U²C PROGRAM

Vehicle Planning Business Case and Market Analysis Basic Requirements

DRAFT

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0 EXECUTIVE SUMMARY

The Jacksonville Transportation Authority (JTA) Skyway has been transporting passengers within the downtown core for over 30 years. Emerging connected and automated vehicle technology and the evolving needs of Jacksonville's downtown have presented a unique opportunity to expand the reach and capacity of this system by deploying automated shuttle technology as U²C Vehicles. The proposed system will provide greater connectivity and mobility by expanding the reach of the system to public at-grade roadways, delivering a cost-effective system upgrade that leverages existing infrastructure and emerging innovations in vehicle technology. Basic business and stakeholder requirements for U²C Vehicles were gathered and assessed during technical and program strategy workshops with JTA stakeholders and additional research by the JTA Automation Division. These requirements are outlined at a high level in Table 1 and presented in more detail throughout this report.

Table 1: High-Level Basic U²C Vehicle Requirements Overview

Topic Area	Requirements

Form Factor	• Deploy a fleet of multiple vehicle types, capacities, and vendors
	• Ensure all vehicles can operate at-grade, including that they have NHTSA approval to operate on public roads
	  o Not all vehicles need to be able to operate on the elevated guideway
	• Speed matches existing train on guideway or posted speed limit at-grade
	  o Vehicles must also be crash worthy up to this speed (35 mph)
	• Vehicles must have the ability to be towed and/or to be steered manually

Infrastructure	• There are two infrastructure environments: elevated guideway and at-grade
	• Vehicles are required to fit in JTA's infrastructure constraints
	  o JTA may modify their infrastructure, but not to fit a vehicle's requirements
	  o This includes traversing slopes of ± 12 degrees with full passenger load
	• Also consider ITS, network, and other infrastructure

Vision Systems	• Ability to operate under differing environmental and topographical constraints, including different levels of complexity on the guideway and at-grade roadway, and how this informs decisions on how to respond to detected objects • Require manufacturers to demonstrate and prove their capabilities
Guidance/ Mapping	• Pursue the appropriate level of accuracy for each environment and type of operation, including: at-grade, guideway, fixed route, flexible route, on-demand • Allow for remote route programming with low latency • Employ redundant systems that complement each other • Maps must be interchangeable across vendors and vehicles
Communications	• Standards-based, flexible system that can evolve with the industry and includes redundant and backup networks • Includes a secure system for larger transfers at the storage location • Vehicle-to-Everything (V2X) capabilities (DSRC and/or C-V2X) that would enable vehicle-to-vehicle applications (like platooning), vehicle-to-infrastructure applications (like traffic signal priority), and other applications (like pedestrian safety)
Passenger Interface	• A universal application with a consistent and user-friendly interface on web, mobile, kiosks, Smart Panel, etc. • Include audio and visual information (for universal access and redundancy) • Create an indoor/outdoor integrated system

Topic Area	Requirements
Accessibility/ ADA	• Fully meet federal and local requirements on access for people with disabilities • Also consider equity, Title VI, and the unbanked • Consider that some passengers will always require human assistance
Physical and Cyber Security	• This includes the safety and security of passengers, vehicles, and infrastructure • Provide protocols, programs, and policies for emergency services and access • Consider security of remote monitoring – only provide suggestions, not control • Complete vehicle monitoring system, including emergency button, health monitoring, and recording/storing video
Miscellaneous	• ≥12 hours of battery life, with fast charge and opportunity charging • May operate during inclement weather ○ Including sustained environmental control inside the vehicle • Enable a sustainable revenue platform with innovative funding sources • Buy America/Buy American compliance • Pursue best practices in procurement, as they continue to evolve

1 INTRODUCTION

1.1 Purpose and Scope

This document intends to elicit **industry feedback** on the desired functional and interoperability requirements of Jacksonville Transportation Authority (JTA) Ultimate Urban Circulator (U^2C) **Vehicles**.

The requirements outlined in this document have been described intentionally at a high-level from various stakeholder perspectives, and will be further detailed in any subsequent Requests for Proposal (RFPs), based on industry feedback and additional engineering.

The scope of this document is to address step 2 of the JTA 7-step U^2C Business Case process outlined as follows:

- *Task 1 – Initiation*
- ***Task 2 – Outline Basic Requirements***
- *Task 3 – Market Study Analysis*
- *Task 4 – Market Soundings*
- *Task 5 – Issue RFI with Draft Requirements*
- *Task 6 – RFI Responses*
- *Task 7 – Prepare RFP Documents*

JTA has authorized the first 3 steps of this process to establish a Program Planning Business Case and Market Analysis. *Task 2 – Outline Basic Requirements* builds on the input received during *Task 1 – Initiation*, and serves as direct input into *Task 3 – Market Study Analysis*.

Task 2 – Outline Basic Requirements breaks further down into sub-tasks 2A and 2B, and addresses the following vehicle and interoperability requirements:

A. Basic Vehicle Requirements
    i. Applicable Standards
    ii. Safety Requirements
    iii. Passenger Capacity
    iv. ADA Accessibility
    v. Operating Speed
    vi. Operating Range
    vii. Vehicle Dimensions
        1. Length
        2. Width
        3. Weight
        4. Height
    viii. System Constraints
        1. Elevated
        2. At Grade
        3. Dedicated Lanes
        4. Mixed Traffic
    ix. Charging Considerations

1. Base Charging
2. Opportunity Charging
3. Replaceable vs Non-Replaceable Batteries

x. Maintenance Considerations
xi. Navigation Systems

B. Basic Interoperability Requirements

i. Vehicle-to-Vehicle (V2V)
ii. Vehicle-to-Infrastructure (V2I)
iii. Vehicle-to-Everything (V2X)
iv. Navigation Systems
v. On Board Equipment
vi. Customer Interface
vii. Security
viii. Health Monitoring
ix. Communication with Infrastructure
x. Remote Control
xi. Emergency Shut Down

Each of these requirements were discussed in a series of technical workshop with JTA Stakeholders, organized around the following broader topic areas:

1. Form Factor
2. Infrastructure
3. Vision Systems
4. Guidance/Mapping
5. Communications
6. Passenger Interface
7. Accessibility/ADA
8. Physical and Cyber Security

1.2 Background

1.2.1 U²C System Overview

For nearly 30 years, the Skyway has transported Jacksonville's commuters throughout the urban core.[1] However, at this time, emerging technology and the evolving needs of Jacksonville's downtown development present a unique opportunity to reevaluate existing infrastructure and provide greater connectivity, mobility, and sustained economic growth.

This can be achieved by utilizing investment in the existing elevated Skyway, expanding the area it serves, and employing automated transit technology as depicted in Figure 1-1. Through these

[1] Source: https://u2c.jtafla.com/about/

strategies, U²C can cost-effectively reach beyond the current system to serve existing and planned downtown development. The U²C will provide:

- High frequency service and accessibility
- Service flexibility
- Extensions that can serve at both elevated and at-grade street levels

Figure 1-1: Envisioned U²C Skyway System

The U²C concept takes full advantage of existing Skyway assets and fully integrates advancing technologies. Implementing this bold but necessary vision to enhance the transportation system will require successful agency partnerships, community buy-in, and essential financial resources. While JTA continues coordination with federal, state and local agencies to evaluate funding, right-of-way requirements, environmental compliance, and modifications to the street conditions; the following actions will be taken:

- Continue community outreach to gain strong support for the project
- Maintain existing Skyway vehicles until future vehicles are defined
- Identify the preferred vehicle characteristics and future operating system
- Develop a plan to convert the existing monorail structure for the new vehicles
- Develop an automated vehicle demonstration project
- Prepare a project phasing plan to coordinate the design and construction of the system extensions

1.2.2 U²C Vehicle Overview

The current Skyway system is a tightly coupled system with proprietary interfaces consisting of the guideway (elevated infrastructure including the barrier walls), the guidebeam, stations, vehicles, and the supervisory system. Replacing a single system component – such as vehicles or the supervisory system – requires changes to the interfacing system components and knowledge of the proprietary interfaces, which could result in undesirable vendor lock-in.

The future U²C system is envisioned to be based upon a **Modular Open Systems Approach** (MOSA), following the five (5) MOSA principles as defined by the Department of Defense (DoD):

1. Establish an Enabling Environment
2. Employ Modular Design
3. Designate Key Interfaces
4. Use Open Standards
5. Certify Conformance

In context of the U²C system, **U²C Vehicles** are considered a standalone module of the U²C system that will communicate with other U²C system modules (e.g. the supervisory system) and with other vehicles across multiple manufacturers via well defined, widely used, and open interfaces, thereby establishing **Interoperability**, as presented in Figure 1-2.

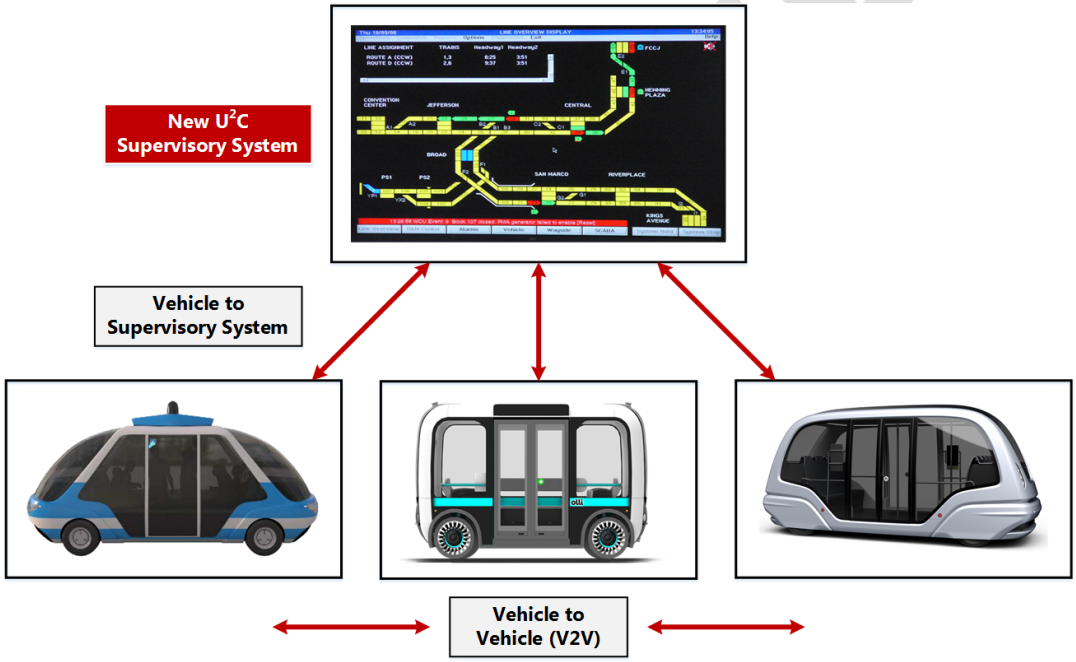

Figure 1-2: Envisioned U²C Interoperable System

For more information on the interoperability of the system, see the U²C Program Supervisory System Planning Business Case and Market Analysis Basic Requirements report.

Skyway vehicles currently run exclusively on a two-way elevated, 2.5-mile long, 11-foot wide monorail track. Trains are controlled by an Automatic Train Control (ATC) system. Trains currently have two cars, though they can have up to six, and travel at up to 35 miles per hour. Each car has a capacity of 28 passengers.

The U²C program plans to expand the existing automated people mover system, elevated above the downtown street network, into an urban circulator system, with transitions to the street level, reaching more destinations than it does today. This will require a technological solution that is able to operate on both the elevated guideway and at-grade public roadways. The preferred solution is next generation Autonomous Vehicles (AV), supported by modifications to the guideway that provide a more similar environment to at-grade roadways (i.e. removal of the monorail beam). Not only will AVs satisfy project requirements, they are also the most cost-effective approach for new service extensions, and are rapidly evolving in their capabilities.

In December 2017, JTA launched the U²C AV Test and Learn track which serves as an outdoor classroom to test and evaluate multiple vehicles and their associated technologies from the AV shuttle industry. This test track is a vital component of the development phase. It has enabled JTA to gain critical information for the development of the U²C program and for other future applications of autonomous transit vehicles as part of its overall public transportation system.

1.3 References

Table 1-1 presents references to additional resources that informed the content of this report.

Table 1-1: References

Reference
Jacksonville Transportation Authority. **TBD**. *Skyway – Requirements Document (**TBD**)*
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US Department of Defense. 2013. *DoD, Open Systems Architecture, Contract Guidebook for Program Mangers*. Version 1.1. (http://www.acqnotes.com/Attachments/Open%20System%20Architecture%20%28OSA%29%20Contract%20Guidebook%20for%20Program%20Managers%20June%2013.pdf)
US Department of Transportation. 2014. *Prioritizing Candidate Connected Vehicle Standards: Candidate Approach and Methodology to Determine USDOT Future Support & Activities*. (http://local.iteris.com/cvria/docs/V2xStandardizationPlanApproachWhitepaper_10March2014.pdf)
US Department of Transportation Volpe National Transportation Systems Center. *Low-Speed Automated Shuttles: State of the Practice*. 2018. https://rosap.ntl.bts.gov/view/dot/37060

1.4 Acronyms and Abbreviations

Table 1-2 presents acronyms and abbreviations used throughout this document.

Table 1-2: Acronyms and Abbreviations

Acronyms and Abbreviations	
4G	Fourth Generation (of Broadband Cellular Network Technology)
5G	Fifth Generation (of Broadband Cellular Network Technology)
AASHTO	American Association of State Highway and Transportation Officials
AI	Artificial Intelligence
ANSI	American National Standards Institute
App	Application

Acronyms and Abbreviations	
APTA	American Public Transportation Association
ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
ASTM	American Society for Testing and Materials
C-ITS	Cooperative Intelligent Transportation System
C/AV	Connected and Automated Vehicle
CFR	Code of Federal Regulations
CVRIA	Connected Vehicle Reference Implementation Architecture
DoD	Department of Defense
DOT	Department of Transportation
DSRC	Dedicated Short-Range Communications
ERB	Enterprise Service Bus
ERP	Enterprise Resource Planning
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
FTA	Federal Transportation Administration
HVAC	Heating, Ventilation and Air-Conditioning
INCOSE	International Council on Systems Engineering
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ISO	International Organization for Standardization
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation System
JPO	Joint Program Office
JTA	Jacksonville Transportation Authority
LT	Long-Term
MOSA	Modular Open System Approach
MT-E	Mid-Term, Elevated (Guideway)
MT-A	Mid-Term, At-Grade (Roadway)
NEMA	National Electrical Manufacturers Association
NHTSA	National Highway Traffic Safety Administration
NTCIP	National Transportation Communications for Intelligent Transportation System Protocol

Acronyms and Abbreviations	
OBE	Onboard Equipment
RFI	Request for Information
RFP	Request for Proposal
RSE	Roadside Equipment
SAE	Society of Automotive Engineer's
SE	Systems Engineering
SCADA	Supervisory Control and Data Acquisition
ST	Short-Term
U²C	Ultimate Urban Circulator
USDOT	United States Department of Transportation
V2I	Vehicle to Infrastructure (Communication)
V2V	Vehicle to Vehicle (Communication)
V2X	Vehicle to Everything (Communication)
W3C	World Wide Web Consortium

1.5 Definitions

Table 1-3 presents definitions used throughout this document, as well as the organization associated with each definition.

Table 1-3: Definitions

Definitions	
Automated Vehicle	SAE: A vehicle that employs a driving automation system to perform part or all of the dynamic driving task on a sustained basis (SAE J3016). There are six defined levels of driving automation: • Level 0: No Automation • Level 1: Driver Assistance • Level 2: Partial Automation • Level 3: Conditional Automation • Level 4: High Automation • Level 5: Full Automation The automated vehicles described in this document will likely be level 4 in the short and mid-term and level 5 in the long-term.
Business Requirement	INCOSE: The definition of the business framework within which stakeholders will define their requirements. Business requirements govern the project, including agreement constraints, quality standards, and cost and schedule constraints.

Definitions	
Connected Vehicle	USDOT: A vehicle that is enabled by device and network technology to communicate with other vehicles, buses, trucks, trains, roads, other infrastructure, smartphones and other devices in real-time.
Interoperability	Ability to exchange information and services with minimal effort. Facilitated by common standards or interfaces.
Mid-Term	JTA: Time horizon for implementation of the desired System Requirements. To be demonstrated on either the converted JTA Elevated Skyway Guideway, or in a shared At-Grade environment (Public Roadways).
Long-Term	JTA: Time horizon for implementation of the desired System Requirements. Full U²C System Build Out, including the converted JTA Elevated Skyway Guideway AND the shared At-Grade environment (Public Roadways).
Short-Term	JTA: Time horizon for implementation of the desired System Requirements. To be demonstrated on the JTA Test Track.
System Requirement	INCOSE: What the system needs to do, how well, and under what conditions, as required to meet the project and design constraints. In the context of this document *System Requirement* refer to the U²C Vehicle requirements.
Stakeholder Requirement	INCOSE: Requirements from various stakeholders that will govern the project, including required system capabilities, functions, and/or services; quality standards; systems constraints; and cost and schedule constrains.
V2I	US DOT: Vehicle-to-Infrastructure communication, technologies that capture vehicle-generated traffic data, wirelessly providing information such as advisories from the infrastructure to the vehicle that inform the driver of safety, mobility, or environment-related conditions.
V2V	US DOT: Vehicle-to-Vehicle communication, the wireless exchange of data among vehicles traveling in the same vicinity which offers significant safety improvements.
V2X	US DOT: Vehicle-to-Everything communication, wireless communication between vehicles, infrastructure, mobile devices, other vehicles, and pedestrians.

2 U²C VEHICLE SYSTEM OVERVIEW

2.1 System Context Diagram

The purpose of this document is to describe the basic requirements of **U²C Vehicles**. As such it is important to define a boundary between U²C Vehicles and other systems and system elements that are also part of the larger U²C system.

The **U²C Vehicle System Context Diagram** as presented in Figure 2-1 identifies the system boundaries between U²C Vehicles and their environment, including interfacing systems and their stakeholders.

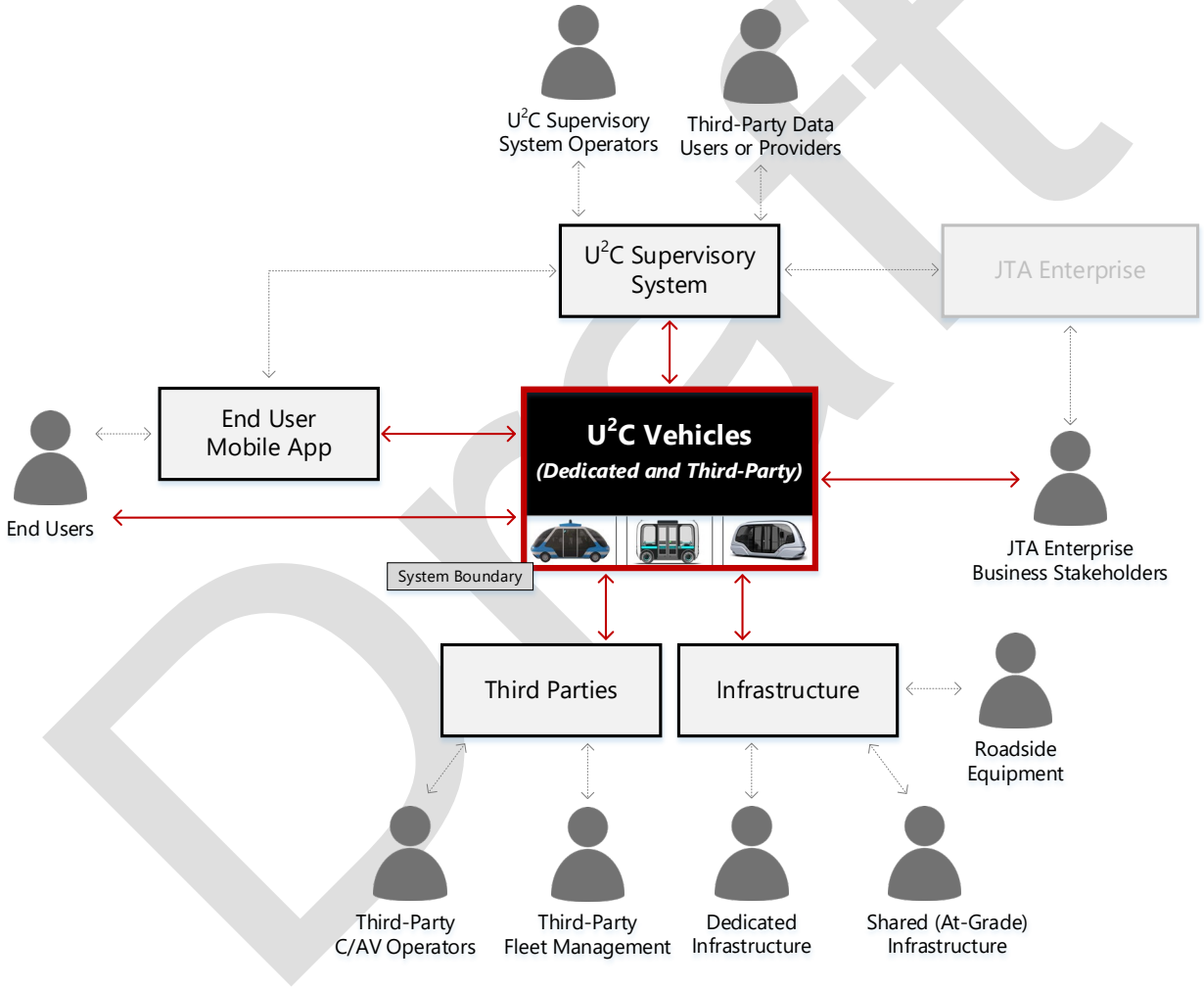

Figure 2-1: U²C Vehicle System Context Diagram

Section 2.2 below analyzes in more detail the U²C Vehicle **Stakeholders and Interfacing Systems,** starting with JTA Enterprise Business Stakeholders.

Section 3 defines the **Basic Requirements** of U²C Vehicles using the U²C stakeholder groups and individual stakeholders identified in Section 2.2 to structure the basic requirements.

Section 4 provides an overview of the **Key Decision Points** that will guide the market study analysis and eventual procurement document development.

2.2 Stakeholders and Interfacing Systems

This section provides additional detail to describe the Stakeholders and Interfacing Systems introduced in Figure 2-1.

Refer to the following sections for each group of stakeholders and interfacing systems:

- JTA Enterprise: Section 2.2.1
- U²C Supervisory System: Section 2.2.2
- End Users: Section 2.2.3
- Third Parties: Section 2.2.4
- Infrastructure: Section 2.2.5

2.2.1 JTA Enterprise Stakeholders

This section identifies JTA Enterprise Stakeholders, who help define the business requirements of U²C Vehicles.

Stakeholders:

- Operations & Maintenance
- Safety & Security
- Information Technology
- Planning
- Capital Programs
- Engineering
- Finance
- Procurement
- Compliance
- Communications

2.2.2 U²C Supervisory System Stakeholders

This section identifies the U²C Supervisory System stakeholders and systems, some of whom are second-degree stakeholders of U²C Vehicles through the U²C Supervisory System. See the U²C Program Supervisory System Planning Business Case and Market Analysis Basic Requirements report for additional detail on the U²C Supervisory System and its stakeholders and requirements.

Stakeholders:

- U²C Supervisory System Operators
- Third-Party Data Users or Providers

Systems:

- Trapeze
- Waze
- Bestmile
- SCADA
- Third-Party Data Interface/System

2.2.3 End User Stakeholders

This section identifies the End User stakeholders and systems.

Stakeholders:

- Passengers

Systems:

- Mobile Application (Smartphone, Tablet)
- Web Interface (Personal Computer, Tablet)
- Telephone (Automated or Human Interface)

2.2.4 Third-Party Stakeholders

This section identifies the Third-Party stakeholders and systems.

Stakeholders:

- Third-Party C/AV Operators
- Third-Party Fleet Management

Systems:

- Third-Party Fleet: C/AVs operating on the dedicated JTA guideway and/or on public roadways, under contract with JTA

2.2.5 Infrastructure Stakeholders

This section identifies the Infrastructure stakeholders and systems.

Stakeholders:

- Dedicated JTA Guideway
- Shared At-Grade
- Roadside Equipment

Systems:

- Dedicated JTA Guideway
- Shared At-Grade Environment (Public Roadways)
- Roadside Equipment

3 U²C BASIC VEHICLE REQUIREMENTS

This section describes the **Basic Requirements** of **U²C Vehicles** as a black box, defining an initial set of requirements as input into *Task 3 – Market Study Analysis* (see Section 1.1). These requirements are not all inclusive and there may be circumstances which dictate the need to add to or modify this list. For more information on interoperability requirements, refer to the U²C Program Supervisory System Planning Business Case and Market Analysis Basic Requirements report.

The requirements will be further developed to a detailed level suitable for an RFP level at a later stage in *Task 7 – Prepare RFP Documents*. In the current state, the requirements can be used to request additional information from industry, as needed. These requirements are particular to the JTA U²C program but are believed to be analogous to critical requirements for all public transit agencies looking to deploy a similar automated shuttle service.

The requirements in this section are **organized by stakeholders** as shown below. This enables stakeholders to readily identify their requirements by means of **keyword search**:

- Heading 2: Stakeholder Group (e.g. Section 3.4 Third-Party Stakeholders)
    - Heading 3: Individual Stakeholders (e.g. Section 3.4.1 Third-Party C/AV Operators)

The requirements are further grouped by **categories** as shown in Table 3-1, generally following the scope of work items identified in Section 1.1. Each requirement will receive a **unique identifier**. Additionally, requirements will be allocated to **U²C stages** as defined in section 1.5:

- **ST**: Short-term
- **MT-E**: Mid-term, use of existing JTA Skyway Elevated Guideway
- **MT-A**: Mid-term, use of shared At-Grade Environment
- **LT**: Long-term, full build out

Table 3-1: U²C Basic Vehicle Requirements – Example

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
	Category: e.g. Cyber Security				
#XYZ	System Requirement: e.g. The U²C Vehicles shall…	X			

3.1 General Requirements

While many U²C Basic Vehicle Requirements can be described from the perspective of stakeholders of the system, some are general requirements essential to the core functionality of the system and not defined by individual stakeholder needs.

3.1.1 System Level Requirements

This section describes "high-level" (system-level) requirements of U²C Vehicles.

Table 3-2: System Level Requirements

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.1.1-01	**Business and Stakeholder**				
3.1.1-01.01	U²C Vehicles shall meet and/or exceed the system requirements set forth in this requirements documents, thereby meeting the JTA Enterprise (business) and stakeholder requirements.		X	X	X
3.1.1-01.02	U²C Vehicles shall be properly insured, with policies that meet or exceed the requirements set by JTA.	X	X	X	X
3.1.1-01.03	U²C Vehicles shall be required to **prove** their capabilities to JTA. This may include possible third-party verification in the longer term, and in the shorter term will include demonstrations on the JTA Test Track.	X	X	X	X
3.1.1-02	**Applicable Standards**				
3.1.1-02.01	U²C Vehicles shall meet and/or exceed applicable federal, state, and local regulations, codes, and standards. Federal, state, and local regulations, codes, and standards include (in alphabetical order), but are not limited to: • American Association of State Highway and Transportation Officials (AASHTO) • American National Standards Institute (ANSI) • American Public Transportation Association (APTA) • American Society for Testing and Materials (ASTM) • Americans with Disabilities Act of 1990 (ADA) • Buy America/Buy American • Code of Federal Regulations (CFR) • Connected Vehicle Reference Implementation Architecture (CVRIA) Standards • Federal Highway Administration (FHWA) • Federal Transit Administration (FTA) • Florida Department of Transportation (FDOT) • Intelligent Transportation System (ITS) Joint Program Office (JPO) • International Organization for Standardization (ISO) • Internet Engineering Task Force (IETF) • Institute of Electrical and Electronics Engineers (IEEE) • Institute of Transportation Engineers (ITE) • National Electrical Manufacturers Association (NEMA) • National Highway Traffic Safety Administration (NHTSA)	X	X	X	X

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
	• National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) • Society of Automotive Engineers (SAE) • United States Department of Transportation (USDOT) • World Wide Web Consortium (W3C)				
3.1.1-03	**System Functionality**				
3.1.1-03.01	U²C Vehicles shall employ connected and automated vehicle (C/AV) technology with automation levels 4 (high automation) or 5 (full automation), as defined by the Society for Automotive Engineers (SAE).	X	X	X	X
3.1.1-03.02	U²C Vehicles shall provide the functionalities currently provided by the existing JTA Skyway (Monorail) system. More specificity on this requirement is outlined in subsequent sections.		X	X	X
3.1.1-03.03	U²C Vehicles shall demonstrate their functionality on JTA's automated vehicle test track.	X			
3.1.1-03.04	The entire U²C Vehicle fleet shall support operations on shared at-grade infrastructure (public roadways).	X		X	X
3.1.1-03.05	A portion of the U²C Vehicle fleet shall support operations on the dedicated JTA elevated guideway that is currently being used for the existing JTA Skyway system. The guideway will be converted for C/AV operation to provide an environment more similar to typical public roadways.	X	X		X
3.1.1-03.06	U²C Vehicles shall support the following four CVRIA Applications, their sub-groups and associated functionality, including but not limited to: • Environmental, • Mobility, • Safety, and • Support. For more information visit: http://local.iteris.com/cvria/html/applications/applications.html.		X	X	X
3.1.1-03.07	U²C Vehicles shall support the CVRIA functional requirements, presented as CVRIA Processes. For more information visit: http://local.iteris.com/cvria/html/pspecs/processes.html.		X	X	X
3.1.1-03.08	All U²C Vehicle systems shall be based upon a Modular Open Systems Approach (MOSA) employing a modular design, and using widely supported, open (publicly available) and consensus-based standards for all key		X	X	X

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
	interfaces. Proprietary interface standards shall not be acceptable.				
3.1.1-03.09	U²C Vehicles shall be able to skip (pass through) station stops if the vehicle cannot accommodate additional riders and there are no requests to alight.			X	X
3.1.1-03.10	U²C Vehicles shall be able to skip (pass through) station stops if there are no scheduled station stops.			X	X
3.1.1-03.11	U²C Vehicles shall be able to bypass C/AVs (run around) as required by the situation.			X	X
3.1.1-03.12	U²C Vehicles shall be able to platoon with other C/AVs from the same manufacturer.	X	X	X	X
3.1.1-03.13	U²C Vehicles shall be able to platoon with other C/AVs from different manufacturers.	X	X	X	X
3.1.1-03.14	U²C Vehicles shall be able to platoon with dedicated JTA and third-party operated C/AVs.			X	X
3.1.1-03.15	U²C Vehicles shall have back-up systems and protocols for safe operations during inclement weather. This may include a service suspension, especially in the shorter term.	X	X	X	X
3.1.1-04	**System Architecture**				
3.1.1-04.01	U²C Vehicles shall each implement modular and open system architecture, thereby enabling interoperability. A modular and open system architecture is defined in section 1.2.2.	X	X	X	X
3.1.1-04.02	Interfaces between U²C Vehicle onboard equipment (OBE) components shall meet the U²C interoperability requirements.	X	X	X	X
3.1.1-05	**Vehicles from Different Manufacturers**				
3.1.1-05.01	All U²C Vehicles shall be able to interact with other single U²C Vehicles and other C/AVs from the same manufacturer using interoperable interface standards.	X	X	X	X
3.1.1-05.02	All U²C Vehicles shall be able to interact with other platooned U²C Vehicles and other C/AVs from the same manufacturer using interoperable interface standards.		X		X
3.1.1-05.03	All U²C Vehicles shall be able to interact with other single U²C Vehicles and other C/AVs from different manufacturers using interoperable interface standards.		X	X	X
3.1.1-05.04	All U²C Vehicles shall be able to interact with other platooned U²C Vehicles and other C/AVs from different manufacturers using interoperable interface standards.				X
3.1.1-06	**System Capacity**				

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.1.1-06.01	The U²C Vehicle fleet shall be able to handle the current JTA Skyway ridership demand.	X	X		
3.1.1-06.02	The U²C Vehicle fleet shall be able to handle future anticipated U²C ridership demand.		X	X	X
3.1.1-06.03	U²C Vehicles shall have the ability to regulate passenger capacity.	X	X	X	X

3.1.2 Vehicle Specification Requirements

This section describes U²C Basic Vehicle Requirements associated with the form factor and core capabilities of the Vehicles, that inform vehicle specifications.

Table 3-3: Vehicle Specification Requirements

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.1.2-01	**Vehicle Form**				
3.1.2-01.01	U²C Vehicles shall comply with all applicable Federal Motor Vehicle Safety Standards (FMVSS) or have approval to operate under an exemption to the FMVSS.	X		X	X
3.1.2-01.02	U²C Vehicles shall have NHTSA approval to operate on public roadways.	X		X	X
3.1.2-01.03	U²C Vehicles shall have a sleek design.		X	X	X
3.1.2-01.04	The U²C Vehicle fleet shall be comprised of multiple vehicle types with various dimensions and capacities.		X	X	X
3.1.2-01.05	All U²C Vehicles shall have the appropriate dimensions to be able to operate on public roadways.	X		X	X
3.1.2-01.06	Some U²C Vehicles shall have the appropriate dimensions to operate on the elevated guideway, including not exceeding the weight limit.	X	X		X
3.1.2-01.07	U²C Vehicles shall provide both seated and standing options for passengers.	X	X	X	X
3.1.2-01.08	U²C Vehicles shall be crash worthy up to 35 mph.	X	X	X	X
3.1.2-02	**Vehicle Connectivity**				
3.1.2-02.01	U²C Vehicles shall have access to and be capable of communicating with infrastructure and other vehicles over a standards-based, highly reliable communications network. Examples include but are not limited to DSRC or C-V2X.	X	X	X	X
3.1.2-02.02	U²C Vehicles shall have access to redundant, backup systems that provide complementary coverage. Examples include 4G LTE, 3G, and WiFi, in addition to the primary network.	X	X	X	X

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.1.2-02.03	U²C Vehicles shall have access to flexible, interoperable communication systems that can evolve over time as standards and best practices improve.	X	X	X	X
3.1.2-02.04	U²C Vehicles shall communicate over a system using equipment that is not sensitive to hot and/or wet weather conditions, or other conditions that are common in Jacksonville.	X	X	X	X
3.1.2-02.05	U²C Vehicles shall be able to send small datasets (such as information on their current vehicle location) over a wireless network while the vehicle is in operation.	X	X	X	X
3.1.2-02.06	U²C Vehicles shall be able to accommodate higher-bandwidth data, such as video, over a wireless network for remote monitoring, insight into safety-critical onboard situations, and some limited personal entertainment use by passengers (as lowest priority).				X
3.1.2-02.07	U²C Vehicles shall be able to send and receive large data packets such as software updates in a secure and efficient manner when the vehicle is docked at its storage facility.	X	X	X	X
3.1.2-02.08	U²C Vehicles shall have at least one method to manually signal emergency situations within or in close proximity to the vehicle. Examples include but are not limited to a panic button or a telephone that allows voice calls to a central control center and/or emergency services.	X	X	X	X
3.1.2-02.09	Vehicle-to-vehicle communications shall allow platooning of U²C Vehicles, including those of different manufacturers.		X		X
3.1.2-02.10	U²C Vehicles shall be able to connect and interoperate with the interfacing systems as identified in Figure 2-1.	X	X	X	X
3.1.2-02.11	U²C Vehicles shall be able to connect and interoperate with other "Physical Objects", as defined by the CVRIA. For more information visit: https://local.iteris.com/cvria/html/physobjects/physobjects.html.		X	X	X
3.1.2-02.12	U²C Vehicles shall be capable of receiving suggestions on how to proceed when faced with an unfamiliar situation, with actual decisions made on board for security reasons.		X	X	X
3.1.2-02.13	U²C Vehicle OBE shall be able to interact with roadside equipment (RSE) using interoperable interface standards. For more information on roadside equipment visit: http://local.iteris.com/cvria/html/physobjects/physobj11.html#tab-0.	X	X	X	X
3.1.2-02.14	U²C Vehicle OBE shall be able to interact with other CVRIA "Physical Objects" using interoperable interface standards.	X	X	X	X

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
	For more information on CVRIA "Physical View" and "Physical Objects" visit: https://local.iteris.com/cvria/html/viewpoints/physical.html https://local.iteris.com/cvria/html/physobjects/physobjects.html.				
3.1.2-02.15	U²C Vehicles shall be able to interact with the U²C Supervisory System, using interoperable interface standards. For more information on the U²C Supervisory System, refer to section 2.2.2.	X	X	X	X
3.1.2-03	**Vehicle Operating Speed**				
3.1.2-03.01	U²C Vehicles operating on the guideway shall match the speed of existing Skyway vehicles.	X	X	X	X
3.1.2-03.02	U²C Vehicles operating at-grade shall match the roadway speed limit or a safe traffic speed.	X	X	X	X
3.1.2-03.03	U²C Vehicles shall be able to operate bidirectionally up to 35 mph.				
3.1.2-04	**Vehicle Power**				
3.1.2-04.01	U²C Vehicles shall be battery electric.		X		X
3.1.2-04.02	U²C Vehicles shall have a sufficient operating range that allows the fleet to fully service all U²C operating hours. This includes greater than or equal to 12 hours of battery life.	X	X	X	X
3.1.2-04.03	U²C Vehicles shall provide information on the vehicle's energy level, ensuring the vehicles are sufficiently charged or taken out of service early under abnormal conditions after servicing all passengers who are already on board to avoid losing charge during service.	X	X	X	X
3.1.2-04.04	U²C Vehicles shall be capable of operating on their intended paths even when fully loaded and climate controlled.	X	X	X	X
3.1.2-04.05	U²C Vehicles shall be capable of being charged at their overnight storage location.	X	X	X	X
3.1.2-04.06	U²C Vehicles shall be capable of opportunity charging, or receiving additional charge during layover or other midday opportunities.				X
3.1.2-04.07	U²C Vehicles shall have replaceable batteries, fast charging, or another method of quick charging.				X
3.1.2-05	**Navigation Systems**				
3.1.2-05.01	U²C Vehicles shall employ navigation and guidance systems that provide an appropriate level of accuracy for the environment in which they are operating (i.e., elevated guideway, dedicated lane, shared at-grade). This could include GPS and/or GNSS.	X	X	X	X

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.1.2-05.02	U²C Vehicles shall use multiple methods for localization.	X	X	X	X
3.1.2-05.03	U²C Vehicles shall be capable of tracking the nearest distance and best path to a route when off-route.				X
3.1.2-05.04	U²C Vehicles shall have redundant guidance and mapping systems, so if a primary system is down or provides insufficient information, the vehicle still has basic functionality related to safety, obstacle avoidance, and passenger egress locations.	X	X	X	X
3.1.2-05.05	U²C Vehicles shall be able to coordinate sensors with rich, pre-made maps and shall be able to provide these maps for JTA management use and passenger information.				X
3.1.2-05.06	All U²C Vehicles shall be capable of understanding the same interoperable set of maps, so that when a new vehicle is introduced to the system it has all legacy maps available for use.				X
3.1.2-05.07	U²C Vehicles shall have guidance systems that enable them to operate through construction zones and other changing roadway conditions, including planned and unplanned route detours. Remote and/or local human support may be necessary, especially in the shorter term.				X
3.1.2-05.08	U²C Vehicles shall be able to self-navigate using a base city map rather than a full onboard 3D lidar map (or a similar solution that allows for a larger service area given onboard computing capacity) during future on-demand and off-route service.				X
3.1.2-06	**Vision Systems**				
3.1.2-06.01	U²C Vehicles shall have the ability to handle all relevant environmental and topographical constraints they may encounter, including but not limited to local weather conditions, grades (on the guideway, and eventually ramps between the guideway and the at-grade area), and differing pavement types and conditions. This includes traversing slopes of ± 12 degrees with a full passenger load under sustained acceleration/deceleration.	X	X	X	X
3.1.2-06.02	U²C Vehicles shall be able to operate within the narrow guideway width. This will require the vehicles to be able to differentiate between fixed and mobile objects, including the guideway walls. Specifically, U²C Vehicles shall be able to operate at speeds of 15 mph within ± 1 foot of a stationary object and within ± 3 feet of a moving object.	X	X		X

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.1.2-06.03	U²C Vehicles shall be able to operate during all times of day (darkness, brightness, angled sunlight in the morning and evening, etc.).		X	X	X
3.1.2-06.04	U²C Vehicles shall be able to manage and/or switch between different levels of complexity (i.e., pedestrians detected on sidewalks while traveling at-grade may cross the street, while pedestrians at elevated guideway stop locations are unlikely to enter the guideway right-of-way) and employ varying responses to object detection in these different environments (i.e., deciding whether to stop, slow down, or continue).				X
3.1.2-06.05	U²C Vehicles shall utilize various vision sensors and technologies whose strengths complement the weaknesses of others. For example, if one technology is best at detecting objects 50 feet away, but cannot detect objects that are 5 feet away, another system (such as one that senses heat) could be used to provide this information.		X	X	X

3.1.3 Dedicated Vehicle Requirements

Table 3-4: Dedicated Vehicle Requirements

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.1.3-01	**Dedicated Vehicles**				
3.1.3-01.01	Dedicated JTA U²C Vehicles shall be able to interface with Vehicle OBE.		X	X	X
3.1.3-01.02	Dedicated JTA U²C Vehicles shall make provisions for spatial, electrical, mechanical, HAVC, data, and other interfaces, as required.		X	X	X
3.1.3-01.03	Dedicated JTA U²C Vehicles shall be able to provide an equivalent service to JTA passengers as current Skyway vehicles.	X	X		X

3.1.4 Third-Party Vehicle Requirements

Table 3-5: Third-Party Vehicle Requirements

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.1.4-01	**Third-Party Vehicles**				
3.1.4-01.01	Third-party JTA U²C Vehicles shall be able to interface with Vehicle OBE.				X
3.1.4-01.02	Third-party JTA U²C Vehicles shall make provisions for spatial, electrical, mechanical, HVAC, data and other interfaces, as required.				X

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.1.4-01.03	Third-party JTA U²C Vehicles shall be able to provide an equivalent service to JTA passengers as current Skyway vehicles.				X

3.2 JTA Enterprise

3.2.1 Operations & Maintenance

This section describes U²C Basic Vehicle Requirements from a JTA Operations & Maintenance perspective, including all modes of transportation.

Table 3-6: JTA Enterprise – Operations & Maintenance

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.1-01	**Staffing**				
3.2.1-01.01	Acquisitions of U²C Vehicles shall include clarity on staffing requirements, including whether and when onboard operators and/or remote monitors are necessary.	X	X	X	X
3.2.1-02	**Data**				
3.2.1-02.01	U²C Vehicles shall collect data that helps provide JTA Operations & Maintenance personnel a variety of standard performance metrics for operations & maintenance purposes, such as the rate of disengagements of the vehicle system and ongoing maintenance costs.		X	X	X
3.2.1-02.02	Weekly reporting of diagnostic/vehicle performance data provided to the JTA in the form of "raw data" in electronic format, to be mutually agreed upon by both parties. .		X	X	X
3.2.1-03	**Maintenance**				
3.2.1-03.01	U²C Vehicles shall be maintained through modular maintenance procedures when possible. Modular components shall be removed, bench tested, and repaired as needed using on-the-spot diagnostics.		X	X	X
3.2.1-03.02	Whether U²C Vehicles are operated and/or maintained by JTA or a third party, maintenance procedures shall include training of and oversight by JTA staff.	X	X	X	X

3.2.2 Safety & Security

This section describes U²C Basic Vehicle Requirements from a JTA Safety & Security perspective.

Table 3-7: JTA Enterprise – Safety & Security

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.2-01	**Voice Passenger Communications**				

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.2-01.01	U²C Vehicles shall enable onboard voice passenger communication.		X	X	X
3.2.2-02	**Passenger Safety and Security**				
3.2.2-02.01	U²C Vehicles shall be equipped with on-board video cameras that allow viewing of the passenger compartment in real time.		X	X	X
3.2.2-02.02	U²C Vehicles shall be equipped with video cameras that allow viewing of a 360 degree view external to the vehicle in real time.		X	X	X
3.2.2-02.03	U²C Vehicles shall be equipped with a system for storing video and other recordings for at least 30 days.		X	X	X
3.2.2-03	**Passenger Safety and Security**				
3.2.2-03.01	U²C Vehicles shall support a safe and secure passenger ride experience.	X	X	X	X
3.2.2-03.02	U²C Vehicles shall be part of a fail-safe system, and be capable of being routed to a place of safety in case of safety or security issues.	X	X	X	X
3.2.2-03.03	U²C Vehicles shall have protocols for emergency passenger egress and emergency service access, including on the elevated guideway (which may require exits at the front and/or back of the vehicle).	X	X	X	X
3.2.2-04	**Physical and Cyber Security**				
3.2.2-04.01	U²C Vehicles shall support the CVRIA "Security" requirements. For more information visit: http://local.iteris.com/cvria/html/about/security.html		X	X	X
3.2.2-04.02	U²C Vehicle systems shall implement the CVRIA Security Concept and the "Cooperative ITS Credentials Management System". For more information visit: https://local.iteris.com/cvria/html/about/security.html https://local.iteris.com/cvria/html/physobjects/physobj86.html.	X	X	X	X
3.2.2-04.03	U²C Vehicle systems shall implement the CVRIA Safety "Applications", using interoperable interface standards. For more information visit: https://local.iteris.com/cvria/html/applications/applications.html.	X	X	X	X
3.2.2-04.04	U²C Vehicles shall have a safe location for storage (overnight and when otherwise not in service) to keep the	X	X	X	X

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
	sensors and other vehicle components secure from tampering and environmental hazards.				
3.2.2-04.05	U²C Vehicles shall support the safety and security of infrastructure.	X	X	X	X
3.2.2-04.06	U²C Vehicles shall employ a secure and low-latency method of remote operation and/or interventions by an onboard operator employed by JTA.	X	X	X	X
3.2.2-04.07	U²C Vehicles shall provide a means of secure override by passengers (that is limited to requesting support from remote JTA staff and possibly stopping the vehicle and opening the doors).	X	X	X	X

3.2.3 Information Technology

This section describes U²C Basic Vehicle Requirements from a JTA Information Technology perspective.

Table 3-8: JTA Enterprise – Information Technology

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.3-01	**Cyber Security**				
3.2.3-01.01	U²C Vehicle systems shall provide access to authenticated and authorized users and systems only.	X	X	X	X
3.2.3-01.02	U²C Vehicle systems shall use secure communication protocols and secure handshakes when establishing connections with other systems.	X	X	X	X

3.2.4 Planning

This section describes U²C Basic Vehicle Requirements from a JTA Planning perspective.

Table 3-9: JTA Enterprise – Planning

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.4-01	**Data**				
3.2.4-01.01	U²C Vehicles shall collect data that helps provide JTA Planning personnel a variety of standard performance metrics for transportation planning purposes, including ridership, vehicle miles and hours traveled, and actual stop arrival and departure times.		X	X	X
3.2.4-01.02	U²C Vehicles shall be able to collect additional data, to support JTA Planning staff configuration of additional, custom performance metrics.		X	X	X

3.2.5 Capital Programs

This section describes U²C Basic Vehicle Requirements from a JTA Capital Programs perspective.

Table 3-10: JTA Enterprise – Capital Programs

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.5-01	**Data**				
3.2.5-01.01	U²C Vehicles shall collect data that helps provide JTA Capital Program personnel a variety of standard performance metrics for program planning purposes, including the ability to operate in different infrastructure environments, incident reports, and boardings and alightings by stop location.		X	X	X
3.2.5-01.02	U²C Vehicles shall be able to collect additional data, to support JTA Capital Program staff configuration of additional, custom performance metrics.		X	X	X

3.2.6 Engineering

This section describes U²C Basic Vehicle Requirements from a JTA Engineering perspective.

Table 3-11: JTA Enterprise – Engineering

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.6-01	**Data**				
3.2.6-01.01	U²C Vehicles shall collect data that helps provide JTA Engineering personnel a variety of standard performance metrics for engineering purposes, including navigational variances, samples of sensor and/or probe data, and other vehicle performance metrics such that they can be associated with infrastructure conditions.		X	X	X
3.2.6-01.02	U²C Vehicles shall be able to collect additional data, to support JTA Engineering staff configuration of additional, custom performance metrics.		X	X	X

3.2.7 Finance

This section describes U²C Basic Vehicle Requirements from a JTA Finance department perspective.

Table 3-12: JTA Enterprise – Finance

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.7-01	**Data**				
3.2.7-01.01	U²C Vehicles shall collect and share data to improve financial business decisions, including vehicle lifecycle costs.		X	X	X
3.2.7-01.03	U²C Vehicles shall collect data that may be able to provide financial value to JTA. JTA will then assess the value capture potential of this data.		X	X	X
3.2.7-02	**Revenue Potential**				
3.2.7-02.01	U²C Vehicles shall have payment verification functionality.				X

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.7-02.02	U²C Vehicles shall be able to provide real time and location-based information to enable advertisers to provide customized advertisements.				X
3.2.7-02.03	JTA shall leverage opportunities for public-private partnerships to support the acquisition and operation of dedicated and third-party U²C Vehicles.		X	X	X
3.2.7-02.04	U²C Vehicles shall be allowed to be wrapped or otherwise branded, though vendors may provide limitations on the placement of branding to avoid occluding vital system functions.	X	X	X	X
3.2.7-02.05	U²C Vehicles shall be equipped with fare payment technology that provides the same functionalities as current vehicles, including: • JTA's App • TVM ticket that provides a scan enabled RC code • Star Card tap (if the current scanner has the ability to accept this receipt mechanism) Cash will not be collected on the vehicles.			X	X
3.2.7-02.06	The system shall also provide fare payment technology off the vehicles, including: • TVMs at stations (to produce a ticket for cash paying customers) • Cash and credit card acceptance kiosk JTA's goal is to move customers to an account based system and encourage contactless payment options such as mobile. Open payment platforms are ideal.		X	X	X

3.2.8 Procurement

This section describes U²C Basic Vehicle Requirements from a JTA Procurement perspective.

Table 3-13: JTA Enterprise – Procurement

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.8-01	**Informed Best Practice**				
3.2.8-01.01	U²C Vehicles shall be procured via industry best practices (including whether leasing or purchase is appropriate).	X	X	X	X
3.2.8-01.02	U²C Vehicles shall collect and share data to improve procurement decisions, including information on initial cost, lifecycle cost, and useful life, to guide future deployments	X	X	X	X
3.2.8-01.03	U²C Vehicles, both dedicated and third-party, shall have clear contract requirements and service agreements that have been thoroughly reviewed by all appropriate parties at JTA.	X	X	X	X

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.8-01.04	Leased U²C Vehicles shall have extendable contracts, with options for JTA.		X	X	X
3.2.8-01.05	The procurement of U²C Vehicles shall comply with Buy America and Buy American requirements.	X	X	X	X

3.2.9 Compliance

This section describes U²C Basic Vehicle Requirements from a JTA Compliance department perspective.

Table 3-14: JTA Enterprise – Compliance

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.9-01	**Applicable Standards**				
3.2.9-01.01	U²C Vehicles shall be in compliance with applicable standards, including those identified in section 3.1.	X	X	X	X
3.2.9-02	**Data**				
3.2.9-02.01	U²C Vehicles shall track how much revenue each vehicle generates from advertisement to report to the Federal Transportation Administration (FTA).				X

3.2.10 Communications

This section describes U²C Basic Vehicle Requirements from a JTA Communications perspective.

Table 3-15: JTA Enterprise – Communications

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.2.10-01	**Branding and Marketing**				
3.2.10-01.01	All U²C vehicle vendors shall maintain communications with JTA and ensure a consistent external-facing message, especially in the event of any incidents.	X	X	X	X
3.2.10-01.02	U²C Vehicles shall be operated, advertised, and branded to minimize risk to JTA's reputation	X	X	X	X
3.2.10-01.03	U²C Vehicles shall have a method of disseminating a passenger survey, such as an onboard tablet, QR code, or handout with a link, to receive feedback.	X	X	X	X

3.3 U²C Supervisory System

The U²C Supervisory System is an interoperable control system that oversees a variety of JTA systems, including U²C Vehicles.

3.3.1 U²C Supervisory System Operators

This section describes U²C Basic Vehicle Requirements from a U²C Supervisory System Operator perspective.

Table 3-16: U²C Supervisory System – U²C Supervisory System Operators

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.3.1-01	**Control Center**				
3.3.1-01.01	U²C Vehicles shall communicate with the Control Center to receive information that enables efficient operation, avoiding conflicts, congestion, and/or collisions between C/AVs, including but not limited to: • While taking vehicles into or out of service • During service runs • During boarding or alighting of passengers		X	X	X
3.3.1-01.02	U²C Vehicles shall, via the Supervisory System, allow for the monitoring and control of all operations and maintenance system functions from a central (Control Center) location.		X	X	X
3.3.1-01.03	U²C Vehicles shall be able to respond promptly to requests from the Supervisory System to leave standby mode and return into service due to reasons including but not limited to ridership demand				X
3.3.1-01.04	U²C Vehicles shall be able to be taken automatically out of service by the Supervisory System due to reasons including but not limited to: • Planned maintenance activities (e.g. charging) • Unplanned maintenance activities (e.g. repairs) This will be facilitated by a request from the Supervisory System to leave service. However, U²C Vehicles shall have the onboard capability to make the final decision, and will use their normal systems to finish existing passenger trips and navigate to their storage facility or another safe location.				X
3.3.1-02	**Data**				
3.3.1-02.01	U²C Vehicles shall collect passenger count information (boardings and alightings) and share this data with the Supervisory System.	X	X	X	X
3.3.1-02.02	U²C Vehicles shall collect, record, and archive vehicle route information (short-term and long-term) and share this data with the Supervisory System.		X	X	X
3.3.1-02.03	U²C Vehicles shall collect, record, and archive vehicle diagnostic information (short-term and long-term) and share this data with the Supervisory System.		X	X	X

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.3.1-03	**Health Monitoring**				
3.3.1-03.01	U²C Vehicles shall be able to present failure alarms to the Supervisory System.		X	X	X
3.3.1-03.02	U²C Vehicles shall provide information to the Supervisory System on whether a vehicle has stopped, where, and why.		X	X	X
3.3.1-03.03	U²C Vehicles shall be equipped with a complete vehicle monitoring system, including health monitoring.		X	X	X
3.3.1-04	**Location/Route Setting**				
3.3.1-04.01	U²C Vehicles shall receive and follow location/route setting functionality for fixed routes and schedules.		X	X	X
3.3.1-04.02	U²C Vehicles shall receive and follow location/route setting functionality for flexible routes based on ridership demand.				X
3.3.1-04.03	U²C Vehicles shall receive and follow location/route setting functionality for flexible schedules based on ridership demand.				X
3.3.1-04.04	Remote route and schedule programming of U²C Vehicles shall be conducted with low latency.				X
3.3.1-05	**Voice Passenger Communications**				
3.3.1-05.01	U²C Vehicles shall be capable of allowing operations and maintenance personnel to contact riders on the vehicles via the Supervisory System.		X	X	X

3.3.2 Third-Party Data Users or Providers

This section describes U²C Basic Vehicle Requirements from a Third-Party Data User or Provider perspective.

Table 3-17: U²C Supervisory System – Third-Party Data Users or Providers

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.3.2-01	**System Connectivity**				
3.3.2-01.01	U²C Vehicles shall, via the Supervisory System, be able to receive and process data from third parties (e.g. for advertisement purposes).		X	X	X
3.3.2-01.02	U²C Vehicles shall, via the Supervisory System, be able to process and send data to third parties (e.g. for analytics purposes).		X	X	X

3.4 End User

The primary purpose of the U2C System, and thereby U2C Vehicles, is to transport End Users of the system to their destinations.

3.4.1 Passengers

This section describes U²C Basic Vehicle Requirements from the perspective of the End Users, Passengers.

Table 3-18: End User – Passengers

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.4.1-01	**Passenger Comfort**				
3.4.1-01.01	U²C Vehicles shall provide protection from environmental conditions (i.e., weather) and provide climate control (including heating and air conditioning) in the passenger cabin. Internal cab environment control shall include rapid cool capability and the ability to sustain a comfortable temperature with a full passenger load.	X	X	X	X
3.4.1-01.02	U²C Vehicles shall provide infotainment options to passengers, such as onboard WiFi or an onboard screen/tablet. Bandwidth may be limited, especially if needed for more safety-critical purposes.				X
3.4.1-02	**System Connectivity**				
3.4.1-02.01	U²C Vehicles shall be able to receive information from roadside infrastructure on whether a passenger is waiting to be picked up at a stop location, to ensure they are picked up as well as to avoid stopping unnecessarily.				X
3.4.1-02.02	U²C Vehicles shall be capable of serving trips on-demand, as requested by End Users.			X	X
3.4.1-02.03	U²C Vehicles shall be capable of providing a Paratransit service as requested by End Users.			X	X
3.4.1-02.04	U²C Vehicles shall, via data provided to the Supervisory System, provide End Users with service updates, including but not limited to: • Wait/Arrival time • Vehicle real time location • Vehicle visual identification (color, license plates)		X	X	X
3.4.1-03	**Voice Passenger Communications**				
3.4.1-03.01	U²C Vehicles shall enable End Users to use voice passenger communication for information requests.		X	X	X
3.4.1-03.02	U²C Vehicles shall enable End Users to use voice passenger communication reporting criminal activity or unsafe vehicle behavior, resulting in a quick response.		X	X	X
3.4.1-03.03	U²C Vehicles shall enable End Users to use voice passenger communication to call for help in case of an emergency.		X	X	X
3.4.1-04	**Passenger Interface**				

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.4.1-04.01	U²C Vehicles shall, via data provided to the Supervisory System, provide End Users the following user interfaces: • Mobile application (smartphone, tablet) • Website (personal computer) • Onboard (screen, tablet, announcements) • Other (e.g. customer service, kiosks) These systems will work together to provide an indoor/outdoor integrated system for all users.		X	X	X
3.4.1-04.02	The U²C Vehicle interface shall include audio and visual information for passengers.		X	X	X
3.4.1-04.03	U²C Vehicles shall accept payment from End Users, including via tickets bought with their mobile devices/applications, as outlined in Section 3.2.7.			X	X
3.4.1-04.04	U²C Vehicles shall provide passive (i.e., next stop) and active (i.e., service alerts) announcements to passengers.	X	X	X	X
3.4.1-05	**Accessibility**				
3.4.1-05.01	U²C Vehicles shall ensure universal access for passengers will varying needs.	X	X	X	X
3.4.1-05.02	U²C Vehicles shall comply with all applicable federal ADA requirements.	X	X	X	X
3.4.1-05.03	U²C Vehicles shall meet local accessibility requirements and stakeholder needs.	X	X	X	X
3.4.1-05.04	Universal access shall include access for passengers with limited mobility, including wheelchairs.	X	X	X	X
3.4.1-05.05	Universal access shall include access for people who are blind or visually impaired.	X	X	X	X
3.4.1-05.06	Universal access shall include access for people who are deaf or hard-of-hearing.	X	X	X	X
3.4.1-05.07	User interfaces, especially those for computers and smartphones, shall be universally accessible.		X	X	X
3.4.1-05.08	Service provided by U²C Vehicles shall comply with Title VI, including providing access for unbanked communities.	X	X	X	X
3.4.1-05.09	Some passengers will continue to require human assistance, so while U²C Vehicles may not each have a JTA staff member onboard, JTA shall have protocols to provide human assistance when requested.	X	X	X	X
3.4.1-05.10	Protocols for emergency egress, included on the elevated guideway, shall include provisions for passengers with limited mobility.	X	X		X

3.5 Third Parties

Third-party C/AVs may operate as part of the U²C Vehicle fleet. While they will be interoperable with Dedicated C/AVs, they may be operated and/or managed by third parties.

3.5.1 Third-Party C/AV Operators

This section describes U²C Basic Vehicle Requirements from a third-party C/AV Operator perspective.

Table 3-19: Third Parties – Third-Party C/AV Operators

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.5.1-01	**Third-Party Operation**				
3.5.1-01.01	U²C Vehicles, including those dedicated to JTA, shall be able to be operated by Third-Party Operators.				X
3.5.1-01.02	Third-Party C/AV Operators shall be able to operate on the dedicated JTA Elevated Guideway.				X
3.5.1-01.02	C/AVs operated by third parties shall be able to communicate with dedicated JTA C/AVs (including for vehicle platooning).				X

3.5.2 Third-Party Fleet Management

This section describes U²C Basic Vehicle Requirements from a third-party Fleet Management perspective.

Table 3-20: Third Parties – Third-Party Fleet Management

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.5.2-01	**System Connectivity**				
3.5.2-01.01	U²C Vehicles, including those dedicated to JTA, shall be able to be operated by Third-Party Fleet Management.				X
3.5.2-01.02	Third-Party Fleet Management shall be able to make decisions for its dedicated fleet that consider the needs of JTA's dedicated fleet.				X

3.6 Infrastructure

U²C Vehicles will operate on existing and modernized infrastructure. This infrastructure will not be modified to meet vehicle constraints (beyond minor maintenance improvements), rather U²C Vehicles will be designed to operate within the constraints of the infrastructure. This includes physical constraints, as well as network, ITS, and other infrastructure constraints.

3.6.1 Dedicated JTA Guideway

This section describes U²C Basic Vehicle Requirements from a Dedicated JTA Guideway perspective. The elevated JTA guideway will be converted as part of a separate procurement.

Table 3-21: Infrastructure – Dedicated JTA Guideway

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.6.1-01	**Infrastructure Compatibility**				
3.6.1-01.01	Some dedicated JTA U²C Vehicles shall be able to operate on the dedicated JTA Elevated Guideway.	X	X		X
3.6.1-01.02	Some third-party JTA U²C Vehicles shall be able to operate on the dedicated JTA Elevated Guideway.	X			X
3.6.1-01.03	U²C Vehicles operating on the JTA Elevated Guideway shall be capable of being towed and evacuated from the Guideway in emergency situations. U²C Vehicles operating in all environments shall have the ability to be towed, either by being pushed or pulled (by a person, vehicle, or other AV) or steered manually.	X	X	X	X

3.6.2 Shared At-Grade

This section describes U²C Basic Vehicle Requirements from a Shared At-Grade infrastructure perspective, when the vehicles are traveling on public roadways.

Table 3-22: Infrastructure – Shared At-Grade

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.6.2-01	**Infrastructure Compatibility**				
3.6.2-01.01	All dedicated JTA U²C Vehicles shall be able to operate on shared At-Grade Infrastructure (Public Roadways).	X		X	X
3.6.2-01.02	All third-party U²C Vehicles shall be able to operate on shared At-Grade Infrastructure (Public Roadways).				X
3.6.2-01.03	Dedicated and third-party U²C Vehicles shall be capable of providing access to users with limited mobility, including wheelchairs, at all at-grade stop locations. This may involve a vehicle deploying a ramp, kneeling to the height of the entrance, or other solutions. Note that fixed stop locations will likely be designed to be accessible, but in the longer term flexible pull-over locations will not.	X	X	X	X

3.6.3 Roadside Equipment

This section describes U²C Basic Vehicle Requirements from a Roadside Equipment perspective.

Table 3-23: Infrastructure – Roadside Equipment

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
3.6.3-01	**System Connectivity**				
3.6.3-01.01	U²C Vehicle OBE shall be able communicate with Roadside Equipment via Vehicle to Infrastructure (V2I) technology such as Dedicated Short Range Communications (DSRC) and/or Cellular Vehicle to Everything (C-V2X), both of which	X		X	X

ID	U²C Basic Vehicle Requirements	ST	MT-E	MT-A	LT
	represent current technologies for high-bandwidth low-latency connectivity.				

4 KEY DECISION POINTS

As C/AV technology continues to advance, many commercial C/AV vendors are striving to deploy more innovative and cutting-edge platforms and business models. Consumer preferences are also evolving, partially in response to the variety of new mobility services that have been introduced into the transportation landscape. It is possible that within the timeline of this project, including during the deployment period, a selected vendor or the industry as a whole will see a major shift that will influence the requirements outlined this report, and may modify JTA's decisions. These key decision points include:

Table 24: Key Decision Points

Added Capability or Preference Shift	Impact on Requirements
C/AV vendors promote a dynamic operating model, serving a zone rather than serving fixed stops along a fixed route	Operations on the elevated guideway remain the same, while operations at-grade can begin to explore a dynamic operating model
Consumers (potential passengers) begin to expect on-demand service from a transit system	JTA can require this capability from potential C/AV vendors, even if not all C/AV vendors in the industry offer it
C/AV vendors focus on smaller capacity vehicles (i.e., personal rapid transit)	JTA can focus more on vehicle platooning and/or on the vendors that do provide larger vehicles
C/AV vendors introduce enhanced vehicle capabilities, such as operating at higher speeds	C/AVs operating at grade can begin to operate in mixed traffic, rather than in dedicated lanes, if this is not already done. In addition, the at-grade service area can be expanded.
C/AV vendors introduce enhanced vehicle capabilities that allow most or all vehicles to operate on both the elevated guideway and the at-grade roadway	JTA can require that all vehicles, rather than just some, operate on both the elevated guideway and the at-grade roadway
There are shifts in the regulatory environment, placing fewer restrictions on the testing and operation of C/AVs on public roadways	JTA can choose to follow these regulations or place stricter restrictions on operations under its jurisdiction
There are shifts in the regulatory environment, placing additional restrictions on the testing and operation of C/AVs on public roadways	JTA will follow these regulations. If they are restrictive enough that many C/AV vendors cannot comply, JTA may allow some vehicles (such as those with new, unapproved designs) to operate only on the elevated guideway, and possibly dedicated lanes if possible, but not the shared at-grade roadway.
Standards on communication networks become formal requirements, via a federal or state mandate	JTA can require C/AV vendors to meet these requirements, ensuring interoperability of the system
Standards on communication networks become more informal, and there is limited guidance on which technology solution to use	JTA will need to specify which standards-based communications network vehicle vendors are required to communicate over, to ensure the system is interoperable across vehicle types
It continues to be common and best practice to procure C/AVs as a turn-key solution, with an	JTA will assess whether it makes sense to also do so, or whether they can operate the vehicles

Added Capability or Preference Shift	Impact on Requirements
operator, rather than operating these vehicles internally at an agency	themselves after learning from experience with turn-key systems
It continues to be common and best practice to lease, rather than buy, C/AVs from vendors	JTA will assess whether it makes sense to also continue to do so, including for longer-term use
It becomes common and best practice to purchase, rather than lease, C/AVs from vendors	JTA will assess whether it makes sense to also purchase vehicles, given their experience to date with lifecycle costs and other concerns. JTA will also assess whether this may require operating the vehicles in-house, and whether it makes sense to also do so.
JTA has leased vehicles for a few years, and feels confident it would be able to purchase them (i.e., they would be a safe investment) and operate them (i.e., they do not need a third-party operator), whether or not this is common practice elsewhere	JTA will collect data on the C/AVs it is using, and make the case to do so, subject to approval from several internal parties
JTA has frequent procurements of C/AVs, and would like a quicker way to respond to business needs	JTA can develop an approved list of C/AV vendors

Because the timing on some of these changes is unpredictable, it is unclear whether they will impact the short-term, medium-term, or long-term vision of the system, and in some cases whether they will ever occur. However, if any if these changes do occur within the timelines of this program, the team may decide to re-evaluate the requirements and operating characteristics outlined in this document. However, overall project goals will remain the same, as will many high-level project specifications.