



# Addendum #1

## Request for Proposal for Autonomous Shuttle Services for Treasure Island Autonomous Shuttle Pilot Project

Date Issued	Date Addendum #1 Issued	Revised Proposals Due	Contact
May 23, 2022	June 8, 2022	<b>July 6, 2022 at 2:00 p.m.</b> <b>[electronically]</b>	Ron Leong Management Analyst <a href="mailto:Ronald.Leong@sfcta.org">Ronald.Leong@sfcta.org</a>

### ADDENDUM #1

Proposers are hereby notified of the following redline revision to the Request for Proposal for Autonomous Shuttle Services for Treasure Island Autonomous Shuttle Pilot Project (RFP 21/22-01) issued on May 23, 2022.

**Proposers shall include in their response acknowledgement of this addendum in their cover letter.**

The following deleted text is indicated by strikethrough and new text is underlined in red per the following text to Addendum #1:

### SECTION I - SELECTION PROCESS SCHEDULE

Date	Phase/Item Due
May 23, 2022	Release of RFP
May 31 at 5:00 p.m.	Pre-proposal conference attendees requested to submit registration: <a href="#">Zoom Registration</a>
June 1 at 4:00 p.m.	Pre-proposal conference held via Zoom
June 2 at 5:00 p.m.	Proposers to submit written questions to TIMMA
June <del>8</del> <u>10</u> *	TIMMA issues written responses to questions
<del>June 22</del> <u>July 6, 2:00 p.m.</u>	Responses to RFP and sealed/separate cost proposals due electronically. Late submissions will not be accepted.
<del>June 28</del> <u>July 27</u> *	Invitation(s) to interview issued to short list of proposers* (if necessary)



Week of <u>July 5-August 15</u> *	Interviews* (scheduled if necessary)
<u>July-September</u> TBD*	Recommendation to TIMMA Committee for award
<u>July-September</u> TBD*	TIMMA Board awards contract

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**SECTION IV - RFP RESPONSE REQUIREMENTS: CONTENT AND FORMAT**

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4. **Assurances and Miscellaneous Items.** In this section, proposals must provide the following information:

- a. Proposers must complete and include the exhibits listed below within the submittal. These exhibits do not count toward the page limit; please provide as attachments to proposal. Exhibit samples are attached to this RFP.

Exhibit	Prime Consultant	Subconsultant(s)
Exhibit F - Federal Compliance Questionnaire	X	X
Exhibit I - Debarment and Suspension Certification	X	X
Exhibit J - Terminated Contracts	X	X
Exhibit K - Workforce Data Spreadsheets	X	X
Exhibit L - Certification Regarding Lobbying	X	X
Exhibit M - Guidance for Bidders Completing the Good Faith Effort Submittal	N/A	N/A
<u>Exhibit N - Buy America Certificate</u>	<u>X</u>	<u>X</u>
<u>Exhibit O - AV Shuttle Requirements Conformance Matrix (submit in Excel and PDF form)</u>	<u>X</u>	<u>N/A</u>
Exhibit 10-I - Notice to Proposers DBE Information	N/A	N/A
Exhibit 10-O1 - Local Agency Consultant Proposal DBE Commitment	X	N/A
Exhibit 10-O2 - Local Agency Consultant Contract DBE Information	X	N/A
Exhibit 15-H - DBE Information - Good Faith Efforts (if DBE goal is not met)	X	N/A

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Proposers are requested to complete and submit Exhibit O - TIMMA AV Shuttle Requirements Conformance Matrix Checklist in Excel and PDF form by the proposal due date. The Excel form is



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accessible from our website: <https://www.sfcta.org/request-proposals-autonomous-shuttle-services-rfp-2122-01>

Proposers are hereby notified of the following redline additions to Exhibit B - Autonomous Shuttle System Requirements (SySR) - Revised is attached.

## **EXHIBITS**

The following documents are attached:

1. Exhibit N - Certificate of Compliance with Buy America Requirements
2. Exhibit O - TIMMA AV Shuttle Requirements Conformance Matrix Checklist
3. Exhibit B - Autonomous Shuttle System Requirements (SySR) - Revised



**TREASURE ISLAND  
MOBILITY MANAGEMENT AGENCY**

## **Exhibit N**

### **Certificate of Compliance with Buy America Requirements**

The Proposer identified below hereby certifies that it will comply with the requirements of **49 U.S.C. 5323(j)(1)**, **23 U.S.C. 313** and the applicable regulations in **49 CFR part 661**.

<b>Date:</b>	
<b>Signature:</b>	
<b>Company:</b>	
<b>Name:</b>	
<b>Title:</b>	

**Treasure Island Mobility Management Agency  
Exhibit O - AV Shuttle Requirements Conformance Matrix**

**Requirements Conformance Matrix Information and Instructions**

General Instructions for All Sheets	
1	The Proposer shall complete and submit both Excel and PDF versions of the Requirements Conformance Matrix (RCM). The RCM covers the Requirements set forth in Exhibit B.
2	The RCM is password protected. Only those cells in which Proposers may enter data are unlocked for Proposers to enter data. Proposers shall not unlock or otherwise alter the spreadsheets.
3	<p>The following are instructions for completion of the <b>Sheet: Requirements</b></p> <p>a) There are several columns in the sheet as follows:</p> <ul style="list-style-type: none"> <li>i. Req ID (Column A): An ID that matches the Requirement ID in the System Requirements.</li> <li>ii. User Need ID (Column B): An ID that matches the User Need ID in the System Requirements.</li> <li>iii. Functional Group (Column C): A description that matches the Functional Group in the System Requirements.</li> <li>iv. Description (Column D): A Description of each System Requirement.</li> <li>v. Priority (Column E): A description of the Priority of each System Requirement.</li> <li>vi. Verification Method (Column F): A description of the Verification Method of each System Requirement.</li> <li>vii. Compliance (Column G): Proposers must select one of the three (3) response codes for each System Requirement and enter it in this column, as further detailed below: <ul style="list-style-type: none"> <li>1) Fully Compliant = F: Enter a "F" in this column if the System Requirement described will be provided by the</li> <li>2) Partially Compliant = P: Enter a "P" in this column if the System Requirement described will only be partially provided by the Proposer.</li> <li>3) Not Compliant = N: Enter a "N" in this column if the System Requirement described will not be provided by</li> </ul> </li> <li>viii. Comments (Column H): This field must be completed if the Compliance code is entered as "P" or "N" for the particular System Requirement in order to explain why the Proposer is partially or not complying with the System</li> </ul>

**Treasure Island Mobility Management Agency  
Exhibit O - AV Shuttle Requirements Conformance Matrix**

Req ID	User Need ID	Functional Group	Description	Priority	Verification Method	Required Inputs	
						Compliance	Comments
						F - Fully Compliant P - Partially Compliant N - Not Compliant	If "Compliance = P or N" then Proposer must provide an explanation in this column
<b>3.1.1 Functional Requirements</b>							
AVS-FN-VOC-001-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall monitor the area behind and in front of the AVS to determine the proximity of other objects to the AVS.	Essential	Demonstration		
AVS-FN-VOC-002-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall monitor the area to the sides of the AVS to determine the proximity of other objects to the AVS to determine if a control adjustment is needed.	Essential	Demonstration		
AVS-FN-VOC-003-v01	AVS-UN016-v01	Vehicle Control Automation	The AVS shall detect, understand and comply with regulatory signs.	Essential	Demonstration		
AVS-FN-VOC-004-v01	AVS-UN016-v01	Vehicle Control Automation	The AVS shall understand and comply with speed laws.	Essential	Demonstration		
AVS-FN-VOC-005-v01	AVS-UN016-v01	Vehicle Control Automation	The AVS shall detect and understand pavement markings, and be able to operate on streets without clear lane markings.	Essential	Demonstration		
AVS-FN-VOC-006-v01	AVS-UN016-v01	Vehicle Control Automation	The AVS shall detect and understand the directions providing by human traffic control officers, either through the driving system, safety driver, or remote operator, or any combination of these.	Essential	Demonstration		
AVS-FN-VOC-007-v01	AVS-UN016-v01 AVS-UN045-v01	Vehicle Control Automation	The AVS shall detect, understand, and comply with traffic signals.	Essential	Demonstration		
AVS-FN-VOC-008-v01	AVS-UN02-v01	Vehicle Control Automation	The AVS shall arbitrate between detector concurrent regulatory signs, pavement markings, traffic signs, and object detections.	Essential	Demonstration		
AVS-FN-VOC-009-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall provide its location with lane-level accuracy to on-board control automation applications.	Essential	Demonstration		
AVS-FN-VOC-010-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall determine the status of host vehicle systems including AVS speed, heading, yaw, wheelspin, ABS, traction control, and wiper status. (host vehicle refers to the originator of a vehicular transmission of information).	Essential	Demonstration		
AVS-FN-VOC-011-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall determine a potentially hazardous road condition.	Essential	Demonstration		
AVS-FN-VOC-012-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall calculate AVS paths to determine if an impending collision is detected.	Essential	Analyze		
AVS-FN-VOC-013-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall evaluate the likelihood of a collision between two vehicles or a AVS and a stationary object, based on the proximity of other objects to the AVS, roadway characteristics, and the current speed and direction of the AVS.	Essential	Demonstration		
AVS-FN-VOC-014-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall provide position control adjustments.	Essential	Demonstration		
AVS-FN-VOC-015-v01	AVS-UN017-v01 AVS-UN018-v01 AVS-UN022-v01 AVS-UN037-v01	Vehicle Control Automation	The AVS shall provide an interface through which an Operator can initiate, monitor, and terminate automatic control of the AVS.	Essential	Demonstration		
AVS-FN-VOC-016-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall be capable of performing control actions based upon warnings received regarding pedestrians, cyclists, and other non-motorized and motorized users that are sharing the roadway with the AVS.	Essential	Demonstration		
AVS-FN-VOC-017-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS should be capable of performing control actions based upon information received from the infrastructure regarding the status of the intersection the AVS is approaching.	Desirable	Demonstration		
AVS-FN-VOC-018-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall automatically perform pre-crash actions, including seatbelt tightening, brake assist, airbag pre-arming, bumper raising/extension.	Essential	Demonstration		
AVS-FN-VOC-019-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall take speed control actions (e.g., throttle, brakes).	Essential	Demonstration		
AVS-FN-VOC-020-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall take steering control actions.	Essential	Demonstration		
AVS-FN-VOC-021-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall present AVS control information to the Operator in audible or visual forms without impairing the Operator's ability to control the AVS in a safe manner.	Essential	Demonstration		
AVS-FN-VOC-022-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall analyze its own applications' performance and enter fail-safe mode (a mode such that the application cannot provide information or perform actions that affect its host) when critical components fail.	Essential	Demonstration		
AVS-FN-VOC-023-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall notify the Operator when onboard components or safety applications are offline.	Essential	Demonstration		
AVS-FN-VOC-024-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall collect and monitor data concerning the safety of the AVS - including, steering, braking, acceleration, emissions, fuel economy, engine performance, etc.	Essential	Demonstration		
AVS-FN-VOC-025-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall determine the status of the AVS in terms of its continued ability to operate in a safe manner.	Essential	Demonstration		
AVS-FN-VOC-026-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall provide warnings to the Operator of potential dangers based on sensor input and analysis concerning the safety of the AVS.	Essential	Demonstration		
AVS-FN-VOC-027-v01	AVS-UN023-v01	Vehicle Control Automation	The AVS shall be able to determine when it is uncertain regarding which action to take.	Essential	Demonstration		
AVS-FN-VOC-028-v01	AVS-UN023-v01	Vehicle Control Automation	The AVS shall decrease speed and pull over in a legal stopping location, if safe, when it determines uncertainty regarding which action to take.	Essential	Demonstration		
AVS-FN-VSE-001-v01	AVS-UN013-v01	Vehicle System Executive	The AVS shall manage the overall device software configuration and operation and support configuration management, computer resource management, and govern software installation and upgrade.	Essential	Demonstration		
AVS-FN-VSE-002-v01	AVS-UN013-v01	Vehicle System Executive	The AVS shall allow a service center to remotely install or upgrade software in the AVS. Security of this data exchange shall be addressed in the vendor's Security/Data Management Plan.	Essential	Demonstration		
AVS-FN-VSE-003-v01	AVS-UN013-v01	Vehicle System Executive	The AVS shall provide the capability for an Operator to update the configuration of software or hardware in the AVS.	Essential	Demonstration		
AVS-FN-VSM- 001-v01	AVS-UN020-v01 AVS-UN032-v01	Vehicle System Monitoring and Diagnostics	The AVS shall be able to monitor on-board sensors to determine the operating conditions of on-board systems critical to safe and efficient operation of the AVS.	Essential	Demonstration		
AVS-FN-VSM- 002-v01	AVS-UN020-v01	Vehicle System Monitoring and Diagnostics	The AVS shall be capable of performing diagnostic tests using on-board data to identify problems in AVS system operation and to determine possible causes of the problems.	Essential	Demonstration		

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Exhibit O - AV Shuttle Requirements Conformance Matrix**

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						Compliance	Comments
						F - Fully Compliant P - Partially Compliant N - Not Compliant	If "Compliance = P or N" then Proposer must provide an explanation in this column
AVS-FN-VSM-003-v01	AVS-UN020-v01	Vehicle System Monitoring and Diagnostics	The AVS shall be capable of providing diagnostic information regarding on-board systems to the Operator.	Essential	Demonstration		
AVS-FN-VSM-004-v01	AVS-UN032-v01	Vehicle System Monitoring and Diagnostics	The AVS Management System shall monitor the status of AVSs.	Essential	Demonstration		
AVS-FN-ECA-001-v01	AVS-UN033-v01	AVS Electric Charging Assist	The AVS shall be able to provide the operational status of the electrical system, the charging capacity and charging rate for the AVS, and % charge complete to an electric charging station.	Essential	Demonstration		
AVS-FN-ECA-002-v01	AVS-UN031-v01	AVS Electric Charging Assist	The AVS shall maintain power throughout the operational period.	Essential	Demonstration		
AVS-FN-VEM-001-v01	AVS-UN034-v01	Vehicle Emergency Notification	The AVS shall provide the capability for an Operator to report an emergency and summon assistance.	Essential	Demonstration		
AVS-FN-VEM-002-v01	AVS-UN004-v01	Vehicle Emergency Notification	The AVS shall provide the capability to accept input from an Operator, passengers or emergency responders via a panic button or some other functionally similar form of input device provided as part of the in-vehicle equipment.	Essential	Demonstration		
AVS-FN-VEM-003-v01	AVS-UN034-v01	Vehicle Emergency Notification	The AVS shall acknowledge the Operator's request for emergency assistance.	Essential	Demonstration		
AVS-FN-VEM-004-v01	AVS-UN034-v01	Vehicle Emergency Notification	The AVS shall collect AVS operational state and all sensor information from the host vehicle.	Essential	Demonstration		
AVS-FN-VEM-005-v01	AVS-UN034-v01	Vehicle Emergency Notification	The AVS shall determine if the host vehicle has been involved in a collision.	Essential	Demonstration		
AVS-FN-VEM-006-v01	AVS-UN034-v01	Vehicle Emergency Notification	The AVS should forward a request for assistance to AVS Management System containing the AVS's current location, its identity and basic vehicle data relevant to its current condition, as well as any other data, such as AVS orientation, etc., that may be developed in-vehicle by other systems.	Desirable	Demonstration		
AVS-FN-VIW-001-v01	AVS-UN015-v01 AVS-UN019-v01 AVS-UN019-v01	Vehicle Intersection Warning	The AVS shall provide AVS path information to identify if AVS is performing an unpermitted movement at an intersection such as a stop sign violation.	Essential	Demonstration		
AVS-FN-VIW-002-v01	AVS-UN045-v01	Vehicle Intersection Warning	The AVS should be able to receive intersection signal timing information from roadside infrastructure for the AVS to determine if it will safely cross the intersection given its current location and speed.	Desirable	Demonstration		
AVS-FN-VIW-003-v01	AVS-UN045-v01	Vehicle Intersection Warning	The AVS should be able to receive warning from the infrastructure if an intersection violation appears to be imminent.	Desirable	Demonstration		
AVS-FN-VLD-001-v01	AVS-UN015-v01	Vehicle Location Determination	The AVS shall provide the AVS's current location to other in-vehicle functions.	Essential	Analyze		
AVS-FN-VLD-002-v01	AVS-UN015-v01	Vehicle Location Determination	The AVS shall calculate the location from one or more data sources including positioning systems such as GPS, sensors that track AVS movement, and maps used to determine the likely AVS route.	Essential	Analyze		
AVS-FN-VLD-003-v01	AVS-UN015-v01	Vehicle Location Determination	The AVS should obtain position correction data from the Connected Vehicle Roadside Equipment.	Desirable	Analyze		
AVS-FN-VLD-004-v01	AVS-UN015-v01	Vehicle Location Determination	The AVS shall apply position correction data to its base positional data.	Essential	Analyze		
AVS-FN-VMP-001-v01	AVS-UN027-v01	Vehicle Map Management	The AVS shall make basemap, roadway geometry, intersection geometry and parking facility geometry information available to other onboard vehicle applications.	Essential	Analyze		
AVS-FN-VMP-002-v01	AVS-UN027-v01	Vehicle Map Management	The AVS should provide its location to AVS Management System.	Desirable	Analyze		
AVS-FN-VMP-003-v01	AVS-UN027-v01	Vehicle Map Management	The AVS should obtain basemap updates from AVS Management System.	Desirable	Analyze		
AVS-FN-VMP-004-v01	AVS-UN027-v01	Vehicle Map Management	The AVS should obtain roadway geometry information from AVS Management System.	Desirable	Analyze		
AVS-FN-VMP-005-v01	AVS-UN027-v01	Vehicle Map Management	The AVS should obtain intersection geometry information from AVS Management System.	Desirable	Demonstration		
AVS-FN-SDM-001-v01	AVS-UN030-v01	Vehicle Situation Data Monitoring	The AVS shall receive data collection parameters from AVS Management System.	Essential	Demonstration		
AVS-FN-SDM-002-v01	AVS-UN030-v01	Vehicle Situation Data Monitoring	The AVS shall provide traffic-related data including snapshots of measured speed and heading and events including starts and stops, speed changes, and other vehicle control.	Essential	Demonstration		
AVS-FN-SDM-003-v01	AVS-UN030-v01	Vehicle Situation Data Monitoring	The AVS shall provide data to AVS Management System in accordance with data collection parameters provided.	Essential	Demonstration		
AVS-FN-SMA-001-v01	AVS-UN030-v01	Vehicle Speed Management Assist	The AVS shall travel at speed appropriate for the real-time road conditions (shall not exceed posted speed at any time).	Essential	Demonstration		
AVS-FN-RIR-001-v01	AVS-UN016-v01	AVS Roadside Information Reception	The AVS shall present to the Operator a visual display of static sign information or dynamic roadway conditions information.	Essential	Demonstration		
AVS-FN-FRO-001-v01	AVS-UN027-v01	Fixed-Route Operations	The AVS Management System shall provide the interface to the system Operator to control the generation of new routes and schedules.	Desirable	Demonstration		
AVS-FN-FRO-002-v01	AVS-UN027-v01	Fixed-Route Operations	The AVS Management System shall dispatch fixed route AVS.	Essential	Demonstration		
AVS-FN-FRO-003-v01	AVS-UN038-v01	Fixed-Route Operations	The AVS Management System shall consult with SFMTA on the generation of routes and schedules.	Essential	Demonstration		
AVS-FN-FRO-004-v01	AVS-UN027-v01 AVS-UN046-v01	Fixed-Route Operations	The AVS Management System shall receive information from SFCTA concerning work zones, roadway conditions, weather conditions, incidents, asset restrictions, work plans, etc. for use in scheduling.	Essential	Demonstration		
AVS-FN-FRO-005-v01	AVS-UN051-v01	Fixed-Route Operations	The AVS Management System shall disseminate up-to-date schedules and route information to SFMTA.	Essential	Demonstration		

**Treasure Island Mobility Management Agency  
Exhibit O - AV Shuttle Requirements Conformance Matrix**

Req ID	User Need ID	Functional Group	Description	Priority	Verification Method	Required Inputs	
						Compliance	Comments
						F - Fully Compliant P - Partially Compliant N - Not Compliant	If "Compliance = P or N" then Proposer must provide an explanation in this column
AVS-FN-FRO-006-v01	AVS-UN009-v01	Fixed-Route Operations	The AVS Management System should provide an interface to the archive data repository to enable the SFCTA to retrieve historical operating data for use in planning AVS routes and schedules.	Desirable	Demonstration		
AVS-FN-FRO-007-v01	AVS-UN029-v01	Fixed-Route Operations	The AVS Management System shall monitor AVS schedule adherence to manage AVS operations.	Essential	Demonstration		
AVS-FN-CVT-001-v01	AVS-UN029-v01	Center Vehicle Tracking	The AVS Management System shall monitor the locations of all AVS within its network.	Essential	Demonstration		
AVS-FN-CVT-002-v01	AVS-UN029-v01	Center Vehicle Tracking	The AVS Management System shall determine adherence of AVSs to their assigned schedule.	Essential	Demonstration		
AVS-FN-ASM-001-v01	AVS-UN029-v01	AVS Schedule Management	The AVS shall receive a vehicle assignment including shuttle route information, and shuttle service instructions for the Operator.	Essential	Demonstration		
AVS-FN-ASM-002-v01	AVS-UN029-v01	AVS Schedule Management	The AVS shall determine the deviation from the predetermined schedule.	Essential	Demonstration		
AVS-FN-ASM-003-v01	AVS-UN029-v01	AVS Schedule Management	The AVS shall calculate the estimated times of arrival (ETA) at shuttle stops.	Essential	Demonstration		
AVS-FN-ASM-004-v01	AVS-UN043-v01	AVS Schedule Management	The AVS should determine scenarios to correct the schedule deviation.	Desirable	Demonstration		
AVS-FN-ASM-005-v01	AVS-UN043-v01	AVS Schedule Management	The AVS should provide the schedule deviations and instructions for schedule corrections to the AVS Operator.	Desirable	Demonstration		
AVS-FN-ASM-006-v01	AVS-UN029-v01	AVS Schedule Management	The AVS should send the schedule deviation and estimated arrival time information to the AVS Management System.	Desirable	Demonstration		
AVS-FN-ASM-007-v01	AVS-UN028-v01	AVS Schedule Management	The AVS shall notify the AVS Management System of AVS location and operational status as the AVS exits and returns to the Maintenance/storage facility to support future AVS assignments.	Essential	Demonstration		
AVS-FN-APC-001-v01	AVS-UN009-v01	AVS Passenger Counting	The AVS shall count passengers boarding and alighting.	Essential	Demonstration		
AVS-FN-APC-002-v01	AVS-UN009-v01	AVS Passenger Counting	The passenger counts shall be related to location to support association of passenger counts with routes, route segments, or shuttle stops.	Essential	Demonstration		
AVS-FN-APC-003-v01	AVS-UN009-v01	AVS Passenger Counting	The passenger counts shall be timestamped so that ridership can be measured by time of day and day of week.	Essential	Demonstration		
AVS-FN-APC-004-v01	AVS-UN009-v01	AVS Passenger Counting	The AVS shall send the collected passenger count information to the AVS Management System.	Essential	Demonstration		
AVS-FN-CPC-001-v01	AVS-UN009-v01	Center Passenger Counting	The AVS Management System shall collect passenger count information from each AVS.	Essential	Demonstration		
AVS-FN-CPC-002-v01	AVS-UN009-v01	Center Passenger Counting	The AVS Management System shall calculate shuttle ridership data by route, route segment, shuttle stop, time of day, and day of week based on the collected passenger count information.	Essential	Demonstration		
AVS-FN-CPC-003-v01	AVS-UN009-v01	Center Passenger Counting	The AVS Management System shall provide compiled ridership data available to the SFCTA.	Essential	Demonstration		
AVS-FN-CSE-001-v01	AVS-UN014-v01	Center Security	The AVS Management System shall monitor AVS operational data to determine if the AVS is off- route and assess whether a security incident is occurring.	Essential	Demonstration		
AVS-FN-CSE-002-v01	AVS-UN014-v01	Center Security	The AVS Management System shall receive reports of emergencies on-board AVSs entered directly by the AVS Operator or from a traveler through interfaces such as panic buttons or alarm switches.	Essential	Demonstration		
AVS-FN-CSE-003-v01	AVS-UN014-v01	Center Security	The AVS Management System authenticate AVS Operators.	Essential	Demonstration		
AVS-FN-CSE-004-v01	AVS-UN014-v01	Center Security	The AVS Management System shall provide shuttle incident information along with other service data to emergency centers.	Essential	Demonstration		
AVS-FN-CSE-005-v01	AVS-UN014-v01	Center Security	The AVS Management System shall receive information pertaining to a wide-area alert such as weather alerts, disaster situations, or child abductions.	Essential	Demonstration		
AVS-FN-CSE-006-v01	AVS-UN034-v01	Center Security	The AVS Management System shall send wide- area alert information to travelers (on-board AVS).	Essential	Demonstration		
AVS-FN-CSE-007-v01	AVS-UN034-v01	Center Security	The AVS Management System shall notify the response to cybersecurity incidents involving the shuttle including notifying Emergency Management, SFCTA and SFMTA.	Essential	Demonstration		
AVS-FN-CSE-008-v01	AVS-UN034-v01	Center Security	The AVS Management System should be able to remotely disable (or reset the disabling of) a AVS in service.	Desirable	Demonstration		
AVS-FN-ASE-001-v01	AVS-UN014-v01	AVS Security	The AVS shall perform video and audio surveillance inside of AVSs and output raw video or audio data for local monitoring (for processing or direct output to the AVS Operator). Surveillance must comply with the City's Privacy First and Surveillance policies.	Essential	Demonstration		
AVS-FN-ASE-002-v01	AVS-UN014-v01	AVS Security	The AVS shall perform video and audio surveillance inside of AVSs and output raw video or audio data for remote monitoring.	Essential	Demonstration		
AVS-FN-ASE-003-v01	AVS-UN014-v01	AVS Security	The AVS shall perform video and audio surveillance inside of AVSs and output raw video or audio data for local storage (e.g., in an event recorder).	Essential	Demonstration		
AVS-FN-ASE-004-v01	AVS-UN014-v01	AVS Security	The AVS shall monitor and output surveillance and sensor equipment status and fault indications.	Essential	Demonstration		
AVS-FN-ASE-005-v01	AVS-UN014-v01	AVS Security	The AVS shall receive acknowledgments of the emergency request from the AVS Management System and output this acknowledgment to the AVS Operator or to the travelers.	Essential	Demonstration		
AVS-FN-ASE-006-v01	AVS-UN014-v01	AVS Security	The AVS shall be capable of receiving an emergency message for broadcast to the travelers or to the AVS Operator.	Essential	Demonstration		
AVS-FN-ASE-007-v01	AVS-UN037-v01	AVS Security	The AVS shall be capable of being disabled or enabled based on commands from the authentic inputs from the AVS Operator.	Essential	Demonstration		
AVS-FN-ASE-008-v01	AVS-UN003-v01	AVS Security	The AVS shall perform authentication of the AVS Operator.	Essential	Demonstration		
AVS-FN-CIS-001-v01	AVS-UN003-v01	Center Information Services	The AVS Management System shall exchange shuttle schedules, real-time arrival information, and general shuttle service information with SFMTA to support transit traveler information systems.	Essential	Demonstration		
AVS-FN-CIS-002-v01	AVS-UN003-v01	Center Information Services	The SFCTA shall provide AVS advisory data, including alerts and advisories pertaining to major emergencies, or man-made disasters.	Essential	Demonstration		
AVS-FN-AIS-001-v01	AVS-UN003-v01	AVS On-Board Information Services	The AVS should enable traffic and travel advisory information to be requested and output to the traveler. Such information may include shuttle routes, status, schedules, real-time schedule adherence.	Desirable	Demonstration		



**Treasure Island Mobility Management Agency  
Exhibit O - AV Shuttle Requirements Conformance Matrix**

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AVS-FN-AIS-002-v01	AVS-UN003-v01	AVS On-Board Information Services	The AVS shall broadcast advisories about the imminent arrival of the AVS at the next stop via an on-board automated annunciation system.	Essential	Demonstration		
AVS-FN-AIS-003-v01	AVS-UN003-v01 AVS-UN006-v01	AVS On-Board Information Services	The AVS shall support input and output forms that are suitable for travelers with physical disabilities.	Essential	Demonstration		
AVS-FN-AIS-004-v01	AVS-UN003-v01	AVS On-Board Information Services	The AVS shall gather advisory data, including alerts and advisories pertaining to major emergencies, or man-made disasters.	Essential	Demonstration		
AVS-FN-AIS-005-v01	AVS-UN003-v01	AVS On-Board Information Services	The AVS shall tailor the output of the request traveler information based on the current location of the AVS.	Essential	Demonstration		
AVS-FN-CMM-001-v01	AVS-UN044-v01	Center Multi-modal Coordination	The AVS Management System should coordinate with other transportation providers on schedules and services.	Desirable	Demonstration		
AVS-FN-CMM-002-v01	AVS-UN044-v01	Center Multi-modal Coordination	The AVS Management System should share transfer cluster and transfer point information with other transit centers. A transfer cluster is a collection of stop points, stations, or terminals where transfers can be made conveniently.	Desirable	Demonstration		
AVS-FN-ATM-001-v01	AVS-UN001-v01 AVS-UN002-v01 AVS-UN007-v01 AVS-UN008-v01	AVS On-Board Trip Monitoring	The AVS shall support the computation of the location of a AVS using on-board sensors to augment the location determination function. This may include proximity to the shuttle stops or other known reference points as well as recording trip length.	Essential	Demonstration		
AVS-FN-ATM-002-v01	AVS-UN038-v01	AVS On-Board Trip Monitoring	The AVS shall record shuttle trip monitoring data including vehicle mileage and electric charge.	Essential	Demonstration		
AVS-FN-ATM-003-v01	AVS-UN038-v01	AVS On-Board Trip Monitoring	The AVS shall record shuttle trip monitoring data including operational status information such as doors open/closed, running times, etc.	Essential	Demonstration		
AVS-FN-ATM-004-v01	AVS-UN030-v01	AVS On-Board Trip Monitoring	The AVS shall send the AVS trip monitoring data to AVS Management System-based trip monitoring functions.	Essential	Demonstration		
AVS-FN-ATM-005-v01	AVS-UN001-v01 AVS-UN002-v01	AVS On-Board Trip Monitoring	The AVS shall stop at all designated shuttle stops.	Essential	Demonstration		
AVS-FN-ATM-006-v01	AVS-UN007-v01 AVS-UN008-v01	AVS On-Board Trip Monitoring	The AVS should receive (and act upon) requests from travelers to stop at designated shuttle stop.	Desirable	Demonstration		
AVS-FN-CGM-001-v01	AVS-UN038-v01	Garage Maintenance	The Maintenance/Storage Facility shall collect operational and maintenance data from AVS.	Desirable	Demonstration		
AVS-FN-CGM-002-v01	AVS-UN013-v01	Garage Maintenance	The Maintenance/Storage Facility shall monitor the condition of a AVS to analyze brake, drive train, sensors, battery charge, steering, tire, processor, communications equipment, and AVS mileage to identify mileage based maintenance, out-of-specification or imminent failure conditions.	Essential	Demonstration		
AVS-FN-CGM-003-v01	AVS-UN013-v01	Garage Maintenance	The Maintenance/Storage Facility shall generate AVS maintenance schedules that identify the maintenance or repair to be performed and when the work is to be done.	Essential	Demonstration		
AVS-FN-CGM-004-v01	AVS-UN013-v01	Garage Maintenance	The Maintenance/Storage Facility shall verify that the AVS maintenance activities were performed correctly, using the AVS's status, the maintenance personnel's work assignment, and the AVS maintenance schedules.	Essential	Demonstration		
AVS-FN-CGM-005-v01	AVS-UN013-v01	Garage Maintenance	The Maintenance/Storage Facility shall generate a time-stamped maintenance log of all maintenance activities performed on an AVS.	Essential	Demonstration		
AVS-FN-CGM-006-v01	AVS-UN013-v01	Garage Maintenance	The Maintenance/Storage Facility shall provide AVS operations personnel with the capability to update AVS maintenance information and receive reports on all AVS operations data.	Essential	Demonstration		
AVS-FN-OBM-001-v01	AVS-UN038-v01	AVS On-Board Maintenance	The AVS shall collect and process AVS mileage data from the sensors on-board.	Essential	Demonstration		
AVS-FN-OBM-002-v01	AVS-UN038-v01	AVS On-Board Maintenance	The Maintenance/Storage Facility shall collect and process the AVS's operating conditions such as engine temperature, brake wear, internal lighting, environmental controls, etc.	Essential	Demonstration		
AVS-FN-APS-001-v01	AVS-UN015-v01	AVS Pedestrian Safety	The AVS shall determine if pedestrians are near an AVS.	Essential	Demonstration		
AVS-FN-APS-002-v01	AVS-UN015-v01	AVS Pedestrian Safety	The AVS shall determine if pedestrians are at risk of crash due to proximity of AVS.	Essential	Demonstration		
AVS-FN-APS-003-v01	AVS-UN015-v01	AVS Pedestrian Safety	The AVS shall take appropriate actions to prevent collision.	Essential	Demonstration		
AVS-FN-APS-004-v01	AVS-UN011-v01	AVS Pedestrian Safety	The AVS shall make itself visible with lights.	Essential	Demonstration		
AVS-FN-APS-005-v01	AVS-UN011-v01	AVS Pedestrian Safety	The AVS shall emit an alert sound to warn pedestrians of the shuttle's presence.	Essential	Demonstration		
AVS-FN-ABA-001-v01	AVS-UN039-v01 AVS-UN040-v01	AVS Boarding/Alighting	The AVS should determine when its position is near a shuttle station/stop.	Desirable	Demonstration		
AVS-FN-ABA-002-v01	AVS-UN039-v01 AVS-UN040-v01	AVS Boarding/Alighting	The AVS should determine whether pedestrians are at AVS stops.	Desirable	Demonstration		
AVS-FN-ABA-003-v01	AVS-UN039-v01 AVS-UN040-v01	AVS Boarding/Alighting	The AVS should stop at the designated shuttle stop (if pedestrians are present).	Desirable	Demonstration		
AVS-FN-AVS-001-v01	AVS-UN001-v01 AVS-UN002-v01	AVS V2V Safety	The AVS shall provide to other vehicles an audio and/or visual indication of its intent to leave a designated shuttle stop.	Essential	Demonstration		
AVS-FN-AVS-002-v01	AVS-UN001-v01 AVS-UN002-v01	AVS V2V Safety	The AVS shall take appropriate action if a collision threat exists as it prepares to leave a stop or station.	Essential	Demonstration		

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AVS-FN-AVS-003-v01	AVS-UN001-v01 AVS-UN002-v01	AVS V2V Safety	The AVS shall be able to identify if another vehicle is pulling in front of it to make a right turn using its sensors that can detect the location of other vehicles.	Essential	Demonstration		
AVS-FN-AFM-001-v01	AVS-UN041-v01	AVS On-Board Fare Management	The AVS should support payment for shuttle fares.	Desirable	Demonstration		
AVS-FN-CFM-001-v01	AVS-UN041-v01	AVS Center Fare Management	The AVS Management System should support the payment of shuttle fare transactions.	Desirable	Demonstration		
AVS-FN-AFM-001-v01	AVS-UN043-v01	AVS Performance Improvement	The AVS Management System should optimize route operations and minimize passenger travel time by limiting dwell times and maintaining consistent headways on its route.	Desirable	Demonstration		
<b>3.1.2 Operational Requirements</b>							
AVS-OP-OPS-001-v01	AVS-UN012-v01 AVS-UN042-v01	Operations	The Operator shall be responsible for keeping the AVS charged/fueled for the duration of the daily service period.	Essential	Demonstration		
AVS-OP-OPS-002-v01	AVS-UN012-v01	Operations	The charging/fueling shall be able to be performed manually.	Essential	Demonstration		
AVS-OP-OPS-003-v01	AVS-UN042-v01	Operations	The AVS should be able to automatically connect to a charging/fueling source independently of human assistance from the operations staff.	Desirable	Demonstration		
AVS-OP-OPS-004-v01	AVS-UN005-v01	Operations	The Operator shall always remain within the AVS while in operation and shall be responsible for greeting and assisting guests.	Essential	Inspection		
AVS-OP-OPS-005-v01	AVS-UN035-v01	Operations	The Operator within the AVS always shall be responsible for taking control of the AVS, if necessary. (Greeting role and the taking control roles may be played by the same person.)	Essential	Demonstration		
AVS-OP-OPS-006-v01	AVS-UN005-v01	Operations	Operator shall have received training from the Vendor to: <ul style="list-style-type: none"> <li>• Assisting and interacting with passengers, including providing mobility assistance during passenger boarding and alighting, as necessary, and how to properly secure people who use mobility devices</li> <li>• Provide accurate basic information about the AVS, and the purpose of the route</li> <li>• Receive and record passenger feedback</li> <li>• Operate a ramp, door, and/or charging station, if not automated</li> <li>• Road test an AVS</li> <li>• Have a working knowledge of AVS equipment</li> <li>• Perform clean-up, including bodily fluid</li> <li>• Intervene in AVS operations, if necessary</li> <li>• Collect data necessary to evaluate the pilot</li> <li>• Comply with all the training requirements set forth by the DMV and CPUC for both safety drivers and remote operators.</li> </ul>	Essential	Verification		
AVS-OP-OPS-007-v01	AVS-UN005-v01	Operations	Operators shall be employees, contractors, or agents of the Vendor. Operators shall obtain and maintain: <ul style="list-style-type: none"> <li>• Defensive driving certification</li> <li>• First Aid training</li> <li>• A valid driver's license that is recognized by the State of California</li> <li>• No more than two traffic violations or preventable accidents in the last three years</li> <li>• All necessary permits to operate an autonomous vehicle in the state of California.</li> </ul>	Essential	Inspection		
AVS-OP-OPS-008-v01	AVS-UN005-v01	Operations	The Vendor shall be responsible for developing Standard Operating Procedures for the AVSs and Operations staff.	Essential	Inspection		
AVS-OP-OPS-009-v01	NA	Operations	The Operator shall ensure the AVSs are sufficiently charged or taken out of service early under abnormal conditions after servicing all passengers who are already on board.	Essential	Demonstration		
AVS-OP-OPS-010-v01	AVS-UN031-v01	Operations	The Vendor shall monitor local weather patterns.	Essential	Demonstration		
AVS-OP-OPS-011-v01	AVS-UN046-v01	Operations	The Vendor shall define and document the operational design domain (ODD) of the AVS. This includes identifying how the AVS will respond when operating outside of its ODD, or when the ODD changes during daily operations (e.g.: weather-related impacts). The Vendor shall also identify when and how SFCTA will be notified when a vehicle leaves its ODD.	Essential	Demonstration		
AVS-OP-OPS-012-v01	AVS-UN024-v01	Operations	The Vendor shall collaboratively work with SFCTA to define an upcoming inclement weather event threshold that would risk placing the shuttle in service when outside its ODD (such as ponding water on the roadway, visibility, or other physical limitations) at which it would suspend or limit operations or shift to manual mode.	Essential	Demonstration		
AVS-OP-OPS-013-v01	AVS-UN046-v01	Operations	The Vendor shall notify SFCTA in the event this inclement weather threshold is met.	Essential	Demonstration		
AVS-OP-OPS-014-v01	AVS-UN046-v01	Operations	The Vendor shall suspend or limit operations or shift to manual mode when the inclement weather threshold is met.	Essential	Demonstration		
AVS-OP-OPS-015-v01	AVS-UN046-v01	Operations	The AVS Management System should be able to monitor local weather patterns and be aware of an approaching severe weather event or other conditions that may impact AVS operations.	Desirable	Demonstration		
AVS-OP-OPS-016-v01	AVS-UN046-v01	Operations	The Vendor shall immediately notify SFCTA of any crashes involving any road user or incidents related to passengers.	Essential	Inspection		
AVS-OP-OPS-017-v01	AVS-UN046-v01	Operations	The Vendor shall have an incident response plan in the event of an incident.	Essential	Inspection		
AVS-OP-VEH-001-v01	NA	Vehicle	The Operator shall ensure sufficient tire pressure and enough tread to safely operate AVS.	Essential	Inspection		
AVS-OP-VEH-002-v01	AVS-UN001-v01 AVS-UN002-v01	Vehicle	The AVS shall stop and open doors at designated locations to allow passengers to board and alight.	Essential	Demonstration		
AVS-OP-VEH-003-v01	AVS-UN001-v01 AVS-UN002-v01	Vehicle	The AVS doors shall have a safety sensitive edge and/or mechanism to open if an object is stuck in the doorway.	Essential	Demonstration		
AVS-OP-VEH-004-v01	NA	Vehicle	The AVS shall not park in a spot blocking access to a fire hydrant or crosswalk or any other prohibited location.	Essential	Demonstration		
AVS-OP-VEH-005-v01	AVS-UN005-v01	Vehicle	The AVS shall stop and open doors if they have detected that there is an issue on board, through sensors, passenger input, and/or secure override.	Essential	Demonstration		
AVS-OP-VEH-006-v01	AVS-UN005-v01	Vehicle	The AVS shall also have multiple secure means of egress, in the event the primary exit is blocked and/or power failure occurs.	Essential	Inspection		
AVS-OP-VEH-007-v01	AVS-UN039-v01 AVS-UN040-v01	Vehicle	The AVS should allow passengers to board and alight on-demand at designated stops without stopping at each stop.	Desireable	Demonstration		
AVS-OP-VEH-008-v01	AVS-UN041-v01	Vehicle	The AVS may have the ability to collect fares. Fares will not be collected as part of the pilot but could be demonstrated for use in other scenarios where AVSs may be deployed.	Desirable	Demonstration		

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AVS-OP-VEH-009-v01	AVS-UN003-v01	Vehicle	The AVS shall be capable of providing directional (i.e., eastbound to Avenue B & 9th Street) information in audible and visual form to passengers on both the inside and the outside of the AVS.	Essential	Demonstration		
AVS-OP-VEH-010-v01	NA	Vehicle	The AVS shall be able to operate on the public roads as defined above in mixed traffic (integrated with other vehicles, trucks, bicyclists, pedestrians, etc.) without Operator intervention, except in cases of failure or degraded conditions and maintenance conditions. (Refer to ConOps for definition of these conditions.)	Essential	Demonstration		
AVS-OP-VEH-011-v01	AVS-UN024-v01	Vehicle	The Vendor shall identify the ability of AVS to operate the following operating functions in automated mode:	Essential	Demonstration		
AVS-OP-VEH-011.1-v01	AVS-UN024-v01	Vehicle	Following the specified route.	Essential	Demonstration		
AVS-OP-VEH-011.2-v01	AVS-UN024-v01	Vehicle	Pulling over to the side of the road.	Essential	Demonstration		
AVS-OP-VEH-011.3-v01	AVS-UN024-v01	Vehicle	Moving out of the travel lane and stopping to service stop locations.	Essential	Demonstration		
AVS-OP-VEH-011.4-v01	AVS-UN024-v01	Vehicle	Performing car following when approaching intersections.	Essential	Demonstration		
AVS-OP-VEH-011.5-v01	AVS-UN024-v01	Vehicle	Performing car following in stop and go traffic conditions by maintaining a safe distance behind the vehicle in front of them and determining when to proceed based on that vehicle's behavior.	Essential	Demonstration		
AVS-OP-VEH-011.6-v01	AVS-UN024-v01	Vehicle	Navigating unsignalized intersections.	Essential	Demonstration		
AVS-OP-VEH-011.7-v01	AVS-UN024-v01	Vehicle	Performing left and right turns.	Essential	Demonstration		
AVS-OP-VEH-011.8-v01	AVS-UN024-v01	Vehicle	Entering and emerging from a stop-controlled traffic circle.	Essential	Demonstration		
AVS-OP-VEH-011.9-v01	AVS-UN024-v01	Vehicle	Crossing intersections with traffic speed limits up to 35 mph. (	Essential	Demonstration		
AVS-OP-VEH-011.10-v01	AVS-UN024-v01	Vehicle	Changing lanes (both left and right lane change).	Essential	Demonstration		
AVS-OP-VEH-011.11-v01	AVS-UN024-v01	Vehicle	Making right-of-way decisions when merging from a shuttle stop.	Essential	Demonstration		
AVS-OP-VEH-011.12-v01	AVS-UN024-v01	Vehicle	Making right-of-way decisions at intersections.	Essential	Demonstration		
AVS-OP-VEH-011.13-v01	AVS-UN024-v01	Vehicle	Making right-of-way decisions when interacting with vulnerable road users.	Essential	Demonstration		
AVS-OP-VEH-011.14-v01	AVS-UN024-v01	Vehicle	Detecting and responding to encroaching oncoming vehicles.	Essential	Demonstration		
AVS-OP-VEH-011.15-v01	AVS-UN024-v01	Vehicle	Detecting stopped vehicles in their path.	Essential	Demonstration		
AVS-OP-VEH-011.16-v01	AVS-UN024-v01	Vehicle	Passing stopped vehicles when necessary and safe.	Essential	Demonstration		
AVS-OP-VEH-011.17-v01	AVS-UN024-v01	Vehicle	Detecting and responding to static obstacles in their path.	Essential	Demonstration		
AVS-OP-VEH-011.18-v01	AVS-UN024-v01	Vehicle	Detecting and responding to moving obstacles in their path (include construction equipment).	Essential	Demonstration		
AVS-OP-VEH-011.19-v01	AVS-UN024-v01	Vehicle	Detecting emergency vehicles, and when their sirens are on, and yielding appropriately or following directions of emergency officials.	Essential	Demonstration		
AVS-OP-VEH-011.20-v01	AVS-UN024-v01	Vehicle	Detecting that they are being asked by law enforcement to move a specific way, and responding accordingly.	Essential	Demonstration		
AVS-OP-VEH-011.21-v01	AVS-UN024-v01	Vehicle	Detecting and responding to vulnerable road users, such as pedestrians, cyclists, and scooters, in the vehicle's projected travel path, including at intersections and crosswalks.	Essential	Demonstration		
AVS-OP-VEH-011.23-v01	AVS-UN024-v01	Vehicle	Providing a safe distance from vehicles, pedestrians, bicyclists, and scooters on the side of the road.	Essential	Demonstration		
AVS-OP-VEH-011.24-v01	AVS-UN024-v01	Vehicle	Decreasing speed when there is uncertainty regarding which action to take.	Essential	Demonstration		
AVS-OP-VEH-011.25-v01	AVS-UN024-v01	Vehicle	Detecting and responding to detours and other temporary changes in traffic patterns, such as people (including construction workers and police officers) directing traffic in unplanned or planned events. (An acceptable response includes informing the human Operator of the need to take manual control.)	Essential	Demonstration		
AVS-OP-VEH-011.26-v01	AVS-UN024-v01	Vehicle	Operating in normal rain, fog, and light snow conditions not deemed a weather emergency.	Essential	Demonstration		
AVS-OP-VEH-011.27-v01	AVS-UN024-v01	Vehicle	Operating in the roadway of the project area (With steep slopes and other conditions).	Essential	Demonstration		
AVS-OP-VEH-011.28-v01	AVS-UN024-v01	Vehicle	Performing a low-speed merge.	Essential	Demonstration		
<b>3.1.3 Performance Requirements</b>							
AVS-PR-OPS-001-v01	NA	Operations	The Vendor shall provide service as detailed in the scope of work and agreed to with SFCTA.	Essential	Inspection		
AVS-PR-OPS-002-v01	NA	Operations	Ridership shall be monitored by time-of-day and day-of-week, and operating hours may be adjusted to better accommodate demand, considering AVS capabilities.	Essential	Demonstration		
AVS-PR-OPS-003-v01	NA	Operations	The Vendor shall meet a minimum headway of as detailed in the scope of work and agreed to with SFCTA. As with operating hours, desired minimum headway may be modified during certain time periods depending on ridership but shall remain within the capabilities of the Vendor's originally proposed AVS fleet size. Stop departure times shall be scheduled to complement nearby Muni services.	Essential	Inspection		
<b>3.1.4 Non-Functional Requirements</b>							
<b>3.1.4.1 Physical Requirements</b>							
AVS-PY-VEH-001-v01	NA	Vehicle	Each AVS shall have a minimum capacity of at least 4 passengers excluding the Operator.	Essential	Inspection		
AVS-PY-VEH-002-v01	NA	Vehicle	While the AVS should have a minimum capacity of 4 passengers (excluding the Operator), higher (10+ person) capacity AVSs are preferred.	Desirable	Inspection		
AVS-PY-VEH-003-v01	NA	Vehicle	The AVS shall also have space for passengers to store foldable wheelchairs and mobility devices, small amounts of luggage, such as grocery bags and strollers.	Essential	Inspection		
AVS-PY-VEH-004-v01	NA	Vehicle	The Vendor shall agree to allow the AVSs to be wrapped or otherwise branded consistent with the intent of the deployment. Branding may include the Vendor's logo if desired alongside other graphics and sponsor brands. The Vendor shall provide limitations on placement of branding, to not occlude vital system functions, as part of its proposal. The final design will be coordinated with SFCTA.	Essential	Inspection		
AVS-PY-VEH-005-v01	AVS- UN048-v01	Vehicle	The AVS should be all-electric or hybrid (electric with another fuel type).	Desirable	Inspection		
AVS-PY-VEH-006-v01	NA	Vehicle	Each AVS shall have seatbelts for all seated passengers.	Essential	Inspection		
AVS-PY-VEH-007-v01	NA	Vehicle	The AVS shall have non-slip covers for seats.	Essential	Inspection		
AVS-PY-VEH-008-v01	NA	Vehicle	The AVS shall have handrails on the interior.	Essential	Inspection		
AVS-PY-VEH-009-v01	AVS- UN049-v01	Vehicle	The AVS should have bike racks.	Desirable	Inspection		
AVS-PY-VEH-010-v01	AVS- UN050-v01	Vehicle	The AVS should have free Wi-Fi (for passenger access).	Desirable	Inspection		
AVS-PY-VEH-011-v01	NA	Vehicle	The AVS shall be model/manufacturer year 2020 or newer.	Essential	Inspection		
AVS-PY-VEH-012-v01	NA	Vehicle	The AVS shall be free of any major dents, scratches, or other damage that may prevent the AVS from operating correctly or be cosmetically unappealing.	Essential	Inspection		
AVS-PY-VEH-013-v01	NA	Vehicle	The Vendor shall include responses for the AVS's status to the USDOT National Highway Traffic Safety Administration (NHTSA) 12-point safety assessment, as well as whether the AVS has completed the assessment, whether the assessment has been submitted to NHTSA and, if not, whether there are any plans to do so.	Essential	Inspection		

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AVS-PY-VEH-014-v01	NA	Vehicle	The AVS shall comply with all applicable FMVSS or have approval to operate under an exemption to the FMVSS. If not compliant, describe how the items not in compliance are directly related to the full automation capability with no driver.	Essential	Test		
AVS-PY-VEH-015-v01	AVS- UN025-v01	Vehicle	The AVS shall have climate control capabilities (heat and air conditioning).	Essential	Test		
AVS-PY-VEH-016-v01	AVS- UN006-v01	Vehicle	The AVS shall be accessible to those with disabilities. (Onboard Operators will be on board each AVS during operations, and they may aid passengers beyond what the AVS is independently capable of (such as securing a wheelchair or providing audible alerts).	Essential	Test		
AVS-PY-VEH-017-v01	AVS-UN019-v01	Vehicle	The AVS shall be equipped with brake lights.	Essential	Test		
<b>3.1.4.2 Availability and Reliability Requirements</b>							
AVS-AR-AOP-001-v01	NA	AVS Operations	The AVS shall be available for operations during the identified operational period for at least 98% of the pilot duration. (for example, if the total pilot is 90 days with 8 hours of operational period, the then the AVS shall be available for 98% x 90 x 8 = 705.6 hours).	Essential	Inspection		
AVS-AR-AOP-002-v01	AVS- UN047-v01	AVS Operations	The AVS should be available for 24/7 operations for at least 98% of the pilot duration.	Desirable	Inspection		
AVS-AR-CMS-001-v01	AVS- UN013-v01	AVS Management System	The AVS Management system shall be available for operations during the AVS operational period for at least 99.999% of the time.	Essential	Inspection		
AVS-AR-AOP-001-v01	AVS- UN013-v01	AVS On-Time Performance	The AVS shall arrive at a stop within 5 mins of arrival schedule.	Essential	Inspection		
AVS-AR-AOP-002-v01	AVS- UN013-v01	AVS On-Time Performance	The AVS shall not depart from the stop more than 5 mins after scheduled departure time.	Essential	Inspection		
<b>3.1.4.3 Maintainability Requirements</b>							
AVS-MR-AOP-001-v01	NA	AVS Operations	The AVS shall not be taken out of service for planned maintenance during operational period. (Planned maintenance shall be scheduled only during non- operational period).	Essential	Inspection		
AVS-MR-AOP-002-v01	NA	AVS Operations	The AVS shall maintain electric charge for operations during the entire operational period (charging shall be done during off operational hours. Additional AVS may be used to provide service if AVS can't maintain charge through the operational period).	Essential	Inspection		
AVS-MR-AOP-003-v01	NA	AVS Operations	The mean time to repair shall be less than 3 days for failure of any AVS component. (Vendor shall maintain the operational service by providing an alternate AVS during the repair period.)	Essential	Inspection		
AVS-MR-AOP-004-v01	NA	AVS Operations	The vendor shall identify time and frequency of preventative maintenance as part of the Operations and Maintenance Plan.	Essential	Inspection		
AVS-MR-AOP-005-v01	NA	AVS Operations	The vendor shall make available appropriately trained maintenance personnel (for performing charging, planned, and unplanned maintenance) as needed during the pilot duration.	Essential	Inspection		
<b>3.1.4.4 Storage and Transport Requirements</b>							
AVS-ST-TPT-001-v01	AVS-UN026-v01	Transportation	The AVS shall have the ability to be towed or pushed by a support vehicle.	Essential	Inspection		
AVS-ST-STG-001-v01	NA	Storage	The AVS shall be stored in a secured location during non-operational period.	Essential	Inspection		
AVS-ST-STG-002-v01	NA	Storage	The Vendor shall maintain a maintenance and storage facility within the project area.	Essential	Inspection		
AVS-ST-CHG-001-v01	NA	Charging	The Vendor shall install (or use an existing) charge station.	Essential	Inspection		
<b>3.1.5 Data Requirements</b>							
AVS-DT-DAT-001-v01	AVS-UN030-v01	Data	The Vendor shall agree to collect and store all raw data, including video, audio and sensor data. Video and audio shall be stored separately. Data should be made available to the SFMTA and SFCTA in the form and format requested (identified in these sub-requirements).. (Optionally, data that would be useful to potential passengers (such as real-time vehicle location information) will be shared via the APIs from the AVS Management System.)	Essential	Analyze		
AVS-DT-DAT-001.1-v01	AVS- UN038-v01	Data	• Vehicle route and schedule in General Transit Feed Specification (GTFS) in real- time or near real-time.	Essential	Analyze		
AVS-DT-DAT-001.2-v01	AVS- UN038-v01	Data	• Real-time vehicle location information in real-time or near real-time.	Essential	Analyze		
AVS-DT-DAT-001.3-v01	AVS- UN038-v01	Data	• Trip updates and service alerts in real-time or near real-time.	Essential	Analyze		
AVS-DT-DAT-001.4-v01	AVS- UN009-v01	Data	• Ridership (stop-level boardings and alightings), including time of rider boarding and alighting (daily).	Essential	Analyze		
AVS-DT-DAT-001.5-v01	AVS- UN038-v01	Data	• Actual stop arrival and departure times (daily).	Essential	Analyze		
AVS-DT-DAT-001.6-v01	AVS- UN038-v01	Data	• Vehicles miles traveled (daily).	Essential	Analyze		
AVS-DT-DAT-001.7-v01	AVS- UN038-v01	Data	• Vehicle hours traveled (hours the vehicle is in service) (daily).	Essential	Analyze		
AVS-DT-DAT-001.8-v01	AVS- UN038-v01	Data	• Number of route-trips served (daily).	Essential	Analyze		
AVS-DT-DAT-001.9-v01	AVS- UN038-v01	Data	• Duration of each trip (daily).	Essential	Analyze		
AVS-DT-DAT-001.10-v01	AVS- UN038-v01	Data	• Grams of CO2 per passenger mile (if applicable) (weekly).	Essential	Analyze		
AVS-DT-DAT-001.11-v01	AVS- UN038-v01	Data	• Battery capacity/usage (such that it can be associated with weather, temperature, vehicle load, etc.) (weekly).	Essential	Analyze		
AVS-DT-DAT-001.12-v01	AVS- UN038-v01	Data	• Average vehicle speeds along each segment of the route (weekly).	Essential	Analyze		
AVS-DT-DAT-001.13-v01	AVS- UN038-v01	Data	• Count and duration of wheelchair ramp or lift deployments (weekly).	Essential	Analyze		
AVS-DT-DAT-001.14-v01	AVS- UN038-v01	Data	• Sensor and other telemetry data (weekly).	Essential	Analyze		
AVS-DT-DAT-001.15-v01	AVS- UN038-v01	Data	• Navigation variances (weekly).	Essential	Analyze		
AVS-DT-DAT-001.16-v01	AVS- UN038-v01	Data	• Mechanical data (vehicle condition) (weekly).	Essential	Analyze		
AVS-DT-DAT-001.17-v01	AVS- UN038-v01	Data	• Disengagements by the operator or the system with the disengagement timestamps, locations, and causes (weekly).	Essential	Analyze		
AVS-DT-DAT-001.18-v01	AVS- UN038-v01	Data	• Any other safety incidents events (hard stops, near misses, evasive maneuvers, unruly passenger behavior, etc.) (weekly).	Essential	Analyze		
AVS-DT-DAT-001.19-v01	AVS- UN038-v01	Data	• Percent of time during operating hours the system is shut down (cause)(weekly).	Essential	Analyze		
AVS-DT-DAT-001.20-v01	AVS- UN038-v01	Data	• Number of security breach attempts, immediate reporting (weekly aggregate).	Essential	Analyze		
AVS-DT-DAT-001.21-v01	AVS- UN038-v01	Data	• Number of successful security breaches, immediate reporting (weekly aggregate).	Essential	Analyze		
AVS-DT-DAT-001.22-v01	AVS- UN038-v01	Data	• Conditions driven in (weather, congestion, etc.) (weekly).	Essential	Analyze		
AVS-DT-DAT-001.23-v01	AVS- UN038-v01	Data	• Incident reports (including any collisions or crimes) within 24 hours or sooner, following an incident. All data (video, audio, sensors, etc.) 5 minutes before and after each incident should be included.	Essential	Analyze		

Treasure Island Mobility Management Agency  
 Exhibit O - AV Shuttle Requirements Conformance Matrix

Req ID	User Need ID	Functional Group	Description	Priority	Verification Method	Required Inputs	
						Compliance	Comments
						F - Fully Compliant P - Partially Compliant N - Not Compliant	If "Compliance = P or N" then Proposer must provide an explanation in this column
AVS-DT-DAT-001.24-v01	AVS- UN038-v01	Data	<ul style="list-style-type: none"> <li>Passenger Behavior reports (including any situations when an external entity is called upon for assistance and is not deemed an imminent passenger safety concern) within one week following an incident. All data (video, audio, sensors, etc.) 5 minutes before and after each incident should be included.</li> </ul>	Essential	Analyze		
AVS-DT-DAT-001.25-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>User and non-user surveys (before and after the pilot).</li> </ul>	Essential	Analyze		
AVS-DT-DAT-001.26-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Number of times people with disabilities were able to hail, board, secure themselves, or alight with and without concierge assistance (weekly), and number of times people with disabilities were not able to hail, board, secure themselves, or alight with and without concierge assistance (weekly).</li> </ul>	Essential	Analyze		
AVS-CO-DAT-001.27-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Number of bicycles on board the AVS (weekly) and number of bicycles that were not able to board AVs due to space constraints.</li> </ul>	Essential	Analyze		
AVS-CO-DAT-001.28-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Annualized operating expense per service mile (end of pilot).</li> </ul>	Essential	Analyze		
AVS-CO-DAT-001.29-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>If a Connected Vehicle On-Board Unit is used, a record of operational data exchanged (includes SPaT and MAP messages the vehicle receives, BSM it sends, etc.) (weekly).</li> </ul>	Desirable	Analyze		

Exhibit 4  
Autonomous Shuttle System Requirements  
(SySR) - Revised

SYSTEM REQUIREMENTS

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March 2021

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## List of Acronyms and Abbreviations

ADA	Americans with Disabilities Act
ADS	Automated Driving Systems
AVS	Autonomous Vehicle Shuttle
CA MUTCD	California Manual on Uniform Traffic Control Devices
Caltrans	California Department of Transportation
ConOps	Concept of Operations
DSRC	Dedicated Short-Range Communications
FHWA	Federal Highway Administration
FMLM	First-Mile/Last-Mile
FMVSS	Federal Motor Vehicle Safety Standards
FR	Functional Requirements
GTFS	General Transit Feed Specifications
NF	Non-Functional Requirements
NHTSA	National Highway Traffic Safety Authority
OR	Operational Requirements
PR	Performance Requirements
TIDA	Treasure Island Development Authority
TIMMA	Treasure Island Mobility Management Agency
TITIP	Treasure Island Transportation Implementation Plan
TI/YBI	Treasure Island and Yerba Buena Island
USDOT	United States Department of Transportation
USG	United States Government

## 1 Introduction

This Systems Requirements document is intended to provide the requirements that drive the specifications, design, development, implementation, integration and testing of the Treasure Island Mobility Management Agency (TIMMA) Autonomous Vehicle Shuttle (AVS) Pilot Project. The System Requirements document is a “black box” description of what the facility must do, but not how it will do it.

### 1.1 Document Purpose

This System Requirements document serves as the second in a series of engineering documents intended to describe the TIMMA AVS Pilot Project, building upon the Concept of Operations (ConOps) document. The System Requirements document describes a set of requirements that, when realized, will satisfy the expressed needs of the facility. This document includes the identification, organization, and presentation of the requirements for the TIMMA AVS Pilot Project, which is made up of various components and features. These requirements are derived from the user needs, constraints, and interfaces that the facility is expected to implement. This System Requirements document addresses conditions for incorporating operational concepts, design constraints, and design configuration requirements as well as the necessary characteristics and quality of individual requirements and the set of all requirements.

This document contains the following chapters:

1. **Chapter 1. Introduction** provides an overview of the key project elements that guide the development of this System Requirements document, including an overview of the project, the stakeholders, requirements development process, and referenced materials.
2. **Chapter 2. System Description** focuses on describing and extending the TIMMA AVS Pilot Project system concepts established in the ConOps, including system capabilities, conditions, constraints, and decomposing the system into its functional groups for establishing requirements.
3. **Chapter 3. System Requirements** contains the requirements for each functional group that make up the system.
4. **Chapter 4. Engineering Principles** provides a description of engineering principles applied to the system and requirements definition process.

### 1.2 Reference Documents

The following documents form a part of this document to the extent specified herein. In the event of a conflict between the documents referenced herein and the contents of this document, this document shall be considered the superseding requirement.

### **1.3 Government Documents**

- 2010 Americans with Disabilities Act (ADA) Standards for Accessible Design
- California Manual on Uniform Traffic Control Devices 2014 Rev 5
- Systems Engineering Guide for Intelligent Transportation Systems, Version 3.0, USDOT

### **1.4 Nongovernment Documents**

Nongovernment documents may include:

- Treasure Island Community Development, LLC – Treasure Island Transportation Implementation Plan (TITIP)
- Concept of Operations for TIMMA AVS Pilot Project

## 2 System Description

### 2.1 System Definition

The proposed system includes an AVS, supporting AVS management system, charging/maintenance facility, and their interfaces among each other and with the passengers and road users. Refer to project ConOps for the detailed description of the proposed system.

This document proposes functional and non-functional requirements for the system to be developed and tested. These requirements are generated solely for the system created within this project and are not intended to be prescriptive for AVS developed outside the project.

### 2.2 User Characteristics

This section defines the stakeholders, users, and their roles and responsibilities for the TIMMA AV Shuttle Pilot Project. Stakeholders refers to an individual or organization affected by the activities, inputs and outputs of the system being developed. They may have a direct or indirect interest in the system and their level of participation may vary. This includes public agencies, private organizations or the traveling public (end users) with a vested interest or "stake" in one or more aspects of the TIMMA AV Shuttle Pilot Project as identified in **Table 1: TIMMA AV Shuttle Pilot Stakeholders and Users** and Users. Users are classified based on their perception of the system and the needs identified. Note that some key personnel may serve in multiple roles based on the user needs and functions.

**Table 1: TIMMA AV Shuttle Pilot Stakeholders and Users**

Target Stakeholders	Users			
	AVS Passengers	AVS Management System	Operations Staff	Emergency Vehicle / Operator
TI/YBI Residents	X			
TI/YBI Visitors	X			
AVS Vendor and Operator		X	X	
Law Enforcement				X
Emergency Medical Services				X
Fire and Rescue				X
Towing Agencies				X

Source: SFCTA

### **2.2.1 AVS Passengers**

AVS Passengers are any riders who use the AVS and are not AVS operations staff. AVS Passengers may be TI/YBI residents, visitors, employees. AVS Passengers may also be users who transferred from another mode of transportation (i.e. pedestrians, bicyclists, shuttle passengers, etc.).

### **2.2.2 AVS Management System Administrators**

AVS Management System users are those who oversee the operations of the shuttle. The AVS Management System users are remote users who may work in the maintenance facility or offsite in a remote operations center.

### **2.2.3 Operations Staff**

AVS Operations Staff users are those who operate the shuttle (i.e. the on-board Operator). These users are located on the AVS but are not considered an AVS Passenger.

### **2.2.4 Emergency Vehicle / Operator**

Emergency Vehicle / Operator users are any users who belong to an emergency response team. These users could be law enforcement, emergency medical services, fire and rescue, and towing agencies. The users may need to access the AVS in the event of an emergency but would not be considered AVS Passengers or Operations Staff.

## **2.3 Policies and Constraints**

The system constraints limit the activities that can be performed during the pilot. The system is constrained by the available budget, the changing environment on TI/YBI, the controlled land use of TI/YBI, and the changing technology landscape.

The available budget limits the duration of the pilot. The pilot is anticipated to last three months. Due to the high fixed cost of deploying the pilot, the variable cost of extending the pilot duration is relatively low to the three-month duration cost.

The changing environment on TI/YBI will affect how well the AVS must perform in work zones. The AVS must be able to perform well in environments that are continuously changing, with both changing lane configurations and surrounding benchmarks like buildings and trees. The AVS or on-board Operator will need to respond to temporary signage and traffic control officers accordingly. In addition, the AVSs will be traveling on roads with mixed-traffic, and even in cases where the roads are closed for testing, they will need to be able to detect and respond to traditional regulatory signs.

SFMTA must be consulted on proposed AVS routes and shuttle stops on Treasure Island.

The controlled land use on TI/YBI will constrain the location of charging and maintenance facilities. While vendors may be free to pick their own facility location on other projects, Treasure Island Development Authority (TIDA) will provide the vendor with facility options.

Automated vehicle technologies are an emerging field and the technology is still under development. There are various plans, guidance, policies, and procedures that have been adopted, published, or currently within rulemaking that govern the use of autonomous vehicles in the state of California and the United States. These include:

- Federal Automated Vehicles Policy, published by the United States Department of Transportation (USDOT) and the National Highway Traffic Safety Administration (NHTSA), provides guidance for developing an approach to automated vehicle performance specifications, the roles delegated to states, and current and proposed regulatory tools to maintain safety in this new transportation environment while not restricting technological innovation.
  - Automated Driving Systems: A Vision for Safety 2.0 (ADS 2.0), published by NHTSA, provides USDOT's cornerstone voluntary guidance document for ADS.
  - Preparing for the Future of Transportation (AV 3.0) builds upon ADS 2.0 and expands the scope to provide USDOT framework and multimodal approach to the safe integration of AVs into the Nation's broader surface transportation system.
  - Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0 (AV 4.0) builds upon AV 3.0 and expands the scope to 38 relevant US Government (USG) components that have direct or tangential equities in the safe development and integration of AV technologies. AV 4.0 seeks to ensure a consistent USG approach to AV technologies, and to detail the authorities, research, and investments being made across the USG so that the US can continue to lead AV technologies' research, development, and integration.
  - Automated Vehicles Comprehensive Plan, developed by USDOT, builds upon the principles stated in AV 4.0, advancing the Department's work to prioritize safety while preparing for the future of transportation.
- Federal Motor Vehicle Safety Standards (FMVSS), also developed by NHTSA, regulate features required for motor vehicles operated on public roads, in categories such as crash avoidance, crashworthiness, and post-crash survivability. Some AVS must receive FMVSS exemptions to operate on public roads.
- The State of California has passed legislation that allows autonomous vehicles that comply with FMVSS to operate on public roadways if a CA DMV permit is issued.
- The California Public Utilities Commission has authorized two pilot programs to test the private prearranged transportation of passengers and has also issued regulations for

the Phase I deployment of AV passenger services. The AVS vendor will need the appropriate California Public Utilities Commission permit prior to providing passenger service. .

The AVS vendor must comply with FMVSS or seek a federal exemption. The vendor must also obtain the appropriate testing permits from the state for testing on public roads and for providing passenger service. These existing regulations and any potential changes or opportunities for exemptions will continue to be monitored by the vendor during the pilot.



### 3 Requirements

This section of the document lists the identified requirements for TIMMA AVS Pilot Project. The requirements are organized first by requirement type, then by system and services.

The requirements tables in this section include a column for the requirement identifier, user need ID, functional group, description, priority, and verification method:

- The first column, Requirements Identify, includes a requirement identifier to provide traceability through other documents.
- The second column, User Needs, identifies traceability to user needs, use cases, and/or policies and constraints. The Requirements that doesn't address the identified User Needs directly but addresses the use cases, policies, and constraints, are labeled Not Application (NA).
- The third column, Functional Group, provides the functional group. This is intended to organize the requirements in a manner that allows similar requirements to be grouped together. The following functional groups are considered:
  - Vehicle Control Automation
  - Vehicle System Executive
  - Vehicle System Monitoring and Diagnostics
  - AVS Electric Charging Assist
  - Vehicle Emergency Notification
  - Vehicle Intersection Warning
  - Vehicle Location Determination
  - Vehicle Map Management
  - Vehicle Situation Data Monitoring
  - AVS Roadside Information Reception
  - Fixed-Route Operations
  - Center Vehicle Tracking
  - AVS Schedule Management
  - Center Passenger Counting
  - AVS Passenger Counting
  - Center Security
  - AVS Security
  - Center Information Services
  - AVS On-Board Information Services
  - Center Multi-modal Coordination
  - AVS On-Board Trip Monitoring
  - Garage Maintenance
  - AVS On-Board Maintenance
  - AVS Pedestrian Safety
  - AVS Boarding/Alighting
  - AVS V2V Safety
  - AVS On-Board Fare Management
  - AVS Center Fare Management
  - AVS Performance Improvement
  - AVS Operations
  - Operations
  - Vehicle
  - Transportation
  - Storage
  - Data

- The fourth column, Description, provides the requirement description, which is intended to be well-formed as specified by the *Systems Engineering Guide for Intelligent Transportation Systems*<sup>1</sup>: necessary, clear, complete, correct, feasible, and verifiable.
- The fifth column, Priority, identifies the requirements priorities. The essential priorities are anticipated to be implemented for the pilot. The Desirable priority identifies those requirements which are desirable for future deployments. However, if the vendor can meet the desirable priorities, the vendor may choose to implement and test as part of the pilot project.
- The last column, Verification Method, provides the verification method – the four fundamental verification methods considered include: inspection, demonstration, test, and analysis. Definitions of these methods are provided in Methods of Verification in Chapter 4. Engineering Principles.

**Table 2: List of Requirement Types** describes the classifications of the requirements in this document.

**Table 2: List of Requirement Types**

Type	Description
<b>Functional (FN)</b>	The Functional requirements specify actionable and qualitative behaviors (e.g. functions, tasks) of the core system of interest, which in the case of TIMMA AVS Pilot Project.
<b>Operational Requirements (OR)</b>	The Operational requirements are capabilities that are desired to address mission area deficiencies, evolving applications or threats, emerging technologies, or system cost improvements.
<b>Performance (PR)</b>	The Performance requirements specify quantifiable characteristics that define the extent, or how well, and under what conditions, a function or task is to be performed (e.g. rates, velocities).
<b>Non-Functional (NF)</b>	The Non-Functional requirements define the characteristics of the overall operation of the system, including the following: <ul style="list-style-type: none"> <li>• <b>Physical (PY)</b> – specifies the construction, durability, adaptability, and environmental characteristics of the system</li> <li>• <b>Availability and Recovery (AR)</b> – define the times of day, days of year, and overall percentage the system can be used and when it will not be available for use as well as recovery point and time objectives.</li> <li>• <b>Maintainability (MT)</b> – specify the level of effort required to locate and correct an error during operation.</li> </ul>

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<sup>1</sup> <https://www.fhwa.dot.gov/cadiv/segb/files/segbversion3.pdf>

	<ul style="list-style-type: none"><li>• <b>Storage and Transport (ST)</b> – specify the physical location and environment for the system, including designated storage facility, installation site, repair facility, requirements for transporting equipment, etc.</li></ul>
<b>Data Requirements</b>	The Data Requirements specify the data that are anticipated to be collected as part of the pilot.
<b>ADA Requirements</b>	The ADA Requirements specific the requirements that needs to be satisfied as part of the vendor’s compliance with ADA Act of 1990.

Source: SFCTA

### 3.1 System Requirements

This section itemizes the requirements associated with each of the system’s capabilities. A “function” is defined as a group of related requirements. TIMMA AVS Pilot Project’s system requirements correspond to the project’s various components.

### 3.1.1 Functional Requirements

This section provides the high-level requirements for the system of interest (i.e. what the system will do). The requirements in **Table 3: Functional Requirements** are organized by the functional groups and are related to the user needs documented in the project ConOps.

**Table 3: Functional Requirements**

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-VOC-001-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall monitor the area behind and in front of the AVS to determine the proximity of other objects to the AVS.	Essential	Demonstration
AVS-FN-VOC-002-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall monitor the area to the sides of the AVS to determine the proximity of other objects to the AVS to determine if a control adjustment is needed.	Essential	Demonstration
AVS-FN-VOC-003-v01	AVS-UN016-v01	Vehicle Control Automation	The AVS shall detect, understand and comply with regulatory signs.	Essential	Demonstration
AVS-FN-VOC-004-v01	AVS-UN016-v01	Vehicle Control Automation	The AVS shall understand and comply with speed laws.	Essential	Demonstration
AVS-FN-VOC-005-v01	AVS-UN016-v01	Vehicle Control Automation	The AVS shall detect and understand pavement markings, and be able to operate on streets without clear lane markings.	Essential	Demonstration

TIMMA Autonomous Shuttle Pilot Project  
System Requirements

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-VOC-006-v01	AVS-UN016-v01	Vehicle Control Automation	The AVS shall detect and understand the directions providing by human traffic control officers, either through the driving system, safety driver, or remote operator, or any combination of these.	Essential	Demonstration
AVS-FN-VOC-007-v01	AVS-UN016-v01 AVS-UN045-v01	Vehicle Control Automation	The AVS shall detect, understand, and comply with traffic signals.	Essential	Demonstration
AVS-FN-VOC-008-v01	AVS-UN02-v01	Vehicle Control Automation	The AVS shall arbitrate between detector concurrent regulatory signs, pavement markings, traffic signs, and object detections.	Essential	Demonstration
AVS-FN-VOC-009-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall provide its location with lane-level accuracy to on-board control automation applications.	Essential	Demonstration
AVS-FN-VOC-010-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall determine the status of host vehicle systems including AVS speed, heading, yaw, wheelspin, ABS, traction control, and wiper status.  (host vehicle refers to the originator of a vehicular transmission of information).	Essential	Demonstration

TIMMA Autonomous Shuttle Pilot Project  
System Requirements

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-VOC-011-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall determine a potentially hazardous road condition.	Essential	Demonstration
AVS-FN-VOC-012-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall calculate AVS paths to determine if an impending collision is detected.	Essential	Analyze
AVS-FN-VOC-013-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall evaluate the likelihood of a collision between two vehicles or a AVS and a stationary object, based on the proximity of other objects to the AVS, roadway characteristics, and the current speed and direction of the AVS.	Essential	Demonstration
AVS-FN-VOC-014-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall provide position control adjustments.	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-VOC-015-v01	AVS-UN017-v01 AVS-UN018-v01 AVS-UN022-v01 AVS-UN037-v01	Vehicle Control Automation	The AVS shall provide an interface through which an Operator can initiate, monitor, and terminate automatic control of the AVS.	Essential	Demonstration
AVS-FN-VOC-016-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall be capable of performing control actions based upon warnings received regarding pedestrians, cyclists, and other non-motorized and motorized users that are sharing the roadway with the AVS.	Essential	Demonstration
AVS-FN-VOC-017-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS should be capable of performing control actions based upon information received from the infrastructure regarding the status of the intersection the AVS is approaching.	Desirable	Demonstration
AVS-FN-VOC-018-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall automatically perform pre-crash actions, including seatbelt tightening, brake assist, airbag pre-arming, bumper raising/extension.	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-VOC-019-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall take speed control actions (e.g., throttle, brakes).	Essential	Demonstration
AVS-FN-VOC-020-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall take steering control actions.	Essential	Demonstration
AVS-FN-VOC-021-v01	AVS-UN015-v01 AVS-UN019-v01	Vehicle Control Automation	The AVS shall present AVS control information to the Operator in audible or visual forms without impairing the Operator's ability to control the AVS in a safe manner.	Essential	Demonstration
AVS-FN-VOC-022-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall analyze its own applications' performance and enter fail-safe mode (a mode such that the application cannot provide information or perform actions that affect its host) when critical components fail.	Essential	Demonstration
AVS-FN-VOC-023-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall notify the Operator when onboard components or safety applications are offline.	Essential	Demonstration
AVS-FN-VOC-024-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall collect and monitor data concerning the safety of the AVS - including, steering, braking, acceleration, emissions, fuel economy, engine performance, etc.	Essential	Demonstration



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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-VOC-025-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall determine the status of the AVS in terms of its continued ability to operate in a safe manner.	Essential	Demonstration
AVS-FN-VOC-026-v01	AVS-UN020-v01	Vehicle Control Automation	The AVS shall provide warnings to the Operator of potential dangers based on sensor input and analysis concerning the safety of the AVS.	Essential	Demonstration
AVS-FN-VOC-027-v01	AVS-UN023-v01	Vehicle Control Automation	The AVS shall be able to determine when it is uncertain regarding which action to take.	Essential	Demonstration
AVS-FN-VOC-028-v01	AVS-UN023-v01	Vehicle Control Automation	The AVS shall decrease speed and pull over in a legal stopping location, if safe, when it determines uncertainty regarding which action to take.	Essential	Demonstration
AVS-FN-VSE-001-v01	AVS-UN013-v01	Vehicle System Executive	The AVS shall manage the overall device software configuration and operation and support configuration management, computer resource management, and govern software installation and upgrade.	Essential	Demonstration
AVS-FN-VSE-002-v01	AVS-UN013-v01	Vehicle System Executive	The AVS shall allow a service center to remotely install or upgrade software in the AVS. Security of this data exchange shall be addressed in the vendor's Security/Data Management Plan.	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-VSE-003-v01	AVS-UN013-v01	Vehicle System Executive	The AVS shall provide the capability for an Operator to update the configuration of software or hardware in the AVS.	Essential	Demonstration
AVS-FN-VSM-001-v01	AVS-UN020-v01 AVS-UN032-v01	Vehicle System Monitoring and Diagnostics	The AVS shall be able to monitor on-board sensors to determine the operating conditions of on-board systems critical to safe and efficient operation of the AVS.	Essential	Demonstration
AVS-FN-VSM-002-v01	AVS-UN020-v01	Vehicle System Monitoring and Diagnostics	The AVS shall be capable of performing diagnostic tests using on-board data to identify problems in AVS system operation and to determine possible causes of the problems.	Essential	Demonstration
AVS-FN-VSM-003-v01	AVS-UN020-v01	Vehicle System Monitoring and Diagnostics	The AVS shall be capable of providing diagnostic information regarding on-board systems to the Operator.	Essential	Demonstration
AVS-FN-VSM-004-v01	AVS-UN032-v01	Vehicle System Monitoring and Diagnostics	The AVS Management System shall monitor the status of AVSs.	Essential	Demonstration
AVS-FN-ECA-001-v01	AVS-UN033-v01	AVS Electric Charging Assist	The AVS shall be able to provide the operational status of the electrical system, the charging capacity and charging rate for the AVS, and % charge complete to an electric charging station.	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-ECA-002-v01	AVS-UN031-v01	AVS Electric Charging Assist	The AVS shall maintain power throughout the operational period.	Essential	Demonstration
AVS-FN-VEM-001-v01	AVS-UN034-v01	Vehicle Emergency Notification	The AVS shall provide the capability for an Operator to report an emergency and summon assistance.	Essential	Demonstration
AVS-FN-VEM-002-v01	AVS-UN004-v01	Vehicle Emergency Notification	The AVS shall provide the capability to accept input from an Operator, passengers or emergency responders via a panic button or some other functionally similar form of input device provided as part of the in-vehicle equipment.	Essential	Demonstration
AVS-FN-VEM-003-v01	AVS-UN034-v01	Vehicle Emergency Notification	The AVS shall acknowledge the Operator's request for emergency assistance.	Essential	Demonstration
AVS-FN-VEM-004-v01	AVS-UN034-v01	Vehicle Emergency Notification	The AVS shall collect AVS operational state and all sensor information from the host vehicle.	Essential	Demonstration
AVS-FN-VEM-005-v01	AVS-UN034-v01	Vehicle Emergency Notification	The AVS shall determine if the host vehicle has been involved in a collision.	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-VEM-006-v01	AVS-UN034-v01	Vehicle Emergency Notification	The AVS should forward a request for assistance to AVS Management System containing the AVS's current location, its identity and basic vehicle data relevant to its current condition, as well as any other data, such as AVS orientation, etc., that may be developed in-vehicle by other systems.	Desirable	Demonstration
AVS-FN-VIW-001-v01	AVS-UN015-v01 AVS-UN019-v01 AVS-UN019-v01	Vehicle Intersection Warning	The AVS shall provide AVS path information to identify if AVS is performing an unpermitted movement at an intersection such as a stop sign violation.	Essential	Demonstration
AVS-FN-VIW-002-v01	AVS-UN045-v01	Vehicle Intersection Warning	The AVS should be able to receive intersection signal timing information from roadside infrastructure for the AVS to determine if it will safely cross the intersection given its current location and speed.	Desirable	Demonstration
AVS-FN-VIW - 003-v01	AVS-UN045-v01	Vehicle Intersection Warning	The AVS should be able to receive warning from the infrastructure if an intersection violation appears to be imminent.	Desirable	Demonstration
AVS-FN-VLD-001-v01	AVS-UN015-v01	Vehicle Location Determination	The AVS shall provide the AVS's current location to other in-vehicle functions.	Essential	Analyze

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-VLD-002-v01	AVS-UN015-v01	Vehicle Location Determination	The AVS shall calculate the location from one or more data sources including positioning systems such as GPS, sensors that track AVS movement, and maps used to determine the likely AVS route.	Essential	Analyze
AVS-FN-VLD-003-v01	AVS-UN015-v01	Vehicle Location Determination	The AVS should obtain position correction data from the Connected Vehicle Roadside Equipment.	Desirable	Analyze
AVS-FN-VLD-004-v01	AVS-UN015-v01	Vehicle Location Determination	The AVS shall apply position correction data to its base positional data.	Essential	Analyze
AVS-FN-VMP-001-v01	AVS-UN027-v01	Vehicle Map Management	The AVS shall make basemap, roadway geometry, intersection geometry and parking facility geometry information available to other onboard vehicle applications.	Essential	Analyze
AVS-FN-VMP-002-v01	AVS-UN027-v01	Vehicle Map Management	The AVS should provide its location to AVS Management System.	Desirable	Analyze
AVS-FN-VMP-003-v01	AVS-UN027-v01	Vehicle Map Management	The AVS should obtain basemap updates from AVS Management System.	Desirable	Analyze
AVS-FN-VMP-004-v01	AVS-UN027-v01	Vehicle Map Management	The AVS should obtain roadway geometry information from AVS Management System.	Desirable	Analyze

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-VMP-005-v01	AVS-UN027-v01	Vehicle Map Management	The AVS should obtain intersection geometry information from AVS Management System.	Desirable	Demonstration
AVS-FN-SDM-001-v01	AVS-UN030-v01	Vehicle Situation Data Monitoring	The AVS shall receive data collection parameters from AVS Management System.	Essential	Demonstration
AVS-FN-SDM-002-v01	AVS-UN030-v01	Vehicle Situation Data Monitoring	The AVS shall provide traffic-related data including snapshots of measured speed and heading and events including starts and stops, speed changes, and other vehicle control.	Essential	Demonstration
AVS-FN-SDM-003-v01	AVS-UN030-v01	Vehicle Situation Data Monitoring	The AVS shall provide data to AVS Management System in accordance with data collection parameters provided.	Essential	Demonstration
AVS-FN-SMA-001-v01	AVS-UN030-v01	Vehicle Speed Management Assist	The AVS shall travel at speed appropriate for the real-time road conditions (shall not exceed posted speed at any time).	Essential	Demonstration
AVS-FN-RIR-001-v01	AVS-UN016-v01	AVS Roadside Information Reception	The AVS shall present to the Operator a visual display of static sign information or dynamic roadway conditions information.	Essential	Demonstration
AVS-FN-FRO-001-v01	AVS-UN027-v01	Fixed-Route Operations	The AVS Management System shall provide the interface to the system Operator to control the generation of new routes and schedules.	Desirable	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-FRO-002-v01	AVS-UN027-v01	Fixed-Route Operations	The AVS Management System shall dispatch fixed route AVS.	Essential	Demonstration
AVS-FN-FRO-003-v01	AVS-UN038-v01	Fixed-Route Operations	The AVS Management System shall consult with SFMTA on the generation of routes and schedules.	Essential	Demonstration
AVS-FN-FRO-004-v01	AVS-UN027-v01 AVS-UN046-v01	Fixed-Route Operations	The AVS Management System shall receive information from SFCTA concerning work zones, roadway conditions, weather conditions, incidents, asset restrictions, work plans, etc. for use in scheduling.	Essential	Demonstration
AVS-FN-FRO-005-v01	AVS-UN051-v01	Fixed-Route Operations	The AVS Management System shall disseminate up-to-date schedules and route information to SFMTA.	Essential	Demonstration
AVS-FN-FRO-006-v01	AVS-UN009-v01	Fixed-Route Operations	The AVS Management System should provide an interface to the archive data repository to enable the SFCTA to retrieve historical operating data for use in planning AVS routes and schedules.	Desirable	Demonstration
AVS-FN-FRO-007-v01	AVS-UN029-v01	Fixed-Route Operations	The AVS Management System shall monitor AVS schedule adherence to manage AVS operations.	Essential	Demonstration
AVS-FN-CVT-001-v01	AVS-UN029-v01	Center Vehicle Tracking	The AVS Management System shall monitor the locations of all AVS within its network.	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-CVT-002-v01	AVS-UN029-v01	Center Vehicle Tracking	The AVS Management System shall determine adherence of AVSs to their assigned schedule.	Essential	Demonstration
AVS-FN-ASM-001-v01	AVS-UN029-v01	AVS Schedule Management	The AVS shall receive a vehicle assignment including shuttle route information, and shuttle service instructions for the Operator.	Essential	Demonstration
AVS-FN-ASM-002-v01	AVS-UN029-v01	AVS Schedule Management	The AVS shall determine the deviation from the predetermined schedule.	Essential	Demonstration
AVS-FN-ASM-003-v01	AVS-UN029-v01	AVS Schedule Management	The AVS shall calculate the estimated times of arrival (ETA) at shuttle stops.	Essential	Demonstration
AVS-FN-ASM-004-v01	AVS-UN043-v01	AVS Schedule Management	The AVS should determine scenarios to correct the schedule deviation.	Desirable	Demonstration
AVS-FN-ASM-005-v01	AVS-UN043-v01	AVS Schedule Management	The AVS should provide the schedule deviations and instructions for schedule corrections to the AVS Operator.	Desirable	Demonstration
AVS-FN-ASM-006-v01	AVS-UN029-v01	AVS Schedule Management	The AVS should send the schedule deviation and estimated arrival time information to the AVS Management System.	Desirable	Demonstration



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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-ASM-007-v01	AVS-UN028-v01	AVS Schedule Management	The AVS shall notify the AVS Management System of AVS location and operational status as the AVS exits and returns to the Maintenance/storage facility to support future AVS assignments.	Essential	Demonstration
AVS-FN-APC-001-v01	AVS-UN009-v01	AVS Passenger Counting	The AVS shall count passengers boarding and alighting.	Essential	Demonstration
AVS-FN-APC-002-v01	AVS-UN009-v01	AVS Passenger Counting	The passenger counts shall be related to location to support association of passenger counts with routes, route segments, or shuttle stops.	Essential	Demonstration
AVS-FN-APC-003-v01	AVS-UN009-v01	AVS Passenger Counting	The passenger counts shall be timestamped so that ridership can be measured by time of day and day of week.	Essential	Demonstration
AVS-FN-APC-004-v01	AVS-UN009-v01	AVS Passenger Counting	The AVS shall send the collected passenger count information to the AVS Management System.	Essential	Demonstration
AVS-FN-CPC-001-v01	AVS-UN009-v01	Center Passenger Counting	The AVS Management System shall collect passenger count information from each AVS.	Essential	Demonstration
AVS-FN-CPC-002-v01	AVS-UN009-v01	Center Passenger Counting	The AVS Management System shall calculate shuttle ridership data by route, route segment, shuttle stop, time of day, and day of week based on the collected passenger count information.	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-CPC-003-v01	AVS-UN009-v01	Center Passenger Counting	The AVS Management System shall provide compiled ridership data available to the SFCTA.	Essential	Demonstration
AVS-FN-CSE-001-v01	AVS-UN014-v01	Center Security	The AVS Management System shall monitor AVS operational data to determine if the AVS is off-route and assess whether a security incident is occurring.	Essential	Demonstration
AVS-FN-CSE-002-v01	AVS-UN014-v01	Center Security	The AVS Management System shall receive reports of emergencies on-board AVSs entered directly by the AVS Operator or from a traveler through interfaces such as panic buttons or alarm switches.	Essential	Demonstration
AVS-FN-CSE-003-v01	AVS-UN014-v01	Center Security	The AVS Management System authenticate AVS Operators.	Essential	Demonstration
AVS-FN-CSE-004-v01	AVS-UN014-v01	Center Security	The AVS Management System shall provide shuttle incident information along with other service data to emergency centers.	Essential	Demonstration
AVS-FN-CSE-005-v01	AVS-UN014-v01	Center Security	The AVS Management System shall receive information pertaining to a wide-area alert such as weather alerts, disaster situations, or child abductions.	Essential	Demonstration
AVS-FN-CSE-006-v01	AVS-UN034-v01	Center Security	The AVS Management System shall send wide-area alert information to travelers (on-board AVS).	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-CSE-007-v01	AVS-UN034-v01	Center Security	The AVS Management System shall notify the response to cybersecurity incidents involving the shuttle including notifying Emergency Management, SFCTA and SFMTA.	Essential	Demonstration
AVS-FN-CSE-008-v01	AVS-UN034-v01	Center Security	The AVS Management System should be able to remotely disable (or reset the disabling of) a AVS in service.	Desirable	Demonstration
AVS-FN-ASE-001-v01	AVS-UN014-v01	AVS Security	The AVS shall perform video and audio surveillance inside of AVSs and output raw video or audio data for local monitoring (for processing or direct output to the AVS Operator). Surveillance must comply with the City's Privacy First and Surveillance policies.	Essential	Demonstration
AVS-FN-ASE-002-v01	AVS-UN014-v01	AVS Security	The AVS shall perform video and audio surveillance inside of AVSs and output raw video or audio data for remote monitoring.	Essential	Demonstration
AVS-FN-ASE-003-v01	AVS-UN014-v01	AVS Security	The AVS shall perform video and audio surveillance inside of AVSs and output raw video or audio data for local storage (e.g., in an event recorder).	Essential	Demonstration
AVS-FN-ASE-004-v01	AVS-UN014-v01	AVS Security	The AVS shall monitor and output surveillance and sensor equipment status and fault indications.	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-ASE-005-v01	AVS-UN014-v01	AVS Security	The AVS shall receive acknowledgments of the emergency request from the AVS Management System and output this acknowledgment to the AVS Operator or to the travelers.	Essential	Demonstration
AVS-FN-ASE-006-v01	AVS-UN014-v01	AVS Security	The AVS shall be capable of receiving an emergency message for broadcast to the travelers or to the AVS Operator.	Essential	Demonstration
AVS-FN-ASE-007-v01	AVS-UN037-v01	AVS Security	The AVS shall be capable of being disabled or enabled based on commands from the authentic inputs from the AVS Operator.	Essential	Demonstration
AVS-FN-ASE-008-v01	AVS-UN003-v01	AVS Security	The AVS shall perform authentication of the AVS Operator.	Essential	Demonstration
AVS-FN-CIS-001-v01	AVS-UN003-v01	Center Information Services	The AVS Management System shall exchange shuttle schedules, real-time arrival information, and general shuttle service information with SFMTA to support transit traveler information systems.	Essential	Demonstration
AVS-FN-CIS-002-v01	AVS-UN003-v01	Center Information Services	The SFCTA shall provide AVS advisory data, including alerts and advisories pertaining to major emergencies, or man-made disasters.	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-AIS-001-v01	AVS-UN003-v01	AVS On-Board Information Services	The AVS should enable traffic and travel advisory information to be requested and output to the traveler. Such information may include shuttle routes, status, schedules, real-time schedule adherence.	Desirable	Demonstration
AVS-FN-AIS-002-v01	AVS-UN003-v01	AVS On-Board Information Services	The AVS shall broadcast advisories about the imminent arrival of the AVS at the next stop via an on-board automated annunciation system.	Essential	Demonstration
AVS-FN-AIS-003-v01	AVS-UN003-v01 AVS-UN006-v01	AVS On-Board Information Services	The AVS shall support input and output forms that are suitable for travelers with physical disabilities.	Essential	Demonstration
AVS-FN-AIS-004-v01	AVS-UN003-v01	AVS On-Board Information Services	The AVS shall gather advisory data, including alerts and advisories pertaining to major emergencies, or man-made disasters.	Essential	Demonstration
AVS-FN-AIS-005-v01	AVS-UN003-v01	AVS On-Board Information Services	The AVS shall tailor the output of the request traveler information based on the current location of the AVS.	Essential	Demonstration
AVS-FN-CMM-001-v01	AVS-UN044-v01	Center Multi-modal Coordination	The AVS Management System should coordinate with other transportation providers on schedules and services.	Desirable	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-CMM-002-v01	AVS-UN044-v01	Center Multi-modal Coordination	The AVS Management System should share transfer cluster and transfer point information with other transit centers. A transfer cluster is a collection of stop points, stations, or terminals where transfers can be made conveniently.	Desirable	Demonstration
AVS-FN-ATM-001-v01	AVS-UN001-v01 AVS-UN002-v01 AVS-UN007-v01 AVS-UN008-v01	AVS On-Board Trip Monitoring	The AVS shall support the computation of the location of a AVS using on-board sensors to augment the location determination function. This may include proximity to the shuttle stops or other known reference points as well as recording trip length.	Essential	Demonstration
AVS-FN-ATM-002-v01	AVS-UN038-v01	AVS On-Board Trip Monitoring	The AVS shall record shuttle trip monitoring data including vehicle mileage and electric charge.	Essential	Demonstration
AVS-FN-ATM-003-v01	AVS-UN038-v01	AVS On-Board Trip Monitoring	The AVS shall record shuttle trip monitoring data including operational status information such as doors open/closed, running times, etc.	Essential	Demonstration
AVS-FN-ATM-004-v01	AVS-UN030-v01	AVS On-Board Trip Monitoring	The AVS shall send the AVS trip monitoring data to AVS Management System-based trip monitoring functions.	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-ATM-005-v01	AVS-UN001-v01 AVS-UN002-v01	AVS On-Board Trip Monitoring	The AVS shall stop at all designated shuttle stops.	Essential	Demonstration
AVS-FN-ATM-006-v01	AVS-UN007-v01 AVS-UN008-v01	AVS On-Board Trip Monitoring	The AVS should receive (and act upon) requests from travelers to stop at designated shuttle stop.	Desirable	Demonstration
AVS-FN-CGM-001-v01	AVS-UN038-v01	Garage Maintenance	The Maintenance/Storage Facility shall collect operational and maintenance data from AVS.	Desirable	Demonstration
AVS-FN-CGM-002-v01	AVS-UN013-v01	Garage Maintenance	The Maintenance/Storage Facility shall monitor the condition of a AVS to analyze brake, drive train, sensors, battery charge, steering, tire, processor, communications equipment, and AVS mileage to identify mileage based maintenance, out-of-specification or imminent failure conditions.	Essential	Demonstration
AVS-FN-CGM-003-v01	AVS-UN013-v01	Garage Maintenance	The Maintenance/Storage Facility shall generate AVS maintenance schedules that identify the maintenance or repair to be performed and when the work is to be done.	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-CGM-004-v01	AVS-UN013-v01	Garage Maintenance	The Maintenance/Storage Facility shall verify that the AVS maintenance activities were performed correctly, using the AVS's status, the maintenance personnel's work assignment, and the AVS maintenance schedules.	Essential	Demonstration
AVS-FN-CGM-005-v01	AVS-UN013-v01	Garage Maintenance	The Maintenance/Storage Facility shall generate a time-stamped maintenance log of all maintenance activities performed on an AVS.	Essential	Demonstration
AVS-FN-CGM-006-v01	AVS-UN013-v01	Garage Maintenance	The Maintenance/Storage Facility shall provide AVS operations personnel with the capability to update AVS maintenance information and receive reports on all AVS operations data.	Essential	Demonstration
AVS-FN-OBM-001-v01	AVS-UN038-v01	AVS On-Board Maintenance	The AVS shall collect and process AVS mileage data from the sensors on-board.	Essential	Demonstration
AVS-FN-OBM-002-v01	AVS-UN038-v01	AVS On-Board Maintenance	The Maintenance/Storage Facility shall collect and process the AVS's operating conditions such as engine temperature, brake wear, internal lighting, environmental controls, etc.	Essential	Demonstration
AVS-FN-APS-001-v01	AVS-UN015-v01	AVS Pedestrian Safety	The AVS shall determine if pedestrians are near an AVS.	Essential	Demonstration
AVS-FN-APS-002-v01	AVS-UN015-v01	AVS Pedestrian Safety	The AVS shall determine if pedestrians are at risk of crash due to proximity of AVS.	Essential	Demonstration



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AVS-FN-APS-003-v01	AVS-UN015-v01	AVS Pedestrian Safety	The AVS shall take appropriate actions to prevent collision.	Essential	Demonstration
AVS-FN-APS-004-v01	AVS-UN011-v01	AVS Pedestrian Safety	The AVS shall make itself visible with lights.	Essential	Demonstration
AVS-FN-APS-005-v01	AVS-UN011-v01	AVS Pedestrian Safety	The AVS shall emit an alert sound to warn pedestrians of the shuttle's presence.	Essential	Demonstration
AVS-FN-ABA-001-v01	AVS-UN039-v01 AVS-UN040-v01	AVS Boarding/Alighting	The AVS should determine when its position is near a shuttle station/stop.	Desirable	Demonstration
AVS-FN-ABA-002-v01	AVS-UN039-v01 AVS-UN040-v01	AVS Boarding/Alighting	The AVS should determine whether pedestrians are at AVS stops.	Desirable	Demonstration
AVS-FN-ABA-003-v01	AVS-UN039-v01 AVS-UN040-v01	AVS Boarding/Alighting	The AVS should stop at the designated shuttle stop (if pedestrians are present).	Desirable	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-FN-AVS-001-v01	AVS-UN001-v01 AVS-UN002-v01	AVS V2V Safety	The AVS shall provide to other vehicles an audio and/or visual indication of its intent to leave a designated shuttle stop.	Essential	Demonstration
AVS-FN-AVS-002-v01	AVS-UN001-v01 AVS-UN002-v01	AVS V2V Safety	The AVS shall take appropriate action if a collision threat exists as it prepares to leave a stop or station.	Essential	Demonstration
AVS-FN-AVS-003-v01	AVS-UN001-v01 AVS-UN002-v01	AVS V2V Safety	The AVS shall be able to identify if another vehicle is pulling in front of it to make a right turn using its sensors that can detect the location of other vehicles.	Essential	Demonstration
AVS-FN-AFM-001-v01	AVS-UN041-v01	AVS On-Board Fare Management	The AVS should support payment for shuttle fares.	Desirable	Demonstration
AVS-FN-CFM-001-v01	AVS-UN041-v01	AVS Center Fare Management	The AVS Management System should support the payment of shuttle fare transactions.	Desirable	Demonstration
AVS-FN-AFM-001-v01	AVS-UN043-v01	AVS Performance Improvement	The AVS Management System should optimize route operations and minimize passenger travel time by limiting dwell times and maintaining consistent headways on its route.	Desirable	Demonstration

### 3.1.2 Operational Requirements

Table 4. Operational Requirements below identifies the AVS operational requirements for the project.

Table 4. Operational Requirements

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-OP-OPS-001-v01	AVS-UN012-v01 AVS-UN042-v01	Operations	The Operator shall be responsible for keeping the AVS charged/fueled for the duration of the daily service period.	Essential	Demonstration
AVS-OP-OPS-002-v01	AVS-UN012-v01	Operations	The charging/fueling shall be able to be performed manually.	Essential	Demonstration
AVS-OP-OPS-003-v01	AVS-UN042-v01	Operations	The AVS should be able to automatically connect to a charging/fueling source independently of human assistance from the operations staff.	Desirable	Demonstration
AVS-OP-OPS-004-v01	AVS-UN005-v01	Operations	The Operator shall always remain within the AVS while in operation and shall be responsible for greeting and assisting guests.	Essential	Inspection
AVS-OP-OPS-005-v01	AVS-UN035-v01	Operations	The Operator within the AVS always shall be responsible for taking control of the AVS, if necessary.  (Greeting role and the taking control roles may be played by the same person.)	Essential	Demonstration

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-OP-OPS-006-v01</b>	AVS-UN005-v01	Operations	<p>Operator shall have received training from the Vendor to:</p> <ul style="list-style-type: none"> <li>• Assisting and interacting with passengers, including providing mobility assistance during passenger boarding and alighting, as necessary, and how to properly secure people who use mobility devices</li> <li>• Provide accurate basic information about the AVS, and the purpose of the route</li> <li>• Receive and record passenger feedback</li> <li>• Operate a ramp, door, and/or charging station, if not automated</li> <li>• Road test an AVS</li> <li>• Have a working knowledge of AVS equipment</li> <li>• Perform clean-up, including bodily fluid</li> <li>• Intervene in AVS operations, if necessary</li> <li>• Collect data necessary to evaluate the pilot</li> <li>• Comply with all the training requirements set forth by the DMV and CPUC for both safety drivers and remote operators.</li> </ul>	Essential	Verification
<b>AVS-OP-OPS-007-v01</b>	AVS-UN005-v01	Operations	Operators shall be employees, contractors, or agents of the Vendor.	Essential	Inspection

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-OP-OPS-008-v01</b>	AVS-UN005-v01	Operations	Operators shall obtain and maintain: <ul style="list-style-type: none"> <li>• Defensive driving certification</li> <li>• First Aid training</li> <li>• A valid driver’s license that is recognized by the State of California</li> <li>• No more than two traffic violations or preventable accidents in the last three years</li> <li>• All necessary permits to operate an autonomous vehicle in the state of California.</li> </ul>	Essential	Inspection
<b>AVS-OP-OPS-009-v01</b>	NA	Operations	The Vendor shall be responsible for developing Standard Operating Procedures for the AVSs and Operations staff.	Essential	Inspection
<b>AVS-OP-OPS-010-v01</b>	AVS-UN031-v01	Operations	The Operator shall ensure the AVSs are sufficiently charged or taken out of service early under abnormal conditions after servicing all passengers who are already on board.	Essential	Demonstration
<b>AVS-OP-OPS-011-v01</b>	AVS-UN046-v01	Operations	The Vendor shall monitor local weather patterns.	Essential	Demonstration
<b>AVS-OP-OPS-012-v01</b>	AVS-UN024-v01	Operations	The Vendor shall define and document the operational design domain (ODD) of the AVS. This includes identifying how the AVS will respond when operating outside of it’s ODD, or when the ODD changes during daily operations (e.g.: weather-related impacts). The Vendor shall also identify when and how SFCTA will be notified when a vehicle leaves it’s ODD.	Essential	Demonstration

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-OP-OPS-013-v01</b>	AVS-UN046-v01	Operations	The Vendor shall collaboratively work with SFCTA to define an upcoming inclement weather event threshold that would risk placing the shuttle in service when outside its ODD (such as ponding water on the roadway, visibility, or other physical limitations) at which it would suspend or limit operations or shift to manual mode.	Essential	Demonstration
<b>AVS-OP-OPS-014-v01</b>	AVS-UN046-v01	Operations	The Vendor shall notify SFCTA in the event this inclement weather threshold is met.	Essential	Demonstration
<b>AVS-OP-OPS-015-v01</b>	AVS-UN046-v01	Operations	The Vendor shall suspend or limit operations or shift to manual mode when the inclement weather threshold is met.	Essential	Demonstration
<b>AVS-OP-OPS-016-v01</b>	AVS-UN046-v01	Operations	The AVS Management System should be able to monitor local weather patterns and be aware of an approaching severe weather event or other conditions that may impact AVS operations.	Desirable	Demonstration
<b>AVS-OP-OPS-017-v01</b>	AVS-UN046-v01	Operations	The Vendor shall immediately notify SFCTA of any crashes involving any road user or incidents related to passengers.	Essential	Inspection
<b>AVS-OP-OPS-018-v01</b>	AVS-UN046-v01	Operations	The Vendor shall have an incident response plan in the event of an incident.	Essential	Inspection
<b>AVS-OP-VEH-001-v01</b>	NA	Vehicle	The Operator shall ensure sufficient tire pressure and enough tread to safety operate AVS.	Essential	Inspection

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-OP-VEH-002-v01</b>	AVS-UN001-v01 AVS-UN002-v01	Vehicle	The AVS shall stop and open doors at designated locations to allow passengers to board and alight.	Essential	Demonstration
<b>AVS-OP-VEH-003-v01</b>	AVS-UN001-v01 AVS-UN002-v01	Vehicle	The AVS doors shall have a safety sensitive edge and/or mechanism to open if an object is stuck in the doorway.	Essential	Demonstration
<b>AVS-OP-VEH-004-v01</b>	NA	Vehicle	The AVS shall not park in a spot blocking access to a fire hydrant or crosswalk or any other prohibited location.	Essential	Demonstration
<b>AVS-OP-VEH-005-v01</b>	AVS-UN005-v01	Vehicle	The AVS shall stop and open doors if they have detected that there is an issue on board, through sensors, passenger input, and/or secure override.	Essential	Demonstration
<b>AVS-OP-VEH-006-v01</b>	AVS-UN005-v01	Vehicle	The AVS shall also have multiple secure means of egress, in the event the primary exit is blocked and/or power failure occurs.	Essential	Inspection
<b>AVS-OP-VEH-007-v01</b>	AVS-UN039-v01 AVS-UN040-v01	Vehicle	The AVS should allow passengers to board and alight on-demand at designated stops without stopping at each stop.	Desireable	Demonstration

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-OP-VEH-008-v01</b>	AVS-UN041-v01	Vehicle	The AVS may have the ability to collect fares. Fares will not be collected as part of the pilot but could be demonstrated for use in other scenarios where AVSs may be deployed.	Desirable	Demonstration
<b>AVS-OP-VEH-009-v01</b>	AVS-UN003-v01	Vehicle	The AVS shall be capable of providing directional (i.e., eastbound to Avenue B & 9 <sup>th</sup> Street) information in audible and visual form to passengers on both the inside and the outside of the AVS.	Essential	Demonstration
<b>AVS-OP-VEH-010-v01</b>	NA	Vehicle	The AVS shall be able to operate on the public roads as defined above in mixed traffic (integrated with other vehicles, trucks, bicyclists, pedestrians, etc.) without Operator intervention, except in cases of failure or degraded conditions and maintenance conditions. (Refer to ConOps for definition of these conditions.)	Essential	Demonstration
<b>AVS-OP-VEH-011-v01</b>	AVS-UN024-v01	Vehicle	The Vendor shall identify the ability of AVS to operate the following operating functions in automated mode:	Essential	Demonstration
<b>AVS-OP-VEH-011.1-v01</b>	AVS-UN024-v01	Vehicle	Following the specified route.	Essential	Demonstration
<b>AVS-OP-VEH-011.2-v01</b>	AVS-UN024-v01	Vehicle	Pulling over to the side of the road.	Essential	Demonstration



ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-OP-VEH-011.3-v01</b>	AVS-UN024-v01	Vehicle	Moving out of the travel lane and stopping to service stop locations.	Essential	Demonstration
<b>AVS-OP-VEH-011.4-v01</b>	AVS-UN024-v01	Vehicle	Performing car following when approaching intersections.	Essential	Demonstration
<b>AVS-OP-VEH-011.5-v01</b>	AVS-UN024-v01	Vehicle	Performing car following in stop and go traffic conditions by maintaining a safe distance behind the vehicle in front of them and determining when to proceed based on that vehicle's behavior.	Essential	Demonstration
<b>AVS-OP-VEH-011.6-v01</b>	AVS-UN024-v01	Vehicle	Navigating unsignalized intersections.	Essential	Demonstration
<b>AVS-OP-VEH-011.7-v01</b>	AVS-UN024-v01	Vehicle	Performing left and right turns.	Essential	Demonstration
<b>AVS-OP-VEH-011.8-v01</b>	AVS-UN024-v01	Vehicle	Entering and emerging from a stop-controlled traffic circle.	Essential	Demonstration
<b>AVS-OP-VEH-011.9-v01</b>	AVS-UN024-v01	Vehicle	Crossing intersections with traffic speed limits up to 35 mph. (	Essential	Demonstration
<b>AVS-OP-VEH-011.10-v01</b>	AVS-UN024-v01	Vehicle	Changing lanes (both left and right lane change).	Essential	Demonstration

<b>ReqID</b>	<b>User Need ID</b>	<b>Functional Group</b>	<b>Description</b>	<b>Priority</b>	<b>Verification Method</b>
<b>AVS-OP-VEH-011.11-v01</b>	AVS-UN024-v01	Vehicle	Making right-of-way decisions when merging from a shuttle stop.	Essential	Demonstration
<b>AVS-OP-VEH-011.12-v01</b>	AVS-UN024-v01	Vehicle	Making right-of-way decisions at intersections.	Essential	Demonstration
<b>AVS-OP-VEH-011.13-v01</b>	AVS-UN024-v01	Vehicle	Making right-of-way decisions when interacting with vulnerable road users.	Essential	Demonstration
<b>AVS-OP-VEH-011.14-v01</b>	AVS-UN024-v01	Vehicle	Detecting and responding to encroaching oncoming vehicles.	Essential	Demonstration
<b>AVS-OP-VEH-011.15-v01</b>	AVS-UN024-v01	Vehicle	Detecting stopped vehicles in their path.	Essential	Demonstration
<b>AVS-OP-VEH-011.16-v01</b>	AVS-UN024-v01	Vehicle	Passing stopped vehicles when necessary and safe.	Essential	Demonstration
<b>AVS-OP-VEH-011.17-v01</b>	AVS-UN024-v01	Vehicle	Detecting and responding to static obstacles in their path.	Essential	Demonstration
<b>AVS-OP-VEH-011.18-v01</b>	AVS-UN024-v01	Vehicle	Detecting and responding to moving obstacles in their path (include construction equipment).	Essential	Demonstration

<b>ReqID</b>	<b>User Need ID</b>	<b>Functional Group</b>	<b>Description</b>	<b>Priority</b>	<b>Verification Method</b>
<b>AVS-OP-VEH-011.19-v01</b>	AVS-UN024-v01	Vehicle	Detecting emergency vehicles, and when their sirens are on, and yielding appropriately or following directions of emergency officials.	Essential	Demonstration
<b>AVS-OP-VEH-011.20-v01</b>	AVS-UN024-v01	Vehicle	Detecting that they are being asked by law enforcement to move a specific way, and responding accordingly.	Essential	Demonstration
<b>AVS-OP-VEH-011.21-v01</b>	AVS-UN024-v01	Vehicle	Detecting and responding to vulnerable road users, such as pedestrians, cyclists, and scooters, in the vehicle's projected travel path, including at intersections and crosswalks.	Essential	Demonstration
<b>AVS-OP-VEH-011.23-v01</b>	AVS-UN024-v01	Vehicle	Providing a safe distance from vehicles, pedestrians, bicyclists, and scooters on the side of the road.	Essential	Demonstration
<b>AVS-OP-VEH-011.24-v01</b>	AVS-UN024-v01	Vehicle	Decreasing speed when there is uncertainty regarding which action to take.	Essential	Demonstration
<b>AVS-OP-VEH-011.25-v01</b>	AVS-UN024-v01	Vehicle	Detecting and responding to detours and other temporary changes in traffic patterns, such as people (including construction workers and police officers) directing traffic in unplanned or planned events. (An acceptable response includes informing the human Operator of the need to take manual control.)	Essential	Demonstration
<b>AVS-OP-VEH-011.26-v01</b>	AVS-UN024-v01	Vehicle	Operating in normal rain, fog, and light snow conditions not deemed a weather emergency.	Essential	Demonstration

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-OP-VEH-011.27-v01	AVS-UN024-v01	Vehicle	Operating in the roadway of the project area (With steep slopes and other conditions).	Essential	Demonstration
AVS-OP-VEH-011.28-v01	AVS-UN024-v01	Vehicle	Performing a low-speed merge.	Essential	Demonstration

Source: SFCTA

### 3.1.3 Performance Requirements

Table 5: Performance Requirements below identifies the AVS performance requirements for the project.

Table 5: Performance Requirements

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-PR-OPS-001-v01	NA	Operations	The Vendor shall provide service as detailed in the scope of work and agreed to with SFCTA.	Essential	Inspection
AVS-PR-OPS-002-v01	NA	Operations	Ridership shall be monitored by time-of-day and day-of-week, and operating hours may be adjusted to better accommodate demand, considering AVS capabilities.	Essential	Demonstration

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-PR-OPS-003-v01	NA	Operations	The Vendor shall meet a minimum headway of as detailed in the scope of work and agreed to with SFCTA. As with operating hours, desired minimum headway may be modified during certain time periods depending on ridership but shall remain within the capabilities of the Vendor’s originally proposed AVS fleet size. Stop departure times shall be scheduled to complement nearby Muni services.	Essential	Inspection

Source: SFCTA

### 3.1.4 Non-Functional Requirements

The non-functional requirements (NF) for the core system of interest specifies the characteristics of the overall operation of the system such as physical, availability, reliability, maintainability and storage and transport.

#### 3.1.4.1 Physical Requirements

**Table 6: Physical Requirements below identifies the AVS physical requirements for the project.**

**Table 6: Physical Requirements**

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-PY-VEH-001-v01</b>	NA	Vehicle	Each AVS shall have a minimum capacity of at least 4 passengers excluding the Operator.	Essential	Inspection
<b>AVS-PY-VEH-002-v01</b>	NA	Vehicle	While the AVS should have a minimum capacity of 4 passengers (excluding the Operator), higher (10+ person) capacity AVSs are preferred.	Desirable	Inspection
<b>AVS-PY-VEH-003-v01</b>	NA	Vehicle	The AVS shall also have space for passengers to store foldable wheelchairs and mobility devices, small amounts of luggage, such as grocery bags and strollers.	Essential	Inspection
<b>AVS-PY-VEH-004-v01</b>	NA	Vehicle	The Vendor shall agree to allow the AVSs to be wrapped or otherwise branded consistent with the intent of the deployment. Branding may include the Vendor's logo if desired alongside other graphics and sponsor brands. The Vendor shall provide limitations on placement of branding, to not occlude vital system functions, as part of its proposal. The final design will be coordinated with SFCTA.	Essential	Inspection

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-PY-VEH-005-v01</b>	AVS-UN048-v01	Vehicle	The AVS should be all-electric or hybrid (electric with another fuel type).	Desirable	Inspection
<b>AVS-PY-VEH-006-v01</b>	NA	Vehicle	Each AVS shall have seatbelts for all seated passengers.	Essential	Inspection
<b>AVS-PY-VEH-007-v01</b>	NA	Vehicle	The AVS shall have non-slip covers for seats.	Essential	Inspection
<b>AVS-PY-VEH-008-v01</b>	NA	Vehicle	The AVS shall have handrails on the interior.	Essential	Inspection
<b>AVS-PY-VEH-009-v01</b>	AVS-UN049-v01	Vehicle	The AVS should have bike racks.	Desirable	Inspection
<b>AVS-PY-VEH-010-v01</b>	AVS-UN050-v01	Vehicle	The AVS should have free Wi-Fi (for passenger access).	Desirable	Inspection
<b>AVS-PY-VEH-011-v01</b>	NA	Vehicle	The AVS shall be model/manufacturer year 2020 or newer.	Essential	Inspection
<b>AVS-PY-VEH-012-v01</b>	NA	Vehicle	The AVS shall be free of any major dents, scratches, or other damage that may prevent the AVS from operating correctly or be cosmetically unappealing.	Essential	Inspection

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-PY-VEH-013-v01</b>	NA	Vehicle	The Vendor shall include responses for the AVS's status to the USDOT National Highway Traffic Safety Administration (NHTSA) 12-point safety assessment, as well as whether the AVS has completed the assessment, whether the assessment has been submitted to NHTSA and, if not, whether there are any plans to do so.	Essential	Inspection
<b>AVS-PY-VEH-014-v01</b>	NA	Vehicle	The AVS shall comply with all applicable FMVSS or have approval to operate under an exemption to the FMVSS. If not compliant, describe how the items not in compliance are directly related to the full automation capability with no driver.	Essential	Test
<b>AVS-PY-VEH-015-v01</b>	AVS-UN025-v01	Vehicle	The AVS shall have climate control capabilities (heat and air conditioning).	Essential	Test
<b>AVS-PY-VEH-016-v01</b>	AVS-UN006-v01	Vehicle	The AVS shall be accessible to those with disabilities.  (Onboard Operators will be on board each AVS during operations, and they may aid passengers beyond what the	Essential	Test



ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
			AVS is independently capable of (such as securing a wheelchair or providing audible alerts).		
<b>AVS-PY-VEH-017-v01</b>	AVS-UN019-v01	Vehicle	The AVS shall be equipped with brake lights.	Essential	Test

Source: SFCTA

### 3.1.4.2 Availability and Reliability Requirements

Table 7: Availability and Reliability Requirements below identifies the AVS and AVS Management System availability and reliability requirements for the project.

Table 7: Availability and Reliability Requirements

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-AR-AOP-001-v01</b>	NA	AVS Operations	The AVS shall be available for operations during the identified operational period for at least 98% of the pilot duration. (for example, if the total pilot is 90 days with 8 hours of operational period, the then the AVS shall be available for $98\% \times 90 \times 8 = 705.6$ hours).	Essential	Inspection

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-AR-AOP-002-v01</b>	AVS-UN047-v01	AVS Operations	The AVS should be available for 24/7 operations for at least 98% of the pilot duration.	Desirable	Inspection
<b>AVS-AR-CMS-001-v01</b>	AVS-UN013-v01	AVS Management System	The AVS Management system shall be available for operations during the AVS operational period for at least 99.999% of the time.	Essential	Inspection
<b>AVS-AR-AOP-001-v01</b>	AVS-UN013-v01	AVS On-Time Performance	The AVS shall arrive at a stop within 5 mins of arrival schedule.	Essential	Inspection
<b>AVS-AR-AOP-002-v01</b>	AVS-UN013-v01	AVS On-Time Performance	The AVS shall not depart from the stop more than 5 mins after scheduled departure time.	Essential	Inspection

Source: SFCTA

### 3.1.4.3 Maintainability Requirements

**Table 8: Maintainability Requirements** below identifies the AVS and AVS Management System maintainability requirements for the project.

**Table 8: Maintainability Requirements**

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<b>ReqID</b>	<b>User Need ID</b>	<b>Functional Group</b>	<b>Description</b>	<b>Priority</b>	<b>Verification Method</b>
<b>AVS-MR-AOP-001-v01</b>	NA	AVS Operations	The AVS shall not be taken out of service for planned maintenance during operational period. (Planned maintenance shall be scheduled only during non- operational period).	Essential	Inspection
<b>AVS-MR-AOP-002-v01</b>	NA	AVS Operations	The AVS shall maintain electric charge for operations during the entire operational period (charging shall be done during off operational hours. Additional AVS may be used to provide service if AVS can't maintain charge through the operational period).	Essential	Inspection
<b>AVS-MR-AOP-003-v01</b>	NA	AVS Operations	The mean time to repair shall be less than 3 days for failure of any AVS component. (Vendor shall maintain the operational service by providing an alternate AVS during the repair period.)	Essential	Inspection
<b>AVS-MR-AOP-004-v01</b>	NA	AVS Operations	The vendor shall identify time and frequency of preventative maintenance as part of the Operations and Maintenance Plan.	Essential	Inspection

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-MR-AOP-005-v01</b>	NA	AVS Operations	The vendor shall make available appropriately trained maintenance personnel (for performing charging, planned, and unplanned maintenance) as needed during the pilot duration.	Essential	Inspection

Source: SFCTA

### 3.1.4.4 Storage and Transport Requirements

Table 9: Storage and Transport Requirements below identifies the AVS storage and transport requirements for the project.

Table 9: Storage and Transport Requirements

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-ST-TPT-001-v01</b>	AVS-UN026-v01	Transportation	The AVS shall have the ability to be towed or pushed by a support vehicle.	Essential	Inspection
<b>AVS-ST-STG-001-v01</b>	NA	Storage	The AVS shall be stored in a secured location during non-operational period.	Essential	Inspection

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-ST-STG-002-v01</b>	NA	Storage	The Vendor shall maintain a maintenance and storage facility within the project area.	Essential	Inspection
<b>AVS-ST-CHG-001-v01</b>	NA	Charging	The Vendor shall install (or use an existing) charge station.	Essential	Inspection

Source: SFCTA

### 3.1.5 Data Requirements

Table 10: Data Requirements below identifies the data requirements for the project.

Table 10: Data Requirements

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-DT-DAT-001-v01</b>	AVS-UN030-v01	Data	The Vendor shall agree to collect and store all raw data, including video, audio and sensor data. Video and audio shall be stored separately. Data should be made available to the SFMTA and SFCTA in the form and format requested (identified in these sub-requirements).. (Optionally, data	Essential	Analyze

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
			that would be useful to potential passengers (such as real-time vehicle location information) will be shared via the APIs from the AVS Management System.)		
<b>AVS-DT-DAT-001.1-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Vehicle route and schedule in General Transit Feed Specification (GTFS) in real-time or near real-time.</li> </ul>	Essential	Analyze
<b>AVS-DT-DAT-001.2-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Real-time vehicle location information in real-time or near real-time.</li> </ul>	Essential	Analyze
<b>AVS-DT-DAT-001.3-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Trip updates and service alerts in real-time or near real-time.</li> </ul>	Essential	Analyze
<b>AVS-DT-DAT-001.4-v01</b>	AVS-UN009-v01	Data	<ul style="list-style-type: none"> <li>Ridership (stop-level boardings and alightings), including time of rider boarding and alighting (daily).</li> </ul>	Essential	Analyze
<b>AVS-DT-DAT-001.5-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Actual stop arrival and departure times (daily).</li> </ul>	Essential	Analyze

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-DT-DAT-001.6-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Vehicles miles traveled (daily).</li> </ul>	Essential	Analyze
AVS-DT-DAT-001.7-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Vehicle hours traveled (hours the vehicle is in service) (daily).</li> </ul>	Essential	Analyze
AVS-DT-DAT-001.8-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Number of route-trips served (daily).</li> </ul>	Essential	Analyze
AVS-DT-DAT-001.9-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Duration of each trip (daily).</li> </ul>	Essential	Analyze
AVS-DT-DAT-001.10-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Grams of CO2 per passenger mile (if applicable) (weekly).</li> </ul>	Essential	Analyze
AVS-DT-DAT-001.11-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Battery capacity/usage (such that it can be associated with weather, temperature, vehicle load, etc.) (weekly).</li> </ul>	Essential	Analyze
AVS-DT-DAT-001.12-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Average vehicle speeds along each segment of the route (weekly).</li> </ul>	Essential	Analyze

ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
<b>AVS-DT-DAT-001.13-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Count and duration of wheelchair ramp or lift deployments (weekly).</li> </ul>	Essential	Analyze
<b>AVS-DT-DAT-001.14-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Sensor and other telemetry data (weekly).</li> </ul>	Essential	Analyze
<b>AVS-DT-DAT-001.15-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Navigation variances (weekly).</li> </ul>	Essential	Analyze
<b>AVS-DT-DAT-001.16-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Mechanical data (vehicle condition) (weekly).</li> </ul>	Essential	Analyze
<b>AVS-DT-DAT-001.17-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Disengagements by the operator or the system with the disengagement timestamps, locations, and causes (weekly).</li> </ul>	Essential	Analyze
<b>AVS-DT-DAT-001.18-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Any other safety incidents events (hard stops, near misses, evasive maneuvers, unruly passenger behavior, etc.) (weekly).</li> </ul>	Essential	Analyze



ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
AVS-DT-DAT-001.19-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Percent of time during operating hours the system is shut down (cause)(weekly).</li> </ul>	Essential	Analyze
AVS-DT-DAT-001.20-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Number of security breach attempts, immediate reporting (weekly aggregate).</li> </ul>	Essential	Analyze
AVS-DT-DAT-001.21-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Number of successful security breaches, immediate reporting (weekly aggregate).</li> </ul>	Essential	Analyze
AVS-DT-DAT-001.22-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Conditions driven in (weather, congestion, etc.) (weekly).</li> </ul>	Essential	Analyze
AVS-DT-DAT-001.23-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Incident reports (including any collisions or crimes) within 24 hours or sooner, following an incident. All data (video, audio, sensors, etc.) 5 minutes before and after each incident should be included.</li> </ul>	Essential	Analyze
AVS-DT-DAT-001.24-v01	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Passenger Behavior reports (including any situations when an external entity is called upon for assistance and is not deemed an imminent</li> </ul>	Essential	Analyze

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ReqID	User Need ID	Functional Group	Description	Priority	Verification Method
			passenger safety concern) within one week following an incident. All data (video, audio, sensors, etc.) 5 minutes before and after each incident should be included.		
<b>AVS-DT-DAT-001.25-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>User and non-user surveys (before and after the pilot).</li> </ul>	Essential	Analyze
<b>AVS-DT-DAT-001.26-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Number of times people with disabilities were able to hail, board, secure themselves, or alight with and without concierge assistance (weekly), and number of times people with disabilities were not able to hail, board, secure themselves, or alight with and without concierge assistance (weekly).</li> </ul>	Essential	Analyze
<b>AVS-CO-DAT-001.27-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Number of bicycles on board the AVS (weekly) and number of bicycles that were not able to board AVs due to space constraints.</li> </ul>	Essential	Analyze

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<b>ReqID</b>	<b>User Need ID</b>	<b>Functional Group</b>	<b>Description</b>	<b>Priority</b>	<b>Verification Method</b>
<b>AVS-CO-DAT-001.28-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>Annualized operating expense per service mile (end of pilot).</li> </ul>	Essential	Analyze
<b>AVS-CO-DAT-001.29-v01</b>	AVS-UN038-v01	Data	<ul style="list-style-type: none"> <li>If a Connected Vehicle On-Board Unit is used, a record of operational data exchanged (includes SPaT and MAP messages the vehicle receives, BSM it sends, etc.) (weekly).</li> </ul>	Desirable	Analyze

### 3.1.6 ADA Compliance

The Vendor shall identify its ability to comply with all applicable requirements of the Americans with Disabilities Act of 1990 (ADA), 42 U.S.C. 12101 et seq. and 49 U.S.C. 322; Section 504 of the Rehabilitation Act of 1973, as amended, 29 U.S.C. 794; Section 16 of the Federal Transit Act, as amended, 49 U.S.C. app. 1612; and the following regulations and any amendments thereto:

- USDOT regulations, "Transportation Services for Individuals with Disabilities (ADA)," 49 CFR. Part 37;
- USDOT regulations, "Nondiscrimination on the Basis of Handicap in Programs and Activities Receiving or Benefiting from Federal Financial Assistance," 49 CFR. Part 27;
- US. DOT regulations, "Americans With Disabilities (ADA) Accessibility Specifications for Transportation Vehicles," 49 CFR. Part 38;
- Department of Justice (DOJ) regulations, "Nondiscrimination on the Basis of Disability in State and Local Government Services," 28 CFR. Part 35;
- DOJ regulations, "Nondiscrimination on the Basis of Disability by Public Accommodations and in Commercial Facilities," 28 CFR. Part 36;
- General Services Administration regulations, "Construction and Alteration of Public Buildings," "Accommodations for the Physically Handicapped," 41 CFR. Part 101-19;
- Equal Employment Opportunity Commission (EEOC) "Regulations to Implement the Equal Employment Provisions of the Americans with Disabilities Act," 29 CFR. Part 1630;
- Federal Communications Commission regulations, "Telecommunications Relay Services and Related Customer Premises Equipment for the Hearing and Speech Disabled," 47 CFR. Part 64, Subpart F; and FTA regulations, "Transportation for Elderly and Handicapped Persons," 49 CFR Part 609.

## 4 Engineering Principles

This section describes engineering principles that guide composition of the TIMMA Autonomous Vehicle Shuttle Pilot Project.

### 4.1 Methods of Verification

The software and hardware components that make up the TIMMA Autonomous Vehicle Shuttle Pilot Project will be individually verified, then integrated to produce top-level assemblies and microservices. These assemblies will also be individually verified before being integrated with others to produce larger, evolving assemblies until the complete system has been integrated and verified.

The requirements also maintain a verification method, which details the plan for verifying the requirement based on its stated definition. One of the verification methods listed in **Table 11: Methods of Verification** is assigned for each requirement. Using the requirements defined in the previous section,

**Table 11: Methods of Verification**

<b>Type</b>	<b>Description</b>
<b>Inspection</b>	Verification through a visual, auditory, olfactory, or tactile comparison
<b>Demonstration</b>	Verification that exercises the system software or hardware as it is designed to be used, without external influence, to verify the results are specified by the requirement
<b>Test</b>	Verification using controlled and predefined inputs and other external elements (e.g. data, triggers, etc.) that influence or induce the system to produce the output specified by the requirement
<b>Analyze</b>	Verification through indirect and logical conclusion using mathematical analysis, models, calculations, testing equipment and derived outputs based on validated data sets

Source: SFCTA