US Ignite successfully deployed an Automated Vehicle (AV) shuttle at Fort Carson to advance the Department of Defense’s (DoD) understanding of the latest private-sector transportation and technology solutions and how they may address safety, budgetary, and operational challenges on the post. Using a combination of AVs, smart transportation sensors, and data analytics, the project provided valuable insight on how to scale these technologies. This playbook offers an overview of the lessons learned from the AV deployment during the two-year pilot under the Engineer Research and Development Center (ERDC) contract.

Smart communities and other military installations can use the steps and tips outlined here to replicate and improve future AV deployments.
Automated vehicles (AVs) have the potential to reduce traffic congestion, pollution, and transportation costs. However, to realize these benefits, the technology needs additional research and testing. For this reason, the U.S. Army Engineer Research and Development Center (ERDC) provided funding for a two-year pilot of an AV shuttle at Fort Carson in Colorado. The project aimed to show how the military could use AVs to reduce costs, improve on-site service delivery, and overall public safety.

US Ignite deployed the Mountain Express AV shuttle at Fort Carson. It provided transportation services to four station stops over a 3.1-mile fixed route within the central cantonment area of the post. The shuttle ran from September 16, 2020, through March 15, 2021. In that period, the Mountain Express transported 204 passengers.

SELECTING TECHNOLOGY PARTNERS

US Ignite issued a Request for Proposals (RFP) to select an AV technology provider and ran a competitive bidding process. US Ignite found AV vendors provide services in the following four categories:

- Transit Operator
- Automated Vehicle (AV) Integrator
- Vehicle Manufacturer
- Autonomous Technology Stack Developer (A-kit)
The **Transit Operator** is responsible for delivering “autonomous-mobility-as-a-service” to the customer, who is also typically the Site Host, municipality, or in this project, the military installation. This organization hires, trains, and manages the on-site management and staff responsible for the operation of the shuttle. The safety attendants onboard the shuttle have specialized training on AV technology and how to operate the vehicle control systems properly. This role also involves being an ambassador for the transportation service and educating the passengers on how the vehicle functions. This company may employ technical staff to interface with the Automate Vehicle Integrator to address issues experienced in operations.

The **Automated Vehicle Integrator** serves to integrate the vehicle platform, the required suite of sensors and systems, and the autonomous technology stack software and compute devices in a complete vehicle package that can be sold to the transit operators.

The **Vehicle Manufacturer** can be specific to an AV application or a manufacturer of any platform that an autonomy kit (A-kit) supplier may choose to automate.

The **Autonomous Technology Stack Developer** is a company that is typically a subject matter expert in robotics and focused on developing the navigational capabilities of their autonomous technology stack or A-kit. These A-kits are designed with the flexibility to be adapted to multiple platforms and use cases depending on the application.

The graphic below shows the four vendor categories as a vertical stack with the Site Host, or Customer, at the top. Since each of these functional areas requires a unique combination of technical expertise, specialized equipment, and highly trained personnel, they are often separate stand-alone companies. Therefore it takes a combination of these organizations to deliver a fully operational AV shuttle service to the Site Host. This “Deployment Path” is represented by the arrows on the left of the graphic leading up the vertical.

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**Site Host- Customer**
Requests the AV transit service. Provides route, stop locations, and infrastructure to support the Transit Operator.

**Transit Operator**
Provides autonomous-mobility-as-a-service by delivering the AVs and staff to operate the fleet at the Site Host’s location.

**Automated Vehicle (AV) Integrator**
Integrator of the vehicle and tech stack who supplies a functional AV to the Transit Operator.

**Vehicle Manufacturer**
Responsible for the design and production of the vehicle to which the automation is applied.

**Autonomous Technology Stack Developer**
Creator of the stack of software that works with the hardware, compute devices, and sensors that allow for automated driving.
Given that each of these functional areas may fall under a different organization, operational issues can take a long time to resolve as they are communicated and iterated at each level of the vertical. This iterative process is shown on the right side of the diagram as the “Issue Resolution Path.”

Across multiple AV deployments, US Ignite has found issue resolution to be one of the greatest challenges in managing these projects. Issues stalled out due to poor communications or lack of action between the vendors.

Some AV vendors are expanding their internal expertise to provide an integrated solution. The integration allows for operational issues to be addressed more efficiently and thoroughly. Throughout the project, US Ignite observed multiple partnership changes, and even a dissolved company, as the segment matures. Therefore, US Ignite recommends that interested Site Hosts conduct research into the current capabilities of potential vendors to understand how the deployment and issue resolution process will be completed.

CHOOSING A ROUTE AND PREPARING FOR OPERATIONS

US Ignite and its partners identified two different routes for the Mountain Express at Fort Carson before selecting an AV vendor. Both courses were included in the Request For Proposals (RFP) to provide vendors the option of choosing the best operating environment suited to their technical capabilities. However, providing two route options was a source of confusion among the project partners. US Ignite’s subsequent recommendation is for site hosts to define a single route, or operating environment, in the RFP process.

Furthermore, the Site Host needs to identify the desired shuttle stop locations and hours of operation that will best support their transportation needs. For safety reasons, the current generation of automated passenger shuttles operate at average speeds of 12-15mph, with some vehicles reaching a maximum of 25 mph. These slow speeds make driving on standard roadways challenging for AVs and other road users as it can create road congestion and cause frustration among other drivers on the road. Ideally, the route connecting the desired destinations should be less than two miles long and include provisions for passing if the streets have mixed traffic. This route length and speed limitations make it clear that AV shuttle offerings should be a “last-mile” solution – where the destination is beyond a comfortable walk but too close to justify taking a personal car.
The Site Host also needs to provide a staging and storage facility in close proximity to the route for the Transit Operator to run operations. The ideal facility would include the following listed features.

**Staging and Storage Facility Features**

1. Located close to the shuttle route. Ideally, on the route for improved transit time.
2. Enclosed, secure, and temperature-controlled storage area that is large enough for the entire AV fleet.
3. Electric service that is sufficient for Level 2 vehicle charging.
5. Office facilities, desks, chairs, storage, and restroom facilities.
6. Service bay area with access to electrical power, pressurized air, wash stations, etc.

**DEFINING OPERATIONAL DESIGN DOMAIN**

The Operational Design Domain (ODD) describes the conditions under which an automated vehicle is designed to function. The ODD can include aspects of the environment, geography, time, and the presence or absence of certain traffic or roadway characteristics. Throughout the project, US Ignite learned that a mutually agreed-upon ODD is critical for success. All stakeholders need to contribute to defining the AV system’s capability limits and agree on its boundaries. It is not unreasonable to expect changes in the original use case definition or in the Autonomous Technology Stack to obtain this alignment.

There is a significant project cost and schedule risk if a program does not implement this best practice. Ultimately, the Site Host must assess and manage the operational risk so that the passengers and those around the AV are not at risk.

Another recommended approach is to dedicate time to defining the ODD before the supplier selection. Ideally, the RFP would include the ODD in industry-standard terminology to allow the AV vendors to assess what level of technology is appropriate for the project.

**ENSURING PROJECT SAFETY**

As with any emerging technology, safety is a priority and should be discussed thoroughly during the planning phase of an AV project. Understanding the importance of safety standards and regulations for AV technology, US Ignite sought a vendor to complete a third-party assessment of the Mountain Express to ensure the safety of the passengers, pedestrians, and operators.

Initially, US Ignite envisioned the safety assessment as a sign-off of the vehicle before transporting passengers. However, this type of evaluation is not common in the industry, and identifying a qualified third-party evaluator to conduct the safety assessment became a challenge.

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US Ignite changed the assessment burden from the original vision of a “pass/fail” sign-off to an evaluation of the vehicle’s performance relative to current draft standards under development. This change helped to bring on UL Labs to conduct the safety assessment. Moreover, the shuttle vendors felt more comfortable with the new assessment scope, given the sensitive nature of safety documentation.

To define the safety standards for future AV projects, US Ignite recommends the AV vendor, a third-party safety assessor, and the Site Host’s safety officers are engaged at the onset of the project. After there is concurrence on the risk assessment, the parties should meet periodically throughout the project to ensure the established safety standards are being maintained. It is important to recognize that both the autonomous technology stack and control software are proprietary to the vendor and can be challenging to modify in operations. To ensure a successful project, the Site Host should include an onsite development cycle before operations in the AV vendor’s scope of work.

COMMUNICATIONS AND OUTREACH PLAN

AV deployments offer a combination of tangible transportation services and an opportunity to educate the community on the benefits of the technology. Creating a Communications and Outreach Plan for the project is recommended to make the most out of these two opportunities. The plan would include developing a branded name and identifying the shuttle and station stops with this name. In addition, Site Hosts should plan on creating information cards, a webpage, and press releases announcing the service. A reliable, repeatable transportation service must be provided over several months to gain ridership. Eventually, ridership and word of mouth will bring greater awareness of the AV shuttle service, increasing the number of passengers served.
CONCLUSION

Previously AV pilots were deployed for 60 and 90 days of service as a demonstration of the technology. However, the AV industry is moving toward multi-shuttle, longer-term operational deployments of AVs as last-mile transportation solutions. The “shuttles-as-a-service” model provides straightforward pricing options for customers and speeds up the implementation of the AV technology. While this shift creates a more viable business model for service providers, it may also result in the need for a more considerable investment from clients. Therefore, communities and DoD bases interested in deploying AV shuttles for transportation services should prepare budgets, capacity, and plans accordingly while remaining observant of ongoing AV industry trends.

Rapid changes in business models and technologies ensure that the path of AV evolution needs more projects like the Fort Carson Mountain Express. The lessons learned through the design and execution of this AV project, contained in this playbook, can help communities and bases implement successful AV pilots and further advance the adoption of this technology.