



Connected Autonomous Shuttle Supporting Innovation (CASSI) in Cary's Bond Park

Final Report

October 2023



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For more information about the Connected Autonomous Shuttle Supporting Innovation (CASSI) program, please visit: ncdot.gov/CASSI.

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Executive Summary

The North Carolina Department of Transportation (NCDOT) partnered with Cary, NC (Cary) and Beep, Inc. (Beep) to bring a novel-design, all-electric, low-speed automated shuttle to Fred G. Bond Metro Park (Bond Park) in Cary for a 13-week pilot through the Connected Autonomous Shuttle Supporting Innovation (CASSI) program. Beep operated a Navya Autonom shuttle on a 1.6-mile, four-stop route within the park that connected the Cary Senior Center, a large park shelter and amphitheater, a lakeside boathouse, and a community center. The shuttle was free and open to the public on weekdays from 10:00 a.m. to 4:00 p.m. during the pilot period (March 6 through June 2, 2023). The pilot provided a first and last mile option in a fixed-route, circulator service.

NCDOT advanced their exploration of shared autonomous vehicles by piloting the low-speed automated shuttle in Bond Park. The pilot was the first under NCDOT's CASSI program to include Vehicle-to-Infrastructure (V2I) communications between the shuttle and a traffic signal on the shuttle's route. NCDOT seeks to incrementally increase the complexity of future automated shuttle pilots by considering distinctly different use cases, vehicle form factors, Automated Driving System (ADS) technologies, and service designs and advancing the testing of connected vehicle features. Cary invested considerable funding and staff resources to meet the shuttle's route, storage, and charging requirements and support marketing, communications, and public engagement that ensured the pilot's success. NCDOT and Cary demonstrated their strong partnership by working together to plan, prepare for, and launch the pilot and mitigate unanticipated issues throughout the pilot period. Through their perseverance and adaptability, NCDOT and Cary were able to complete the pilot, document successes and challenges, and capture lessons learned to inform future pilots.

NCDOT and Cary learned that the capabilities and limitations of the shuttle's technology constrain its route design, service design, and operating conditions. The pilot was not able to achieve the same level of service as established and standardized transit options. Service suspensions and interruptions occurred often. NCDOT and Cary learned that a service interruption plan and protocols should be developed proactively prior to launch.

Results from the rider survey showed that most riders had a good experience using the shuttle and with the attendant on the shuttle. Some riders commented that the attendant was knowledgeable, welcoming, and helpful and that the shuttle was safe because of the attendant. Those who did not have a good experience with the shuttle commented on their discomfort with the shuttle's jerky braking and sudden stops. The shuttle was the only transit option within the park. The results from the rider survey indicated that new trips within the park resulted from the introduction of the shuttle and some personal vehicle trips were replaced by the shuttle during the pilot period.

Additional key findings from ridership and operations data reported by Beep, rider survey data collected by NCDOT and Cary, and feedback collected by NCDOT and Cary from community members with disabilities and their caregivers are summarized in the following and on Cary's Open Data Portal.¹

¹ Cary, NC. (2023, October 30). CASSI in Cary's Bond Park – Autonomous Shuttle Pilot Project – Cary, NC Open Data Portal. <https://data.townofcary.org/pages/cassi-autonomous-shuttle-bond-park/>

Key Findings from the CASSI in Cary's Bond Park Pilot

Ridership and Operations*	<ul style="list-style-type: none"> • 1,718 Total Riders Served • 494 Total Trips • 86% Uptime (331 actual hours operated out of 384 scheduled hours of service) • 98.3% Time Spent in Autonomous Mode • 5.4 mph Average Vehicle Speed on Route • 11.4 mph Maximum Vehicle Speed on Route
Rider Feedback**	<ul style="list-style-type: none"> • 79% Visited Bond Park to ride the shuttle • 88% Rode the shuttle for a fun experience • 92% Had a good experience using the shuttle • 97% Had a good experience with the attendant • 78% Thought the shuttle arrived at their stop within a reasonable amount of time • 86% Thought they were able to get to their destination in a reasonable amount of time • 81% Would ride the shuttle again • 88% Support seeing more driverless shuttles in Cary
Community Engagement*** <i>What works well for you in the shuttle?</i>	<ul style="list-style-type: none"> • Beautiful, clean, modern, lots of windows, open • Good size and speed • Smells nice, no exhaust that may trigger asthma • Not too noisy inside, easy to understand friends talking onboard, quiet, no noise • Wide entrance accommodates bariatric wheelchairs/walkers • Easy to get on and off • Air conditioning works well
Community Engagement*** <i>How could the shuttle work better for you?</i>	<ul style="list-style-type: none"> • Automatic ramp, automatic wheelchair restraints • Better kneeling to make the ramp less steep • Room for more than one wheelchair so friends can ride together • Smaller gap at platforms for wheelchairs • Audible stop announcements • Shoulder harness, handrails, grab bar for taller passengers, wider seats with curved cushion • Separation among seats, cup holder, radio • Dedicated assistance from the attendant • No hard brakes • No signal loss, modernization from 3G to 5G
Lessons Learned <i>State of the Technology</i> <i>Traffic Signal Integration</i> <i>Accessibility</i>	<ul style="list-style-type: none"> • An on-board attendant and an exemption from Federal Motor Vehicle Safety Standards (FMVSS) are required for low-speed automated shuttles like the one piloted in Bond Park – the technology is still under development, not commercialized, and not ready to be mainstreamed or scaled as a conventional transit service. • The most common cause of the shuttle's disengagement from autonomous mode into manual mode was the signalized intersection – more testing prior to launch would have been beneficial to minimize issues or intervention during the pilot period and to maximize learning related to the signal integration. • Most low-speed automated shuttles do not include the full set of accessibility-related features needed to serve people with disabilities – feedback collected during the pilot will inform future automated shuttle pilots and a Request for Information (RFI).

Ridership and operations data were provided by Beep in weekly reports. **Rider survey data were collected by NCDOT and Cary using an online survey. Results are for the respondents that rode the shuttle (145 respondents total). *Community engagement data were collected by NCDOT and Cary during an engagement event with community members with disabilities and their caregivers (8 respondents total).*

Introduction

The North Carolina Department of Transportation (NCDOT) envisions a transportation system in the state where shared mobility options are convenient, reliable, affordable, clean, and safe, and everyone has equal access to opportunities and services. NCDOT is exploring how shared autonomous vehicles can help achieve that vision through the Connected Autonomous Shuttle Supporting Innovation program, or CASSI. CASSI shows the public what autonomous vehicle technology can do in safe, real-world settings. CASSI evaluates how autonomous vehicles can best be used by riders with different needs and in different environments. NCDOT and communities statewide are partnering to test and evaluate autonomous vehicles in pilots that provide free shared rides to the public. Pilots focus on transit applications such as first mile/last mile solutions and demonstrating connected vehicle infrastructure.

NCDOT partnered with Cary, NC (Cary) and Beep, Inc. (Beep) to bring a novel-design, all-electric, low-speed automated shuttle to Fred G. Bond Metro Park (Bond Park) in Cary for a 13-week pilot through the CASSI program. Beep operated a Navya Autonom shuttle on a 1.6-mile, four-stop route within the park that connected the Cary Senior Center, a large park shelter and amphitheater, a lakeside boathouse, and a community center. The shuttle was free and open to the public on weekdays from 10:00 a.m. to 4:00 p.m. during the pilot period (March 6 through June 2, 2023). The pilot provided a first and last mile option in a fixed-route, circulator service.

Through their partnership, NCDOT and Cary sought to:

- Learn more about how shared autonomous vehicles can be safely and effectively used in the future,
- Allow visitors to experience up close what autonomous vehicle technology can do in a safe, real-world setting,^{2,3}
- Further Cary's priority for innovation and imagining how new ideas can be used to benefit their citizens,
- Get a sense of how autonomous vehicles might figure into future Cary projects, and
- Hear from riders about their experience on the shuttle.⁴

The pilot advanced NCDOT's goal of incrementally increasing the complexity of projects while learning from past challenges and building on successes. The pilot included two special features compared to previous projects under the CASSI program. The Cary Senior Center stop was shared with GoCary Routes 4 and 8. Riders could explore riding the local

² Cary, NC. (n.d.). CASSI. <https://www.carync.gov/projects-initiatives/smart-connected-communities-program/cassi>

³ NCDOT. (n.d.). CASSI. <https://www.ncdot.gov/divisions/integrated-mobility/innovation/cassi/Pages/default.aspx>

⁴ Cary, NC. (2023, February 28). Cary and NCDOT Partnership Brings Autonomous Shuttle to Bond Park for Three-month Pilot. News Releases. <https://www.carync.gov/Home/Components/News/News/16112/715>

bus system and complete their trip within the park on the shuttle. Further, NCDOT and Cary collaborated to install a temporary traffic signal at one of the intersections on the route to demonstrate the shuttle's Vehicle-to-Infrastructure (V2I) communication capabilities. This was the first project under the CASSI program to include traffic signal integration.

Overview

Partners

NCDOT, Cary, and Beep collaborated to plan and launch the pilot.

The project teams included:

- North Carolina Department of Transportation
 - Integrated Mobility Division (program and project management)
 - Contract Unit and Purchasing Section (contracting and legal)
 - Communications Office (marketing and communications)
 - Transportation Mobility and Safety Division – Intelligent Transportation Systems (ITS) and Signals Management Section (temporary traffic signal)
 - Division of Highways – Fleet and Materials Management (shuttle delivery and transport, temporary storage, and inspection)
 - Division of Motor Vehicles (inspection, titling, and registration)
- Kimley-Horn
 - Consultant support to NCDOT
- Cary
 - Transportation
 - Transit
 - Traffic Services
 - Town Manager's Office
 - Town Clerk's Office
 - Town Attorney's Office
 - Specialized Recreation and Inclusion Services
 - Public Works
 - Police and Fire Departments
 - Parks, Recreation, and Cultural Resources
 - Marketing
 - Information Technology
 - Finance
 - 311
- Beep
 - Shuttle operator
- Navya
 - Shuttle manufacturer

Timeline

NCDOT and Cary initially expected to partner with EasyMile Inc. (EasyMile) to complete the automated shuttle pilot in Bond Park. NCDOT had previously completed pilots with EasyMile using their EZ10 Gen 3 shuttle at NC State University’s Centennial Campus in 2020 and at the Wright Brothers National Memorial in partnership with the National Park Service in 2021. NCDOT and Cary began route discussions for a project with EasyMile in June 2021, completed a site visit and route review with EasyMile in September 2021, completed contracting and agreements for the project in March 2022, and anticipated launching the pilot in May 2022. NCDOT and Cary cancelled the project with EasyMile due to technical issues with the vehicle and extensive project delays. NCDOT decided not to pursue additional projects with the vendor. NCDOT cancelled their contract with EasyMile effective October 1, 2022.

NCDOT established a new contract with Beep in November 2022 to complete the automated shuttle pilot in Bond Park and cover additional projects through calendar year 2024 using a shuttle manufactured by Navya S.A. (Navya) called an Autonom. Cary was able to apply the assets that they invested in for the EasyMile project (e.g., storage, charging equipment, signs, route and stops, and marketing materials) to the project with Beep. Cary’s extensive preparation and knowledge from their first attempt at a pilot helped reduce the lead time from kickoff to start of operations for the project with Beep. The timeline from contract execution to start of operations is summarized in Figure 1.

November 2022	NCDOT executes contract with Beep
December 2022	Beep delivers shuttle to North Carolina
January 2023	Kickoff meeting completed
February 2023	NCDOT, Cary, and Beep execute agreements
	Letter received from the National Highway Traffic Safety Administration (NHTSA) granting permission to Beep to operate the shuttle on its route in Bond Park
	Shuttle wrapped, inspected, titled, and registered
	Shuttle transported to Bond Park
March 2023	Route preparations completed including installation of temporary traffic signal
	Beep completes commissioning activities including mapping and testing
	First Responder Workshop completed
	Shuttle opens to the public

Figure 1. Timeline from contract execution to start of operations. (Image courtesy of NCDOT)

Funding

The pilot was funded as a 50/50 cost share between NCDOT and Cary. The cost share covered the lease and operating expenses related to the commissioning of the shuttle, attendant training, and public operations associated with the pilot. Cary was responsible for costs associated with on-site work for the project.

Setting

Bond Park is the largest municipal park in the town of Cary and the second largest municipal park in Wake County. The park features 310 acres of recreational space, including an amphitheater, community center, hiking trails and greenways, lake with boathouse, playgrounds, bathrooms, picnic shelters, senior center, challenge rope course, two soccer fields, and seven fields for baseball and softball. NCDOT and Cary selected a 1.6-mile, four-stop route within the park that connected the Cary Senior Center, a large park shelter (Kiwaniis Shelter) and the amphitheater (Sertoma Amphitheater), the lakeside boathouse (Bond Park Boathouse), and the community center (Bond Park Community Center). The posted speed limit throughout the park was 15 mph.

Route

NCDOT and Cary selected the route and stops in Bond Park during the planning process for their first attempted pilot with EasyMile. Because the appropriate operating conditions for the EasyMile EZ10 Gen 3 and Navya Autonom shuttles are similar, NCDOT and Cary worked with Beep to confirm that the route and stops could be retained.

Beep visited Bond Park in November 2022 to video the route, take pictures of the storage location and charging equipment, and identify a suitable location to install their Global Navigation Satellite System (GNSS) antenna used as a Real-Time Kinematic (RTK) base station. Beep used the information gathered during the visit for their exemption application to the National Highway Traffic Safety Administration (NHTSA) for permission to operate the shuttle on the route and accept passengers. Beep summarized their review of the route in Route Analysis documentation. Beep shared the Route Analysis documentation with NCDOT and Cary to be included as an appendix to the general agreement between NCDOT and Cary. A map of the route and stops is provided in Figure 2.

Beep confirmed that the route chosen by NCDOT and Cary met the appropriate operating conditions for the Navya Autonom shuttle as described in Appendix A.



Figure 2. Map of the shuttle's route and stops in Cary's Bond Park. (Image courtesy of NCDOT)

Vehicle

Form Factor

France-based Naveya manufactured the Autonom shuttle and Florida-based Beep operated the shuttle. Beep provided a trained attendant to take manual control of the shuttle if needed. The attendant also provided customer service, including answering riders' questions about the technology and assisting riders using mobility devices.

The Naveya Autonom shuttle has four wheels and is approximately 15.6 feet long, 8.7 feet high, and 6.9 feet wide with a 9.4-foot wheelbase, 6.7-inch ground clearance, and 14.7-foot turning radius. The shuttle's curb weight is 5,291 lb and its gross vehicle weight is 7,605 lb. The Naveya Autonom shuttle does not feature a traditional driver's cockpit, mirrors, steering wheel, accelerator, or brake pedals and has an unconventional seating configuration. The

shuttle has an advertised maximum operating speed of 15.5 mph but operates on its route at speeds up to 12 mph per the operating conditions approved by NHTSA.

The Navya Autonom shuttle has 11 seats. The seated capacity is ten passengers or one wheelchair plus up to eight passengers. Like the passengers, the attendant must be seated with their seatbelt fastened, including while operating the shuttle. The shuttle includes a manual ramp to ensure access for riders using mobility devices. The attendant can also kneel the shuttle (i.e., lower the suspension of the vehicle to decrease the height of the vehicle floor) to enable easier access for riders stepping up into or out of the shuttle. The shuttle has an air conditioning and heating system to regulate the interior temperature. The shuttle is fully electric with up to seven hours operating time on a four-hour charge, dependent on factors such as weather, slope of the route, passenger load, and idling time at the stops. The shuttle can operate in temperatures ranging from 14 °F to 104 °F and stored in temperatures ranging from 32 °F to 86 °F.

Level of Automation

The shuttle operates at Society of Automotive Engineers (SAE) Level 3 automation (known as “conditional automation”).⁵ This means that the shuttle’s Automated Driving System (ADS) can drive the vehicle under limited conditions and that the human in the driver’s seat, meaning an onboard attendant, must take over driving when the ADS requests. The conditions under which an ADS is designed to function is known as the Operational Design Domain (ODD).⁶ The ODD includes, but is not limited to, environmental, geographic, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics. The onboard attendant is responsible for monitoring the shuttle’s operation and must be ready to take over control when required. The shuttle is programmed to automatically disengage from autonomous mode and come to a complete stop when an obstacle is too close or when all required conditions for operation are not met. The attendant can also manually disengage from autonomous mode when deemed necessary. The attendant uses an industrial controller connected to the shuttle to take over driving or to perform an emergency stop.

The shuttle is programmed to stop at all stop signs and permissive left turns. The attendant must prompt the shuttle to proceed through stop sign controlled intersections and uncontrolled left turns. The attendant looks to confirm that the roadway is clear then presses a button on a touchscreen inside the shuttle to authorize the shuttle to move forward on the route. The shuttle is also programmed to slow and stop at priority zones, such as crosswalks, when an obstacle is detected within the zone. If the zone is clear when the shuttle approaches, the shuttle will cross the zone without slowing or stopping.

⁵ SAE International. (2021, May 3). SAE Levels of Driving Automation Refined for Clarity and International Audience. <https://www.sae.org/blog/sae-j3016-update>

⁶ SAE International. (2021, July 15). J3259 (WIP) Taxonomy & Definitions for Operational Design Domain (ODD) for Driving Automation Systems. <https://www.sae.org/standards/content/j3259>

Technology

The Navya Autonom shuttle is programmed to operate on a pre-determined, pre-mapped route and navigates the roadway using the following technologies:

- Light Detection and Ranging (LiDAR) sensors – remote sensing technology that uses lasers to measure distances and create precise, two-dimensional (2D) and three-dimensional (3D) maps of the shuttle’s surroundings; used for vehicle positioning and obstacle detection
- Cameras – front, interior, and rear cameras; used for supervision purposes only (not for obstacle detection)
- Global Positioning System (GPS) sensor – receiver with an antenna that uses a satellite-based radio navigation system to provide position, velocity, and timing information; used for vehicle positioning
- Inertial Measurement Unit (IMU) – an electronic device that measures acceleration, orientation, angular rates, and other gravitational forces; used for vehicle positioning
- Odometry – measurement of the shuttle’s velocity and change in position relative to a specific starting location using motion sensors in the shuttle’s wheels called wheel encoders that count the number of times the wheel has rotated; used for vehicle positioning

The shuttle uses eight LiDAR sensors, three cameras, one GPS sensor/GNSS antenna, and one IMU in total. The sensor systems provide localization (knowing where the vehicle is), navigation (knowing where the vehicle is going), and obstacle detection (knowing what is happening around the vehicle).

The Navya Autonom shuttle’s localization is supported by a GNSS antenna used as a RTK base station that provides additional known location information to improve the accuracy of the positioning information received by the GPS sensor on the shuttle to enable it to maintain its pre-mapped route to centimeter-level accuracy. The shuttle’s localization is also supported by the onboard LiDAR sensors that collect real-time point cloud data to create a 3D map while the shuttle operates on its route that is compared to a stored 3D map.

Storage and Charging

Cary provided a secure location adjacent to the Cary Senior Center (Figure 3) to store the shuttle that included the appropriate charging equipment to power the all-electric shuttle as listed in Appendix B. For the attempted pilot with EasyMile, the vendor used localization signs for vehicle positioning. Instead of localization signs, Beep used a GNSS antenna as a RTK base station for vehicle positioning. Beep required access to a rooftop location within Bond Park to install their antenna. Cary provided access to the roof of the storage location so Beep could securely mount the antenna with a 90° view of the sky at minimum (Figure 4).



Figure 3. Shuttle inside its storage and charging location in Cary's Bond Park. (Image courtesy of Beep)



Figure 4. GNSS antenna installed on the roof of the shuttle's storage and charging location in Cary's Bond Park. (Image courtesy of Beep)

Remote Monitoring

Beep monitored the operation of the Navya Autonom shuttle during the pilot through their “Beep Command Center” (BCC). Beep uses the BCC as their central hub for data collection and analysis. The BCC collects and analyzes operational data throughout the duration of a project and provides support for and monitors automated vehicle operations during the operational hours of Beep’s deployments across the United States.

Regulations

Beep operates the Navya Autonom shuttle on public roadways in the United States for research and demonstration purposes through importation under Box 7 on the HS-7 declaration form⁷ in accordance with 49 U.S.C. § 30114(a)⁸ and 49 CFR Part 591.⁹ Vehicles that do not conform with all applicable Federal Motor Vehicle Safety Standards (FMVSS) may be imported under Box 7 for the purpose of research, investigations, demonstrations, training, or competitive racing events. Under their contract with NCDOT, Beep submitted a request to NHTSA for an exemption from FMVSS for the Navya Autonom shuttle and permission to operate the shuttle in a pilot on the route in Bond Park in compliance with Box 7 requirements.

Planning

NCDOT, Cary, and Beep held a formal project kickoff meeting to discuss and confirm roles and responsibilities for each team and its members, establish a timeline with key activities towards opening the shuttle to the public, and review Beep’s commissioning process for preparing the shuttle for operations on the route. NCDOT and Cary used standardized agenda and meeting summary templates that organized key activities by category: administrative, operations, infrastructure, marketing and promotion, incident response plan and first responder workshop, data collection, commissioning by Beep, and start of service (Appendix C). Updates with action items by category were communicated through bi-weekly check in meetings between NCDOT, Cary, and Beep. Additional meetings were scheduled as needed to discuss specific topics such as the temporary traffic signal, data collection, marketing and promotion, and logistics for special events.

⁷ National Highway Traffic Safety Administration. (2023). Information for Importing a Vehicle. <https://www.nhtsa.gov/importing-vehicle>

⁸ Special exemptions, 49 U.S.C. § 30114. (2021). <https://www.govinfo.gov/app/details/USCODE-2021-title49/USCODE-2021-title49-subtitleVI-partA-chap301-subchapII-sec30114>

⁹ Importation of Vehicles and Equipment Subject to Federal Safety, Bumper and Theft Prevention Standards, 49 CFR Part 591. (2023). <https://www.ecfr.gov/current/title-49/subtitle-B/chapter-V/part-591>

Administrative

Contract

NCDOT executed a contract with Beep in November 2021 with respect to NC General Statute § 136-28.1(h).¹⁰ The contract covered multiple projects in North Carolina under the CASSI program, including the pilot in Bond Park. NC General Statute § 136-28.1(h) allows NCDOT to enter into contracts for applied research and experimental work without soliciting bids or proposals. The use of Beep's automated shuttle meets the definition of applied research or experimental work. Any shuttle supplied by Beep would be deployed to research and evaluate autonomous vehicle technology and not as an NCDOT vehicle fleet.

Vehicle Delivery to North Carolina

Beep contracted with Eagle Express to deliver the shuttle from Navya's facility in Michigan to North Carolina in December 2021 (Figure 5). The shuttle was delivered to and stored in a warehouse managed by Fleet and Materials Management at NCDOT that was proximate to a certified inspection station. Beep transported the shuttle to Bond Park on a flatbed truck after the shuttle was inspected, titled, and registered and immediately prior to the start of commissioning activities (Figure 6).



Figure 5. Delivery of the shuttle to NCDOT's warehouse. (Image courtesy of NCDOT)

¹⁰ North Carolina General Assembly. (n.d.). North Carolina General Statute § 136-28.1(h). https://www.ncleg.gov/EnactedLegislation/Statutes/PDF/BySection/Chapter_136/GS_136-28.1.pdf



Figure 6. Transport of the shuttle from NCDOT's warehouse to Cary's Bond Park. (Image courtesy of Beep)

General Agreement

NCDOT and Cary executed a general agreement that documented the funding arrangement, responsibilities, and expectations for the pilot. The general agreement detailed the project timeline, key activities, dates, and responsible parties; the total cost for the lease and operating expenses; the expected cost share amount; joint and individual responsibilities of NCDOT and Cary; and additional provisions. Joint and individual responsibilities per the agreement are summarized in Appendix D. The basic project timeline as included in the general agreement is provided in Appendix E.

Permission to Enter Agreement

Cary executed a permission to enter agreement with Beep prior to Beep conducting any on-site work within Bond Park. The agreement detailed insurance requirements, including minimum limits for general liability, commercial automobile liability, commercial excess liability (umbrella policy), worker's compensation, and employer's liability, with Cary named as additional insured on all insurance policies (except worker's compensation and professional liability).

Insurance

NCDOT maintained an updated certificate of coverage through the NC Department of Insurance for the pilot and, like Cary, were named as additional insured on all of Beep's insurance policies (except worker's compensation and professional liability).

Inspection, Titling, and Registration

NCDOT coordinated with Beep and the North Carolina Division of Motor Vehicles (NC DMV) to ensure that the shuttle was inspected, titled, and registered prior to operating on roadways in North Carolina. As the owner of the shuttle, Beep was the registrant and title holder for the vehicle. A representative from Beep was on site for the inspection, titling, and registration activities.

An agent from NC DMV License and Theft conducted a vehicle examination and a certified mechanic performed a safety inspection to ensure that the shuttle's equipment met state statutory requirements as listed in Appendix F.¹¹ Since the shuttle does not have mirrors, Beep installed two cameras (backup camera to substitute for the rearview mirror and side camera to substitute for the side driver mirror) and an interior video display to meet the statutory requirements.

To title and register the shuttle in North Carolina, Beep was required to provide standardized documentation to NC DMV as listed in Appendix G, including the safety inspection report and an approval document from NHTSA that grants permission to Beep to operate the shuttle on its route in Bond Park under certain defined conditions (Appendix H) in a research and demonstration program involving interaction with members of the public. As an out-of-state business, Beep was also required to register with the NC Secretary of State to certify that they can transact business in the state and provide the certification as a requirement for titling and registration.

The vehicle examination and safety inspection were completed first and the titling and registration was completed the following week due to an issue with the shuttle's Vehicle Identification Number (VIN). The VIN on the plates inside the shuttle did not match the number on the documentation provided by Beep, including the approval document from NHTSA. Beep corrected the documentation.

For the first time, NCDOT applied the fee exemption enacted in Senate Bill 201, Session Law 2022-68 (NC General Statute § 105-187.6)¹² to a project under the CASSI program (exemption from fees associated with a certificate of title or registration for vehicles to be used by a state agency in a research pilot or demonstration project).

¹¹ North Carolina General Assembly. (n.d.). North Carolina General Statutes, Article 20 – Motor Vehicles. <https://www.ncleg.gov/Laws/GeneralStatuteSections/Chapter20>

¹² North Carolina General Assembly. (n.d.). North Carolina General Statute § 105-187.6. https://www.ncleg.gov/enactedlegislation/statutes/html/bysection/chapter_105/gs_105-187.6.html

Operations

Service Schedule

NCDOT, Cary, and Beep worked together to set a service schedule for the pilot. They agreed that the shuttle would operate up to forty (40) hours per week only during weekdays, excluding public holidays unless otherwise specified. Service was scheduled for eight (8) hours each weekday, and the shuttle accepted riders during six (6) of those hours (10:00 a.m. to 4:00 p.m.). The service schedule also included a stationary display of the shuttle at the annual Spring Daze Arts and Crafts Festival, a one-day event held within Bond Park on April 29, 2023.

Service Interruption Plan

NCDOT, Cary, and Beep designed a service interruption plan that outlined the actions to be taken in the event of a service interruption due to attendant absence, inclement weather, or battery insufficiency, including how the change in service would be communicated to the public. NCDOT, Cary, and Beep were prompted to create the service interruption plan when the attendant was sick and unable to report for duty during the third week of service. Because there were no backup attendants local to the Bond Park area, the shuttle was out of service for an entire day. Beep sought to mitigate the issue by training a pool of five additional attendants assigned to one of their projects in Georgia on how to operate on the route in Bond Park. A replacement attendant from the pool was then available by the next shift at the earliest to fill in if the assigned attendant at Bond Park was absent. Beep provided after-hours service to support rides during engagement events as compensation for hours of lost service due to service interruptions. The service interruption plan is provided in Appendix I.

Infrastructure

Site Modifications

Cary invested significant funding and staff resources to meet requirements for the shuttle's route, storage location, and charging equipment. Cary upfitted their carpentry shop adjacent to the Cary Senior Center stop into a suitable shelter and charging location for the shuttle by purchasing and installing charging equipment, a Wi-Fi cradle point, and Heating, Ventilation, and Air Conditioning (HVAC) upgrades. Cary assisted Beep with access to the roof of the carpentry shop to install the GNSS antenna and provided the mount for the antenna. Cary designed, fabricated, and installed signs along the route and at the stops, including A-frame signs with information about the pilot and a Quick Response (QR) code that linked to Cary's webpage for the project (Figure 7). Cary trimmed back vegetation along the route to ensure that branches and foliage did not intrude into the shuttle's route or be detected as obstacles. Three of the four stops did not have adequate curbs to deploy the shuttle's wheelchair ramp, so Cary leased temporary modular ramps (Figure 8) to ensure access for riders using mobility devices (Appendix J).

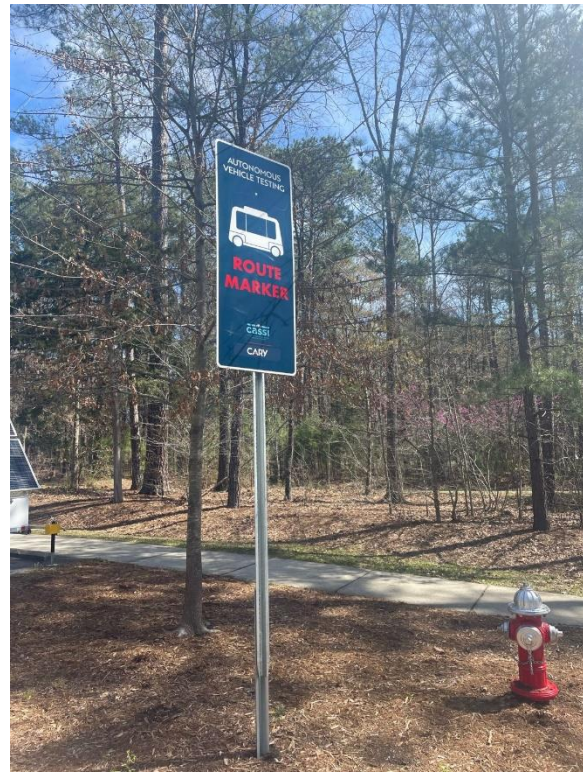


Figure 7. Signs along the shuttle's route and at the stops in Cary's Bond Park. (Images courtesy of NCDOT)



Figure 8. The four stops on the shuttle's route in Cary's Bond Park. (Images courtesy of NCDOT)

Temporary Traffic Signal

The deployment at Cary's Bond Park was the first project under the CASSI program to include traffic signal integration (Figure 9). A temporary two-phase traffic signal equipped with a Roadside Unit (RSU) transmitted Signal Phasing and Timing (SPaT) messages from the signal controller. The messages were received by an Onboard Unit (OBU) installed on the shuttle. The shuttle used the phasing and timing information to operate autonomously through one intersection on its route (Figure 2).



Figure 9. Shuttle at the temporary traffic signal-controlled intersection in Cary's Bond Park. (Image courtesy of Cary)

NCDOT designed the signal based on discussion with Cary and applied to the Federal Communications Commission (FCC) for a Dedicated Short-Range Communications (DSRC) license. NCDOT provided the wooden poles, signal heads, cabinet, and power cabling. Cary provided the controller and worked with the local power company to run electricity to the signal. Applied Information provided the RSU, antenna, and validation support through a separate ongoing project and contract with Cary.

The RSU used for the pilot included:

- AI-500-085-02¹³ – Preempt/Priority FMU2 4G Video with 4-port switch
- AI-500-095CD¹⁴ – C-V2X and DSRC Capability
- RSU cabinet, antenna, antenna bracket
- Bandit strapping and clips, Ethernet cable, power cable, antenna cable, and connectors for each cable type

¹³ Applied Information. (n.d.). AI-500-085-02 Series Glance Preempt & Priority. <https://appinfoinc.com/wp-content/uploads/2018/11/AI-500-085-02-Preempt-Priority-Video-Capable-Intersection-Controller.pdf>

¹⁴ Applied Information. (n.d.). AI-500-095 Dual Mode DSRC / C-V2X Radio Road Side Unit. <https://appinfoinc.com/wp-content/uploads/2020/06/AI-500-095-Dual-Mode-DSRCC-V2X-RSU.pdf>

NCDOT purchased the OBU through their contract with Beep. The OBU is an Unex OBU-201U¹⁵ that is fully integrated with the shuttle's ADS software.

Marketing and Promotion

NCDOT, Cary, and Beep worked together to communicate information about the pilot to the community leading up to and during public operations.

Media Assets

NCDOT, Cary, and Beep collaborated on and delivered numerous marketing and promotion efforts through various channels (e.g., webpages, media advisories, news releases, and social media). Cary's news release is provided in Appendix K. Beep's news release is provided in Appendix L.

Public Engagement

Cary used their 311 service to keep the public informed about the project and facilitated events with Cary Town Council, media, and citizens. Thirteen documented engagement activities were completed at Bond Park during the pilot period (Figure 10), including a ribbon-cutting event, media day, a stationary display of the shuttle at Cary's annual Spring Daze Arts and Crafts Festival, and visits by staff from the Federal Highway Administration (FHWA) NC Division for their annual spring meeting, students from a local middle school for a field trip, and professionals from local firms and organizations. These activities furthered NCDOT's goal of building public awareness and acceptance of emerging shared mobility options by enabling the community to experience new technologies firsthand.

¹⁵ Federal Communications Commission. (2017, March 6). OBU-201U Specification. <https://apps.fcc.gov/els/GetAtt.html?id=201591>

March 2023	Ribbon-Cutting Event and Media Day
April 2023	NCDOT Integrated Mobility Division's Regional Planning Team Visit
	NCDOT Integrated Mobility Division Staff Meeting
	Stationary Shuttle Display at Cary's Spring Daze Arts and Crafts Festival
May 2023	NC DMV Vehicle Services Team Visit
	NCDOT Executive Leadership Visit
	Urban Land Institute (ULI) Triangle and Regional Transportation Alliance (RTA) Event
	Town of Cary Transportation Working Group Meeting
	Engagement Event with Community Members with Disabilities and Their Caregivers
	Reedy Creek Middle School 7th and 8th Grade Field Trip
	Kimley-Horn Raleigh, NC Office Visit
	FHWA NC Division Annual Spring Meeting
	North Carolina Section of the Institute of Transportation Engineers (NCSITE) Transportation Planning Council (TPC) and Traffic Engineering Council (TEC) Joint Meeting

Figure 10. List of documented engagement activities during the pilot in Cary's Bond Park. (Image courtesy of NCDOT)

Wrap Design

Cary created the design for the shuttle's wrap. Beep was contracted to print and install the wrap. Beep contracted with a local company for the printing and installation of the wrap.

Incident Response Plan

NCDOT, Cary, and Beep created an incident response plan that defines the actions to be taken by NCDOT, Cary, Beep, the attendant, and first responders in the event of a non-emergency or emergency incident. A non-emergency incident was defined as an incident whereby the vehicle has become immobilized for reasons that do not pertain to involvement with another vehicle, pedestrian, or object. An emergency incident was defined as an incident whereby the vehicle has struck or been struck by any object, car, or person, or a crash has occurred to jeopardize the safety of a person or inflicted damage to the vehicle. The incident categorization was aligned with Beep's internal safety protocol.

The incident response plan included phone numbers for all responsible parties and a list of towing companies with phone numbers as a reference in the event the shuttle was inoperable and needed to be removed from the roadway. The incident response plan with contact information redacted is provided in Appendix M.

First Responder Workshop

NCDOT, Cary, and Beep held a first responder workshop with staff from the Cary Police and Fire Departments. Beep shared a slide presentation that reviewed the project details and scope, incident categorization, and response flow then provided hands-on training on the shuttle, including how to tow and lift the vehicle, disable its power supplies, and access and extract its occupants. NCDOT then reviewed the incident response plan that was created with input from Cary and Beep. Feedback from attendees was incorporated into the final version of the plan that was distributed to the first responders assigned to the Bond Park area.

Commissioning

Beep completed a standardized set of activities to commission the shuttle, i.e., prepare the shuttle to operate on the route and provide passenger service to the public.

Commissioning by Beep involved the following activities and time commitments:

- Installing the GNSS antenna – one day
- Completing route mapping (environment mapping) using a mobile scanning unit installed on a conventional vehicle – one day
- Processing the mapping data – seven days
- Completing path creation (mapping data analyzed in office) – two days
- Completing path validation using the shuttle – three days
- Validating the RSU/OBU – one day
- Training the on-site attendant on the route – five days
- Handing off the shuttle and service to the on-site attendant – two days

Approval of Beep's exemption application and receipt of a permission letter from NHTSA was required before path validation on the shuttle's route could commence.

Evaluation

NCDOT and Cary used multiple data sources to evaluate the shuttle and its service, including:

- Ridership and operations data provided by Beep in weekly data reports
- Feedback from riders captured by NCDOT and Cary through an online survey
- Feedback from community members with disabilities and their caregivers captured by NCDOT and Cary through an engagement event and exit survey

Data Collection

Ridership and Operations Data

For their first attempted pilot with EasyMile, Cary created a data entry application to be installed and used on an in-vehicle tablet by the attendant to capture key data points such as number of riders, ramp deployments, emergency stops, suspension of service, attendant intervention, attendant breaks, and start/end of shifts. NCDOT and Cary met with Beep to share the application for their feedback. Beep preferred to follow their existing protocol and procedures for data collection.

Beep provided weekly data reports to NCDOT and Cary that included ridership and operations data manually captured by the attendant or obtained from the shuttle's computer system. NCDOT and Cary compiled Beep's reports for the 13-week pilot period. The dataset includes ridership as number of passengers, number of trips, ramp deployments and wheelchair securements, scheduled hours and hours operated, uptime percentage (hours operated divided by scheduled hours), battery percentage, service suspensions, vehicle speed, and time in autonomous mode. The dataset also includes the shuttle's disengagements from autonomous mode into manual mode and the reported cause for each event.

Cary reviewed and spot checked the data for outliers, duplicates, inconsistencies, and errors on a weekly basis. Cary discussed any data issues with Beep to determine the appropriate approach to correct, remove, or standardize the data as required. Cary aggregated the data reports to create cumulative datasets week over week.

Cary created new fields in the datasets to support their analyses. Created fields include:

- Day of week
- Day of week as number
- Week of year
- Number of weeks into pilot
- Battery percentage used
- Number of passengers per hour operated
- Number of passengers per round trip
- Number of round trips per hour operated
- Incident datetime
- Weather_cloudy
- Weather_partly cloudy
- Weather_rain
- Weather_sunny
- Weather_windy
- Meteostat hourly weather condition
- Meteostat hourly precipitation in millimeters

A log that lists the changes to the ridership and operations data that resulted from data

cleaning and the creation of new fields is provided on Cary's Open Data Portal along with the final cleaned datasets.¹⁶

Rider Survey

NCDOT created and implemented an online rider survey using Smartsheet. The survey questions were informed by surveys from prior projects under the CASSI program and were updated to reflect the context of the pilot in Bond Park. The survey was accessible through URL and QR codes at the shuttle stops and inside the shuttle during the pilot period (Figure 11). The survey asked riders about their travel patterns and trip purpose, experience with the shuttle and attendant, and their basic demographics. 160 responses were collected in total. 145 respondents rode the shuttle, and 15 respondents did not ride the shuttle. The survey questions and response categories are provided in Appendix N.



Figure 11. Quick Response (QR) codes inside the shuttle and at the shuttle's stops on the route in Cary's Bond Park that link to the online rider survey. (Images courtesy of NCDOT)

NCDOT downloaded and reviewed the survey responses on a weekly basis during the pilot period. Outliers, duplicates, inconsistencies, and errors were identified and flagged. When the pilot ended, NCDOT performed data cleaning to review the flagged records and then correct, remove, or standardize the data. NCDOT created separate datasets for the raw

¹⁶ Cary, NC. (2023, October 30). CASSI in Cary's Bond Park – Autonomous Shuttle Pilot Project – Cary, NC Open Data Portal. <https://data.townofcary.org/pages/cassi-autonomous-shuttle-bond-park/>

survey responses as received, the annotated and cleaned survey responses, and the final cleaned dataset used for analyses that was limited to the responses for the respondents that rode the shuttle. A log that lists the changes to the survey responses that resulted from data cleaning is provided on Cary's Open Data Portal along with the final cleaned datasets.¹⁷

Engagement with Community Members with Disabilities

In addition to the ridership and operations data from Beep and the results from the rider survey, NCDOT and Cary held an engagement event in partnership with Beep to gather feedback about the accessibility of the shuttle and service. NCDOT worked with staff from GoCary and Cary's Specialized Recreation and Inclusion Services to invite community members with disabilities and their caregivers to view, engage with, and ride the shuttle (Figure 12). NCDOT collected participants' feedback on the shuttle's accessibility and usefulness to meet their transportation needs through an exit survey. Eight participants shared their thoughts on their typical trips, what works well for them in the shuttle, and how the shuttle could work better for them.

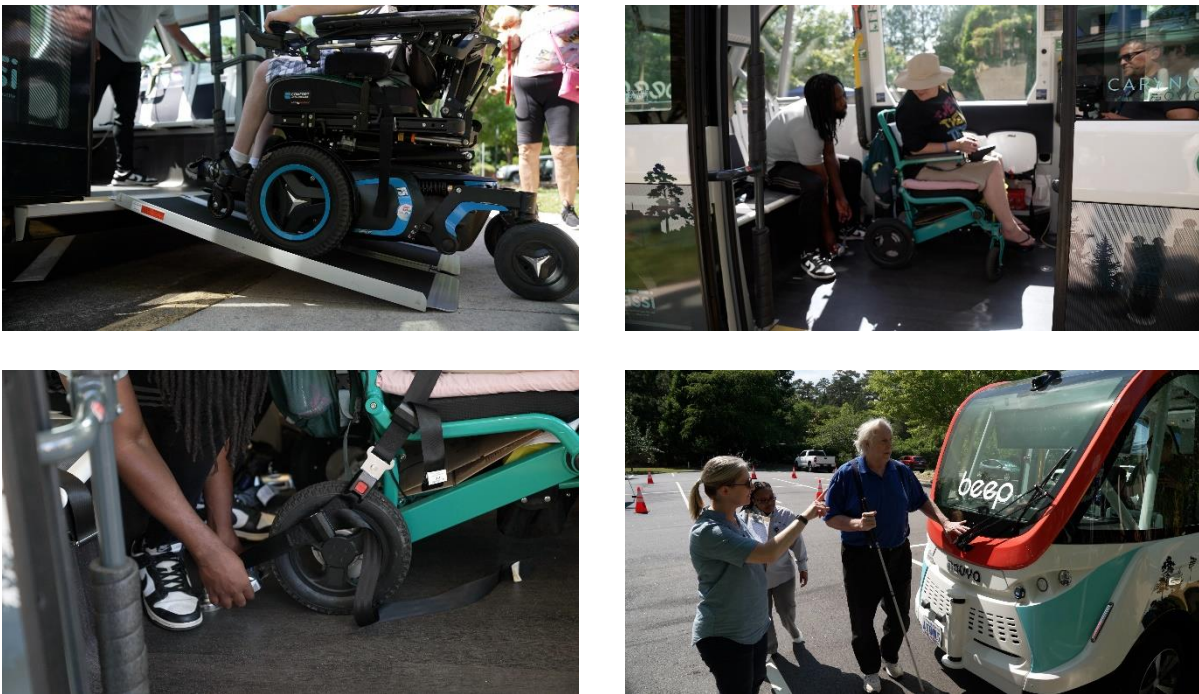
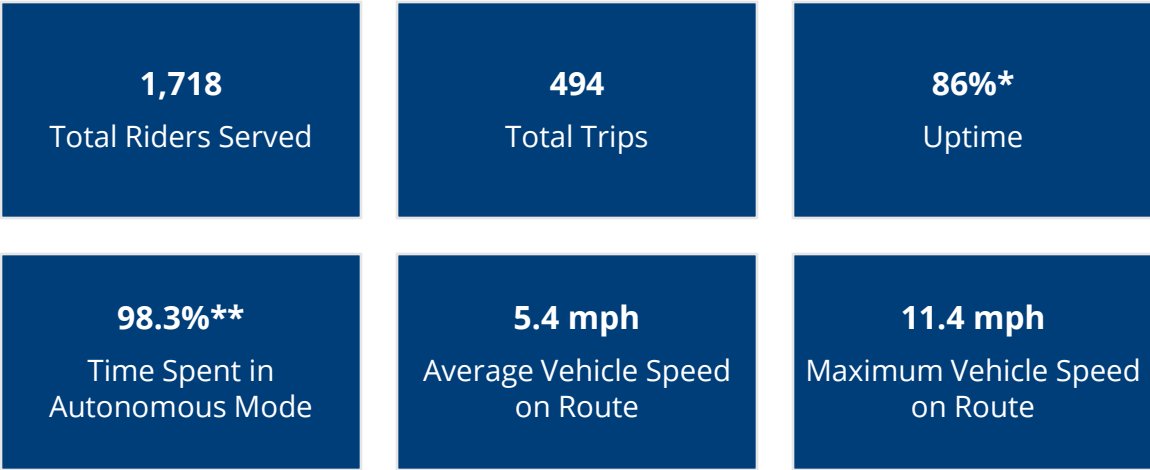


Figure 12. Community members provide feedback about the accessibility of the shuttle and service. (Images courtesy of Cary)

Data Analysis

A sample of the results from the ridership and operations data are provided in Figure 13 and Figure 14.

¹⁷ Ibid.



*The shuttle was in operation for 331 out of 384 scheduled hours of service.

**The leading causes of disengagement from autonomous mode into manual mode were lost connection or miscommunication between the shuttle's Onboard Unit (OBU) and the Roadside Unit (RSU) at the signalized intersection and signal loss between the shuttle and the Global Navigation Satellite System (GNSS) base antenna installed within the park for the pilot.

Figure 13. Results from Beep's ridership and operations data collected during the pilot in Cary's Bond Park. (Image courtesy of NCDOT)

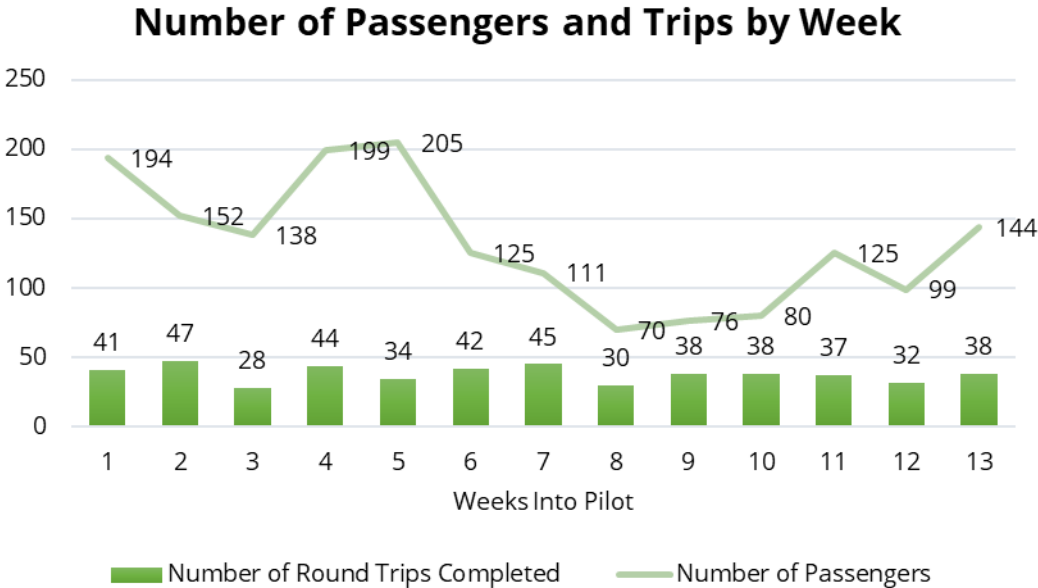


Figure 14. Number of passengers and trips by week during the pilot in Cary's Bond Park based on Beep's ridership and operations data. (Image courtesy of NCDOT)

A sample of the results from the rider survey are summarized in Figure 15.

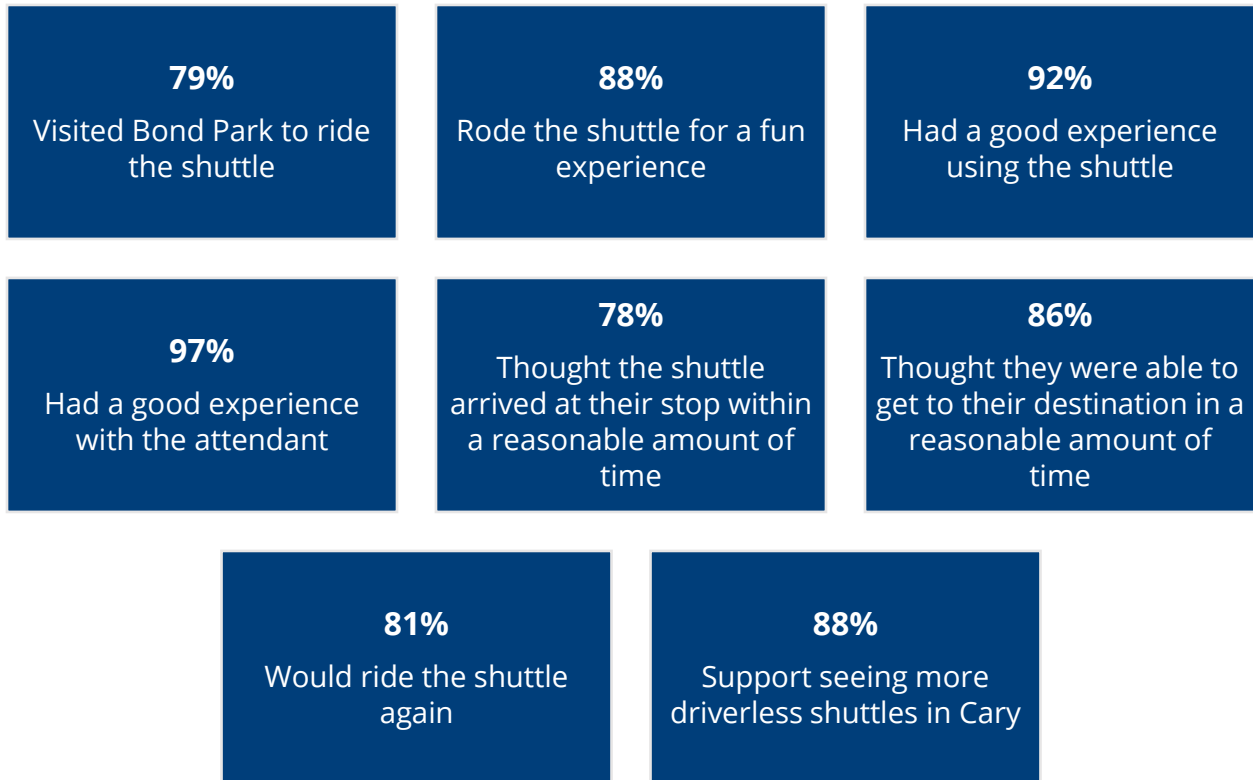


Figure 15. Results from NCDOT's rider survey collected during the pilot in Cary's Bond Park for respondents that rode the shuttle (145 respondents total). (Image courtesy of NCDOT)

Tables that summarize the ridership and operations data and the survey results for respondents that rode the shuttle are provided in Appendix O. Additional results can be found in Cary's data story, "CASSI in Cary's Bond Park – Autonomous Shuttle Pilot Project."¹⁸

Results from the exit survey collected at the engagement event with community members with disabilities and their caregivers are summarized in Figure 16.

¹⁸ Ibid.

What works well for you in the shuttle?
Beautiful, clean, modern, lots of windows, open
Good size and speed
Smells nice, no exhaust that may trigger asthma
Not too noisy inside, easy to understand friends talking onboard, quiet, no noise
Wide entrance accommodates bariatric wheelchairs/walkers
Easy to get on and off
Air conditioning works well
How could the shuttle work better for you?
Automatic ramp, automatic wheelchair restraints
Better kneeling to make the ramp less steep
Room for more than one wheelchair so friends can ride together
Smaller gap at platforms for wheelchairs
Audible stop announcements
Shoulder harness, handrails, grab bar for taller passengers, wider seats with curved cushion
Separation among seats, cup holder, radio
Dedicated assistance from the attendant
No hard brakes
No signal loss, modernization from 3G to 5G

Figure 16. Results from the exit survey collected at the engagement event with community members with disabilities and their caregivers during the pilot in Cary's Bond Park (8 respondents total). (Image courtesy of NCDOT)

Successes

Experience with Shuttle

Feedback from the rider survey indicated that most riders (92% of survey respondents) had a good experience using the shuttle. Those that did not have a good experience commented on their discomfort with the shuttle's jerky braking and sudden stops.

Experience with Attendant

Feedback from the rider survey showed that most riders (97% of survey respondents) had a good experience with the attendant on the shuttle. Some riders commented that the attendant was knowledgeable, welcoming, and helpful and that the shuttle was safe because of the attendant.

Park's Accessibility

Feedback from the rider survey indicated that most riders would have traveled in a personal vehicle (41% of survey respondents), walked (35% of survey respondents), or would not have taken the trip (19% of survey respondents) if they had not taken the

shuttle. The shuttle was the only transit option within the park during the pilot period. The results from the rider survey indicate that new trips within the park resulted from the introduction of the shuttle and some personal vehicle trips were replaced by the shuttle during the pilot period.

Partnerships

Strong partnerships and trusting relationships between NCDOT, Cary, and Beep contributed to the pilot's successful planning and delivery. The teams held regular meetings to check in on roles and assigned activities, share progress, troubleshoot issues, and work together to craft solutions.

Challenges

Service Suspensions

The shuttle was in operation for 331 out of 384 scheduled hours of service for 86% uptime during the pilot period (Figure 17 and Figure 18). Thirty hours of service were scheduled per week, or six hours per weekday. There were 28 days with complete service, 33 days with partial service, three days with complete suspension of service, and one day with no scheduled service.

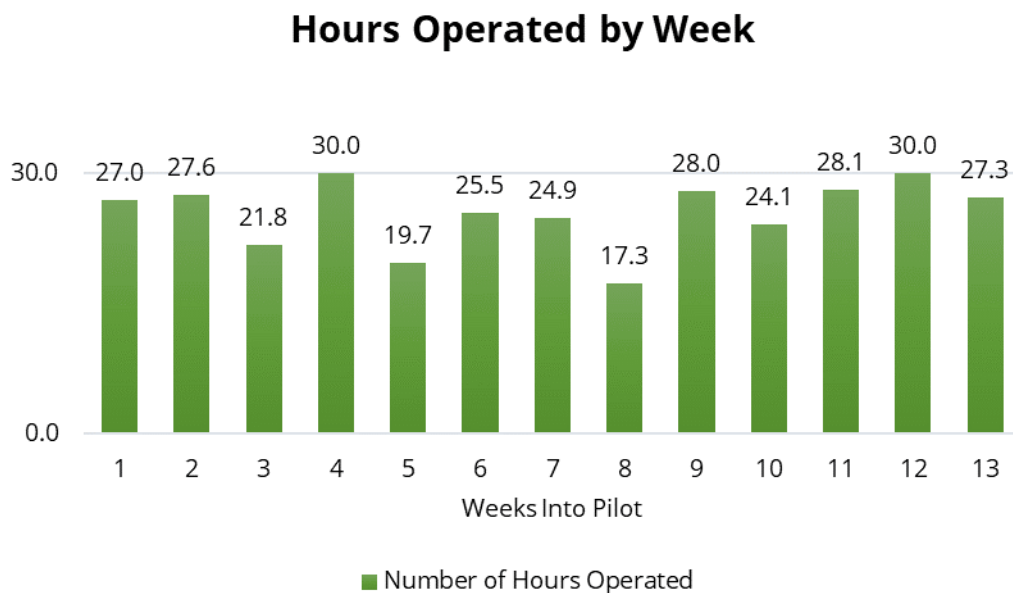


Figure 17. Hours operated by week during the pilot in Cary's Bond Park based on Beep's ridership and operations data. (Image courtesy of NCDOT)

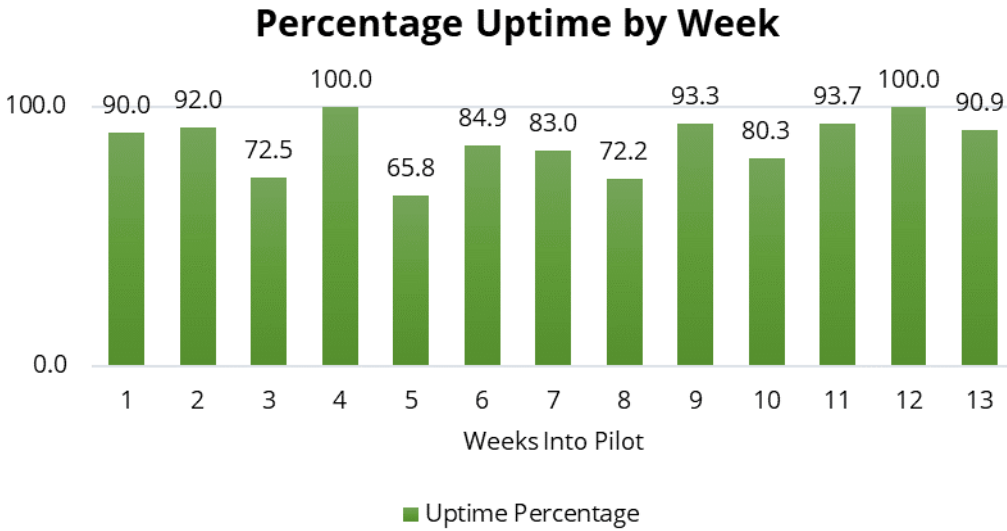


Figure 18. Percentage uptime by week during the pilot in Cary's Bond Park based on Beep's ridership and operations data. (Image courtesy of NCDOT)

Complete suspension of service was due to attendant absence (March 21), inclement weather (April 7), and the controller not connecting to the shuttle (April 25). One day had no scheduled service due to a road closure for the Spring Daze Arts and Crafts Festival setup that impacted access to the Sertoma (Kiwanis) Shelter and Bond Park Boathouse stops (April 28). Partial suspension of service was most commonly due to inclement weather (4 service suspensions) or battery insufficiency (24 service suspensions).

Midday charging of the shuttle was implemented on May 22, 2023 through the end of the pilot period to mitigate battery insufficiency resulting from demand on the shuttle's air conditioning system on hot days. Cary placed A-frame signs at the stops on the route to notify the public that the shuttle was unavailable while it was charging (Figure 19).



Figure 19. Signs placed at the shuttle's stops on the route in Cary's Bond Park to notify the public that the shuttle was unavailable while it was charging. (Images courtesy of NCDOT)

Across the pilot period, 53 hours of scheduled service were lost in total due to service interruptions, which equates to nearly nine days of service. Beep provided after-hours service to support rides during engagement events to make up the hours of lost service.

Disengagement from Autonomous Mode into Manual Mode

According to Beep, the shuttle spent 98.3% of its time on the route in autonomous mode during the pilot period. There were 179 documented disengagements from autonomous mode into manual mode or 2.9 per day on average on days of complete or partial service. The most common causes of disengagement were:

- Signalized intersection (28%)
- Signal loss (20%)
- Station blocked (15%)
- Other road users (13%)
- Fault code/error code (12%)

The signalized intersection was a common cause of disengagement from autonomous mode into manual mode early in the pilot period through week seven, whereas signal loss was a common cause of disengagement later in the pilot period, particularly in week eleven (Figure 20).

Disengagements by Week

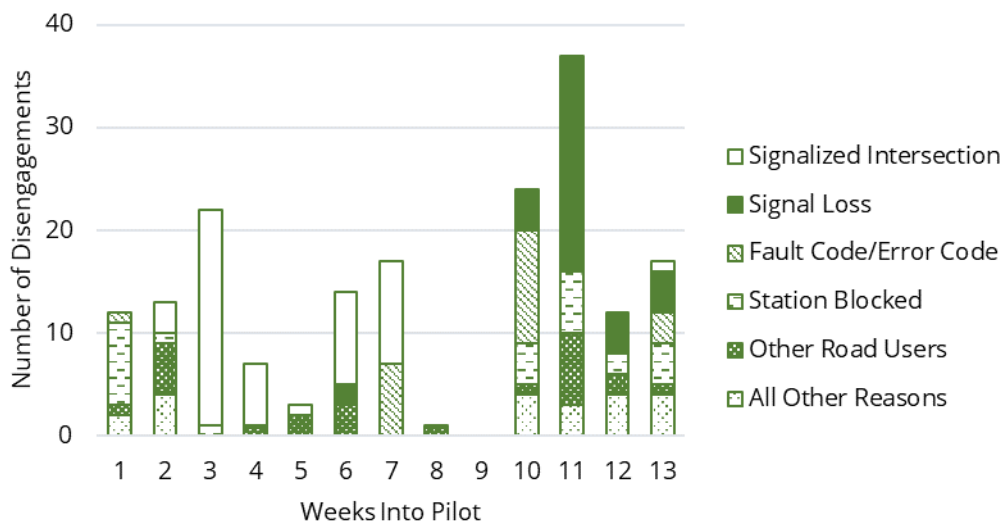


Figure 20. Disengagements by week during the pilot in Cary's Bond Park based on Beep's ridership and operations data. (Image courtesy of NCDOT)

Vehicle-to-Infrastructure Miscommunication

The leading cause of disengagement from autonomous mode into manual mode was when the vehicle's Onboard Unit (OBU) lost connection to or experienced miscommunication with the Roadside Unit (RSU) at the temporary traffic signal at the intersection of Maury Odell Place and Metro Park Drive. The vehicle's OBU was expected to receive messages from the RSU about the signal's phasing and timing and use the information to operate autonomously through the intersection. The attendant resolved this issue by manually operating the vehicle within range of the RSU until the connection was reestablished and autonomous mode resumed.

Signal Loss

The second leading cause of disengagement from autonomous mode into manual mode was signal loss between the shuttle's GPS unit and the GNSS antenna installed within the park for the pilot. The shuttle lost signal (3G/GNSS/RTK positioning) and was unable to continue in autonomous mode. The attendant resolved this issue by navigating in manual mode until signal strengthened then resumed autonomous mode.

Real-Time Tracking

NCDOT, Cary, and Beep desired real-time tracking of the shuttle on the route using Automatic Vehicle Location (AVL) technology. The preferred option for real-time tracking was integrating the shuttle into Cary's existing service for their GoCary transit fleet. This

option was not feasible since the vendor providing the service adjusted their business model to end support for all real-time systems.

NCDOT and Cary investigated Beep's solution for real-time tracking offered on a platform separate from GoCary's trip planning platform. NCDOT and Cary ultimately decided to forego real-time tracking since the shuttle could not be tracked against GoCary's other transit options using Beep's solution and the time and resources needed to establish a new solution were too great relative to the short duration of the pilot.

Shuttle's Comfort

Feedback from the rider survey indicated that some riders felt unsafe or uncomfortable while riding the shuttle due to jerky braking and abrupt stops. The shuttle was programmed to brake sharply when an obstacle was detected by its sensors. The shuttle also braked abruptly when stopping at intersections and upon disengagement from autonomous mode into manual mode.

Shuttle's Speed

Some riders commented on the slow speed of the shuttle. The shuttle was programmed to operate at a defined maximum speed on each segment of the route based on roadway geometry and environmental conditions. The shuttle moved the slowest through parking areas. While the maximum allowable speed of the shuttle was 12 mph as documented in the permission letter from NHTSA, its average speed on the route during the pilot period was 5.4 mph.

Shuttle's Accessibility

The feedback gathered from the engagement event with community members with disabilities and their caregivers was shared with Beep with the expectation that two features of the shuttle could be immediately improved before the shuttle was moved to its next project in North Carolina: adding an automatic wheelchair ramp and adding stop announcements. Beep was not able to meet the request. Since the vehicle was manufactured in France, the automatic ramp that was available did not meet existing Americans with Disabilities Act (ADA) requirements in the United States. While the vehicle has an interior speaker system, Beep has no existing service or protocol for incorporating automated stop announcements and other auditory cues.

Lessons Learned

Technology

Automated vehicle technology has not been commercialized and is currently in the research and development (R&D) (includes prototyping and testing) and demonstration (includes pilots) phases of development. Automated vehicle technology is not advanced

enough to be a complete substitute for conventional transportation options. An on-board attendant and an exemption from FMVSS are required for shuttles like the one piloted in Bond Park. Due to limitations to their sensor systems, the shuttles cannot operate in heavy rain, snow, fog, hail or when connectivity between the GPS sensor and the GNSS antenna is disrupted, and quality of service can be disrupted by extreme heat or cold.

Expectations need to be appropriately managed, and the realities of the technology need to be communicated up front related to commercial availability, capabilities, and limitations (such as speed, capacity, and non-compliance with FMVSS and ADA).

Temporary Traffic Signal

The most common cause of the shuttle's disengagement from autonomous mode into manual mode was the signalized intersection. NCDOT and Cary determined that more testing between the OBU and RSU prior to launch would have been beneficial to ensure the shuttle operated through the signalized intersection with minimal issue or intervention from the attendant throughout the pilot period and to maximize learning related to the signal integration.

Route Design

Route design influences how much time an automated vehicle is in autonomous mode compared to manual mode. Routes for shuttles like the one piloted in Bond Park should include vertical, regular surfaces such as poles, walls, buildings, or other hardscape to enable accurate localization using the shuttle's LiDAR sensors. Routes should be kept stable and unchanging to the extent possible since localization is dependent on validating real-time data against a historic high-definition map of the route and environment. Vegetation must be routinely trimmed and maintained along the route, so branches and leaves are not detected as obstacles. The roadway must be kept clear of debris that may be detected as obstacles. Tall buildings and dense tree cover should be assessed to determine impacts to GPS connectivity. The slope of the roadway should be assessed to determine impacts to the shuttle's performance including its battery sufficiency. Additional route considerations are provided in Appendix A.

Infrastructure

Significant investment is sometimes needed to meet an automated vehicle's storage and charging requirements. For shuttles like the one used in Bond Park, a secure, climate-controlled building that is large enough to hold the vehicle must be provided to meet requirements listed in Appendix B. While the shuttle featured a manual wheelchair ramp, some curbs were not adequate for its safe deployment, so temporary modular ramps were added at stops where necessary. Cary designed, fabricated, and installed signs along the route and at the stops to notify visitors that the shuttle was being tested in Bond Park and to advertise where and how they could take a ride.

Operations

Traditional transit service can handle and is expected to run in conditions that current automated vehicle models cannot, such as extreme weather and low light, varying terrain, and congested areas with high volumes of pedestrians, bicyclists, and other non-motorists. Further, traditional transit service can and is expected to handle accessibility, where vehicles and transit professionals are equipped to accommodate people with disabilities and using mobility devices such as a wheelchair, walker, or cane.

Automated vehicle pilots will not be able to achieve the same level of service as established and standardized transit options due to technology limitations that constrain route and service design options. Goals and measures of success should be clearly defined from the onset with these limitations in mind.

Service Suspensions

Service suspensions and interruptions are likely to occur during automated vehicle pilots since the technology is being tested and evaluated while providing passenger service to the public. NCDOT and Cary developed a service interruption plan “on the fly” in reaction to the attendant’s absence during the first month of service. NCDOT plans to proactively develop the service interruption plan and protocols in collaboration with the partnering community prior to launch for future pilots.

Real-Time Tracking

Riders expect consistency with transit schedules including reliable arrival and departure times. The results from the rider survey for the pilot in Bond Park showed the lowest level of agreement for the question that asked about wait time. 78% of respondents thought the shuttle arrived at their stop within a reasonable amount of time.

NCDOT and Cary did not include real-time tracking in the pilot since the shuttle could not be tracked against GoCary’s other transit options using Beep’s platform and the time and resources needed to establish a new solution were too great relative to the short duration of the pilot. The lack of AVL technology coupled with inconsistency in the shuttle’s timing due to frequent service interruptions and the shuttle’s disengagements from autonomous mode into manual mode led to long wait times at the stop locations for riders and confusion about whether the shuttle was coming or going. NCDOT plans to include real-time tracking as a mandatory feature in future pilots.

Data

Since automated vehicle technology is still in the R&D and demonstration phases of development, key performance indicators or measures of success related to its use for public transportation should be sensitive to the limitations of the technology in comparison to conventional options. Shuttles like the one piloted in Bond Park have historically been

operated for research and demonstration purposes only and have not been implemented in standardized transit services.

To the extent possible, the project partners should discuss and define data needs and design an evaluation plan prior to commencing public passenger services. Project partners may consider scoping data needs and expectations at the procurement and contracting stage to hold the vendor accountable to provide the data necessary to support the evaluation plan. The evaluation plan should connect pilot findings to the project partners' vision and goals and appropriately quantify the successes or challenges of automated vehicles for use in transit.

Regulations

Federal Motor Vehicle Safety Standards (FMVSS) compliance is a key issue for novel-design, low-speed automated shuttles like the one piloted in Bond Park. For the shuttle to operate on public roads and accept passengers, the National Highway Traffic Safety Administration (NHTSA) grants an exemption from FMVSS to the owner and operator of the shuttle after a lengthy application and review process.

Novel-design, low-speed automated shuttles do not meet additional federal regulations such as Federal Transit Administration (FTA) funding requirements and Americans with Disabilities Act (ADA) requirements as documented in multiple federal guidance documents and research reports.^{19,20,21,22,23}

Accessibility

The full set of accessibility-related features needed to serve people with disabilities does not currently exist for most automated vehicles. Some vehicles have been designed or retrofitted to include all features for wheelchair users, but few models include features to support people with cognitive and sensory disabilities. NCDOT plans to be more intentional to hold vendors accountable to include desired and required accessibility features in their vehicles and services at the procurement and contracting stage for future automated shuttle projects. Universal design of automated vehicles will be important as the vehicles

¹⁹ Cregger, Joshua, et al. (2018, September). Low-Speed Automated Shuttles: State of the Practice – Final Report. (FHWA-JPO-18-692). United States Department of Transportation. <https://rosap.ntl.bts.gov/view/dot/37060>

²⁰ Federal Transit Administration. (2019, November 1). Transit Bus Automation Policy FAQs. <https://www.transit.dot.gov/research-innovation/transit-bus-automation-policy-faqs>

²¹ Coyner, Kelley, et al. (2021). Low-Speed Automated Vehicles (LSAVs) in Public Transportation. (TCRP Research Report 220). National Academies of Sciences, Engineering, and Medicine. <https://nap.nationalacademies.org/catalog/26056/low-speed-automated-vehicles-lsavs-in-public-transportation>

²² U.S. Access Board. (2021, July). Public Forum on Inclusive Design of AVs: Summary Report. <https://www.access-board.gov/av/report.html>

²³ Berg, Ian, et al. (2022, August). Accessibility in Transit Bus Automation: Scan of Current Practices and Ongoing Research. (FTA Report No. 0228). Federal Transit Administration. <https://rosap.ntl.bts.gov/view/dot/64112>

are tested and ultimately adopted across transit service types including on-demand and demand response applications.

Conclusions

NCDOT in partnership with Cary and Beep advanced their exploration of shared autonomous vehicles through the pilot of a novel-design, all-electric, low-speed automated shuttle in Bond Park. The pilot was the first under the CASSI program to include V2I communications between the shuttle and a traffic signal on the shuttle's route. While the traffic signal integration would have benefited from additional testing prior to the launch of the pilot, the teamwork and troubleshooting to ensure the OBU and RSU communications provided a solid foundation of learning to inform future pilots.

Cary invested considerable funding and staff resources to meet the shuttle's route, storage, and charging requirements and support marketing, communications, and public engagement that ensured the pilot's success. NCDOT and Cary demonstrated their strong partnership by working together to plan, prepare for, and launch the pilot and mitigate unanticipated issues throughout the pilot period. Through their perseverance and adaptability, NCDOT and Cary were able to complete the pilot, document successes and challenges, and capture lessons learned to inform future pilots.

NCDOT seeks to incrementally increase the complexity of future automated shuttle pilots by considering distinctly different use cases, vehicle form factors, ADS technologies, and service designs and advancing the testing of connected vehicle features.

Recommendations for Future Work

NCDOT's current project under the CASSI program is on the University of North Carolina at Charlotte (UNC Charlotte)'s campus.²⁴ Service opened to the public on July 12, 2023 and will run through December 22, 2023. This project continues to advance NCDOT's goal of incrementally increasing the complexity of projects while learning from past challenges and building on successes. Lessons learned from the project in Cary's Bond Park were applied towards the deployment at UNC Charlotte. The project increases the complexity of the V2I communications from a single temporary traffic signal to four naturalistic traffic signals and features the longest route and most complex operating environment to date. NCDOT's focus is on providing safe, reliable, and useful transit service while familiarizing the public with new technologies and enabling further testing and evaluation.

NCDOT is evolving the CASSI program to include the latest technological advancements. NCDOT will continue to pilot automated shuttles. The agency is further exploring how automated vehicles can be tested and integrated into high quality, on-demand transit

²⁴ Parking and Transportation Services, UNC Charlotte. (n.d.). CASSI. <https://pats.charlotte.edu/CASSI>

services that address transportation challenges, including through grant applications²⁵ to the USDOT Advanced Transportation Technology and Innovation (ATTAIN) program. NCDOT is also supporting N.C. A&T State University²⁶ to develop shared autonomous vehicles, an innovative rural test track, and an automated shuttle pilot between the university and downtown Greensboro.

NCDOT will use the feedback gathered from community members with disabilities and their caregivers during the project in Cary's Bond Park to inform a Request for Information (RFI) on automated bus technologies including automated wheelchair ramps and securement systems. The community feedback and RFI results will be used to inform the procurement of automated vehicles in the future that are more accessible and better meet the needs of all riders.

²⁵ NCDOT. (n.d.). Connected, Rural, Equitable, and Autonomous Transportation for Everyone (CREATE). <https://connect.ncdot.gov/resources/ATTAIN2022-CREATE/Pages/default.aspx>

²⁶ N.C. A&T State University. (n.d.). Connecting the Future: Autonomy at A&T. <https://www.aggieauto.com/>

Appendices

Appendix A. Appropriate Operating Conditions for the Navya Autonom

The following are the appropriate operating conditions for the Navya Autonom:

- Route length: ≤ 2 miles
- Posted speed limit: ≤ 25 mph
- Paved roadway surfaces only (asphalt or concrete; smooth surfaces preferred)
- 12-foot travel lanes preferred; ≥ 10 -foot travel lanes required
- Operating temperatures: 14 °F – 104 °F; quality of service is impaired by heavy rain, snow, fog, hail, and extreme heat or cold
- Buildings or fixed elements along the route are helpful for localization
- Cellular coverage along the route required (various bands of cellular connectivity may be used depending on the signal strength and area of deployment)
- Dedicated shuttle stops must be provided with a pull off area of at least 69 feet; circulator style route preferred
- Avoid routes where the slope frequently exceeds 7%; maximum slope = 12%
- Avoid routes with high traffic density or dedicate a lane for the shuttle
- Avoid railroad crossings, construction or work zones, and routes that require switching or merging lanes with other traffic
- Ensure vegetation is trimmed and maintained along the route

Appendix B. Appropriate Charging Equipment and Storage for the Navya Autonom

The following are the electrical specifications and storage requirements for the Navya Autonom:

- Electrical Specifications
 - Power: 208V/220V/240V; 50A
 - Outlet type: NEMA 14-50
 - Operating temperatures: 14 °F – 113 °F
- Storage Requirements
 - Storage dimensions: ≥ 23 feet long, 11 feet wide, and 13 feet high
 - Storage temperatures: 32 °F – 86 °F

Appendix C. Key Planning Activities by Category with Responsible Parties and Completion Date

Category	Activity	Responsible Parties	Completion Date
Administrative	Execute contract for the automated shuttle lease and operations	NCDOT/Beep	11/22/2022
Administrative	Deliver shuttle to North Carolina	Beep	12/29/2022
Administrative	Submit exemption application to NHTSA	Beep	11/21/2022
Administrative	Receive NHTSA approval (permission letter)	NHTSA	2/3/2023 (original letter); 2/16/2023 (revised letter)
Administrative	Complete vehicle inspection, titling, and registration	NCDOT/Beep	2/8/2023 (inspection); 2/17/2023 (titling and registration)
Administrative	Execute general agreement	NCDOT/Cary	2/23/2023
Administrative	Execute permission to enter agreement (access agreement)	Cary/Beep	2/17/2023
Administrative	Transport shuttle to carpentry shop at Bond Park	Beep	2/10/2023
Operations	Confirm public operations period	NCDOT/Cary	1/9/2023 (kickoff meeting)
Operations	Confirm hours of operation	NCDOT/Cary	1/9/2023 (kickoff meeting)
Operations	Create service interruption plan	NCDOT/Cary/Beep	4/18/2023
Operations	Confirm special events	NCDOT/Cary	6/2/2023 (ongoing during pilot period)
Infrastructure	Prepare storage location and install charging equipment	Cary	n/a (completed for first attempted pilot with EasyMile)
Infrastructure	Complete HVAC upgrades	Cary	n/a (completed for first attempted pilot with EasyMile)
Infrastructure	Install Wi-Fi cradle point	Cary	n/a (completed for first attempted pilot with EasyMile)
Infrastructure	Install temporary modular ADA ramps	Cary	2/9/2023
Infrastructure	Install signs along the route and at stops	Cary	2/6/2023

Category	Activity	Responsible Parties	Completion Date
Infrastructure	Trim vegetation along the route	Cary	n/a (trees were bare at launch of pilot)
Infrastructure	Install temporary traffic signal	NCDOT/Cary	2/9/2023
Infrastructure	FCC approval (permission letter) for DSRC license	NCDOT/Cary	2/7/2023
Infrastructure	Install RSU/OBU	NCDOT/Cary/Beep	2/3/2023
Marketing and Promotion	Create wrap design	Cary	2/6/2023
Marketing and Promotion	Print and install wrap	Beep	2/9/2023
Marketing and Promotion	Create media packet (webpage, news release, and social media post calendar)	NCDOT/Cary	2/6/2023 (media packet); 2/10/2023 (first social media post); 2/28/2023 (news release)
Incident Response Plan	Create and confirm Incident Response Plan	NCDOT/Cary	3/2/2023
First Responder Workshop	Organize and hold First Responder Workshop	Beep	3/1/2023
Data Collection	Create and administer rider survey	NCDOT/Cary	3/3/2023
Data Collection	Develop data entry application (in-vehicle tablet)	NCDOT/Cary	n/a (used Beep's data collection protocol and procedures)
Data Collection	Collect and share ridership and operations data	Beep	Weekly basis during pilot period
Commissioning	Install GNSS antenna	Beep	2/8/2023
Commissioning	Complete route mapping (environment mapping) using a mobile scanning unit installed on a conventional vehicle	Beep	2/9/2023
Commissioning	Vendor processes mapping data	Beep	2/17/2023
Commissioning	Complete path creation (mapping data analyzed in office)	Beep	2/20/2023

Category	Activity	Responsible Parties	Completion Date
Commissioning	Complete path validation using the shuttle	Beep	2/22/2023
Commissioning	Validate RSU/OBU	Beep	2/24/2023
Commissioning	Train on-site attendant on route	Beep	3/2/2023
Commissioning	Hand off the shuttle and service to on-site attendant	Beep	3/3/2023
Start of Service	Coordinate and complete ribbon cutting event	NCDOT/Cary	3/14/2023
Start of Service	Operate shuttle on the route during scheduled hours	Beep	Ongoing during pilot period
Start of Service	Coordinate and complete special events	NCDOT/Cary	Ongoing during pilot period
Start of Service	Weekly check in meetings	NCDOT/Cary	As needed
Start of Service	Weekly check in meetings	NCDOT/Beep	Weekly basis during pilot period

Appendix D. Joint and Individual Responsibilities per the General Agreement Between NCDOT and Cary for the CASSI in Cary's Bond Park Project

NCDOT:

- Provide a fully functioning autonomous shuttle per the contract between NCDOT and Beep for the term of the agreement.
- Coordinate with Cary on any agreed upon wrapping or branding of the shuttle for the project.
- Collaborate with Beep and Cary to provide and honor a project schedule with target dates and milestones by providing information, reviewing information, and meeting as needed to meet various key milestones.
- Provide project management, including coordination of the project with Cary, Beep, any third-party operator involved in operations of the shuttle, and other partners designated by Cary.
- Provide the design, cabinet, and signal heads for and assist Cary with the installation, testing, and validation of the temporary traffic signal.
- Assist Beep in coordinating with Cary on passenger engagement prior to passengers boarding the shuttle and provide general information to the public about the CASSI program and the project underway.
- Handle all communications with Beep unless otherwise directed by Cary.
- Provide Cary with all data on operations of the shuttle received from Beep, including, but not limited to, data on ridership, stop departure times, route performance, disengagements, and interventions.
- Develop a plan for data sharing with Cary prior to the start of public operations.
- Develop and administer a rider survey for the project in consultation with Cary.
- Set a schedule of public operations in consultation with Cary and Beep to operate up to forty (40) hours per week only during weekdays, excluding public holidays.
- Facilitate weekly or biweekly project meetings through conference call.
- Notify Cary immediately of anything impacting the shuttle, route, or operations in accordance with the project's Incident Response Plan.
- Confirm that operations of the shuttle are compliant or have received appropriate documentation from NHTSA prior to the shuttle operating on the route.
- Purchase and maintain all insurance policies for operations of the shuttle for the project.
- Ensure that Beep and its permitted subcontractors purchase and maintain all insurance policies for operations of the shuttle for the project (except worker's compensation and professional liability) and that Beep names Cary, its elected officials, officers, employees, and volunteers as an additional insured on their policy.

- Confirm that operations of the shuttle, including those conducted by Beep or a third-party operator, are compliant with all applicable state and local public health guidelines related to the COVID-19 pandemic.
- Coordinate with Cary on any press and media information related to the project.

Cary:

- Complete on-site work for the project (e.g., temporary signage installation, infrastructure improvements, etc.) and provide a secure storage facility in accordance with Beep's requirements as mutually acceptable to Cary for the shuttle for the term of the agreement.
- Work closely with NCDOT to meet a project schedule with target dates and milestones by providing information, reviewing information, and meeting as needed to meet various key milestones.
- Provide an operating schedule for services that total forty (40) hours per week (during weekdays) and accounts for holidays; public operations will total eight (8) hours each weekday, and six (6) of those hours (10:00 a.m. to 4:00 p.m.) will include passenger carrying services.
- Coordinate with Beep and NCDOT to display the shuttle during Spring Daze.
- Provide storage location, charging equipment, and power supply for the shuttle that is compliant with information provided by NCDOT and Beep.
- Furnish site modifications determined by Beep to be necessary for public operations, including, but not limited to, temporary signage, appropriate accessibility ramp connections, OBU/RSU validation, and other items mutually agreed to by Cary as provided within Beep's Route Analysis documentation.
- Furnish a building roof with adequate support, coverage, and access to support Beep's need for a temporary antenna as mutually agreed to by Cary.
- Provide NCDOT with branding and logo information for design of a shuttle wrap (as applicable); shuttle wrap design shall be limited to logos and branding of Cary, NCDOT, and Beep.
- Notify NCDOT immediately of anything impacting the shuttle, route, or operations in accordance with the project's Incident Response Plan to be developed by NCDOT and Cary.
- Coordinate with NCDOT on passenger engagement prior to passengers boarding the shuttle and provide general information to the public about the CASSI program and the project underway.
- Coordinate with NCDOT on any press and media information related to the project.
- Review and approve, if appropriate, necessary plans and documents to facilitate public operations under the demonstration program, including, but not limited to, materials submitted to NHTSA and additional reports required by NCDOT.
- Participate in weekly or biweekly project meetings held through conference call.
- Inform NCDOT immediately of any concerns or issues that arise pertaining to any responsibilities of NCDOT, Beep, or a third-party operator.

- Inform NCDOT immediately of any safety-related concerns or incidents in accordance with the agreed upon, documented safety protocol.
- Agree to consider and apply recommendations and instructions from reports produced by Beep, including, but not limited to, the Route Analysis documentation.
- Provide contact information for a local designee who can be accessible 24/7 in the event of an emergency.

NCDOT and Cary:

- Work collaboratively to facilitate the deployment of a fully operational shuttle leased by NCDOT and capable of operating on non-flat surfaces on a predetermined fixed route as shown in the Route Analysis documentation.
- Make every effort to jointly and with Beep adhere to the project schedule.
- Provide a public operation period of three (3) months from March 6, 2023 through June 2, 2023; public operations will total eight (8) hours each weekday, and six (6) of those hours (10:00 a.m. to 4:00 p.m.) will include passenger carrying services; public operations are provided only during weekdays, excluding holidays, unless otherwise specified.
- Define predetermined stops for the shuttle to provide public transportation service to destinations within Bond Park.

Appendix E. Basic Project Timeline per the General Agreement Between NCDOT and Cary for the CASSI in Cary's Bond Park Project

Activity	Timeline	Responsible Parties
Submit exemption application to NHTSA	11/21/2022	Beep
Official project kickoff meeting	1/9/2023	NCDOT/Cary/Beep
Submit exemption application to FCC for DSRC license	1/30/2023	NCDOT
Receive FCC approval (permission letter)	2/6/2023	FCC
Confirm wrap design	2/6/2023	NCDOT/Cary
Receive NHTSA approval (permission letter)	2/8/2023	NHTSA
Vehicle examination and safety inspection at local NCDOT facility	2/8/2023	NCDOT/NC DMV/Beep
Wrap print and installation	2/9/2023	Beep
Vehicle arrives to Cary	2/10/2023	Beep (transport/loading/unloading)
Complete infrastructure updates	2/10/2023	NCDOT/Cary
Titling and registration	2/17/2023	NC DMV/Beep
Commissioning by Beep	2/6/2023 - 3/3/2023	Beep
Stationary shuttle display (Spring Daze)	4/29/2023	Beep
Operations (3 months)	3/6/2023 - 6/2/2023	Beep
Vehicle picked up	6/2/2023	Beep

Appendix F. North Carolina Statutory Requirements for Motor Vehicles

- Tires – §20-122.1 (19A NCAC 03D .0538)
- Steering mechanism – §20-123.1 (19A NCAC 03D .0535)
- Speedometer – §20-123.2
- Brakes – §20-124 (19A NCAC 03D .0532)
- Horns and warning devices – §20-125 (19A NCAC 03D .0533)
- Directional signals – §20-125.1 (19A NCAC 03D .0537)
- Mirrors – §20-126 (19A NCAC 03D .0540)
- Windshield and windshield wiper – §20-127 (19A NCAC 03D .0536)
- Exhaust system and emissions control devices – §20-128 (19A NCAC 03D .0541)
- Required lighting equipment of vehicles – §20-129 (19A NCAC 03D .0533)
- Requirements as to headlamps and auxiliary driving lamps – §20-131
- Safety belts and anchorages – §20-135.2
- Vehicle Identification Number (VIN) – §49 CFR 565

Appendix G. North Carolina Titling and Registration Documentation Requirements for the Navya Autonom Used for the CASSI in Cary's Bond Park Project

- MVR-1 – Title Application
- Manufacturer's Certificate of Origin (MCO)
- Certificate of Liability Insurance with the covered VIN added
- MVR-180 – Odometer Disclosure Statement
- Bill of Sale with the covered VIN added
- Department of Homeland Security, U.S. Customs and Border Protection – Entry Summary
- NC Department of Secretary of State registration for Beep, Inc.
- NHTSA approval document (permission letter) to operate the vehicle according to the research and demonstration program
- Safety inspection report

Appendix H. Operating Conditions Approved by NHTSA for the Navya Autonom Used for the CASSI in Cary's Bond Park Project per the Permission Letter to Beep Dated February 16, 2023

- Vehicle operations must conform to all applicable terms and conditions described in NHTSA's September 30, 2021 letter "NHTSA Review of June 2021 Dunedin Incident and Resulting Safety Operations Mitigations," NHTSA's May 3, 2022 letter "NHTSA Review of 2021 Local Motors Olli Incidents and Resulting Vehicle Platform and Operational Mitigations," NHTSA's July 7, 2022 letter "Modified Intersection Operations for NAVYA Vehicles," and NHTSA's February 1, 2023 letter "Suspension of NAVYA Vehicles from Operations Involving Public Interaction and Return to Service Plan for Mitigation Implementation."
- The grant of permission applies only to the vehicle in the research and demonstration program as described in the permission letter from NHTSA. If Beep seeks to import or use any additional nonconforming vehicles for testing or demonstration purposes, regardless of whether they are the same model as the one that is the subject of the permission letter, Beep will need to separately request and receive permission from NHTSA prior to importation or operation.
- The vehicle's entry and presence in the United States must be in compliance with all U.S. Customs and Border Protection ("CBP") requirements.
- The vehicle may only be operated with a trained safety operator on board who, at all times, can take immediate control of or stop the vehicle should the need arise.
- The vehicle must be configured in such a way to allow movement, in either autonomous or manual mode, out of the path of vehicles, pedestrians, and obstacles. The safety operator must have a means to take control of the vehicle at any time to move it to a safe location.
- The vehicle must allow the safety operator to activate a horn or other audible warning at all times. The horn or other audible warning must be capable of emitting continuous and uniform sound audible under normal conditions from a distance of not less than 200 feet while activated.
- The vehicle and its operation must comply with all state and local laws and requirements at all times. Each vehicle must be duly permitted, if applicable, and authorized to operate within all properties and upon all roadways traversed by the route in the manner and conditions described in the permission letter from NHTSA.
- The vehicle may not be operated in adverse weather and road conditions, which include heavy precipitation, such as heavy rain, heavy snow, fog, or hail; sustained wind speeds greater than 25 mph; or temperatures below 14 °F or above 104 °F.
- Before operating the vehicle under any conditions other than those specified in the permission letter from NHTSA, Beep must either a) request and receive permission from NHTSA if any such change in condition relates to public road operation or to any operation that involves members of the public or b) notify NHTSA if the change solely

involves operation of the vehicle off public roads without interaction with members of the public at least seven (7) calendar days prior to making any of the desired changes.

- Apart from the safety operator, standing passengers are not permitted while operating the vehicle with members of the public on board.
- The vehicle must display the following labels formatted in a manner that can be easily read and be located in a place that is readily visible:
 - A label or labels, affixed to the interior and exterior of the vehicle, warning prospective and actual occupants that the vehicle does not comply with all applicable Federal motor vehicle safety standards.
 - A label or labels, affixed to the interior of the vehicle, warning occupants that the vehicle is a research and demonstration vehicle that may stop suddenly and of the need to fasten their seat belts.
 - A label or labels, affixed to exterior of each vehicle, warning other road users that the vehicle may stop suddenly.
- Safety operators must be regularly trained and monitored. All safety operators shall receive specific training on passenger safety and emergency response scenarios. Operator performance monitoring shall occur at least as frequently as described in Beep's application.
- Beep must notify NHTSA whenever the vehicle is involved in a crash or any other situation in which it posed a risk to the safety of any individual(s), whether such individual(s) were inside or outside of the vehicle at the time of the incident. These include, but are not limited to, situations in which the safety operator or another road user (including pedestrians) reacted to avoid an imminent crash, instances in which the vehicle deviated from the prescribed route, unexpected lane departures, and any situations that resulted in injury to vehicle occupants, pedestrians, bicyclists, or other road users. For any such incident that results in a crash or injury, Beep must provide notification of the incident within twenty-four (24) hours of the event. For any other qualifying event, Beep must provide notification within 5 days of the event. All such notifications shall include a full description of the event. When applicable, copies of all accident report(s) concerning the occurrence prepared by State or local law enforcement authorities must be provided within five (5) business days of when those reports become available. In addition, Beep must provide, as soon as practicable: (1) any video footage captured by cameras onboard the vehicle, or otherwise in Beep's possession, from the time of the incident; and (2) if applicable, a description of anticipated steps or mitigations to prevent or address similar future occurrences.
- Beep must submit a monthly report to NHTSA on the 15th of each month listing all unplanned disengagements occurring during the previous month during operation of the vehicle that involves interaction with the public. The report must include a description of the event(s) that triggered the disengagement, including, how any pedestrians, vehicles, or other objects were involved, as applicable. The report must also include the date, time, location, weather conditions, and speed immediately prior to disengagement. Further, the report must list the ADS software version, the total

number of miles accumulated in the reporting period and, separately, the number of miles accumulated with the Autonomous Driving System engaged.

- Beep must provide NHTSA with documentary proof that the vehicle has been exported or destroyed not later than thirty (30) days following the end of the period for which it has been admitted to the United States.
- Beep must submit an annual report to NHTSA on the status of all vehicles imported by Beep with active permissions as of the date of the report. The report should identify, by vehicle identification number (VIN), all vehicles that remain in the United States. The report should also identify all vehicles removed from service, the reasons for their removal, and their disposition.

Appendix I. Service Interruption Plan for the CASSI in Cary's Bond Park Project

Background

Beep operates a Navya Autonom shuttle for the Bond Park project under their contract with NCDOT and in partnership with the Town of Cary for the CASSI program. Beep provides an attendant on the shuttle as a safety backup and to provide customer service. On Tuesday, March 21, 2023, the attendant was sick and unable to report for duty. Because there are no backup attendants local to the Bond Park project area, the shuttle was out of service for the day. Beep, Town of Cary, and NCDOT recognized that a contingency plan for service interruptions that meets the needs of the Bond Park project was not available.

The following provides guidance on actions to be taken by Beep, Town of Cary, and NCDOT in the event of future service interruptions. This plan has been reviewed and approved by the teams.

If the assigned attendant is unavailable, the following actions will be taken:

Beep

1. Attendant sends down time notification to the site operations manager.
2. Site operations manager immediately assesses if down time will exceed past current day/shift.
3. Site operations manager communicates down time notification and expected duration of down time to the Town of Cary (including the 311 team and staff at the Cary Senior Center, Bond Park Community Center, and Bond Park boathouse) and NCDOT through group email.
4. Pool of 5 additional trained attendants ready to deploy within 24 hours as needed.
 - During the week of April 3, 2023, the site manager from Peachtree Corners was on site in Cary to train on the route and will be available as a backup option as our closest resource.
 - The attendant pool will be virtually trained on the route if they have not yet been on site and handed over any site-specific standard operational procedures.
5. A replacement attendant will be on site by the next shift at the earliest, contingent on when the down time notification is received by the site operations manager from the attendant. Coverage availability will be dependent on flight availability at the time of notification.

Town of Cary & NCDOT

1. Town of Cary (including the 311 team and staff at the Cary Senior Center, Bond Park Community Center, and Bond Park boathouse) and NCDOT receive down time notification from Beep's site operations manager through group email.
2. **If the down time is expected to last longer than two (2) hours**, upon receiving the down time notification, staff at the Cary Senior Center, Bond Park Community Center, and Bond Park boathouse will place messaging at the stops to announce the service interruption to the public. Messaging may take the form of signs placed on the stop signs or A-frame information boards.
3. **If the down time is expected to last longer than four (4) hours**, Town of Cary staff will also post the service interruption on social media (i.e., Twitter) and their webpage.

If the shuttle cannot be operated due to inclement weather (heavy rain, heavy snow, fog, or hail or in sustained winds greater than 25 mph) or battery insufficiency, the following actions will be taken:

Beep

1. Attendant sends down time notification to the site operations manager.
2. Site operations manager immediately assesses if down time will exceed past current day/shift.
3. Site operations manager communicates down time notification and expected duration of down time to the Town of Cary (including the 311 team and staff at the Cary Senior Center, Bond Park Community Center, and Bond Park boathouse) and NCDOT through group email.

Town of Cary & NCDOT

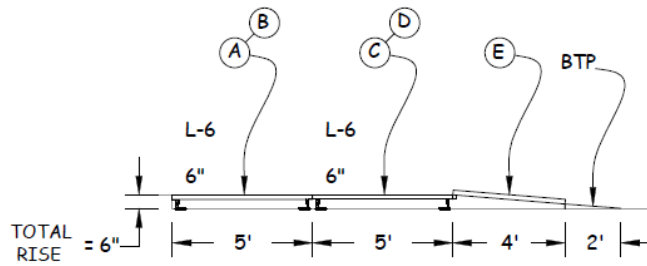
1. Town of Cary (including the 311 team and staff at the Cary Senior Center, Bond Park Community Center, and Bond Park boathouse) and NCDOT receive down time notification from Beep's site operations manager through group email.
2. **If the down time is expected to last longer than two (2) hours**, upon receiving the down time notification, staff at the Cary Senior Center, Bond Park Community Center, and Bond Park boathouse will place messaging at the stops to announce the service interruption to the public. Messaging may take the form of signs placed on the stop signs or A-frame information boards.
3. **If the down time is expected to last longer than four (4) hours**, Town of Cary staff will also post the service interruption on social media (i.e., Twitter) and their webpage.

Appendix J. Temporary Modular Ramps Leased from Amramp Eastern NC for the CASSI in Cary's Bond Park Project

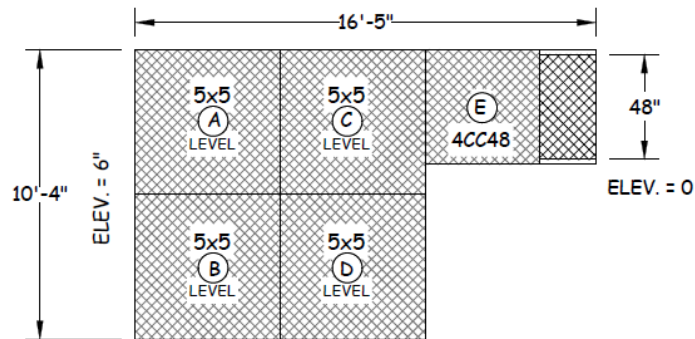
Side View:

$$= \frac{6'' \text{ RISE}}{6' \text{ RAMP}}$$

$$= 1.00'' \text{ RISE} / ' \text{ RAMP}$$



Top View:



NOTES
1. Option 2 Rev None

Appendix K. Cary's News Release for the CASSI in Cary's Bond Park Project

Cary and NCDOT Partnership Brings Autonomous Shuttle to Bond Park for Three-month Pilot

An all-electric, autonomous shuttle will welcome its first passengers March 6 for a three-month pilot in Fred G. Bond Metro Park.

Post Date: 02/28/2023 10:44 AM

- CASSI (Connected Autonomous Shuttle Supporting Innovation) comes to Cary for a three-month pilot project starting March 6 thanks to a partnership with the North Carolina Department of Transportation.
- The shuttle operates at no cost to riders from 10 a.m. to 4 p.m. Monday through Friday; the pilot ends June 2.
- View the shuttle up close in the Earth Day Lane section of the Spring Daze Arts & Crafts Festival in Bond Park on April 29.

Cary, NC – **Visitors to Bond Park can catch a brand-new ride this spring as CASSI (Connected Autonomous Shuttle Supporting Innovation) comes to Cary for a three-month pilot project.** The driverless, low-speed shuttle will run a four-stop route in Bond Park from 10 a.m. to 4 p.m. Monday through Friday between March 6 and June 2.

"We're so excited to test this cutting-edge technology in Cary," said Jerry Jensen, Cary's Director of Transportation. "There's so much innovation happening in autonomous vehicles right now, and it's a great opportunity for Bond Park visitors to see it up close. We're grateful to our partners at the North Carolina Department of Transportation for the chance to bring this pilot project to Cary."

Manufactured by France-based Navya and operated by Lake Nona, Florida-based Beep, the shuttle relies on LiDAR, cameras, and GPS technology to safely transport up to eight passengers and an attendant along a fixed route. A similar shuttle was previously piloted under the CASSI program at the Wright Brothers National Memorial in Kill Devil Hills and on the Centennial Campus of North Carolina State University in Raleigh. The project in Bond Park is a cross-departmental effort, bringing together teams from around Cary to get the pilot off and running.

"Cary's staff and leaders are constantly looking ahead for signs of the next innovation," said Nicole Coughlin, Cary's Chief Information Officer. "We're still in the early days of driverless vehicles, but the technology is continuously improving. Through this pilot, we hope to get a

sense of how autonomous vehicles might figure into future Cary projects, and to hear from riders about their experience on the shuttle. Bringing CASSI to Cary furthers our priority for innovation and imagining how new ideas can be used to benefit our citizens.”

The autonomous shuttle is wheelchair accessible and runs at speeds up to 12 mph. While the shuttle uses cutting-edge technology to operate without a driver and does not feature a traditional steering wheel or manual brakes, a trained attendant will be present at all times to take manual control of the vehicle, if needed, to ensure the safety of the passengers. There is no cost to ride.

Visitors to Spring Daze will have a chance to see the shuttle up close in the Earth Day Lane section of the festival on April 29.

Learn more about the vehicle and the project at carync.gov/CASSI.

Primary Contacts

If you have specific questions about Town services or operations, dial 311 anywhere in Cary, (919) 469-4000 outside town limits, or email 311@carync.gov.

Resources

- [Cary: Meet CASSI](#)
- [NCDOT: About CASSI](#)
- [Beep](#)
- [Fred G. Bond Metro Park](#)

Appendix L. Beep’s News Release for the CASSI in Cary’s Bond Park Project

Mar 14, 2023

North Carolina Department of Transportation and Beep Partner for Autonomous Vehicle Testing Projects



Initial Three-Month Project to Operate in Town of Cary, North Carolina

LAKE NONA, Fla. March 14, 2023 — Beep Inc., provider of autonomous shared mobility solutions, today announced a partnership with the North Carolina Department of Transportation (NCDOT). This partnership expands NCDOT’s Connected Autonomous Shuttle Supporting Innovation (CASSI) program to further the state’s understanding of autonomous technologies and demonstrate the viability of shared autonomy. NCDOT and Beep will test applicable use cases for shared, electric and autonomous shuttles.

The first pilot project will operate in Cary, North Carolina’s Fred G. Bond Metro Park, one of the largest municipal parks in Wake County. The four-stop, two-mile route provides an innovative and environmentally friendly mobility solution for residents and visitors to easily access the 310-acre park at their leisure. Beep will leverage its experience in safely testing and monitoring autonomous mobility networks while gathering operational data and insights for the CASSI program and Cary. The program supports Cary’s Smart and Connected Communities Program, which focuses on using data and technology to optimize city functions and improve the quality of life for its citizens.

“Beep is honored to have been selected by NCDOT to bring innovative autonomous mobility solutions to Cary,” said Beep CEO Joe Moyer. “We are pleased to be working closely with the agency on this pilot, our first in North Carolina, which will showcase how shared autonomous mobility can make a lasting positive impact in the community. Autonomous

shuttles promise to relieve roadway congestion and help address carbon emissions, noise pollution and road safety, while extending mobility access. We are delighted to have the opportunity to work with NCDOT and Cary to showcase these capabilities to residents and visitors.”

“The future of transportation includes shared mobility options that are as convenient, reliable, affordable, clean and as safe as driving, and allow every person equal access to opportunities and services,” said NCDOT Secretary Eric Boyette. “The CASSI shuttle helps make this vision a reality.”

“This project is a great opportunity for Cary residents and visitors to Bond Park to experience the latest in autonomous vehicle technology”, said Cary Chief Information Officer Nicole Coughlin. “Innovation is a priority for Cary, and CASSI will help us better understand how we might integrate and accommodate autonomous technologies into our plans.”

NCDOT and Beep are working to establish additional test locations in the state. These projects will enhance NCDOT’s understanding of shared autonomous mobility in practice and evolve the CASSI program as technology continues to advance.

About Beep

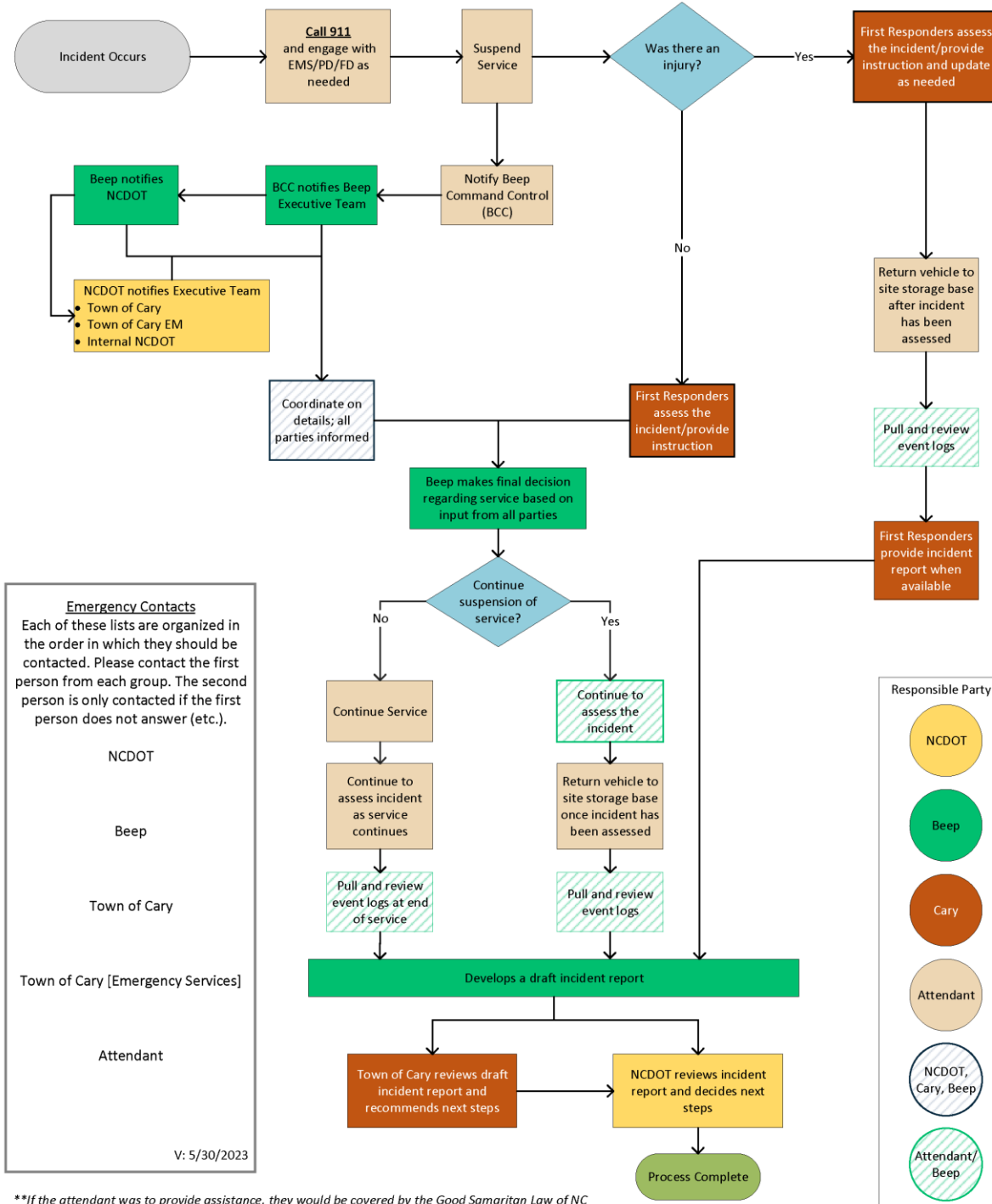
Beep delivers the next generation of autonomous, shared mobility solutions through its software and services. Specializing in planning, deploying and managing autonomous shuttles in dynamic mobility networks, Beep safely connects people and places with solutions that reduce congestion, eliminate carbon emissions, improve road safety and enable mobility for all. Beep leverages the data and learnings from its deployments to enhance and advance the safety, customer experience and operating capabilities of autonomous platforms. For more information visit www.ridebeep.com.

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Appendix M. Incident Response Plan for the CASSI in Cary's Bond Park Project

NCDOT CASSI (EMERGENCY) Incident Response Plan (per Beep Level 2 & 3)

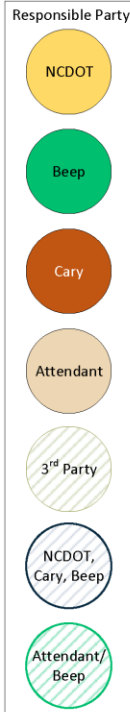
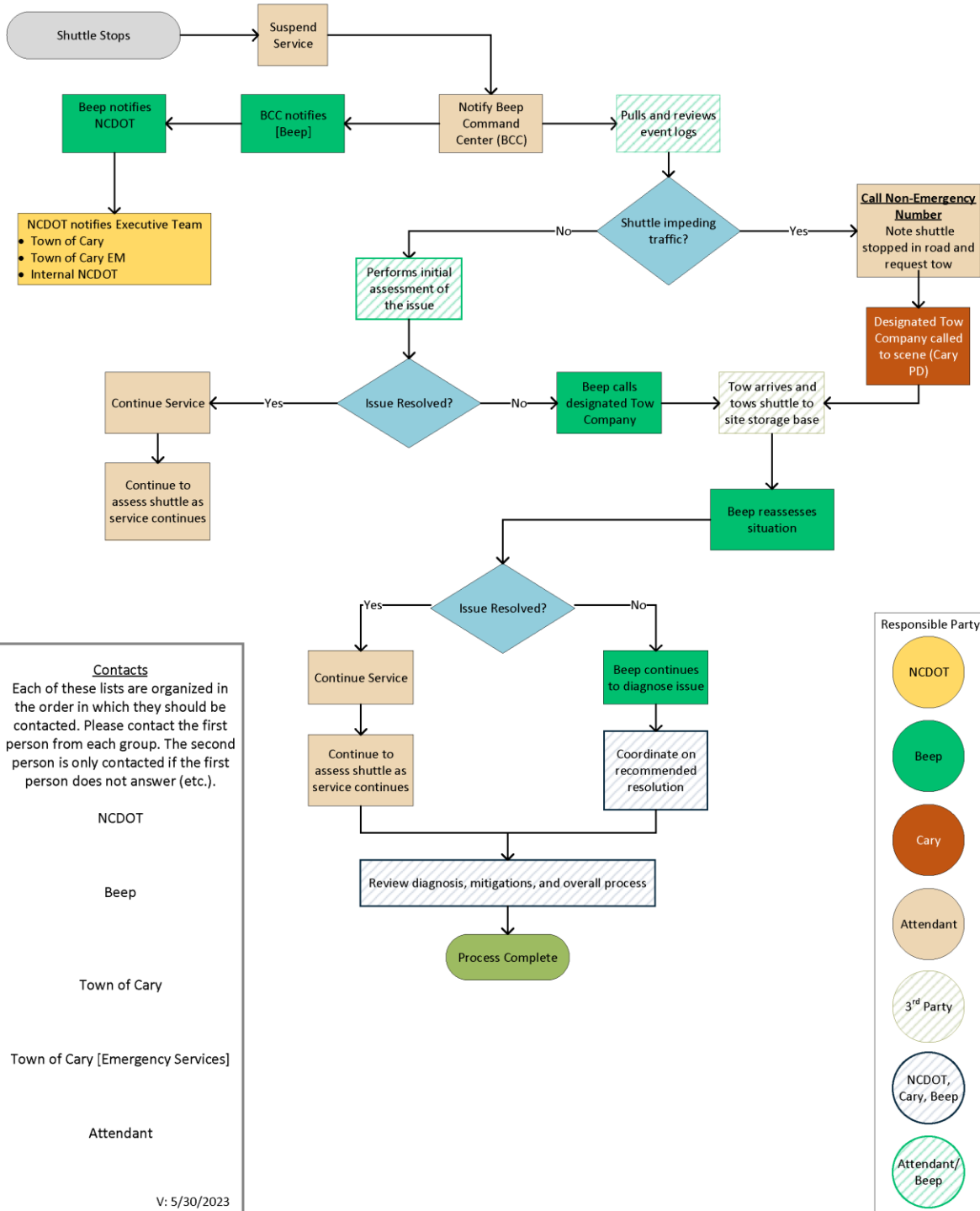
This response plan pertains to any **EMERGENCY** incident whereby the vehicle has struck or been struck by any object, car, or person, or an accident has occurred to jeopardize the safety of a person or inflicted damage to the vehicle.



**If the attendant was to provide assistance, they would be covered by the Good Samaritan Law of NC

NCDOT CASSI (Non-Emergency) Incident Response Plan (per Beep Level 1)

This response plan pertains to any non-emergency incident whereby the vehicle has become immobilized for reasons that do not pertain involvement with another vehicle, pedestrian, or object.



Contacts
Each of these lists are organized in the order in which they should be contacted. Please contact the first person from each group. The second person is only contacted if the first person does not answer (etc.).

- NCDOT
- Beep
- Town of Cary
- Town of Cary [Emergency Services]
- Attendant

V: 5/30/2023

Appendix N. Survey Questions and Response Categories Included in the Rider Survey for the CASSI in Cary's Bond Park Project

Survey Questions	Response Categories
Did you ride the driverless shuttle?	Yes or No
What are your thoughts on driverless shuttles?	Free response
Where did you get on the shuttle?	Senior Center, Sertoma (Kiwanis) Shelter, Boathouse, or Community Center
Where did you get off the shuttle?	Senior Center, Sertoma (Kiwanis) Shelter, Boathouse, or Community Center
Did you visit Bond Park to ride the shuttle?	Yes or No
How did you get to Bond Park?	Walk, Bike, Scooter, Skateboard, Bus or other transit, Carpool, or Personal vehicle
I had a good experience using the shuttle.	1 - Strongly Agree, 2 - Agree, 3 - Neither agree nor disagree, 4 - Disagree, or 5 - Strongly disagree
The shuttle arrived at my stop within a reasonable amount of time.	1 - Strongly Agree, 2 - Agree, 3 - Neither agree nor disagree, 4 - Disagree, or 5 - Strongly disagree
I was able to get to my destination in a reasonable amount of time.	1 - Strongly Agree, 2 - Agree, 3 - Neither agree nor disagree, 4 - Disagree, or 5 - Strongly disagree
I had a good experience with the attendant on the shuttle.	1 - Strongly Agree, 2 - Agree, 3 - Neither agree nor disagree, 4 - Disagree, or 5 - Strongly disagree
I support seeing more driverless shuttles in Cary.	1 - Strongly Agree, 2 - Agree, 3 - Neither agree nor disagree, 4 - Disagree, or 5 - Strongly disagree
Where in Cary would you like to see driverless shuttles?	Free response
BEFORE riding the shuttle, I felt that driverless vehicles are:	1 - Very safe, 2 - Safe, 3 - Neither safe nor unsafe (no opinion), 4 - Unsafe, or 5 - Very unsafe
AFTER riding the shuttle, I feel that driverless vehicles are:	1 - Very safe, 2 - Safe, 3 - Neither safe nor unsafe (no opinion), 4 - Unsafe, or 5 - Very unsafe
If you felt unsafe while riding the shuttle, please tell us why.	Free response

Survey Questions	Response Categories
Did you ride the driverless shuttle for a fun experience or to get to a specific destination?	Fun experience, Specific destination, Both, or Other
Please provide your reason for riding the driverless shuttle.	Free response
If you had not taken the driverless shuttle, which of the following modes of transportation best describes how you would have traveled?	Walk, Bike, Bus or other transit, Carpool, Personal vehicle, Other mode, or Would not have taken the trip
What other mode would you have used to travel?	Free response
Would you ride the shuttle again?	Yes, Maybe, or No
Why or why not?	Free response
Did you use a mobility device during your trip (e.g., wheelchair, cane, crutches, or walker)?	Yes or No
The shuttle comfortably accommodated my mobility device.	Yes or No
What works well in the shuttle to accommodate your mobility device?	Free response
How could the shuttle better accommodate your mobility device?	Free response
Please share any additional feedback about your ride.	Free response
What is your age?	Under 18, 18-29, 30-49, 50-69, or 70 and over
Are you a resident of Cary?	Yes or No
What is the zip code of your residence?	Free response
How did you hear about the driverless shuttle? Select all that apply.	Signs or flyers in Bond Park, Advertisement in the Town of Cary's newsletter, Press release from the Town of Cary or NCDOT, Town of Cary social media or webpage, NCDOT social media or webpage, From a friend or family member, or Other
Created Date	Automatic timestamp when a survey is submitted

Appendix O. Ridership, Operations, and Rider Survey Results for the CASSI in Cary's Bond Park Project

Table 1. CASSI in Cary's Bond Park – Key Characteristics and Summary Statistics.

Category	Fred G. Bond Metro Park
Operator	Beep
Vehicle	Navya Autonom
Pilot Period	March 6-June 2, 2023 (13 weeks)
Number of Shuttles	One shuttle
Operating Days	Five days, Monday-Friday
Hours of Service	10:00 a.m.-4:00 p.m. (with one break)
Planned Hours per Day	6 hours
Number of Unique Routes	One route
Route Miles	1.6 miles
Number of Stops	Four stops
Number of Days in Operation	61
Number of Days with Complete Service	28
Number of Days with Partial Service	33
Number of Days with Complete Suspension of Service	3
Number of Days with No Scheduled Service	1
Scheduled Hours of Operation	384.0
Actual Hours of Operation	331.3
Percentage Uptime	86.3%
Number of Disengagements	179
Average Number of Disengagements per Day	2.9
Percentage Time in Autonomous Mode	98.3%
Average Vehicle Speed	5.4 mph
Maximum Vehicle Speed	11.4 mph
Number of Trips	494
Number of Passengers	1,718
Average Passengers per Trip	3.5
Average Passengers per Vehicle per Day	28.2
Average Trips per Vehicle per Day	8.1
Number of Ramp Deployments	7
Average Number of Ramp Deployments per Day	Less than 1

Table 2. CASSI in Cary's Bond Park – Trips, Ridership, Ramp Deployments, and Wheelchair Securements by Week and Overall.

Weeks Into Pilot	Number of Round Trips Completed	Number of Passengers	Number of Passengers per Round Trip	Number of Ramp Deployments	Number of Wheelchair Securements
1	41	194	4.7	0	0
2	47	152	3.2	1	0
3	28	138	4.9	2	1
4	44	199	4.5	0	0
5	34	205	6.0	0	0
6	42	125	3.0	0	0
7	45	111	2.5	0	0
8	30	70	2.3	0	0
9	38	76	2.0	1	0
10	38	80	2.1	1	2
11	37	125	3.4	2	4
12	32	99	3.1	0	0
13	38	144	3.8	0	0
<i>Across 13-week pilot period</i>	494	1,718	3.5	7	7

Table 3. CASSI in Cary's Bond Park – Scheduled Hours, Hours Operated, Percentage Uptime, and Battery Percentage Used by Week and Overall.

Weeks Into Pilot	Number of Scheduled Hours	Number of Hours Operated	Percentage Uptime	Average of Battery Percentage Used
1	30.0	27.0	90.0	54.0
2	30.0	27.6	92.0	48.4
3	30.0	21.8	72.5	51.8
4	30.0	30.0	100.0	53.8
5	30.0	19.7	65.8	53.0
6	30.0	25.5	84.9	58.4
7	30.0	24.9	83.0	59.0
8	24.0	17.3	72.2	33.8
9	30.0	28.0	93.3	51.0
10	30.0	24.1	80.3	53.2
11	30.0	28.1	93.7	50.0
12	30.0	30.0	100.0	27.6
13	30.0	27.3	90.9	31.4
<i>Across 13-week pilot period</i>	384.0	331.3	86.3	48.3

Table 4. CASSI in Cary's Bond Park – Vehicle Speed at Disengagement, Number of Disengagements, and Number of Disengagements by Type by Week and Overall.

Weeks Into Pilot	Average of Vehicle Speed at Disengagement	Number of Disengagements	Number of Disengagements by Type					
			Signalized Intersection	Signal Loss	Station Blocked	Other Road Users	Fault Code or Error Code	All Other Reasons
1	3.0	12	0	0	8	1	1	2
2	3.6	13	3	0	1	5	0	4
3	2.6	22	21	0	1	0	0	0
4	3.4	7	6	0	0	1	0	0
5	3.0	3	1	0	0	2	0	0
6	3.9	14	9	2	0	3	0	0
7	3.4	17	10	0	0	0	7	0
8	3.0	1	0	0	0	1	0	0
9	N/A	0	0	0	0	0	0	0
10	2.0	24	0	4	4	1	11	4
11	3.9	37	0	21	6	7	0	3
12	3.4	12	0	4	2	2	0	4
13	3.6	17	1	4	4	1	3	4
<i>Across 13-week pilot period</i>	3.3	179	51	35	26	24	22	21

Table 5. CASSI in Cary's Bond Park – Average Vehicle Speed, Maximum Vehicle Speed, Percentage Time in Autonomous Mode, and Percentage Uptime Overall as Reported by Beep.

Across 13-week pilot period per Beep's calculations	
Average Vehicle Speed	5.4 mph
Maximum Vehicle Speed	11.4 mph
Percentage Time in Autonomous Mode	98.3%
Percentage Uptime	86.3%

Table 6. CASSI in Cary's Bond Park – Where did you get on the shuttle?

Where did you get on the shuttle?	Number of Respondents	Percentage of Respondents
Senior Center	57	39%
Sertoma (Kiwanis) Shelter	18	12%
Boathouse	37	26%
Community Center	33	23%
Grand Total	145	100%

Table 7. CASSI in Cary's Bond Park – Where did you get off the shuttle?

Where did you get off the shuttle?	Number of Respondents	Percentage of Respondents
Senior Center	62	43%
Sertoma (Kiwanis) Shelter	23	16%
Boathouse	33	23%
Community Center	27	18%
Grand Total	145	100%

Table 8. CASSI in Cary's Bond Park – Did you visit Bond Park to ride the shuttle?

Did you visit Bond Park to ride the shuttle?	Number of Respondents	Percentage of Respondents
Yes	115	79%
No	30	21%
Grand Total	145	100%

Table 9. CASSI in Cary's Bond Park – How did you get to Bond Park?

How did you get to Bond Park?	Number of Respondents	Percentage of Respondents
Walk	6	4%
Bike	1	1%
Scooter	0	0%
Skateboard	0	0%
Bus or other transit	4	3%
Carpool	24	17%
Personal vehicle	109	76%
Grand Total	144	100%

Table 10. CASSI in Cary's Bond Park – I had a good experience using the shuttle.

I had a good experience using the shuttle.	Number of Respondents	Percentage of Respondents
1 – Strongly agree	95	66%
2 – Agree	39	27%
3 – Neither agree nor disagree	5	3%
4 – Disagree	5	3%
5 – Strongly disagree	1	1%
Grand Total	145	100%

Table 11. CASSI in Cary's Bond Park – The shuttle arrived at my stop within a reasonable amount of time.

The shuttle arrived at my stop within a reasonable amount of time.	Number of Respondents	Percentage of Respondents
1 – Strongly agree	81	56%
2 – Agree	32	22%
3 – Neither agree nor disagree	17	12%
4 – Disagree	9	6%
5 – Strongly disagree	5	3%
Grand Total	144	100%

Table 12. CASSI in Cary's Bond Park – I was able to get to my destination in a reasonable amount of time.

I was able to get to my destination in a reasonable amount of time.	Number of Respondents	Percentage of Respondents
1 – Strongly agree	78	54%
2 – Agree	47	32%
3 – Neither agree nor disagree	16	11%
4 – Disagree	3	2%
5 – Strongly disagree	1	1%
Grand Total	145	100%

Table 13. CASSI in Cary's Bond Park – I had a good experience with the attendant on the shuttle.

I had a good experience with the attendant on the shuttle.	Number of Respondents	Percentage of Respondents
1 – Strongly agree	132	91%
2 – Agree	9	6%
3 – Neither agree nor disagree	4	3%
4 – Disagree	0	0%
5 – Strongly disagree	0	0%
Grand Total	145	100%

Table 14. CASSI in Cary's Bond Park – I support seeing more driverless shuttles in Cary.

I support seeing more driverless shuttles in Cary.	Number of Respondents	Percentage of Respondents
1 – Strongly agree	98	68%
2 – Agree	29	20%
3 – Neither agree nor disagree	14	10%
4 – Disagree	2	1%
5 – Strongly disagree	2	1%
Grand Total	145	100%

Table 15. CASSI in Cary's Bond Park – BEFORE riding the shuttle, I felt that driverless vehicles are:

BEFORE riding the shuttle, I felt that driverless vehicles are:	Number of Respondents	Percentage of Respondents
1 – Very safe	20	14%
2 – Safe	67	46%
3 – Neither safe nor unsafe (no opinion)	43	30%
4 – Unsafe	13	9%
5 – Very unsafe	2	1%
Grand Total	145	100%

Table 16. CASSI in Cary's Bond Park – AFTER riding the shuttle, I feel that driverless vehicles are:

AFTER riding the shuttle, I feel that driverless vehicles are:	Number of Respondents	Percentage of Respondents
1 – Very safe	50	34%
2 – Safe	66	46%
3 – Neither safe nor unsafe (no opinion)	22	15%
4 – Unsafe	5	3%
5 – Very unsafe	2	1%
Grand Total	145	100%

Table 17. CASSI in Cary's Bond Park – Did you ride the driverless shuttle for a fun experience or to get to a specific destination?

Did you ride the driverless shuttle for a fun experience or to get to a specific destination?	Number of Respondents	Percentage of Respondents
Fun experience	127	88%
Specific destination	1	1%
Both	12	8%
Other	4	3%
Grand Total	144	100%

Table 18. CASSI in Cary's Bond Park – If you had not taken the driverless shuttle, which of the following modes of transportation best describes how you would have traveled?

If you had not taken the driverless shuttle, which of the following modes of transportation best describes how you would have traveled?	Number of Respondents	Percentage of Respondents
Walk	49	35%
Bike	3	2%
Bus or other transit	2	1%
Carpool	1	1%
Personal vehicle	57	41%
Other mode	0	0%
Would not have taken the trip	27	19%
Grand Total	139	100%

Table 19. CASSI in Cary's Bond Park – Would you ride the shuttle again?

Would you ride the shuttle again?	Number of Respondents	Percentage of Respondents
Yes	118	81%
Maybe	20	14%
No	7	5%
Grand Total	145	100%

Table 20. CASSI in Cary's Bond Park – Did you use a mobility device during your trip (e.g., wheelchair, cane, crutches, or walker)?

Did you use a mobility device during your trip (e.g., wheelchair, cane, crutches, or walker)?	Number of Respondents	Percentage of Respondents
Yes	0	0%
No	144	100%
Grand Total	144	100%

Table 21. CASSI in Cary's Bond Park – What is your age?

What is your age?	Number of Respondents	Percentage of Respondents
Under 18	10	7%
18-29	18	12%
30-49	53	37%
50-69	46	32%
70 and over	18	12%
Grand Total	145	100%

Table 22. CASSI in Cary's Bond Park – Are you a resident of Cary?

Are you a resident of Cary?	Number of Respondents	Percentage of Respondents
Yes	70	49%
No	73	51%
Grand Total	143	100%

Table 23. CASSI in Cary's Bond Park – What is the zip code of your residence?

What is the zip code of your residence?	Number of Respondents	Percentage of Respondents
14450	2	2%
20190	1	1%
27217	1	1%
27278	1	1%
27312	1	1%
27407	1	1%
27408	1	1%
27502	8	6%
27511	14	11%
27513	27	21%
27514	2	2%
27516	1	1%
27518	4	3%
27519	10	8%
27520	1	1%
27523	6	5%
27526	2	2%
27529	2	2%
27539	2	2%
27540	3	2%
27559	1	1%
27560	6	5%
27565	1	1%

What is the zip code of your residence?	Number of Respondents	Percentage of Respondents
27583	1	1%
27603	1	1%
27604	2	2%
27606	5	4%
27607	1	1%
27608	1	1%
27612	3	2%
27613	1	1%
27615	1	1%
27616	1	1%
27701	1	1%
27703	2	2%
27704	1	1%
27705	2	2%
27707	1	1%
54650	1	1%
60201	2	2%
80701	1	1%
Grand Total	126	100%

Table 24. CASSI in Cary's Bond Park - Where in Cary would you like to see driverless shuttles?

Where in Cary would you like to see driverless shuttles?	Number of Respondents
Yes	1
Academy Street	1
Academy Street, library parking garage to restaurants on Chatham Street	1
All parks and neighborhood	1
Any of the small roads	1
Anywhere they're feasible	1
Around downtown Cary, and the Crossroads shopping area	1
Around the perimeter of and throughout Cary	1
Bond Park	2
Bond Park to downtown Cary	1
Bond Park, downtown Cary	1
Bond Park, downtown Cary (art center, library, City Hall, and Herbert Young Center)	1
Cary Parkway and Maynard Road	1
Connecting parks and libraries	1
Crossroads	1
Crossroads area or Fenton	1

Where in Cary would you like to see driverless shuttles?	Number of Respondents
Definitely in the more congested areas, and from parking lots to those areas, including downtown	1
Downtown	17
Downtown and Fenton	1
Downtown brewery tour	1
Downtown Cary	9
Downtown Cary!	1
Downtown Cary, Regency area	1
Downtown could work well.	1
Downtown near the park	1
Downtown park to parking	1
Downtown restaurant/park/library area	1
Downtown restaurants, art center, train station, park	1
Downtown to making parking easier to access	1
Downtown, west Cary, Thomas Brooks Park	1
Everywhere	2
Everywhere we can afford them.	1
Everywhere, downtown	1
Fenton	1
Fenton Park	1
Fenton Park or Park West	1
From Bond Park to downtown Cary! Wonderful experience.	1
From outside of downtown to downtown	1
Hurry and the movie theater. Probably in downtown Cary, starting at the library and going around city center.	1
I would like them to replace the bus system eventually.	1
I would test from library to community center (include town hall, etc.), staying exclusively on Academy Street plus additional roads for turn around.	1
In parks, downtown, for festivals	1
Koka Booth	1
Lazy Daze transport	1
N/A	1
Not sure because I'm not from here.	1
Nowhere until a level 5 of autonomy is in place.	1
Nowhere. They are in no way better than a shuttle with a driver.	1
Oh my lord, everywhere. Downtown would be really cool, going up and down Academy Street. Very good for Chatham Street, too. There aren't a lot of shopping malls anymore but a driverless shuttle would be very useful for getting people around without having to drive everywhere. Cars suck. Buses are good.	1

Where in Cary would you like to see driverless shuttles?	Number of Respondents
Other parks in Cary, Koka Booth, a route to the hospitals and wellness centers, and grocery stores, pharmacy, a loop through downtown that includes the library and government center	1
Page Walker Hotel	1
Park	1
Parks, schools, large shopping centers	1
S Cary Parkway	1
State park, recreational area	1
The current test route is good, but I am unfamiliar with the Town of Cary so I can't offer any other locations.	1
To and from Apex, between Brooks and Bond Park	1
To downtown	1
Transportation to Senior Center; to/from holiday events. Eventually I'd like to see them throughout Cary and regular buses to take us to Raleigh, Durham, and Chapel Hill.	1
Where it's safe	1
Grand Total	86

Table 25. CASSI in Cary's Bond Park – If you felt unsafe while riding the shuttle, please tell us why.

If you felt unsafe while riding the shuttle, please tell us why.	Number of Respondents
Attendant stopped at every stop.	1
Hard stopping and jerking.	1
Hard stops and seatbelts.	1
Hard stops.	1
I didn't feel unsafe, but it does brake really hard for objects not moving (tree branch).	1
I felt safe because of the attendant.	1
It was a bit too close to cars when going through the parking lot.	1
It's safe only because there's an attendant.	1
Jerky ride, seats didn't have neck/head support.	1
N/A	3
Poor brake lights and turn signals. One larger red light was constantly on bright, as a running light, but looked like the shuttle was constantly braking, confusing drivers following the shuttle.	1
Seat belts and toooooo much jerking.	1
Seating WAY too close together, even without pandemic, especially with pandemic! No one except one person wore a mask!	1
Stopped at green light.	1
Strap seatbelts, abruptly stopping, possible whiplash. A sign for emergency exiting, liability issue. Someone needs to read something upon departure.	1

If you felt unsafe while riding the shuttle, please tell us why.	Number of Respondents
The attendant needed to correct the path several times.	1
The attendant was needed for correcting the vehicle at the stop light and the Senior Center.	1
The jerky starts and stops made it seem like it might be easy to fall if standing too soon. My dog slid around and hated it.	1
The shuttle did NOT make me feel unsafe. Since it was a beta-vehicle and following a programmed route with stops and did not use sensors to find stops and align, it did not alter my opinion one way or the other. I did not consider this an objective/final design of an autonomous vehicle.	1
The shuttle passed uncomfortably close to a cyclist that was riding on the wrong side of the road through a parking lot. The cyclist turned off the road and had to partially dismount. A real driver would've assessed the cyclist to be a dingdong behaving in a dingdong manner and taken extra caution near them.	1
There are times that it stops that seemed dangerous to me. It didn't seem to react to the traffic light.	1
Grand Total	23

Table 26. CASSI in Cary's Bond Park – Please provide your reason for riding the driverless shuttle.

Please provide your reason for riding the driverless shuttle.	Number of Respondents
Information and data point. Since the shuttle was a demonstrator, stopping was rather unrefined. I accepted that but it was unclear if that was software driven or mechanical/hardware response.	1
Learning about AVs.	1
Professional developmental.	1
Wanted to have my son (with autism) experience and familiarize with the driverless vehicle.	1
Grand Total	4

Table 27. CASSI in Cary's Bond Park – Would you ride the shuttle again? Why or why not?

Would you ride the shuttle again? Why or why not?	Number of Respondents
A fantastic experience. Learned a lot, easy, exciting, innovative. Fantastic attendant that taught us a lot as well.	1
A fun ride for the kids and adults.	1
Because I don't think I would learn any more from this "developmental model." I would ride again if you provided the next generation version.	1
Because it is very fun.	1
Because we liked it.	1
Confusing directions and slow/clearly still in beta.	1
Convenient.	1

Would you ride the shuttle again? Why or why not?	Number of Respondents
Exciting technology.	1
Fun activity.	1
Fun experience.	2
Fun, safe, and convenient.	1
Fun.	1
Fun. Faster travel.	1
Good mode of travel.	1
Great experience for seniors getting to the Boathouse without driving.	1
Great experience, unique technology.	1
Great ride.	1
Great way to get around Bond Park!! We need more public transportation in our area!	1
I didn't like the ride. I have back problems and that didn't help.	1
I love it. It's an excellent idea.	1
I support well done public transit opportunities.	1
I want to support the adoption of this world changing technology.	1
I was hoping it would go to much busier streets.	1
I will if it goes somewhere I want to go. But I may take another trial run.	1
I will not ride it again at Bond Park because it won't help me get to my destination much faster than walking. I would ride it another time if it was in another location.	1
I would like to share the experience with my family.	1
I would probably ride it for fun again.	1
If I was tired.	1
If it is to get somewhere.	1
I'll try again when it's going to be 100% driverless.	1
I'll wait for a very slow day for much less riders.	1
It felt safe and fun.	1
It is a novel experience and I like to support new things.	1
It was a fun and relaxing ride!	1
It was a nice experience, quiet.	1
It was a very nice experience and will also help the environment.	1
It was cool.	1
It was fun and cutting edge.	1
It was fun and different.	1
It was fun.	4
It was neat to see the state of this technology.	1
It was safe, fun, and quiet.	1
It was something unique to do.	1

Would you ride the shuttle again? Why or why not?	Number of Respondents
It will be helpful to get from the Senior Center down to the Boathouse. Conveniently without worrying about limited parking.	1
It's interesting to see how the technology evolves.	1
It's new and fun.	1
It's a slightly faster way to get from point a to point b, and it is slightly safer than walking along a road with no sidewalks.	1
It's boring.	1
It's fun and helpful for people who need a ride.	1
It's hope for the future.	1
Just for the fun of it.	1
Nice experience.	1
Nice way to acclimate new visitors to the park especially buildings.	1
No schedule. Thought the shuttle would pick us up at the playground after it went to the lane but it drove right by.	1
Not on time.	1
Not sold that it's safe.	1
Our children loved it and it's fun to be part of something new.	1
Quick, easy, no grill, convenient, clean.	1
Safe, convenient, comfortable mode of travel.	1
Safe.	1
So slow.	1
The idea of a new mode/vehicle for public transit excites me.	1
This shuttle is far from being ready for prime time but I see its potential, so yes, I would ride it again in hopes of seeing improvements.	1
This would be a great way to get around downtown areas that have limited parking.	1
To get from the Senior Center to the Boathouse.	1
To see how it would cope with the many crosswalks on the shuttle route and to determine its following distance when following a slower vehicle.	1
Too busy!	1
Tourist.	1
Unless there was something new, it's been done.	1
Usually I bike or walk around the park, but I can see the driverless shuttle being a good mode of transportation if I would like to get from one end of the Lake Trail (Boathouse) to the GoCary bus stop at the Senior Center.	1
Very intriguing and fun. Low stakes made it feel very safe also.	1
Was cool to see the technology.	1
We actually came to Bond Park multiple days specifically to ride the shuttle. It was such a fun thing for me and my family to do together.	1
With improvements.	1
Yes, to get to places without using gas or having to preplan parking.	1

Would you ride the shuttle again? Why or why not?	Number of Respondents
Grand Total	79

Table 28. CASSI in Cary's Bond Park – Please share any additional feedback about your ride.

Please share any additional feedback about your ride.	Number of Respondents
Although it is a cool concept, I don't know if it is a need for the Town to provide. I never see people on the GoCary transit buses, so I don't understand the need for any public transportation. I like having this but it shouldn't be covered by the taxpayers. It should be covered by the riders. This will show the demand for its need.	1
As a Tesla FSD beta tester, the software needs to improve as it could not go around a person running alongside the road.	1
Attendant was very knowledgeable and welcoming.	1
Cool experience, the attendant let us know that we would stop a couple times because of loss of signal and he was right but he quickly acknowledged the signal loss on his screen and we kept on going with the ride.	1
Experience for wheelchair users needs to be improved. Platform and ad hoc ramp are inadequate. Ramp should deploy from the vehicle to the ground/sidewalk.	1
Great idea for the handicapped! You need to plan more room for wheelchairs and walkers, but this would be useful in a large park or hospital with multiple parking areas.	1
Great job 🍌	1
It was enjoyable.	1
It was great to have the vehicle communicate with the traffic lights.	1
It would be great. Wonderful idea but liability should be thought of in the sense of passengers boarding. Maybe signing a waiver.	1
Just have a shuttle with a bus driver. It's safer, it provides jobs, it's less expensive.	1
Like I mentioned before, this vehicle is not ready for prime time. The attendant didn't provide any information or set any kind of expectations of the ride nor explained what he was doing and why. He practically drove the vehicle giving the impression (probably the case) that the vehicle is not ready to drive itself. The sudden and "jerky" stops certainly don't provide much confidence either. Basic things like obstacles in the parking areas had to be manually mitigated when these are the kind of basic things LiDAR-based self-autonomous vehicles can do, especially on a predetermined route. There are also possible safety issues with the door mechanisms that are too close to passengers sitting on the corners.	1
Make seatbelts optional. You need to turn on the app that shows the live location of the vehicle. There should be a scheduled time of arrival at each stop. There should be an exact duration of waiting at each stop.	1

Please share any additional feedback about your ride.	Number of Respondents
Maybe liability notice in case of injury.	1
Our attendants were wonderfully kind and told us a lot.	1
Please fix the EV chargers at the Boathouse. Bad message that they are out of order for months. :-)	1
Please keep it in our town.	1
Please keep safety including health safety 1st!	1
Put these in context appropriate places ASAP, not just Cary!	1
Really enjoyed it.	1
Seats were too narrow for unrelated passengers to be comfortable. Seatbelts should be color coded to match individual seats.	1
Shuttle opened doors far from ramp. I don't see how a wheelchair could use this.	1
Stops are a little jerky — could be smoother.	1
Stops are very jerky. I understand the need to be able to stop suddenly but hope the brakes can be applied more gently in non-emergency situations.	1
The attendant was very helpful!	1
The driver attendant was very well-versed and very well mannered.	1
The ride is very safe, it stopped at all stop signs, slowed down for standing vehicles. The ride attendant was very nice, had excellent knowledge, greeted us and was very helpful throughout the ride. Will ride again!!	1
The signal drops and jerkiness of the stops at these drops were painful and abrupt.	1
The stops were rather jerky.	1
There were no mobility handicapped persons on our trip. They would have required the attendant to secure them. It was not autonomous.	1
This was such a fun experience! We came to Bond Park multiple days specifically to ride the shuttle. It is great also because there are so many windows, and it was fun for all of us to look outside at the spring flowers and people playing in Bond Park while we were enjoying our ride. I would love to see something like this in downtown Cary as well — I think it would be a great addition!	1
Vehicle requires a good deal of human intervention.	1
Very scenic.	1
Wonderful experience.	1
Wonderful experience. Please do more programs like this in the future!	1
Grand Total	35