



# Connected Autonomous Shuttle Supporting Innovation (CASSI) at UNC Charlotte

## Data Documentation Report

July 2024



# Introduction

The North Carolina Department of Transportation (NCDOT) partnered with the University of North Carolina at Charlotte (UNC Charlotte) and Beep, Inc. (Beep) to bring a novel-design, all-electric, low-speed automated shuttle to UNC Charlotte's campus for a 23-week pilot through the Connected Autonomous Shuttle Supporting Innovation (CASSI) program. Beep operated a Navya Autonom shuttle on a 2.2-mile, six-stop route that connected the main campus LYNX Blue Line light rail station; Greek Village; dormitories, parking, and academic buildings; and the student union. The shuttle was free and open to the public on weekdays from 8:30 to 11:30 a.m. and 1:30 to 4:30 p.m. during the pilot period (July 12 through December 21, 2023). The shuttle was not in service from 11:30 a.m. to 1:30 p.m. due to scheduled midday charging. The pilot provided a first and last mile option in a fixed-route, circulator service. The shuttle shared its route and stops with existing Niner Transit bus services, including the Green, Silver, Gold, Red, and Greek Village routes. The automated shuttle supplemented the conventional shuttles already operating on the Greek Village route. UNC Charlotte also provides scooter share and bikeshare with supporting infrastructure such as shared use paths, bike lanes, and sidewalks alongside their Niner Transit bus, shuttle, and paratransit services, so faculty, staff, students, and visitors have multiple transportation options to reach their destinations on campus.

NCDOT and UNC Charlotte 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 UNC Charlotte through an online survey
- Feedback from community members with disabilities and their caregivers, staff from UNC Charlotte's Office of Disability Services, and paratransit professionals from the Charlotte Area Transit System (CATS) captured by NCDOT and UNC Charlotte through two engagement events and exit surveys

This document describes the data collection, quality control, and cleaning for the ridership and operations data provided by Beep and the rider survey data collected by NCDOT and UNC Charlotte that are shared in Cary's Open Data Portal.<sup>1</sup>

## Ridership and Operations Data

### Overview

Beep provided weekly data reports to NCDOT and UNC Charlotte that included ridership and operations data manually captured by the attendant or obtained from the shuttle's

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<sup>1</sup> Cary, NC. (2024, July 12). Cary, NC Open Data Portal. <https://data.townofcary.org/pages/homepage/>

computer system. NCDOT and UNC Charlotte compiled Beep's reports for the 23-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.

## Quality Control and Cleaning

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

NCDOT 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

NCDOT modeled their approach for reviewing the data reports, creating new data fields, cleaning the data, and sharing the data on Cary's Open Data Portal from the approach developed in partnership with Cary for the CASSI in Cary's Bond Park project.<sup>2</sup>

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 in Table 1.

## Rider Survey

### Overview

NCDOT created and implemented an online rider survey using Smartsheet. The survey questions were informed by surveys from prior projects under the Connected Autonomous Shuttle Supporting Innovation (CASSI) program and were updated to reflect the context of the pilot at UNC Charlotte. The survey was accessible through URL and Quick Response

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<sup>2</sup> NCDOT. (2023, October). CASSI in Cary's Bond Park – Final Report. <https://www.ncdot.gov/divisions/integrated-mobility/innovation/cassi/Documents/cassi-ncdot-cary-final-report.pdf>

(QR) codes at the shuttle stops and inside the shuttle during the pilot period. The survey asked riders about their travel patterns and trip purpose, experience with the shuttle and attendant, and their basic demographics. 62 responses were collected in total. 59 respondents rode the shuttle, and three respondents did not ride the shuttle. The survey questions and response categories are provided in Table 2.

## **Quality Control and Cleaning**

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 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 in Table 3.

Table 1. CASSI at UNC Charlotte – Data Cleaning Log for Ridership and Operations Data.

Dataset Name	Original	Processed	Cleaning Action
CASSI at UNC Charlotte Disengagement	Row 1	Removed	Removed row with Beep, Inc. logo
CASSI at UNC Charlotte Disengagement	Column "Name"	Removed	Removed column to protect Beep, Inc. employee(s)
CASSI at UNC Charlotte Disengagement	Column "Non-Preventable Downtime"	Removed	Removed column to keep data schema consistent with previous reporting
CASSI at UNC Charlotte Disengagement	Column "Preventable Downtime"	Removed	Removed column to keep data schema consistent with previous reporting
CASSI at UNC Charlotte Disengagement	"Signalized Intersection "	Signalized Intersection	Removed double quotes and whitespace on label
CASSI at UNC Charlotte Disengagement	Deviation from Path	Shuttle Manually Deviated from Approved Path	Renamed column to be consistent with Beep, Inc.'s "Cause" column data and naming conventions used in the original dataset
CASSI at UNC Charlotte Disengagement	10:21 AM	10:21:00 AM	Changed to time consistent with reported incident time
CASSI at UNC Charlotte Disengagement	10:16:00 PM	10:16:00 AM	Changed to time consistent with hours operated
CASSI at UNC Charlotte Disengagement	1:50:00 PM	2:35:00 PM	Changed to time consistent with reported incident time
CASSI at UNC Charlotte Disengagement	10:39:00 PM	10:39:00 AM	Changed to time consistent with hours operated
CASSI at UNC Charlotte Disengagement	"(<float>,<float>)"	"<float>, <float>" format	Changed to "<float>, <float>" format for upload into Open Data Software Platform
CASSI at UNC Charlotte Disengagement	"<float>,<float>" format	"<float>, <float>" format	Changed to "<float>, <float>" format for upload into Open Data Software Platform
CASSI at UNC Charlotte Disengagement	"<float> ,<float>" format	"<float>, <float>" format	Changed to "<float>, <float>" format for upload into Open Data Software Platform
CASSI at UNC Charlotte Disengagement	Fault Code/Error Code	Signalized Intersection	Changed to category based on corroborating information from other data fields or RSU/OBU reporting
CASSI at UNC Charlotte Disengagement	Signal Loss	Signalized Intersection	Changed to category based on corroborating information from other data fields or RSU/OBU reporting

Dataset Name	Original	Processed	Cleaning Action
CASSI at UNC Charlotte Disengagement	Column "Signal Loss" values	Added period to end of descriptions	Added period to the end of the existing description to standardize
CASSI at UNC Charlotte Disengagement	Column "Fault/Error Code" values	Added period to end of descriptions	Added period to the end of the existing description to standardize
CASSI at UNC Charlotte Disengagement	Column "Signalized Intersection" values	Added period to end of descriptions	Added period to the end of the existing description to standardize
CASSI at UNC Charlotte Disengagement	Column "Priority Zone" values	Added period to end of descriptions	Added period to the end of the existing description to standardize
CASSI at UNC Charlotte Disengagement	Column "Other Road Users" values	Copy edited descriptions	Copy edited the existing description to standardize
CASSI at UNC Charlotte Disengagement	Shuttle stopped due to trees in the way	Trees in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle stopped due to vegetation	Vegetation in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle stopped, so I had to take over manual due to vegetation	Vegetation in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle stopped due to vegetation	Vegetation in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Tree is blocking the shuttles path	Trees in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle came to a complete in the middle of traffic bc of trees	Trees in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Vehicle was in my path	Vehicle in priority zone	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Trash can	Trash can in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Trash can	Trash can in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Maintenance crew vehicle	Maintenance crew in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Maintenance crew	Maintenance crew in path	Standardized the "Additional Information" column



Dataset Name	Original	Processed	Cleaning Action
CASSI at UNC Charlotte Disengagement	Shuttle didn't go through light in auto	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	UNCC maintenance crew blocking my path	Maintenance crew in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	UNCC maintenance crew	Maintenance crew in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	UNCC maintenance crew blocking path	Maintenance crew in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	UNCC maintenance crew	Maintenance crew in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	UNCC maintenance crew	Maintenance crew in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle didn't go through in auto	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle did not proceed through light in auto.	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	UNCC maintenance crew	Maintenance crew in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU sends meaaages but they are corrupted	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	UNCC maintenance crew blocking path. Had to maneuver around.	Maintenance crew in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle loss GNSS caused severe breaking.	Signal loss	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues	RSU/OBU issue	Standardized the "Additional Information" column

Dataset Name	Original	Processed	Cleaning Action
CASSI at UNC Charlotte Disengagement	RSU Issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	UNCC maintenance truck blocking path	Maintenance crew in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU Issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues at all intersection	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU Issues at all intersections	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU ISSUES	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	RSU issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle stopped in auto mid route. Low GNSS	Signal loss	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle loss signal mid route	Signal loss	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Road users blocking path	Road users in path	Standardized the "Additional Information" column



Dataset Name	Original	Processed	Cleaning Action
CASSI at UNC Charlotte Disengagement	V2X issues. Did an OBU reset	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Loss signal had to take over manual to next station.	Signal loss	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Road users In priority zone	Road users in priority zone	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Low hit ratio/ missing Gnss. Took over manual to next station.	Signal loss	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle didn't go in auto after light changed from red to green.	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle didn't proceed in auto.	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Car was parked on the side of the road preventing the shuttle to go in autonomous	Parked vehicle too close to path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle stopped at green light.	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	After UI reset shuttle didn't go in auto through lighted intersection. Have to do an OBU reset after a UI reset.	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Car is parked too far out. Interfering with shuttles path	Parked vehicle too close to path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	OBU reset	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle stopped at traffic light	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle won't go through light due to V2X issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle stopped at Student Union due V2X issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle was moving through the light	Signal loss	Standardized the "Additional Information" column

Dataset Name	Original	Processed	Cleaning Action
CASSI at UNC Charlotte Disengagement	GNSS corrections	Signal loss	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Sure will not proceed through the traffic due to V2X	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle would not go through light due to V2X	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Localization	Signal loss	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle wont go through light due to V2X issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle stopped at traffic light due to V2X	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle wont go through light due to V2X issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle did not go through path due to V2X issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	The shuttle came to a stop at traffic light due to V2X	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle won't go through light autonomously due to V2X issues	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle stopped at light due to V2X	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Could not proceed through the light	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	UNCC Maintenance in shuttles path	Maintenance crew in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle didn't go in auto at lighted intersection	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle didn't go in auto	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Big F150 truck blocking path	Vehicle in path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle stopped at light	Signal loss	Standardized the "Additional Information" column

Dataset Name	Original	Processed	Cleaning Action
CASSI at UNC Charlotte Disengagement	Lost signal at traffic light	Signal loss	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Lost GNSS	Signal loss	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Food robots were in the priority zone	Delivery robots in priority zone	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Bus was behind me in the bike lane, which caused the shuttle to not turn into station	Bus was following behind the shuttle in the bike lane preventing the shuttle from pulling into stop	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Students parking car on the road which is blocking the shuttles path.	Parked vehicle too close to path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Weather prevented autonomous operations.	Inclement weather	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle isn't going through lighted intersection	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Hard Stop	Hard stop	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Graduation commencement is going on	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Commencement going on. Traffic lights have been altered	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Commencement graduation	RSU/OBU issue	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	Shuttle deviated from path	Shuttle deviated from path	Standardized the "Additional Information" column
CASSI at UNC Charlotte Disengagement	m/d/yyyy h:m:ss "AM/PM" format	mm/dd/yyyy format	Removed incorrect times and standardized dates to "mm/dd/yyyy" format
CASSI at UNC Charlotte Disengagement	Not Present	Column "Incident Datetime"	Created ISO 8601 Timezone-aware column by combining Incident Date and Incident Time
CASSI at UNC Charlotte Disengagement	Not Present	Column "Week of Year"	Created integer value to represent the Week of the Year

Dataset Name	Original	Processed	Cleaning Action
CASSI at UNC Charlotte Disengagement	Not Present	Column "Number of Weeks Into Pilot"	Created integer value to represent the Number of Weeks Into Pilot by subtracting 27 from the "Week of Year" column
CASSI at UNC Charlotte Disengagement	Sorted by "Incident Date" column	Sorted by "Incident Datetime" column	Sorted dataset by the "Incident Datetime" column in ascending order
CASSI at UNC Charlotte Usage	"N/A"	Removed	Removed "N/A" values to keep data types consistent within columns
CASSI at UNC Charlotte Usage	"m/d/yyyy" format	"yyyy-mm-dd" format	Changed data format in "Date" column
CASSI at UNC Charlotte Usage	"H:mm:ss AM/PM" format	<float> format	Converted the time (hours:minutes:seconds AM/PM) format to a float featuring the number of hours (hour/percentage of an hour) in "Scheduled Hrs" and "# Hours Operated" columns
CASSI at UNC Charlotte Usage	<int> format	<float> format	Replaced integers with floats using a number calculated with values from the process listed above ( $[\# \text{ Hours Operated}] * [\text{Scheduled Hrs}] / 100$ ) in "% Uptime" column
CASSI at UNC Charlotte Usage	Not Present	Column "Battery Percentage Used"	Created value by subtracting the Ending Battery % from the Starting Battery % for each row in "Battery Percentage Used" column
CASSI at UNC Charlotte Usage	# of Trips Operated	Number of Trips Operated	Changed column name
CASSI at UNC Charlotte Usage	# Of Passengers	Number of Passengers	Changed column name
CASSI at UNC Charlotte Usage	Ramp Deployment	Number of Ramp Deployments	Changed column name
CASSI at UNC Charlotte Usage	Wheelchair Securement	Number of Wheelchair Securements	Changed column name
CASSI at UNC Charlotte Usage	Scheduled Hrs	Number of Scheduled Hours	Changed column name
CASSI at UNC Charlotte Usage	# Hours Operated	Number of Hours Operated	Changed column name
CASSI at UNC Charlotte Usage	Uptime %	Uptime Percentage	Changed column name
CASSI at UNC Charlotte Usage	Starting Battery %	Starting Battery Percentage	Changed column name
CASSI at UNC Charlotte Usage	Ending Battery %	Ending Battery Percentage	Changed column name
CASSI at UNC Charlotte Usage	Max Speed (MPH)	Maximum Vehicle Speed	Changed column name
CASSI at UNC Charlotte Usage	Avg Speed (MPH)	Average Vehicle Speed	Changed column name

Dataset Name	Original	Processed	Cleaning Action
CASSI at UNC Charlotte Usage	Autonomous %	Autonomous Mode Percentage	Changed column name
CASSI at UNC Charlotte Usage	Outlet replacement required/ vehicle did not charge after previous shift	Vehicle did not charge after previous shift due to broken outlet	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Weather Interruption	Inclement weather	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Weather Interruption	Inclement weather	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Weather Interruption	Inclement weather	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Weather Interruption	Inclement weather	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting; weather interruption	GNSS signal loss & troubleshooting; inclement weather	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Labor Day	No service due to Labor Day holiday	Standardized the "Suspension of Service Details" column

Dataset Name	Original	Processed	Cleaning Action
CASSI at UNC Charlotte Usage	GNSS Signal Loss (37 minutes) and Insufficient Battery (19 minutes)	GNSS signal loss & troubleshooting; insufficient battery	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS Signal loss	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Navya was connected to vehicle at the start of shift	Navya was connected to vehicle at the start of shift	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Navya was connected to vehicle at the start of shift; GNSS Signal loss	Navya was connected to vehicle at the start of shift; GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Charger was not working, UNCC maintenance had to assist with repair	Charger not working	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Motor bracket needs repair, shuttle grounded	Motor bracket needs repair	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Motor bracket needs repair, shuttle grounded	Motor bracket needs repair	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Motor bracket repaired mid day by Beep maintenance	Motor bracket repaired by midday	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Weather Interruption	Inclement weather	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Weather Interruption	Inclement weather	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	No service after 2 PM for home football game	No service after 2 PM due to home football game	Standardized the "Suspension of Service Details" column



Dataset Name	Original	Processed	Cleaning Action
CASSI at UNC Charlotte Usage	Maintenance was finishing installing equipment for environmental data collection over charge break that ran over.	Time needed to install equipment on vehicle for environmental data collection exceeded the charging break	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Weather Interruption	Inclement weather	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Attendant had to upload footage from incident the previous night	Attendant required to upload footage from incident that occurred overnight	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Weather Interruption	Inclement weather	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Attendant had to leave after not feeling well.	Attendant unable to complete shift due to illness	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Campus closed for Thanksgiving	No service due to Thanksgiving holiday	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Campus closed for Thanksgiving	No service due to Thanksgiving holiday	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Weather Interruption	Inclement weather	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	GNSS signal loss/troubleshooting	GNSS signal loss & troubleshooting	Standardized the "Suspension of Service Details" column
CASSI at UNC Charlotte Usage	Not Present	Column "Day of Week"	Created text value to represent the Day of Week
CASSI at UNC Charlotte Usage	Not Present	Column "Day of Week as Number"	Created integer value to represent the Day of Week
CASSI at UNC Charlotte Usage	Not Present	Column "Week of Year"	Created integer value to represent the Week of Year
CASSI at UNC Charlotte Usage	Not Present	Column "Number of Weeks Into Pilot"	Created integer value to represent the Number of Weeks Into Pilot by subtracting 27 from the "Week of Year" column

Dataset Name	Original	Processed	Cleaning Action
CASSI at UNC Charlotte Usage	Not Present	Column "Number of Passengers per Hour Operated"	Created float value by dividing the Number of Passengers by the Number of Hours Operated for each row, rounding the result to the hundredths place
CASSI at UNC Charlotte Usage	Not Present	Column "Number of Passengers per Round Trip"	Created float value by dividing the Number of Passengers by the Number of Round Trips Completed for each row, rounding the result to the hundredths place
CASSI at UNC Charlotte Usage	Not Present	Column "Number of Round Trips per Hour Operated"	Created float value by dividing the Number of Round Trips Completed by the Number of Hours Operated for each row, rounding the result to the hundredths place

Table 2. CASSI at UNC Charlotte – Survey Questions and Response Categories Included in the Rider Survey.

Survey Questions	Response Categories
Did you ride the driverless shuttle?	Yes or No
What are your thoughts on driverless shuttles?	Free response
How many times have you taken the driverless shuttle in the past?	0 times, 1-2 times, 3-5 times, 5-10 times, More than 10 times, or Daily
Where did you get on the shuttle?	Student Union West, Student Union Deck, Light Rail East, Greek Village #1, Greek Village #8, or Science Building
Where did you get off the shuttle?	Student Union West, Student Union Deck, Light Rail East, Greek Village #1, Greek Village #8, or Science Building
Did you visit UNC Charlotte to ride the shuttle?	Yes or No
How did you get to UNC Charlotte?	Walk, Bike, Scooter, Skateboard, Bus, Light rail, 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 prefer a driverless shuttle with an attendant.	1 – Strongly Agree, 2 – Agree, 3 – Neither agree nor disagree, 4 – Disagree, or 5 – Strongly disagree
I support seeing more driverless shuttles on UNC Charlotte's campus.	1 – Strongly Agree, 2 – Agree, 3 – Neither agree nor disagree, 4 – Disagree, or 5 – Strongly disagree
Where on campus 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

Survey Questions	Response Categories
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
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
What is your gender?	Female, Male, Nonbinary, Other, or Prefer not to say
What is your race or ethnicity?	White, Hispanic or Latino, Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, or Prefer not to say

Survey Questions	Response Categories
What is your highest level of education?	Less than 9th grade, 9th to 12th grade (no diploma), High school graduate or equivalency, Some college (no degree), Associate degree, Bachelor's degree, Master's degree, Professional degree, Doctorate degree, or Prefer not to say
What is your annual household income?	Less than \$15,000, \$15,000-\$24,999, \$25,000-\$34,999, \$35,000-\$49,999, \$50,000-\$74,999, \$75,000-\$99,999, \$100,000-\$149,999, \$150,000 or greater, or Prefer not to say
What is your association with UNC Charlotte?	Faculty/staff, Student, Visitor, or Other
What is the zip code of your residence?	Free response
What is your major or area of study?	Free response
Do you live on campus?	Yes or No
How did you hear about the driverless shuttle? Select all that apply.	Signs or flyers on campus, Advertisement in UNC Charlotte's newsletter, Press release from UNC Charlotte or NCDOT, UNC Charlotte 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

Table 3. CASSI at UNC Charlotte – Data Cleaning Log for Rider Survey Responses.

Survey Response ID	Survey Question	Cleaning Action
12	What are your thoughts on driverless shuttles?	Comments were copy edited
13	What are your thoughts on driverless shuttles?	Comments were copy edited
3	Where on campus would you like to see (...)?	Comments were copy edited
5	Where on campus would you like to see (...)?	Comments were copy edited
15	Where on campus would you like to see (...)?	Comments were copy edited
27	Where on campus would you like to see (...)?	Comments were copy edited
43	Where on campus would you like to see (...)?	Comments were copy edited
49	Where on campus would you like to see (...)?	Comments were copy edited
51	Where on campus would you like to see (...)?	Comments were copy edited
53	Where on campus would you like to see (...)?	Comments were copy edited
54	Where on campus would you like to see (...)?	Comments were copy edited
55	Where on campus would you like to see (...)?	Comments were copy edited
59	Where on campus would you like to see (...)?	Comments were copy edited
60	Where on campus would you like to see (...)?	Comments were copy edited
60	If you felt unsafe while riding the shuttle (...).	Comments were copy edited
4	Why or why not?	Comments were copy edited
6	Why or why not?	Comments were copy edited
7	Why or why not?	Comments were copy edited
11	Why or why not?	Comments were copy edited
15	Why or why not?	Comments were copy edited
16	Why or why not?	Comments were copy edited
20	Why or why not?	Comments were copy edited
21	Why or why not?	Comments were copy edited
22	Why or why not?	Comments were copy edited
23	Why or why not?	Comments were copy edited
27	Why or why not?	Comments were copy edited
28	Why or why not?	Comments were copy edited
31	Why or why not?	Comments were copy edited
37	Why or why not?	Comments were copy edited
41	Why or why not?	Comments were copy edited
44	Why or why not?	Comments were copy edited
48	Why or why not?	Comments were copy edited
49	Why or why not?	Comments were copy edited
51	Why or why not?	Comments were copy edited
52	Why or why not?	Comments were copy edited
53	Why or why not?	Comments were copy edited
54	Why or why not?	Comments were copy edited
55	Why or why not?	Comments were copy edited



Survey Response ID	Survey Question	Cleaning Action
56	Why or why not?	Comments were copy edited
59	Why or why not?	Comments were copy edited
60	Why or why not?	Comments were copy edited
61	Why or why not?	Comments were copy edited
2	Please share any additional feedback (...).	Comments were copy edited
7	Please share any additional feedback (...).	Comments were copy edited
14	Please share any additional feedback (...).	Comments were copy edited
16	Please share any additional feedback (...).	Comments were copy edited
19	Please share any additional feedback (...).	Comments were copy edited
20	Please share any additional feedback (...).	Comments were copy edited
22	Please share any additional feedback (...).	Comments were copy edited
23	Please share any additional feedback (...).	Comments were copy edited
24	Please share any additional feedback (...).	Comments were copy edited
51	Please share any additional feedback (...).	Comments were copy edited
29	What is your major or area of study?	Comments were copy edited