this is not a one-time set of

electric vehicles. Indeed, the involvement of the Spinx Corporation network of convenience stores is one way to begin to build a larger network.

Elderly and handicapped individuals are currently served by a relatively high-cost and not always convenient set of transport systems. The A-Taxis offer an opportunity to provide service that is more personalized and with lower public costs. But, there will be important human factor issues as individuals are asked to adapt to an A-Taxi system with new operating characteristics as well as a new "look and feel."

5 TRANSPORTATION SYSTEMS AND SERVICES IN THIS PROJECT

As mentioned in the introduction a growing number of commercial firms exist to take advantage of this new market. Low-speed automated shuttles have been deployed in commercial operation around the world. A few of these automated shuttles qualify as SAE Level 4 automation. While they can be driven by an operator, their main purpose is to operate in full automation – but with audio and visual communication as needed by passengers. Shuttles may offers speeds up to 25 miles per hour and most can operate on local roads with mixed traffic.

Our four to six seat A-Taxis offer on demand and scheduled service. Designated vehicles will be ADA compliant with space for wheelchairs and can be equipped with the automated wheelchair access system developed by Robotic Research. Specialty vehicles to provide non-emergency medical transport services will be deployed in the Parker zip code area. Where relevant, we may use small vans capable of handling 10-12 passengers. A high service level will be achieved by incorporating:

- Fully automated/autonomous vehicles
- Reservation Application that runs on Smart Phones, Tablets, and Web interfaces
- Short walking distances for riders
- Waiting time typically less than five minutes
- Roll-on, roll-off access for wheel-chairs if needed (and automated for some vehicles)
- All passengers are seated
- Trips are generally nonstop and Travel times of less than ten minutes
- Reliable service

Congestion and safety will be improved by removing the present need for many pedestrians to cross roads. Healthcare will be improved by providing dependable transportation to physician directed care plan activities.

6 DEPLOYMENT PLANS IN INNOVATION DISTRICTS

As previously described in the introduction, there will be three distinct phases:

- **Phase 0** will initiate pilot and demonstration stages using automated Cushman 6-passenger electric vehicles around CU-ICAR & along Millennium Drive by EOY 2017 – not funded from this grant application.
- **Phases 1 and 2** will intentionally involve more capable automated vehicles for targeted uses, and more widespread deployment in more complex settings in early 2018. Additional deployment districts will include Verdae and the areas around the Parker zip code (29611).

In Phases 0 and 1, A-Taxi vehicles and systems will utilize a designated area in the Parking Deck at CU-ICAR & Millennium Drive area for storage and service. This is a 5-story deck with approximately 1,500 stalls attached to the CU-ICAR offices.

Many faculty and students need access to a shuttle system to connect with the Center for Manufacturing Innovation operated by Greenville Technology Center– about 0.5 miles away. A-Taxis provide a better solution than automobiles with quick connect times for the CU-ICAR and Millennium Drive area.

Signaling and road sensory equipment will be added as necessary to accommodate A-Taxis and to provide V2I (vehicle to infrastructure) type services. Private funds will be combined with DoD funds that the Department allocates to support commercial deployment of technology originally developed for Defense applications.

Two fully automated Cushman 6-seater electric vehicles will be transferred from the Wounded Warrior project at Fort Bragg to serve the CU-ICAR area in Greenville. A demonstration stage will provide a proof of concept re: safety, technology, and awareness to regional business and political leaders and the general public. As the Phase 0 initial process is being undertaken and successfully completed, work can begin on Phases 1 and 2 using funds from this grant application as well as matching dollars already committed to this effort.

Phases 1 and 2 will involve automation of van or passenger car shuttles using retrofit kits from Robotic Research. In Phase 1, additional vehicles will be acquired to expand service across I-85 into the Verdae district. And in Phase 2, the area in the Parker Zip Code (29611) District around Legacy Charter School will be served. A total of 4-6 A-Taxi shuttles will be needed for both of these two areas – a total of 8-12 vehicles plus the two initial vehicles for Phase 0. The exact routes of the A-Taxi system will be determined as testing and demonstration phases are completed and public demand is quantified. Full deployment for Phase 1 is expected to commence in about six months with Phase 2 to follow by early 2019.

When fully activated, each A-Taxi vehicle is expected to accommodate approximately 30-40 daily passenger shuttle trips from client primary origin (home or work) to daily activity site destinations where clients work, heal, learn, shop, dine, transit or play. One vehicle making 35 trips/day/week will provide more than 200 trips per week, so ten vehicles would make 2,000 trips/week or 100,000/year.

The Phase 2 work will focus on Greenville County Emergency Medical Service (EMS). In 2016, almost 5,000 EMS ambulances with a paramedic team were deployed in the Parker district for non-emergency medical transport at a cost to the County of more than $2 million. Our goal would be to improve access to non-emergency medical services for local residents – and reduce County transportation costs in the process. Part of the County savings would be used to help fund the a-Taxi service. Half of potential savings over the 1.5 years of full operations would total $1.5 million. To be conservative, we assume $1 million in our budget.

Proposals for vehicles will be received in late 2017 from potential van or passenger car suppliers. Final selection of the initial supplier(s) could be completed by early 2018 with intent to automate the first vehicle for service within 3 months and commercial service by mid 2018.

Once in service, the operation will be integrated within the A-Taxi operations system used to manage the CU-ICAR and Verdae phases. This will help control costs and ensure that we use the most up-to-date technology across the full network.

7 CHALLENGES AND OBSTACLES TO DEPLOYMENT

The biggest challenge and obstacle to development is the fear of the unknown and the difficulty of implementing a new technology with a limited track record. Human factors will be important as potential customers need to adapt to a new technology and a new form of transportation services. So far, the perceived benefits outweigh perceived obstacles.

One of the obstacles to deployment is the lack of clear rules and regulations applying to this technology. The State of South Carolina has indicated that, since this is new technology for the State, they have no vehicle standards identified. However, it is a requirement that a licensed driver be behind the wheel and responsible for interventions. There is a possibility that they will develop and impose requirements that could have an unknown impact on the project.

Federal funding would help mitigate some of the financial challenges and aid with project viability, but it may also bring its own set of hurdles. If the Federal FHWA provides funding under this grant, it is unknown what requirements it will impose. Will there be added technical and safety requirements; or added procurement and wage rate requirements? Added requirements could delay the project and increase its costs – neither of which are desirable outcomes.

Concerns about the viability of the suppliers of automation technology are being mitigated by contracting for the automation system through Robotic Research. We plan to use a series of performance measure to track operations and provide early warnings in case of shortfalls.

8 QUANTIFIABLE SYSTEM PERFORMANCE IMPROVEMENTS

During the entire operational period, the system will be subjected to data gathering and analysis to document actual improvements in safety, efficiency, system performance and return on investment. We will rely on reports generated by the nSight™ data collection system for key parts of these performance measures. In addition, the frequent inspections, automated self-monitoring systems and other good practices and technologies associated with A-Taxi vehicles and systems will be tested and observed for lessons-learned related to improving infrastructure management, reducing maintenance costs, prioritizing investment decisions and ensuring a state of good repair. This oversight and ongoing evaluation effort will generate useful lessons learned for Greenville as well as for other locations with an interest in deploying automated vehicles.

This project is planned to demonstrate a broad array of A-Taxi benefits. For each set of benefits, we will identify one or more specific performance measures and track these during deployment and operations. Section 9 asks for detail on the three most important performance measures – safety, mobility and environmental impacts.

We plan to use three techniques to collect relevant performance data.

1. Robotic Research's nSight™ reports will describe vehicle performance and costs parameters in detail. These data will also provide information that is important to customers regarding safety, reliability, and service quality – for example trips started on time and completed on time; average travel time; and circuitry.

2. Customer surveys regarding satisfaction and suggested improvements. These will be particularly important during the early stage of deployment, including pre-commercial operations. We plan to leverage the survey system (survey monkey) currently used by the ARIBO program. In addition, we plan at least one full survey during each year of operation for

each of the three deployment areas. This market research will include focus groups in order to collect more open-ended responses.

3. Data from existing City and County sources. Much of this will include baseline information on traffic congestion, energy use, and general environmental impacts. Some additional data collection will likely be required for specific locations.

Everything begins with efficient operations. How reliable is the service? What are capital and operating costs? How do these vary by load factor? By overall passenger demand? and by neighborhood characteristics (for example, higher density versus lower density locations)? Most of the required data will be collected by Robotic Research's nSight™ reports. These will be summarized in two types of reports:

- Operating characteristics; and
- Customer service – supplemented with additional data from surveys etc.

Improved mobility will be a key benefit, with additional trips and improved access to jobs and health. The A-Taxi network will improve accessibility both for individuals with access to private vehicles who prefer the flexibility and convenience of an A-Taxi and for individuals with more limited access to transportation. Mobility and access will be measured in terms of the number and type of trip completed relative to common practice prior to A-Taxi deployment. These trips will be grouped by type (job, social, medical etc.) and assigned approximate dollar values. We expect to focus on two types of new trips:

- With an emphasis on underserved populations and their access to health services; and
- Mobility options to support new residential and business development, with increased economic activity and reduced use of automobile trips for routine activity

Reduced traffic-related fatalities and injuries will be tracked. We are particularly interested in changes in pedestrian accidents since we expect that the A-Taxis will provide more door-to-door service particularly in the neighborhoods with limited numbers of private vehicles and somewhat scattered public transit service. We will track absolute numbers of accidents, injuries and fatalities and accident rates for A-Taxis versus traditional modes (walk, ride, transit etc.).

Reduced traffic congestion will depend on the ability to divert travel from private cars (single occupancy vehicles in particular). These impacts will be most likely in the Verdae and Cu-ICAR areas. We will collect data on traditional congestion measures (travel time index, planning index, buffer index, etc.) along Woodruff Road and Laurens Road. Trend data exists for these roads (or can be collected from archived GPS-based probe data).

Improved travel time reliability. Travel time reliability will be a major benefit, particularly for people living in areas with limited access to private vehicles or to traditional public transit. Reliable transportation is a key factor for a variety of economic and social goals. Reliable transportation is key to a timely arrival for medical appointments, and many individuals miss or skip appointments due to poor service. Reliable/predictable travel times are vital in obtaining and keeping jobs. We will collect these data in two ways:

- Using operating data from the nSight™ system
- Satisfaction surveys of customers

Reduced transportation-related emissions and reduced energy use due to all-electric vehicles. We will calculate energy use and emission per vehicle mile and passenger mile of travel and compare these with metrics for traditional travel

The A-Taxi system is not meant to provide all travel options. Intermodal connections will be important. The Verdae Mobility Center will provide links with both park and ride and existing Greenville transit service. A-Taxis in the Parker zip code and CU-ICAR will provide similar links with existing transit lines. We will track the number of intermodal transfers, the types of trip involved and expected impact on current transit operations and finance.;

The A-Taxi system will use internet and smart phone apps to communicate with travelers about when and where service would be available. These apps can also be used to call or confirm a trip. This represents a significant change for Greenville and we will monitor the value and use of such near-real-time information in modal shift and in generating additional travel.

Shared rides offer an opportunity to improve the overall efficiency of transportation. We will measure the number of shared or group trips and their characteristics – who and when are people willing to do this? How might shared travel be increased? What offsetting costs might there be – increased travel time, for example.

Performance measures will be an ongoing effort for the Greenville A-Taxi program. We will work to ensure the highest quality service and in order to provide guidance for other regions that consider a similar service. Summary performance reports will be included in our monthly reports to US DOT and a more formal summary will be included in our annual report for the Secretary.

The proposed A-Taxi vehicles provide indirect jobs due to improved access – particularly for residents in the Parker zip code who currently have poor access to transportation. Direct jobs will include approximately 10 new full time equivalent jobs on a continuing basis for system operations and maintenance. These jobs will include operators/assistants, cleaners, maintenance technicians; operations control personnel as well as management positions. We will track 1) the number of new direct jobs generated by the A-Taxi system; 2) the number of new jobs that improved access may stimulate; and estimate increased economic activity due to new trips to local restaurants and retail establishments. Generating a net number will be difficult.

In addition to regular reports on a full range of performance measures, we will prepare an overall rate of return estimate, including a cost-benefit estimate, and an estimate of sensitivity to factors such as cost, service quality etc. These results will be included in a final report to US DOT.

9 QUANTIFIABLE SAFETY, MOBILITY, AND ENVIRONMENTAL PROJECTIONS

These are the “Big Three” impacts. Proposed performance measures were described in Section 8. Projections are difficult given the lack of similar deployments in the US and elsewhere in the world. We have not prepared projections at this stage.

As we begin deployment we expect to generate a better sense of the volume and nature of A-Taxi usage. We will prepare a baseline forecast for each deployment prior to completing the field test stage. Based on comparisons of forecasts with actual results, a projections guide will be prepared for other regions to use – and that we will use in Greenville for additional services.

Of the three categories listed here, we expect mobility benefits will be most substantial. Environmental and safety benefits will be tangible, but the scale of these early deployments is unlikely to generate impacts that will be noticeable on a regional basis. Within safety, we expect that noticeable changes in pedestrian accidents.

Mobility gains are different, in part since these will be focused on specific, compact neighborhoods. The Verdae area (Phase 1) should generate improved access to services in the community (community center, parks etc.) and to nearby restaurants and retail centers. This will be stimulated by the planned expansion of the Swamp Rabbit Trail (abandoned rail line) adjacent to Verdae. The Verdae Development Corporation believes that these impacts will be significant – and have committed $1 million to build a Mobility Center to support A-Taxis and to provide an intermodal link to the existing bus transit service.

We have high expectations for mobility benefits in the Parker zip code. Existing surveys show that limited transportation has a major impact on access of many residents to fulfill non-emergency medical appointments. We also expect gains in access to the job market for residents.

10 VISION, GOALS AND OBJECTIVES

10.1 County Vision

CA4 Innovation's mission is to transform lives through innovation. CA4I forecasts that mobility futures are focused on Automated, Connected, Electric, Shared (ACES) technologies and that GreenVillages are places where people love to live, work, learn, heal, shop, and play.

CA4I's vision is to develop a world-class model for ACES vehicle fleet deployments that support integrated GreenVillages Innovation Districts. The current focus is to pilot and deploy ACES equipped shuttles (A-Taxis) in select districts of Greenville County starting in the CU-ICAR Innovation district and expanding to the area around Verdae Development. Additional districts will include the Parker zip code area around Legacy Schools in West Greenville.

10.2 Project Goals

Greenville's main goal is to use ACES technologies in A-Taxi shuttles to support attractive connected communities that we call GreenVillages development. Deployment of technologies for a multimodal transportation system provides Americans with safe, reliable, and affordable connections to employment, education, obtain and provide healthcare, and other essential services. A-Taxi fleets provide options for ridesharing through communications technologies and social network structures to bring drivers and riders together quickly and efficiently, and ACES technologies will support workforce development, particularly for disadvantaged groups, which include low-income or minority groups, persons with visible and hidden disabilities, or elderly individuals. ACES technologies include information and communication technology solutions. We anticipate benefits of ACES technology with groups that have limited transportation options, such as older Americans who no longer drive or those with disabilities or no driver's license. We join the USDOT in wanting advanced technologies to improve public connections to employment, education, healthcare, and other essential services.

10.3 Project Objectives

Objectives of A-Taxi Shuttle deployment include:

1. Use operationally-validated, commercial vehicles
2. Gather user and non-user data to refine our sustainable business model. After an initial testing period, operating costs will be self-supporting. Available data will help increase system incomes and reduce costs.
3. Compare A-Taxi results with operating costs of private vehicles. Use the adoption rate of the growth of A-Taxis in CU-ICAR (Phase 0) and Verdae (Phase 1) to assess the impacts on

economic development and to deploy AV technology over a wider area, including more disadvantaged areas like Parker (Phase2).

Ultimately, the A-Taxi Shuttle project is meant to open the door on innovation in the realm of alternative public and semi-public/shared transportation. That will encourage proliferation of the technology and reduce the barriers to entry for competitors thus reducing the costs and encouraging the use of autonomous vehicles across a full range of population groups.

11 PUBLIC PRIVATE PARTNERING PLAN

The Greenville A-Taxi project has been designed from the beginning as a public-private partnership or consortium.. We have assembled a highly competent and qualified multi-modal and multi-jurisdictional team of supporters for this project.

Greenville County will manage this project. Mr. Joe Kernell, Greenville County Administrator, will serve as the primary point of contact for the project.

A key element in this project involves active coordination with other public agencies, private sector entities, and universities. These partners may include:

Private: Global Autonomous Vehicle Partnership (GAVP), Verdae Development Corporation, Robotic Research, Michelin NA, , Spinx Corporation, Carolinas Alliance 4 Innovation (CA4I), BMW, IBM, AT&T, Bosch, Cisco, etc.

Academic: Clemson University, CU-International Center for Automotive Research (CU-ICAR), Furman University, Bob Jones University, Greenville Tech, etc.

Public: Greenville County, Cities of Greenville, Mauldin, and Clemson, GPATS, GTAUpstate SC Alliance, Greenville Area Development Corporation, SC Research Authority, etc. . Greenville County EMS (Emergency Medical Services), and Director Tim Gault, will be the key implementer of the Non-Emergency Medical Transportation (NEMT) services as an alternative to an Ambulance Team with two Paramedics. GC EMS will deploy an appropriate A-Taxi shuttle for patients needing NEMT service to access physician approved healthcare services.

Foundations: Greater Greenville Foundation, Hollingsworth Fund

Carolinas Alliance 4 Innovation (CA4 Innovation), a 501.c.6 public service non-profit organization, has been selected by Greenville County to coordinate a competitive, qualifications-based procurement process specifically for the planning, engineering and management of the primary component of this project. The CA4 Innovation team is comprised of the following entities as members and advisors

Private sector matching funds were described earlier.

Robotic Research is a Maryland-based robotic technology company providing planning, design, and engineering and installation of automation equipment and services. In addition to having an overall program management role in this project, they will also be responsible for advising on data collection and analysis services.

CU-ICAR is an advanced-technology research campus based in South Carolina where education, research, and economic development collaborate to create a global venue for the automotive industry. They will leverage their autonomous car experience to assist with the research aspects of this project.

12 LEVERAGING EXISTING INVESTMENTS IN LOCAL AND REGIONAL ADVANCED TRANSPORT TECHNOLOGY

Greenville can leverage many advanced transportation technology assets and is an ideal place to deploy Automated Connected Electric Shared (ACES) technology in close proximity to industry leaders, like BMW, Bosch, ZF, Volvo, and Magna, and research centers like Clemson University's International Center for Automotive Research (CU-ICAR). The world's largest BMW Manufacturing plant is in Greer with a nearby BMW Performance Center.

Many conferences since 2013 have enabled Greenville leaders to leverage ideas promoting ACES vehicles and GreenVillages development. National Association of Counties (NACo) Transportation Peer Reviews in Savannah & Pittsburgh (2017) and (Iowa City, 2016); Smart Driving Cars Summit (Princeton, 2017); Global City Team Challenge (GCTC) in DC (2014-16) and Austin (2016); Automated Transit Association (ATRA) Podcar (2013 and 2015); Bosch IoT Connected World (2016); Urban Mobility (Nashville 2016) and InnoVenture/ InnoMobility (Greenville 2012-2014). In 2014, the GCEDC and Greenville Health System (Greer campus) demonstrated a Navia automated shuttle. The Bob Jones University Robotic Team demonstrated its Bruin-1 automated shuttle (aTaxi) at the GCTC Expo (DC, June 2015).

CU-ICAR and other local educational institutions are actively equipping students in automation technology. Greenville Technical College's new Center for Manufacturing Innovation features automated vehicle & manufacturing training with a CU-ICAR collaborative workspace.

Dr. Venkat Krovi is the Michelin Endowed Chair of Vehicle Automation. CU-ICAR's Deep Orange 8 concept car for 2016-18 is an autonomous vehicle. Clemson University was named by USDOT in 2017 as the Piedmont/Southern megaregion "Beyond Traffic Innovation Center."

South Carolina Technology & Aviation Center (SCTAC), a former Air Force base, is utilized for automotive research and testing. SCTAC includes the International Transportation Innovation Center (ITIC) that operates three automated vehicle test beds (urban, highway, and open tracks). Dynamic and static wireless charging is being tested.

Greenville has worked to attract private sector companies to operate automated or autonomous vehicle pilots within a multimodal transportation network since they help reduce traffic fatalities and injuries as well as carbon emissions. In 2016, both Greenville County and City passed Resolutions inviting autonomous vehicle (AV) testing, R&D, and deployment. State leaders have also demonstrated favorable attitudes and actions toward automated vehicle usage. Our ACES project will show practical value of automated vehicles and demonstrate to state leaders the viability of public-private partnerships for cost-effective deployment of automated vehicles as well as a new way to build needed transportation infrastructure.

13 PROJECT SCHEDULE / TECHNOLOGY / TASKS

13.1 Technology Descriptions

In this section, we detail relevant recent experience for Robotic Research that apply to this effort. We detail the research, testing, developed technology, and historical knowledge that we will leverage to design the ACES system. The end of each subsection (project) highlights all research and technology to be leveraged.

We strongly believe that there is no other team that has our experience in these areas. Our approach reduces cost and risk by leveraging existing solutions for the key aspects of the

problem, both on the technical side and on the safety side. Our solutions are already improving the independence of wounded warriors at Ft. Bragg; with this program, we can further expand the technology to support a wide range of independent living, employment, and health outcomes for individuals with and without disabilities.

13.1.1 Autonomous Technologies (ARIBO)

Robotic Research's program, Applied Robotics for Installation and Base Operations (ARIBO), is a nation-wide effort to join technology with operational needs, demonstrating and evaluating autonomous systems in real-world environments.

The technical issues that were explored and refined include: system reliability, efficiency, and safety; vehicle-to-vehicle and vehicle-to-infrastructure (V2X) communications; data security; human-machine interfaces (HMI); and vehicle obstacle avoidance, navigation, mapping, and fault tolerance. Operational and acceptance data are expected to inform decisions involving policy and infrastructure modifications. Understanding of these issues, and the factors that affect them, will also reduce the future developmental cost of automated systems, as environments and behaviors become more accommodating over time.

It is widely acknowledged that technology can improve the efficiency and safety of vehicles on roadways. Both technical and operational refinement are needed to fully understand the most advantageous and cost-effective applications that will accelerate the widespread adoption of autonomy-enabled systems. In an effort to understand how both users and non-users interact with autonomous vehicles, the ARIBO program is investigating a personal mobility use case in a campus-like setting which involves free-flowing traffic, intersections, parking lots, pedestrians, and bicyclists.

ARIBO addressed the real-world needs of the Warrior Transition Battalion (WTB) at Ft. Bragg. The soldiers in this battalion, some of whom have mobility difficulties, often require transportation assistance from the barracks to the Womack Army Medical Center (WAMC). Prototype automated vehicles are deployed to transport soldiers from the WTB barracks to the WAMC, in order to improve and learn more about the reliability of the automated system, and understand the impact of automated vehicles on operations and the transportation system.

We utilize robotic technology to provide an unmanned transport system and reservation/reminder system for these soldiers and their caretakers. Soldiers, caretakers, researchers, etc. (referred to as either participants or users) request on-demand transport via their personal mobile phone, or public kiosk. In turn, the reservation system sends reminders of transportation appointments through application notifications and SMS. The latter is particularly important for AWTO, because some passengers may be affected with traumatic brain injuries, which can affect memory recall. A typical use cases involves:

- A smartphone app is used to make an appointment for a particular type of therapy for a user (Figure2 Figure a).
- The entry specifies the destination, the expected time for the trip and the desired pick-up location.
- As the time of the pickup approaches, the smart phone of the user provides a set of reminders with sufficient time for the user to get to the pick-up location (Figure 2b).
- The autonomous shuttle then waits at the pickup location for the user to enter the vehicle (Figure 2c) (Robotic Research is currently under contract to automate this process for users that are more physically challenged).

- The vehicle checks that the user is seated and waits for a confirmation that it can move (Figure 2d).
- The vehicle automatically drives the user across the base to the hospital (Figure 2e).
- The vehicle then waits until it receives confirmation that the user has safely exited the vehicle (Figure 2f).

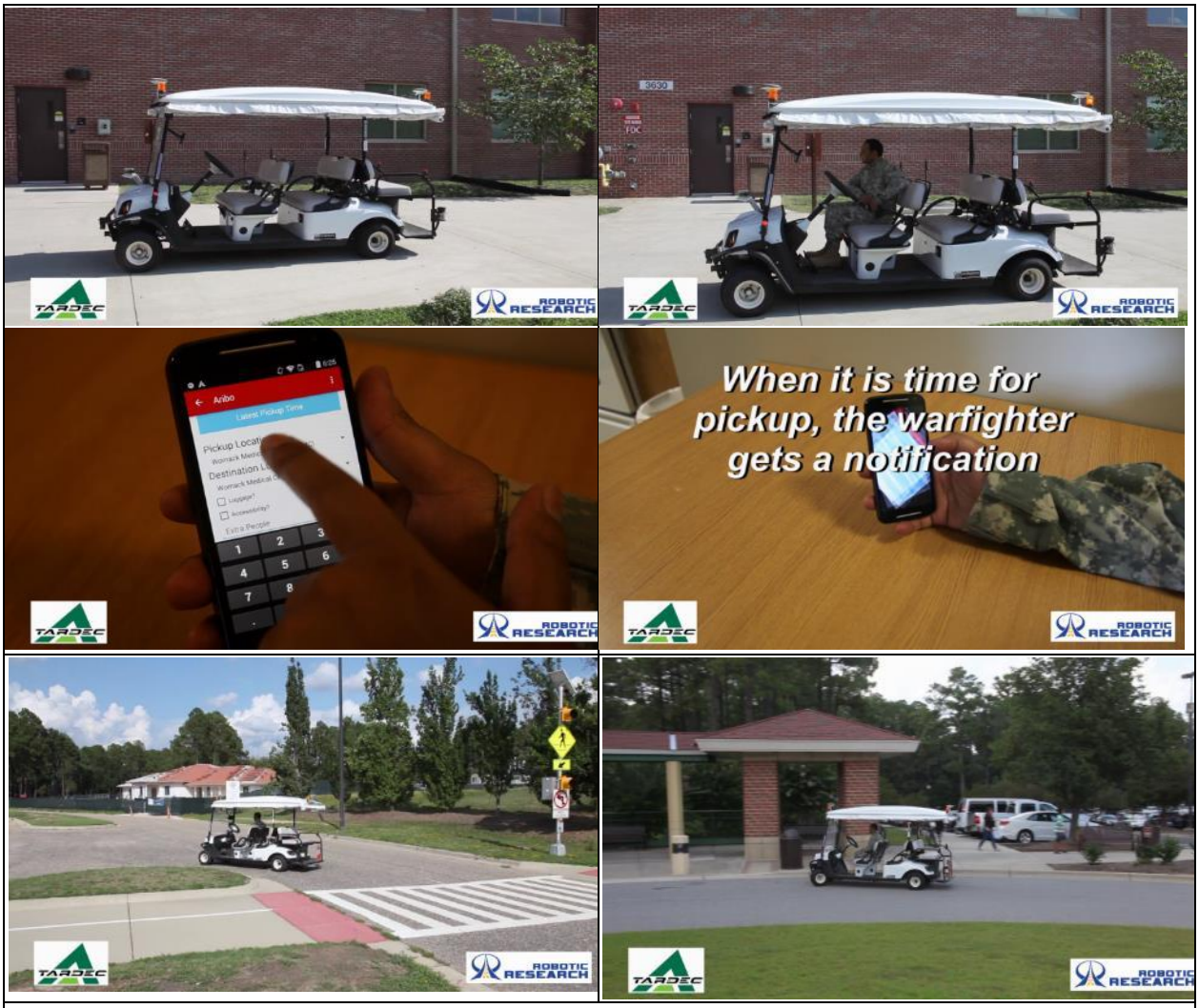
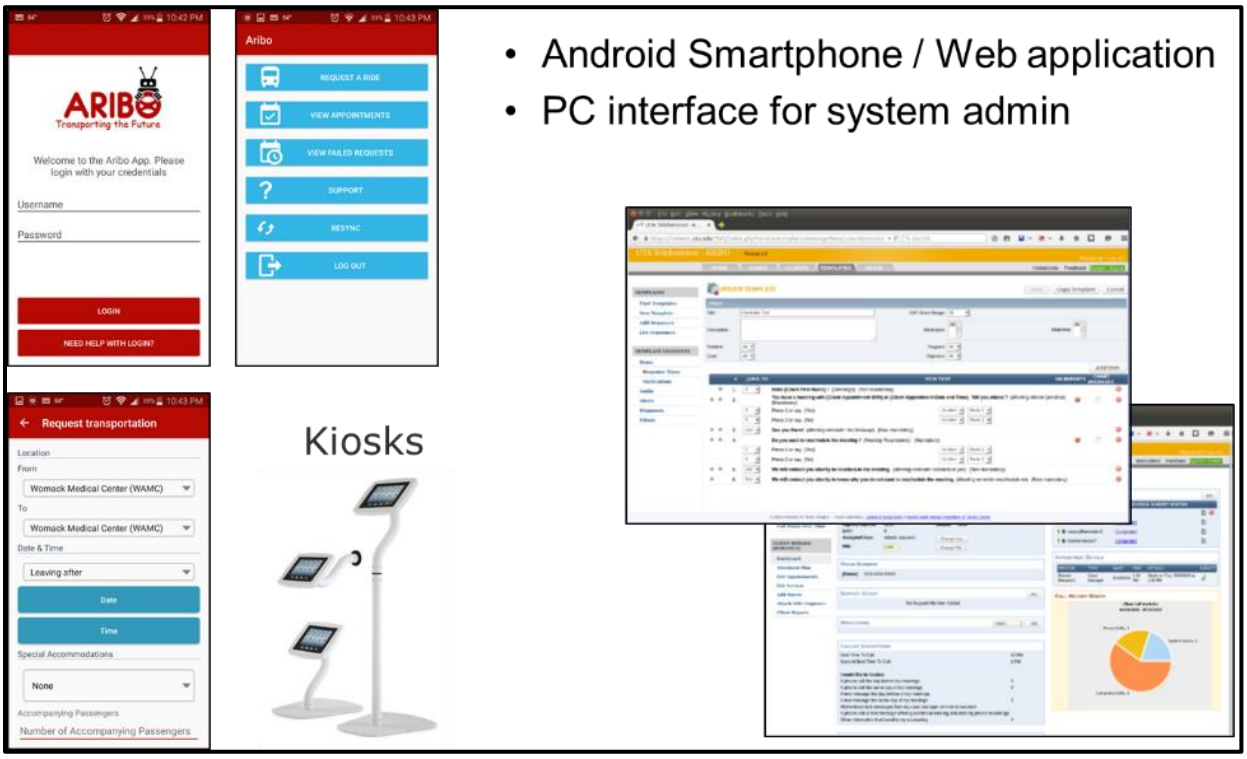


Figure 2 shows a typical service currently being provided at Ft Bragg to wounded warriors. a) an appointment is made using a smart phone or web utility. b) a set of reminders are given to the user with sufficient time to achieve the pickup location. c) the autonomous vehicle arrives to the pickup location with sufficient time and waits for the warrior. d) the system waits until the warrior is securely fastened. e) the shuttle autonomously drives across the base using common roads and through base traffic to deliver the warrior to the appointment location. f) the vehicle waits until the warrior safely exists the vehicle. The process is then repeated for the trip back.

The system is simultaneously processing requests from many users, and automatically adjusts pickup and delivery times accordingly to make sure that everybody makes it to their appointments on time. This system will be adapted to meet the requirements for the Greenville A-Taxi program.

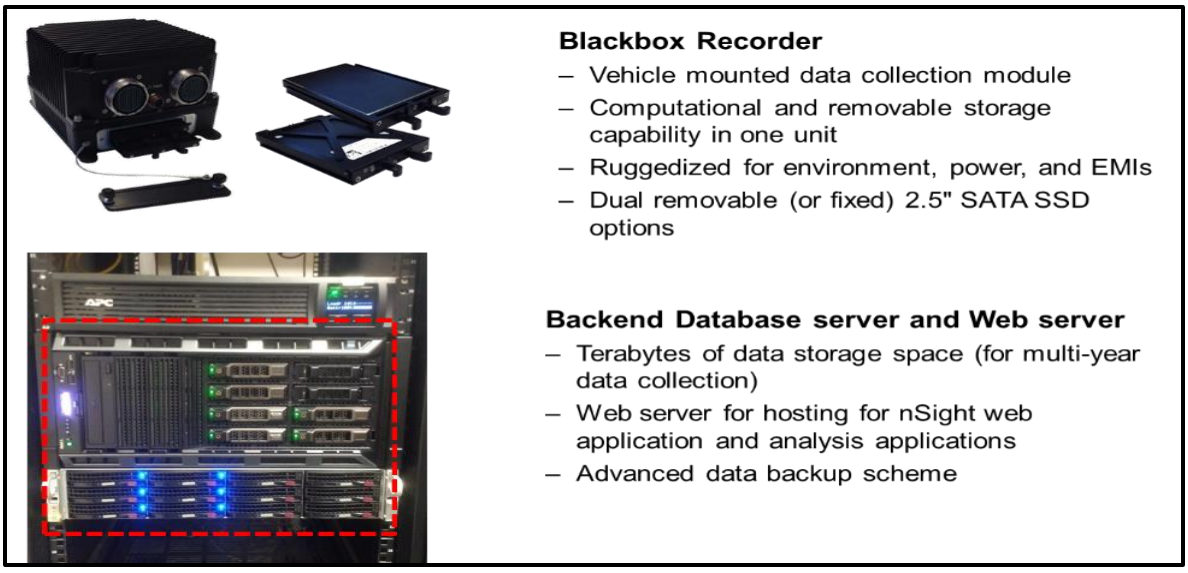
ARIBO - Reservation / Reminder Tools



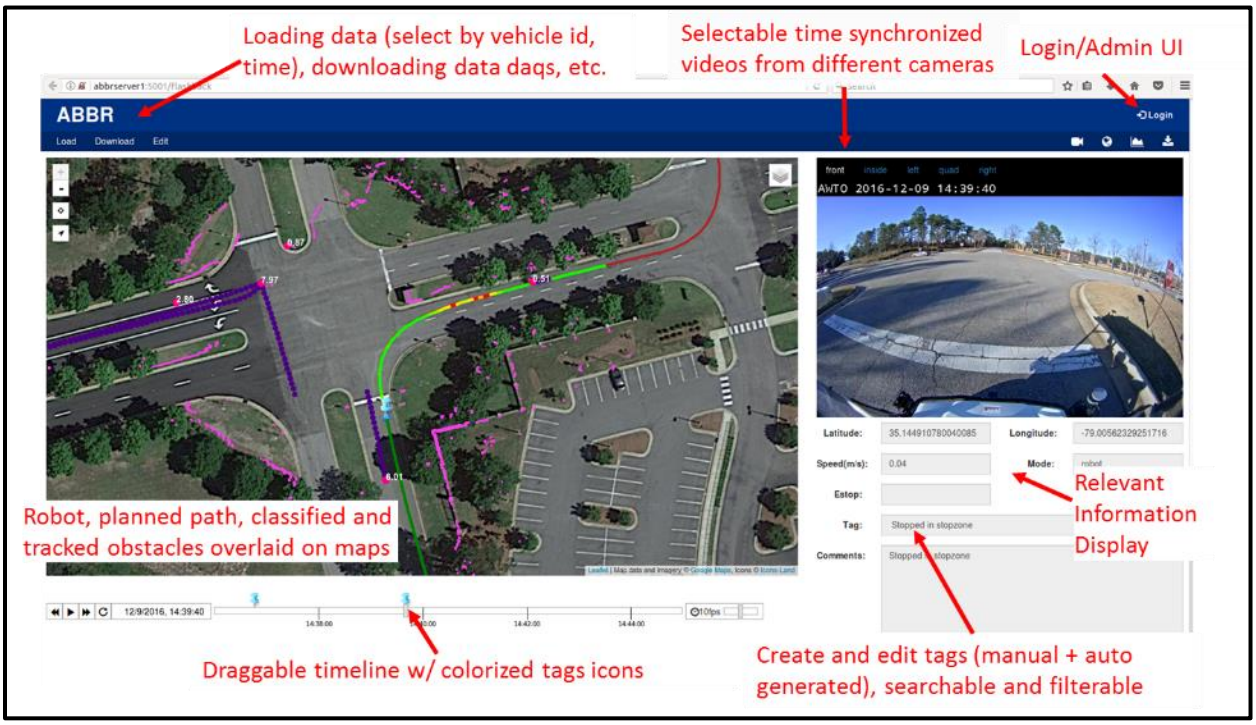
13.1.2 Data Collection and Analytics (nSight™)

ACES is leveraging technology being developed by another ARIBO Pilot Project, nSight™. The nSight™ system is a comprehensive suite of hardware and software that provides the end to end solution from data collection to analysis of manned/unmanned automated system. The system is designed for comparing two or more autonomous systems, or for comparing a human driver to an autonomous system using a comprehensive set of autonomous event detections that exploit our knowledge of ACES autonomous mobility software.

Data Recorder and Backend Server



nSight™ After-Action Review and Automated Analysis



nSight Collected Data examples:

- Distance to stationary objects: average, median, maximum, minimum distance the vehicle comes to stationary objects, such as cars in the CU-ICAR circle.
- Pedestrian Reaction: average, median, maximum, minimum distance at which the vehicle initiates a response.
- Intersection Entrance: average, median, maximum, minimum distance and estimated time to intersect of oncoming traffic when the Shuttle enters the intersection.
- Critical Path Selection: will the Shuttle enter a designated "clear" area, if an obstacle in the distance will force it to stop in an unsafe location, such as while crossing a road?
- Frequency and circumstances when a human took control of a vehicle that was in robot mode. Account for driver comfort level.
- Additional parameters will be identified during Phase I. As data accumulates, patterns will emerge that will warrant deeper investigation of performance variance.

13.1.3 Infrastructure Sensor Enhancements (SAUVI)

Safe Autonomous Unmanned Vehicles for Installations (SAUVI) surveillance tool suite, which identifies, classifies, and analyzes visual data from distributed surveillance sources. This system combines sensor data from fixed and moving sources, to develop a distributed world model of pedestrians and vehicles in the operational areas of the A-Taxis. This system provides a low-cost method for enabling real-time, on-board, system-wide planning, and improves the overall safety of multi-vehicle autonomous operations in highly dynamic urban environments.

Large staffing requirements are not possible for robotic transportation systems as justification for autonomy is cost saving, safety, and efficiency. This method minimizes cost in a similar manner as home alarm system. By automated monitoring that filters and identifies critical data with low false alarm rates, minimize human interaction, and reduces bandwidth.

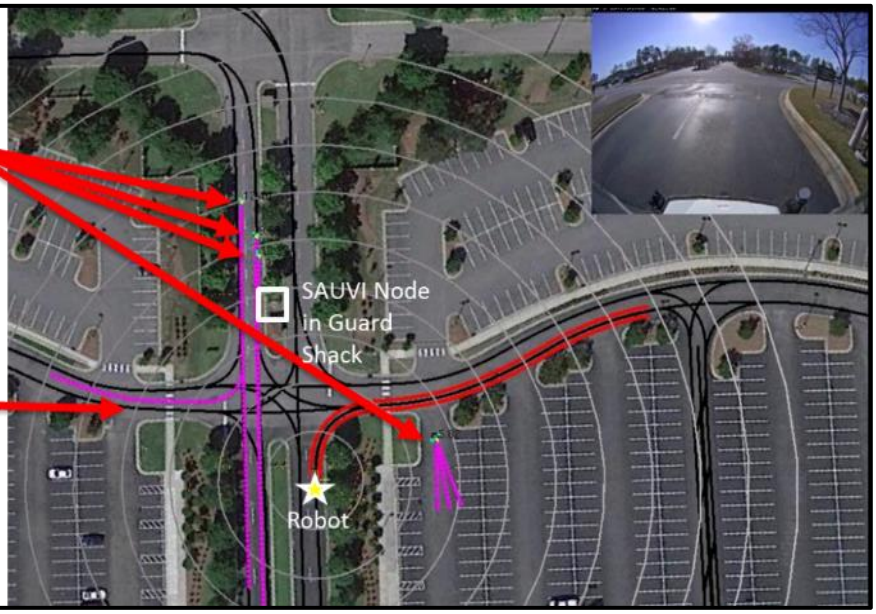
Example of Deployed Infrastructure Sensors:

- Detect moving targets at busy intersections
- Radars mounted 1.5 or more meters above road level
- RADAR and Cameras can be used for moving target detection
- Any number of vehicles can use the sensor information
- Face opposite directions for optimal road coverage

Example of Shared Data (V2I)

SAUVI radars detect 4 vehicles and tells the robot, which the robot otherwise cannot see

Robot generates path predictions, which is used to avoid collisions and make better decisions at intersections



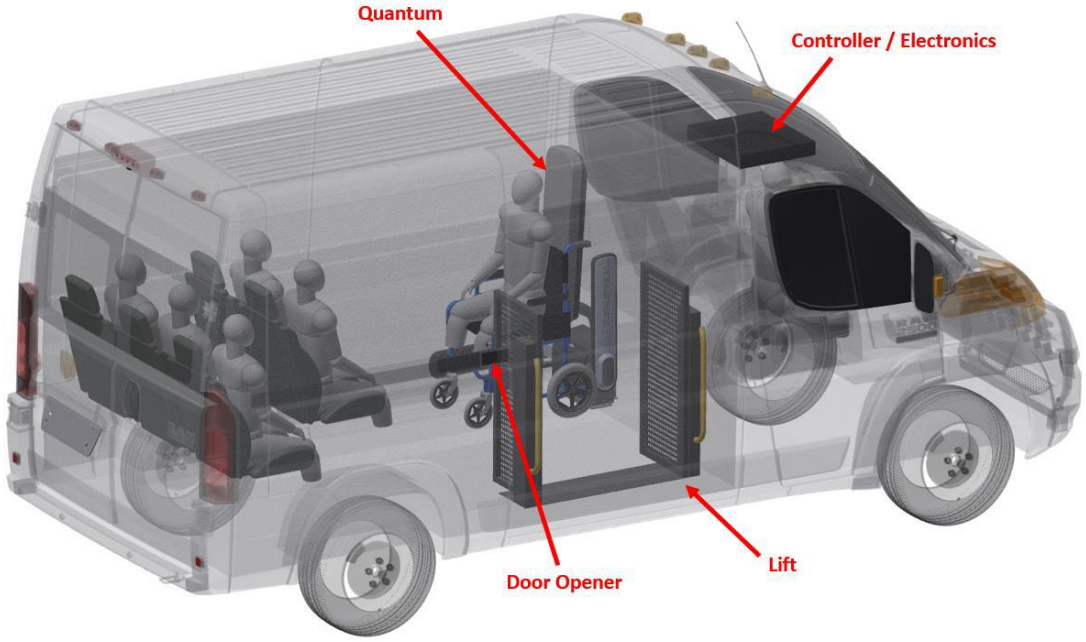
13.1.4 Mobility Impaired Assistance (ROARS)

Technology exists that can automate several aspects of these people's daily wheelchair routine. Imagine your wheelchair autonomously taking you to your vehicle, your vehicle recognizing that you are approaching, automatically lowering the ramp/lift, and autonomously boarding and securing the wheelchair.

Our team has developed The Robotic Occupant Assistive Ramping System (ROARS), an automated loading and securement system, to provide passengers with severely reduced mobility the ability to ingress/egress without any aid from a human. The need for user autonomy is critical for fully-autonomous passenger transport, such as A-Taxis, since the vehicle will not be staffed with people to assist in loading/securement.

ROARS is a comprehensive system that covers all the necessary requirements for day-to-day operational movement of severely reduce-mobility personnel in assisted living housing, government facilities and medical centers. The system is designed to be low cost, A-Taxis compatible, safe, and convenient. As a result, our solution provides:

1. Automated loading system for wheelchair users to board the vehicle. The loading system meets ADA (Americans with Disabilities Act) requirements
2. Automated securement system for wheelchair users to board the vehicle. Currently, most vehicles are outfitted with four point strapping system that often requires the assistance of the driver.
3. Hardware integration into the A-Taxis Drive-By-Wire and Power Distribution system
4. Software integration into the behavior engine to not only safely command-and-control the lift/securement systems, but to also to control the behavior of the vehicle when loading/securement is taking place

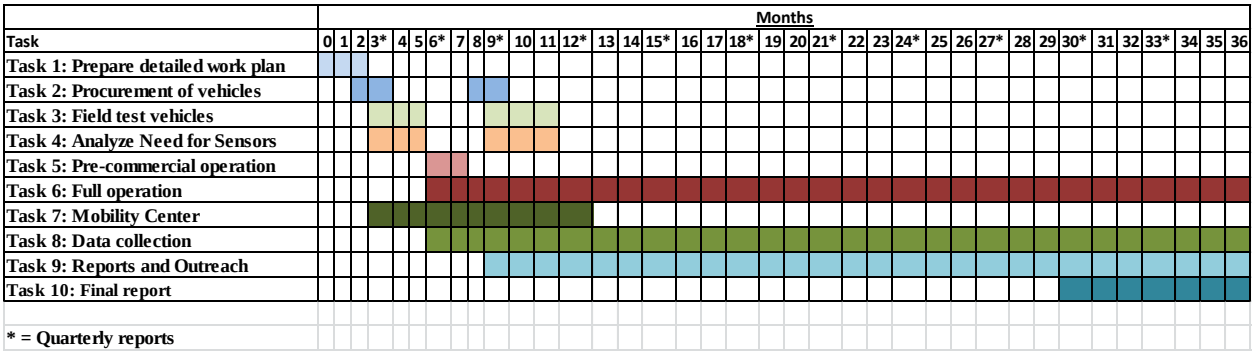


Current ROARS design will be augmented for Phase 1 and 2 Vehicles

13.2 Task Details

Several tasks will be carried out in parallel. Our plan also calls for ongoing surveys and data collection. We will use these data to improve operations, rather than waiting for a nicely bound final report. In sum, we will maximize the time during the next three years that the public and the community in general will be able to make use of the system that we deploy. Within one to three months of award, Greenville County will complete a detailed work plan. This expand upon the tasks listed in this section; more detailed schedule, and define performance goals for each task.

The following Gantt chart depicts the planned project activities and tasks.



Within one month of authorization to proceed, we will organize an in-person meeting with US DOT staff. If possible, we suggest holding this meeting in Greenville so that US DOT staff can visit the specific locations planned for deployment and meet other members of the Greenville team. This will review our plans and receive comments and suggestions for improvement from US DOT. These comments and discussions will be folded into our draft work plan.

Task 1: Prepare detailed work plans

A detailed work plan will describe specific actions, including organizations and individuals responsible for each task. Each task will

- include a time table,
- describe individual leads responsible for each task,
- identify interactions with other Tasks and
- describe specific results that will be expected – deliverables and products.

A detailed plan will be completed over the summer of 2017 and will cover the Phase 0 work that we plan to deploy prior to receiving any funds from US DOT. It will include a sketch plan for Phases 1 and 2. The work plan for these efforts will be completed if we are successful in this grant application. This revised work plan will be completed within the first month after we receive a notice to proceed. The plan will be submitted to the DOT Project Manager for review and comment.

A key part of this plan will be a state-of-the-art evaluation plan. This is important both to inform DOT how we have used their funds including the value generated by the project and to provide information needed to help guide other communities in deploying similar system. The plan will also describe ongoing communication with DOT – and with local public and private organizations. We expect that this plan will call for monthly telephone calls (perhaps more

frequent during the first few months); written monthly reports and plans for regular on-site visits by DOT staff.

Deliverable: Meeting Minutes (Notes) from in-person meeting, and Draft and Final Work Plan

Task 2: Vehicle Procurement

Our approach is flexible, with vehicle types relevant for each specific market. Phase 0 vehicles will be re-deployed from ARIBO at Ft. Bragg. Phase 1 vehicles will use retrofit kits from Robotic Research so the vehicle procurement effort will focus on the specific type of vehicle best suited to each deployment. The specific vehicle types used for Phase 1 (Verdae) and Phase 2 (EMS and Parker) will be selected based on lessons learned from Phase 0, the proposed work plan and our assessment of the specific needs for each community. Vehicles will be selected from among: 1) small 2-4 passenger vehicles (this could range from upgraded golf carts to standard vehicles; 2) vans capable of handling 10-14 passengers; and 3) vehicles capable of handling wheelchairs (this may include versions of the first two types. For each vehicle type, we will:

- Identify candidate vehicles, with an emphasis on those with the necessary electronic equipment support the retrofit kits. We will issue an RFI to identify suitable vendors.
- RFP. This will be issued within a week of receipt of RFI responses.
- Negotiations. Once we select the preferred vendor, we will focus on developing a contract. We will explore sale versus lease options, including lease and maintenance.

We expect to conduct two vehicle procurement efforts – the first for the Phase 1 deployment at Verdae during the first two months of the contract and the second about mid years for the EMS health-focused deployment in the Parker community.

Task 3: Field Test vehicles

The next three months will involve field tests. Following one month to equip each vehicle with the retro fit kits, we will carry out at least two months of field tests with no passengers.

The Greenville deployments will involve new routes. We expect that these tests will identify changes in routes and schedules. While the Phase 1 (Verdae) deployment will use the CU-ICAR maintenance facility, Phase 2 (Parker/Legacy) is located some distance away and will likely require its own storage and maintenance facility. Both areas can use the same remote surveillance facility with video and audio communication. The vehicles will be operated with no passengers during this period in order to identify necessary changes. This will be a key go/no go decision point. We will not begin operations with passengers until the vehicles and supporting equipment have passed performance tests. We will inform the DOT Project Manager of any need to delay completion of this task.

An integral part of this task will be the use of Robotic Research's nSight data collection and analysis system. This system has been specifically designed for the unique demands of automated vehicles. It has been used to help manage and operate similar deployments around the world,

Deliverable: Performance and Safety Report that describes the results of the field test including actions required to fix any perceived problems.

Task 4: Analyze Need for Sensors

Experience has shown that radars can help provide real-time information regarding traffic at some intersections. As part of the Field Test we will identify locations that would benefit from such an installation. These sensors will be installed and integrated into the Field Test effort.

Task 5: Pre-Commercial Operation

The next two months will involve pre-commercial operations. The vehicles will include passengers but will also have an on-board operator. This will help identify any additional problems. The operator will serve as a "guide" to people new to the system. This will be an important task in terms of introducing A-Taxis to a public that will have heard about it in the press, but not have seen the vehicles first hand. It will also help us to identify any necessary changes regarding how we interact with the public – what information do they need to have?

This is another key go/no go task. This may require more than two months. There may be practical issues that involve technology, operations, communication with the public etc. that will call for additional work. We will inform the DOT Project Manager of any need to delay completion of this task.

Deliverable: Tech Report that describes the results of the pre-commercial test including actions required to mitigate any perceived problems.

Task 6: Full operation

We recognize that we may discover problems during Tasks 3 and 4 that require a delay. While we are eager to begin full commercial deployment as rapidly as possible, safety is always job one. Plus, we recognize the importance of generating a positive first impression from our customers. For Phase 1 (Verdae) this will begin within six months of authorization to proceed – mid-2018. For Phase 2 (Parker EMS) this will begin six to eight months later in early 2019. Both operations would continue for the full three contract period (2.5 years of operation for Phase 1 and two years for Phase 2. Phase 0 would operate for three full years.

An important part of this effort will be to determine level of fees and how these will be collected. Funding for Phase 2 (Parker EMS) will come from savings relative to current costs to bring individuals to health facilities (estimated at $450 per trip). Funding for Phase 1 (Verdae) could use a variety of different fee structures: flat charges per ride, monthly fees, peak and off-peak charges etc. We believe it is too early to commit to a specific structure and level of fees. Early stages will not have any charge in order to encourage ridership. We expect to test several alternative fee structures. This effort may take 6-12 months or so before we settle on a practical solution. Part of this will be determined based on the level of demand and when and where this demand occurs. Part will be based on interviews with passengers to help determine price sensitivity. This effort will provide useful lessons for future deployment both within Greenville and in other communities.

Deliverable: Progress reports that describe ridership. Performance measures, and identifies any operating problems and their solutions.

Task 7: Construct Mobility Center

An important part of the A-Taxi project will be an intermodal mobility center. This will provide connections with the City's traditional transit system as well as providing a location for passengers who choose to park and ride. This will also be a location to obtain information about current operations and to purchase tickets. It will also provide information about locations within the network, including retail and restaurants and office locations. This center will be designed

and constructed by Verdae Development Corporation as part of its financial contribution to the project. We expect constructions to begin early the first year and be completed by the end of 2018. We expect that this will be a model for other mobility centers as the network expands.

Task 8: Data Collection

Data collection will be an ongoing effort. This will involve two types of information:

- Cost and vehicle performance data. These data will be linked with performance measures including reliability of vehicles; delays in picking up passengers; speed of travel; mix of travel by time of day, weather, and trip purpose; vehicle occupancy etc. Cost data will cover the direct operating costs of the vehicle as well as supporting costs for communications, maintenance, monitoring, and other activities. We will rely on Robotic Research's nSight system for data on vehicle performance.
- Customer responses regarding satisfaction, complaints, and suggestions for improvement. This information will be particularly useful given the very limited number of commercial deployments (many of which were carried out in Europe). These surveys will be conducted in several ways: on line; smart phone based surveys and in-person interviews. These will be carried out on a regular basis throughout the project.

We will prepare a data base for this information. This will support our own analytic efforts as well as research by other individuals and organizations.

Deliverable: Description of data and related data file. These data will not be provided until after we have prepared our first full performance report for DOT.

Task 9: Prepare Reports and Outreach

Greenville will provide regular written and oral progress reports to DOT. The written reports will be prepared once a month, with a more detail report prepared quarterly. These will describe actions to date, progress, potential problems and proposed solutions. The quarterly report will be in a form that could be more widely distributed if DOT should decide to do so. We will also provide an annual report for the DOT Secretary that will provide a general summary of progress to date, lessons learned, implications for deployment elsewhere in the country, and a summary of goals for the upcoming year.

We will also prepare two stand-alone reports:

1) The Evaluation Plan will evaluate A-Taxis vehicle technologies and document their performance and capabilities. The plan provides the framework to define and capture system performance measures, contains detailed site and vehicle characterizations, and outlines user needs though discussion and surveys. Site characterization includes detailed route classification, which is essential in understanding the operational environment. Attributes such as site population, traffic patterns, road attributes, extreme temperatures, and weather conditions, as well as characterizing vehicle information (such as specifications, performance, and capabilities) are also documented. The plan describes the operational parameters based on the system components, and outlines the evaluations necessary to determine system performance during each phase. Ideally, this will allow the rapid duplication of ACES at other locations, or in other use cases with similar attributes.

2) A Sustainable Business Model to show how similar systems could be funded and deployed. This will cover capital and operating costs and discuss the advantages and disadvantage of different management structures (that is, what activities should be contracted out and which

provided by public sector staff). This plan will incorporate likely implications of improving technology.

The outreach material will draw on these reports, but with a focus on actions that other communities may need to carry out and the types of problems and impacts that they might expect. These materials will be communicated in a variety of ways:

- Via Facebook, LinkedIn, webinars and related tools.
- Via invitations to communities to visit Greenville and see operations first hand. We will prepare a "standard" site visit plan for these groups. This will include a physical tour of the operation and meetings with operators and members of the community. These groups will be coordinated with relevant trade associations (NACO, AASHTO, AMPO etc.). We will need to schedule these visits to ensure that visitors receive the maximum amount of useful information and limit the involvement or our technical staff.
- The CU-ICAR will be used for informal groups ranging from schools to industry groups attending events at CU-ICAR. This is also a logical location for many of these groups from other communities.
- Via speeches and informal meetings at relevant conferences. Greenville is already an active invited participant in these events.
- Via a guidebook (this may not be prepared until near the end of the project). This will be a stand-alone document, including a list of contacts for additional information.
- A supporting slide show including videos of the developed. Academic papers will be written and submitted to organizations such as the Transportation Research Board.

Task 10: Prepare Final Report

The final report will summarize lessons learned, with an emphasis on a business case for deployment and expected impacts on congestion and community benefits regarding access to health, jobs, and recreation. We will highlight specific result of reach of the two major deployments – Verdae and Parker EMS. The impacts will be quantified to the extent possible. This report will draw on Tasks 9 and 10. It will include an executive summary that could be widely distributed as well as a free-standing report and links to supporting Appendix material. The report will include the formal evaluation of the project, including an estimated rate of return on investment and recommended improvements.

Deliverable: A draft report will be provided to DOT three months prior to the end of the project, providing adequate time for review by DOT and the opportunity for Greenville to prepare a final report.

14 SUPPORT/ LEVERAGING INNOVATIVE TECHNOLOGY OR ITS PROGRAM INITIATIVES

Both the City of Greenville and Greenville County have long standing commitments to ITS and related infrastructure technology. The City spends an estimated $12 million a year on these activities. County expenditures are somewhat larger. We will leverage these existing efforts directly (with support for deploying infrastructure sensors (V2I) and indirectly in the form of improved markings and signage. We estimate that the City and County have spent approximately $500,000 in relevant investments in the areas planned for this project (Phases 0, 1, and 2).

This project supports and demonstrates a number of aspects of the Innovative Technology or ITS Strategic Plan. A-Taxi will achieve and demonstrate in public service many proposed ITS technologies – albeit in a relatively protected environment. Technologies, methodologies and protocols to be demonstrated in this project include:

- Connected vehicles
- Fully automated vehicles
- Sensor technologies
- Emerging capabilities
- Safety certification
- On-demand service
- Ridesharing
- Inclement weather mitigation
- Intermodal connectivity

STAFFING PLAN

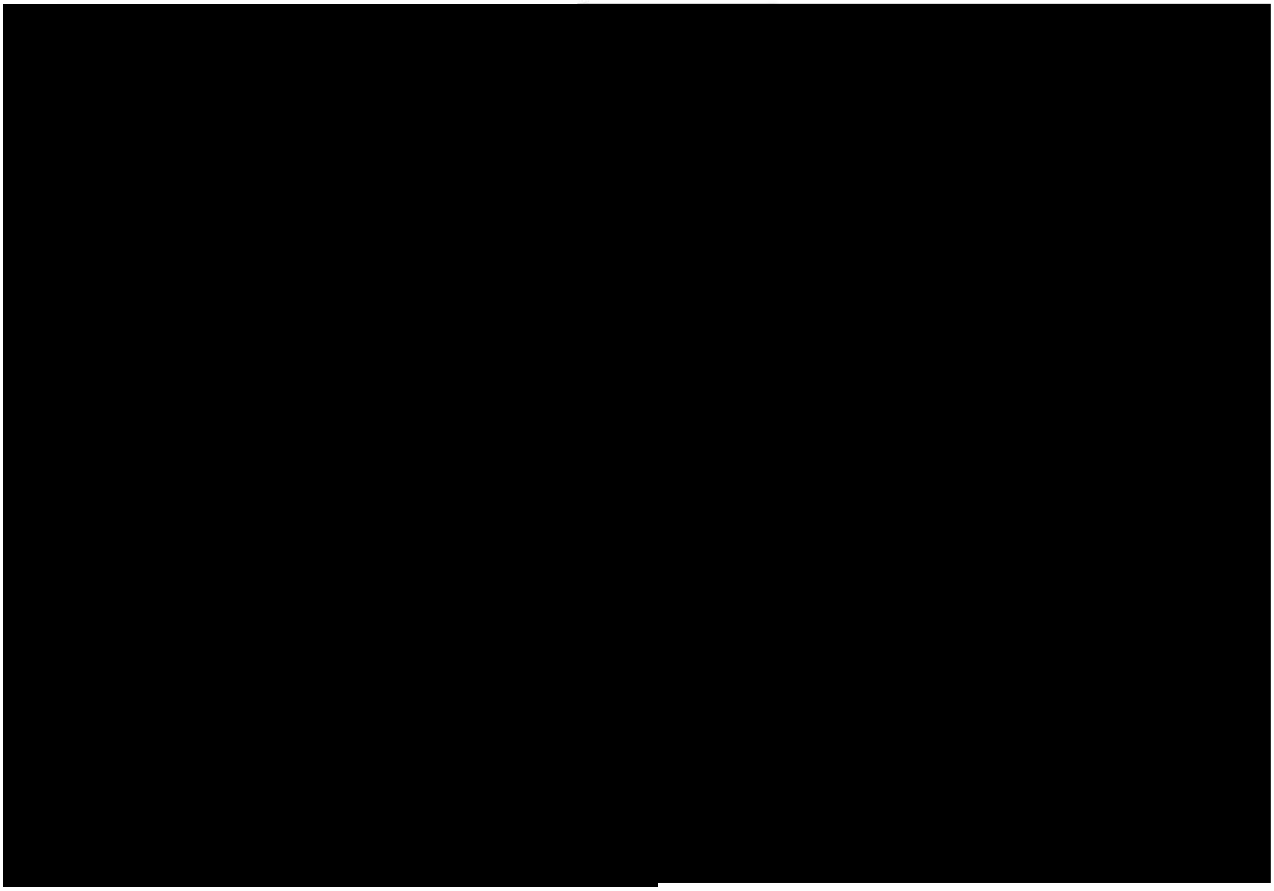
1 KEY PERSONNEL ROLES AND RESPONSIBILITIES

1.1 TECHNICAL QUALIFICATIONS AND RESOURCES

[redacted]

[redacted]

[redacted]



- PRIMARY POINT OF CONTACT

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