Working Paper #5

Government Laws and Regulations – Issues and Changes To Be Considered

To the

National Highway Cooperative Research Program (NCHRP)

On project

20-102 (02): Impacts of Laws and Regulations on CV and AV Technology Introduction in Transit Operations

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Other Transit Industry stakeholder workshop participants which gave input to this specific topic in January 2017 are listed in **Appendix A**.

These contributions are greatly appreciated. It should be noted that the inclusion of their names herein does not necessarily indicate that they are in complete agreement with the contents of this working paper.

Foreword

This working paper uses the following terminology and focus of its content in a manner consistent with all the associated working papers of the NCHRP 20-102(02) project.

Definition of Automated Vehicle (AV) Transit – The "system" comprising AV Transit includes:

Driving automation system(s) and technology per SAE J3016[1];

a. Other vehicle systems and components which provide driver assistance such as lane departure warning when a human driver is performing the dynamic driving task (DDT) from inside the vehicle or from a remote location; and

2. Other monitoring, supervisory control and passenger safety systems, technologies and facilities necessary for public transit service, such as precision docking, automated door operation, and dispatch functions.

Definition of Transit Vehicle Operator – The typical term used to identify the person operating a transit vehicle is the "vehicle operator". However, under SAE J3016 definitions and terminology, a human "driver" is the person who manually exercises in-vehicle braking, accelerating, steering, and transmission gear selection input devices in order to operate a vehicle. In light of the SAE standard's intent to define terms for driving automation systems only, the term vehicle driver is specified. In the working papers, the terms vehicle driver and vehicle operator may be used interchangeably, depending on the context and point of emphasis. Likewise, the terms "remote driver" (per SAE J3016) and "remote operator" will likewise be used interchangeably.

Definition of Transit Operating Agency— Transit operating agencies can be any type of public, governmental or non-profit entity, such as transit authorities created with certain governmental responsibilities; municipal, county and state government public transportation departments; medical/educational institutions; and local management authorities/districts.

Focused Nature of the Working Papers – Each working paper has a focused purpose and is not intended to provide a comprehensive set of steps, actions or preparations encompassing the full evolution of AV Transit technology applications in public transit service. Some aspects of this project's research have focused more on the ultimate operating conditions when AV technology is fully mature in order to understand the long term, ultimate state of automated transit technology, policy and regulations.

Conclusions on AV Transit in the Final Report – The Final Report will address information on the probable benefits and impacts of AV Transit, as well as articulate a roadmap of further research activities that technology, policy and regulations should follow over the next few decades.

[1] SAE J3016 is the Society of Automotive Engineers Standard titled – Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles; the standard was revised September 30, 2016.

1. Introduction to Governmental Laws and Regulations

Public Transit Agencies will face changes in the way they approach operating policy with the introduction of automated roadway vehicle (AV) technology over the next few decades. The impacts could require a rethinking of many aspects of the agency operations, with the results of the decisions affecting employees, agency management structure, and transit patrons. Several policy questions have been identified in this working paper, and many more will become evident as time progresses. The discussion that follows provides an initial summary of the changes that appear to be coming as AV technology is deployed in public transit operations.

The general topic of "policy" is defined as decisions made at the executive management level and/or the board of directors' level within a public transit operating agency. This includes aspects of decision making relative to cost, safety, and coordination with other agencies relative to the introduction of AV technology.

Throughout this project NCHRP 20-102(02), the levels of automation for roadway transit vehicles will be referenced in accord with the definitions given by SAE J3016.

Transit Laws and Regulations

Transit laws and regulations addressed in this working paper are:

- The protection of employees and passengers;
- Regulations of FTA and NHTSA; and
- Regulations related to security and privacy.

The existing framework of laws and regulations will need to be adjusted and adapted over the course of time to address AV transit applications. However, there is an equally important consideration of what must be changed and adapted in transit vehicle designs to satisfy laws and regulations that *will not be changed*.

There are many other relevant laws and regulations that are not being considered in this working paper which do not focus strictly on transit services, such as driving registration and

SAE J3016 Levels of Automation

- **Level 0** – the human driver does everything.
- **Level 1** – an automated system on the vehicle can *sometimes assist* the human driver conduct *some parts of* the driving task.
- **Level 2** – an automated system on the vehicle can *actually conduct* some parts of the driving task, while the human continues to monitor the driving environment and performs the rest of the driving task.
- **Level 3** – an automated system can both actually conduct some parts of the driving task and monitor the driving environment *in some instances*, but the human driver must be ready to take back control when the automated system requests.
- **Level 4** – an automated system can conduct the driving task and monitor the driving environment, and the human need not take back control, but the automated system can operate only in certain environments and under certain conditions.
- **Level 5** – the automated system can perform all driving tasks, under all conditions that a human driver could perform them.

NOTE: These levels of driving automation will be referred to in this document as **L1**, **L2**, **L3**, **L4** and **L5**.

licensing, product/vehicle liability, roadway infrastructure design standards and insurance requirements. The roles of local, state and federal government in establishing these types of laws and regulations are still developing. Other NCHRP 20-102 projects and parallel research efforts at AAMVA, USDOT JPO, and NHTSA are discussing such issues.

Also, not addressed in detail is the means of enforcement that government may use to ensure that a given operating company/agency is in compliance with existing or future laws. Historically the mechanism for corrective action by the federal government when a local transit agency fails to comply with laws or regulations is the termination of federal funds for the affected transit project. It seems reasonable to assume that funding withdrawal will continue to be the mechanism used for non-compliance when and if federal money is being applied to the project. There is precedent, however, for fines to also be a means of federal punitive action when safety violations are found. NHTSA also enforces FMVSS through fines for non-compliance.

Ultimately, the impacts of AV deployment in public transit services are implied by the answers to these two key questions:

1. What changes to the laws and regulations must be addressed?
2. What will the vehicle technology suppliers need to change in their designs to fulfill mandatory laws and regulations?

Purpose and Organization of the NCHRP 20-102(02) Study

This project identifies a roadmap of activities to be performed by industry groups, legislatures, the federal government, and others that will facilitate automated roadway transit operations. The project is focused on the potential barriers imposed by operating authority policies, agency regulations, and governmental laws relative to the transit environment. Without adjustment, the combination of new technology with old rules could result in undue delays and restrictions to deployment, which reduces the cumulative societal benefits that could have accrued if automated systems technology was implemented earlier.

The project consists of five tasks:

1. Develop a technology baseline for the current state of the practice in AV transit
2. Identify issues and impacts on transit vehicle driver and associated staff
3. Identify government regulations and laws impacting AV adoption in transit
4. Develop an implementation plan to address the challenges identified in Tasks 1-3
5. Prepare a final report consolidating Tasks 1-4

We have organized the five tasks to produce six working papers, and an implementation roadmap for transit automation in the final report.

Working Paper #1: Automated Vehicle Technology Deployment Scenarios for Public Transit provides an overview of the deployment scenarios for AV technology in transit applications.

Working Paper #2: Safety Assurance Considerations – Blending Transit and Automotive Safety Analysis Methodologies provides a foundation of technical information concerning

safety from which subsequent considerations of operating agency policy and governmental safety regulations can be addressed.

Working Paper #3 Workforce Deployment – Changes and Provisions of Future Policy and Contracts and **Working Paper #4 Operating Agency Policy – Potential Issues and Changes Required** address the implications of automating roadway transit vehicles with respect to local operating agency issues, including labor relations and training, broad operating planning and policy, and response to governmental laws and regulations.

Working Paper #5: Government Law and Regulations – Issue and Changes to be Considered addresses issues and possible changes to the federal and state governmental laws and regulations over public transit that should be researched, as well as issues and possible changes that may be required in vehicle designs to effectively comply with regulations.

Working Paper #6: Timelines for Industry and Governmental Preparation in Advance of AV Transit Implementationaddresses the preliminary timeline for deployment of progressive transit automation in overall consideration of technology, policy and regulatory changes that will be required.

The final report for the project, provides an assessment of the overall benefits and impacts of AV technology on public transit, and a proposed "roadmap" for further research will be described.

Working Paper #5 Contents

This working paper is organized in a manner that addresses the implication of laws and regulations under four categories:

- Laws Protecting Employees
- Laws Protecting Passengers
- NHTSA Vehicle Safety Regulations
- FTA Transit System Regulations
- Security Regulations and Laws Protecting Privacy

Under each of these categories the existing law is discussed, and the possible changes to the law/regulations for AV deployment are identified. Where relevant, the implications for AV transit vehicle and system design are also discussed.

A brief chapter then follows presenting a broad policy approach describing how AV technology in transit service could be asserted by governmental agencies. The discussion summarizes a proposed policy statement that has been published by UITP, the international transit association based in Brussels, Belgium.

2. Laws Protecting Employees

Section 13c Requirements of the Federal Transit Act

49 U.S.C. 5333(b), also known as "Section 13(c) of the Federal Transit Act," has been maintained by the Office of Labor-Management Standards (OLMS) for many years. The Overview of this law on the OLMS website [2] begins with the paragraph shown below (**underline** emphasis added by the authors of this paper):

> *When federal funds are used to acquire, improve, or operate a mass transit system (public transportation), federal law requires arrangements to protect the interests of mass transit employees. 49 U.S.C. § 5333(b) (formerly Section 13(c) of the Urban Mass Transportation Act). Section 5333(b) specifies that these protective arrangements must provide for the preservation of rights and benefits of employees under existing collective bargaining agreements, the continuation of collective bargaining rights, the protection of individual employees against a worsening of their positions in relation to their employment, assurances of employment to employees of acquired transit systems, priority of reemployment, and paid training or retraining programs. 49 U.S.C. § 5333(b)(2).*

The law states in part that as a **condition of financial assistance** from the federal government to a transit operating agency, the interests of employees shall be protected under arrangements which the Secretary of Labor concludes to be fair and equitable. These arrangements are administered under the Office of Labor-Management Standards and include:

- **Preservation of rights, privileges and benefits** under existing collective bargaining agreements
- Continuation of **collective bargaining rights**
- Assurances of **priority of re-employment** of employees who (…are displaced by changes, notably via automation technology systems in this context)
- **Paid training** or retraining programs

These Section 13(c) stipulations are existing law and may contain some of the most challenging aspects of bringing AV technology into the mainstream of public transit system operations as evidenced by the proportion of time devoted to this topic at our recent project stakeholder meeting. The retraining and reassignment of responsibilities of employees is anticipated to receive strong pushback from the union and employee perspective. Further to this employee retraining and reassignment issue, there will need to be reorganization and reclassification of employee roles and responsibilities to address new job descriptions and titles, which will also involve participation with the union representatives and employees.

With the requirement for the Department of Labor to sign off on federal grants to public transit agencies along with FTA, these issues related to employees can directly impact the availability of funds. One example of such challenges arose when the State of California made changes to

[2] https://www.dol.gov/olms/regs/compliance/compltransit.htm

its funding of employee pensions. In response, the DOL and FTA withheld federal transit funds to all California transit agencies for several years[3].

Based on this possibility, transit operating agencies currently receiving federal funding could risk losing their funding due to labor law compliance impacts when implementing L4 AV technology, if the changes are not first vetted with their employee's labor unions. Notably new services such as first-mile connections using low(er) speed L4 shuttles may not displace existing employees at all (and in fact may actually require additional employees).

Possible Options for Operating Agencies – Another possible view that has been expressed in stakeholder discussions is to treat this transition to AV technology application in transit service as an opportunity to wean an agency off federal funding by a potential reduction in operating costs resulting from automation. If there is a possibility to move away from Federal funding in contrast to impacts of 13(c), agencies may still be able to optimize costs through other funding solutions, such as local taxes. This is only speculative and research is likely needed to assess the different cost variables of such adjustments. Such a study might consider the hypothetical conversion of a medium sized transit agency (as defined by APTA) to progressive application of AV technology in its operations. A thorough benefit/cost analysis could then assess the overall employee workforce and financial impacts of this transition over the course of time, including impacts such as loss of federal funding due to potential reduction of employee staffing levels. No systematic analysis of employee re-organization has yet been done (that we know of). While the general speculation is that many fewer employees would be needed to "supervise" an AV transit system than drive each vehicle manually, it is not clear yet how significant the reductions in staff would be.

Possible Changes to the Law – Other possible changes to the federal transit employee protection law may need to be considered based on the following questions:

1. As automation of the driving task and employee presence on each vehicle gradually begins to reduce the size of the workforce, should the federal law be revised to allow for attrition?
2. Does the law need to address how or in what way employees can be retrained and redeployed in public transit agencies?
3. How will these changes to employee roles and responsibilities impact contracted employees, and should federal funds be allowed for contracted services in the workforce if those services are not compliant with these federal rules?

Occupational Safety and Health Administration (OSHA) Regulations

OSHA operates as a division of the Department of Labor, and the OSHA Standards regarding workplace safety are contained within 29 CFR Part 1910 — OCCUPATIONAL SAFETY AND HEALTH STANDARDS. OSHA has published standards regarding the application of machines in industrial settings for many years. Chapter Six – *Robotics in the Workplace from OSHA*

[3] http://www.mercurynews.com/2015/08/20/california-transit-agency-says-federal-grants-blocked-over-public-employee-pension-plan/

Publication 3067 – Concepts and Techniques of Machine Safeguarding[4] as last updated in 1992 is included as **Appendix B** for reference. OSHA has not (yet) provided any specific instructions concerning the use of AV technology and most of the references to robotics in OSHA standards and guidelines are generic, having been developed many years ago.

This aspect of OSHA regulations is worthy of further studies to determine if specific requirements are necessary for AV transit. This is specifically important for operations facilities (dispatching and storage yards), as well as maintenance facilities where OSHA directives and guidelines may need to address processes and procedures concerning robotic vehicles and the potential for workplace hazards. During discussion of this topic in industry stakeholder workshops, one suggestion was to require that the vehicle must be "aware" of human(s) in the vicinity and communicate desired automated actions through some means (audio, lights, text, etc.). Such vehicle awareness functions are integral to operation in the long term.

Automation in the manufacturing workplace using robotic systems over the last 30 years provides a large collection of technical articles and other published materials that should be studied and catalogued for reference of transit operating agencies. Procedures and safety features concerning the protection of employees in the workplace should be studied for application to the maintenance and storage facilities supporting AV transit technology.

[4] https://www.osha.gov/Publications/Mach_SafeGuard/chapt6.html

3. Laws Protecting Passengers

Title VI of the Civil Rights Act – FTA Regulations

In 1964 the Civil Rights Act established major tenets of social justice in the United States of America. The Department of Justice Title VI provisions of federal law affecting federal funding of transit projects has the following introduction:

> *Title VI, 42 U.S.C. § 2000d et seq., was enacted as part of the landmark Civil Rights Act of 1964. It prohibits discrimination on the basis of race, color, and national origin in programs and activities receiving federal financial assistance. As President John F. Kennedy said in 1963:*
>
> > *Simple justice requires that public funds, to which all taxpayers of all races [colors, and national origins] contribute, not be spent in any fashion which encourages, entrenches, subsidizes or results in racial [color or national origin] discrimination.*
>
> *If a recipient of federal assistance is found to have discriminated and voluntary compliance cannot be achieved, the federal agency providing the assistance should either initiate fund termination proceedings or refer the matter to the Department of Justice for appropriate legal action. Aggrieved individuals may file administrative complaints with the federal agency that provides funds to a recipient, or the individuals may file suit for appropriate relief in federal court. Title VI itself prohibits intentional discrimination. However, most funding agencies have regulations implementing Title VI that prohibit recipient practices that have the effect of discrimination on the basis of race, color, or national origin.*

As guidance for the applicability of Title VI requirements relative to transit system projects, FTA Circular C.4702.1B [5] was last updated in 2012 and it serves to protect people from discrimination in transit programs receiving federal financial assistance. The Federal Transit Administration's Office of Civil Rights monitors FTA grant recipients' Title VI internal programs to ensure their compliance with the federal law. The Justice Department is also involved in the process, if violations are found.

The impacts of AV technology deployment will be assessed under Title VI criteria for the ways in which minority populations are served by each new AV transit service. This seems particularly important with the demographic trends showing the suburbanization of the poor. These demographic shifts can create concentrations of transit dependent populations in locations where transit service cannot effectively serve their needs, when compared to populations in the urban core where the heaviest transit investments have traditionally been made. The ability of AV transit deployment is suburban areas will therefore be an important factor in determining the Title VI impacts or benefits.

Workshop Discussion – During the January 2017 workshop discussions involving of both transit industry stakeholders and government agency representatives, the following issues

[5] https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FTA_Title_VI_FINAL.pdf

were discussed. There was a general consensus that these points may have a bearing on the deployment of AV technology in areas with low density and high transit dependency.

1. **Fare payment** is one area where a negative impact could potentially discriminate against the poor, since AV transit is generally based on the idea of allowing smart phone or other devices to pay the transit fare. Someone without banking services could be potentially discriminated against.
2. A contrasting benefit of AV technology involves the **mitigation of the problem of transit vehicle operator assaults** and the related safety/security implications for passengers, which can be a major problem for agencies operating in areas with economically depressed conditions. The use of AV technology with remote operations personnel monitoring the vehicle will be an important factor in resolving this safety concern for transit vehicle operators and passengers.
3. There is a conjunction of these two issues of fare box payments and driver assaults. Relevant examples exist where transit operators have provided free rides for some services when subsidized funding was available. The results of these operations without cash transactions have resulted in no operator assaults or altercations. **The exchange of cash in fare payment typically attracts higher rates of assault**, and deployment of AV technology along with access for economically-deprived transit passengers to non-cash payment of fares would therefore also serve to substantially benefit overall safety in low-income areas.

Environmental Justice Policy – Issues such as those discussed above must be carefully assessed, since FTA's "environmental justice" (i.e. discriminatory impacts of a new transit service) requirements[6] can be a major factor in receiving approval for a given transit project's Environmental Record of Decision (ROD) and the resulting release of New Start funding from FTA.

Even after enactment of the Title VI of the Civil Rights Act requiring equal access to transportation programs and services, many scholars believed that additional safeguards were needed to project these special populations. As a response, President Clinton issued Executive Order (EO) 12898: *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. The Executive Order requires each Federal agency to develop what became known as an environmental justice strategy that identifies and addresses disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. To facilitate this matter across all Executive Branch agencies, an Interagency Working Group[7] was established whose charge is to ensure the protection of minority and low income populations.

The Executive Order further requires that the environmental justice strategy shall list programs, policies, planning and public participation processes, enforcement, and/or rulemakings related to human health or the environment that should be revised to, at a minimum:

[6] https://www.transit.dot.gov/regulations-and-guidance/fta-circulars/environmental-justice-policy-guidance-federal-transit

[7] https://www.epa.gov/environmentaljustice/federal-interagency-working-group-environmental-justice-ej-iwg

1. Promote enforcement of all health and environmental statutes in areas with minority populations and low-income populations;
2. Ensure greater public participation;
3. Improve research and data collection relating to the health of and environment of minority populations and low-income populations; and
4. Identify differential patterns of consumption of natural resources among minority populations and low-income populations.

The most basic of environmental justice implications for the introduction of AV transit technology in public transit service is the requirement that the metropolitan planning organizations and transit operating agencies implement a strategy to ensure greater public participation in the decision-making process. **In particular, the federal requirements stipulate that this public involvement must include minority populations and low-income populations** that could be affected by the AV transit deployment and the associated environmental hazards, urban renewal programs, and transportation projects.

These issues raise important policy questions that need to be addressed:

1. **How will adequate public involvement of minority populations and low-income populations** be provided by each MPO and public transit operating agency when AV transit services are being planned?
2. **Should FTA consider allowances or exceptions** for deployment of AV technology in selected areas during the early transitional years as to not constrain innovation, even if AV technology deployment is not uniformly applied across all demographics throughout the service area?
3. **Should FTA provide incentives through Title VI** to encourage AV transit deployment in low density, high transit dependence situations that are becoming more common with the trends in suburbanization of the poor?

A more complete discussion of Environmental Justice is included in **Appendix C**.

Americans with Disabilities Act (ADA) – FTA Regulations

The Americans with Disabilities Act first became law in 1990, and today its public transit application is administered by the Civil Rights Department of FTA[8]. There are multiple components of the federal law defining aspects of ADA requirements for public transit agencies:

- CFA 49 – Transportation, including Part 37 Transportation Services for Individuals with Disabilities, and
- Part 38 Accessibility Specifications for Transportation Vehicles.

Part 38 has *more than 30 pages* of regulatory law specifically dedicated to ADA requirements for public transit systems, vehicle equipment and facilities.

[8] https://www.transit.dot.gov/regulations-and-guidance/civil-rights-ada/ada-regulations

FTA Circular C4710.1 has been published for guidance in the application of the law[9], and this 300+ page document is an important reference for transit operating agencies who manage the day-to-day issues of serving their elderly and disabled passengers. FTA's factsheet[10] on ADA regulations provides a simple overview of the comprehensive circular's content with the following statement in its introduction:

> *Since passage of the ADA in 1990, transit agencies have worked to make America's public transit system accessible for people with disabilities. Today, nearly all transit buses and rail vehicles are ADA accessible, as well as two-thirds of rail transit stations. As transit agencies continue to improve accessibility, many generate questions or receive public inquiries about complying with the comprehensive ADA regulations. To help transit system leadership and staff, FTA published detailed guidance in a user-friendly, one-stop resource on ADA requirements and how to implement them in the ADA Circular.*

By the nature of such comprehensive requirements of ADA for both transit systems and associated facilities, there are many exceptions granted in the Circular for equipment and facilities that were placed in service decades before the law was passed. The interpretation of "exceptions" are handled under the auspices of the FTA Civil Rights Office. The realities of operating a public transit system result in occasional situations in which a transit operating agency cannot operate in total compliance with the law's strict requirements because of operational reliability limitations of equipment dedicated to ADA provisions. Therefore, individual exceptions can be allowed at the discretion of the FTA's Civil Rights Office. Eventually changes to the law to specifically address AV transit will likely be addressed through a normal process over the course of time as experience with this new type of vehicle technology is obtained.

General ADA Criteria – In CFR 49, Part 38 ADA Accessibility Specifications for Transportation Vehicles requirements, there are a few general criteria that apply across all vehicle types:

- **Minimum clear space** of 48 inches by 30 inches for wheelchair parking inside vehicles, with wheelchair securement against movement while the vehicle is in motion.
- **Interior vehicle handrails and stanchions** required.
- **Wheelchair Access/Circulation Clearance** internal to the vehicle to allow wheelchair maneuvering that allows a "route at least 32 inches wide".
- **Priority Seating and Signs** designating seating locations for passengers with disabilities.
- **Audio Announcements and Visual Instructions** for the hearing and visually impaired.

For buses, vans and fixed guideway systems, there are specifications of the number of wheelchair securement locations (e.g., 2 wheelchair position for vehicles over 22 feet in length), and the minimum forces that each securement device must be able to withstand (e.g., 2,000 lbs.). There are also provisions for "automatic attachment" as well as operability by a person

[9] https://www.transit.dot.gov/regulations-and-guidance/fta-circulars/americans-disabilities-act-guidance-pdf

[10] https://www.transit.dot.gov/node/23381

familiar with the system and mobility aid. The Part 38 requirements contain detailed specifications for wheelchair lift design and lifting capacity.

When considering New Start transit projects that will deploy AV transit technology, a suitable design of facilities and vehicle/station equipment will be required to fulfill the ADA law. This compliance is mandated as a condition of receiving federal funding assistance for the project, as discussed below.

Wheel Chair Ramps – The most challenging requirements for AV technologies that are written into existing law for conventional rubber-tired transit vehicles are those that address vehicle floor height above the boarding surface where the passengers stand, creating conditions where a step up is typically required to board a vehicle. In a general framework of requirements that FTA has established in the Part 38 regulations, the maximum amount of slope that wheelchair ramps must provide can be summarized as follows:

- Leading edge slope of 1:4 (rise over run) for a wheelchair lift with a lift surface a maximum of 3 inches above the boarding platform/surface.
- Ramp slope of 1:8 (rise over run) for a vehicle floor height difference of between 3 inches and 9 inches above the boarding platform/surface.
- Ramp slope of 1:12 (rise over run) for a vehicle floor height difference of greater than 9 inches above the boarding platform/surface.

Using the example of a vehicle floor that is 10 inches above the boarding platform/surface level, this requirement would mean that the wheelchair ramp would have to be 10 feet long with a 1:12 slope. A vehicle that was 8 inches above the boarding platform/surface level would require a 5 foot 4-inch ramp length with a 1:8 slope.

These general criteria are adapted in different ways for different vehicle types as discussed in the FTA Circular.

Vehicle/Platform Edge Gap – FTA's specific requirements for rail mass transit systems stipulate that level platform boarding with a maximum 3-inch gap be provided between the platform edge and the vehicle door threshold at all stations, including a maximum 5/8 inch vertical height difference. The regulations also require that a low speed people mover system (operating at a speed no greater than 20 mph) must have a maximum gap of 1 inch and a maximum height differential of 1/2 inch.

Another relevant benchmark for ADA considerations in the design of fully automated transit systems is the ASCE-21 Automated People Mover Standards that have been in existence for over twenty years. This industry consensus standard has stipulations that for any fully automated guideway system operating at speeds higher than 20 mph, there is a requirement that the vehicle threshold and station platform edge have a 2-inch maximum gap, with less than 5/8-inch height differential.

Key Issues for ADA Requirements with AV Applications – The benchmarks of ADA regulatory requirements described above are of critical importance as new provisions in the law are created for application to AV transit vehicles. There could be one set of requirements during the early stage of AV transit deployment when L3 automation still requires an operations person in every vehicle who can assist with ADA accommodations in the boarding/alighting

process. Then a different set of requirements may apply over the long term when under L4 and L5 automation there will be no operations person present in the vehicle, or at boarding locations.

Other questions that are relevant to discuss, investigate and consider through follow-on studies or research activities include:

1. **Will AV transit vehicles be viable for public service with ramps or lifts that are automatically deployed** to board a passenger in a wheelchair, and, if so, what new safety hazards might be induced?
2. **If AV technology supplier designs for unmanned vehicle operations do not provide equivalent ADA compliance** as do conventional human-operated transit vehicles, can regulatory changes be made to accommodate this through exceptions or otherwise?
3. **Will wheelchair securement be required in AV transit vehicles, and how will that be safely automated** if no operator is onboard?

Precision Docking of Vehicles – All three of the Industry Stakeholder Workshops have also included discussion of requiring that AV transit vehicles to perform precision docking of the vehicle at raised platforms in each station and boarding location. The technology challenges and possible solutions for this feature were discussed in Working Paper #4, Appendix B. This raises an additional question that is directly relevant to meeting ADA regulations:

1. **Should AV technology suppliers be changing their vehicle designs to ensure highly reliable maneuvering capabilities for precise docking at stations** that complies with the existing ADA regulations for level platform boarding?

An overview of additional challenges of ADA regulations, as discussed in the stakeholder workshops, is provided in **Appendix D**.

4. FTA Transit System Regulations

The Federal Transit Administration has also developed regulations that are specific to transit and are not applications of other primary laws to transit (such as the Title VI and ADA nondiscrimination laws described above). The two major laws where transit specific regulations affect AV technology adoption are Buy America and Safety Management System requirements.

Buy America Requirements

FTA funding for New Starts transit projects is normally contingent on compliance with Buy America regulations in the procurement of systems, facilities and rolling stock. The stipulations of the regulations generally require that equipment and construction materials be purchased from American manufacturing sources specified as a percentage of total content for the subsystems and component parts. The full law has recently been revised by the FAST Act, and established as law in 49 U.S.C. Section 5323(j) / FAST Section 3011.

As one feature of the FAST Act, the US manufactured content of rolling stock will soon to be raised to 70%. In addition, foreign transit vehicle manufacturers must establish a final assembly plant on U.S. soil, as well as meeting the required percentage of the subsystem equipment from American sources. The percentage content of American supply of all subsystem equipment is carefully tracked and documented for inclusion in the percentage calculations, which then supports the submission of a Buy America certificate. This Buy America percentage content calculation is audited both before manufacturing as well as after manufacturing has been completed. Deficiency of only a single percentage point in this calculation can make the difference between funding being granted and funding being denied.

The Buy America overview that is provided on the FTA website[11] reads as quoted below, and FTA's one page Fact Sheet[12] – "Buy America 5323(j)" is provided in **Appendix E**.

> *FTA's Buy America requirements prevent FTA from obligating an amount that may be appropriated to carry out its program for a project unless "the steel, iron, and manufactured goods used in the project are produced in the United States." 49 U.S.C. § 5323(j)(1). FTA's Buy America requirements apply to third-party procurements by FTA grant recipients. A Grantee must include in its bid or request for proposal (RFP) specification for procurement of steel, iron or manufactured goods (including rolling stock) an appropriate notice of the Buy America provision and require, as a condition of responsiveness, that the bidder or offeror submit with the bid or offer a completed Buy America certificate in accordance with 49 CFR §§661.6 or 661.12.*
>
> *Under limited circumstances, FTA may waive Buy America if FTA finds that: (1) application of Buy America is inconsistent with the public interest; (2) the steel, iron, and goods produced in the U.S. are not produced in a sufficient and reasonably available amount or are not of a satisfactory quality; or (3) including domestic material will increase the cost of the overall project by more than 25 percent for rolling stock. The process for seeking a waiver is set forth in 49 CFR part 661. Grantees are encouraged to*

[11] https://www.transit.dot.gov/buyamerica

[12] https://www.transit.dot.gov/funding/grants/buy-america-fact-sheet

apply for a waiver as soon as possible and to provide detailed requests in order to expedite FTA's review of waiver requests. FTA's determination on waiver requests will be published in the Federal Register for notice and comment.

When procuring rolling stock, which includes train control, communication, traction power equipment, and rolling stock prototypes, the cost of the components and subcomponents produced in the U.S. must be more than:

- *more than 60 percent for FY2016 and FY2017*
- *more than 65 percent for FY2018 and FY2019*
- *more than 70 percent for FY2020 and beyond*

Final assembly for rolling stock also must occur in the U.S. Additionally, rolling stock procurements are subject to the pre-award and post-delivery Buy America audit provisions set forth in 49 U.S.C. § 5323(m) and 49 CFR part 663.

The phased increase in domestic content was included in the FAST Act. Please consult the Buy America FAST Act Fact Sheet for more information.

Unlike rolling stock, manufactured goods must be 100 percent produced in the U.S. A manufactured good is considered produced in the United States if: (1) All of the manufacturing processes for the product take place in the United States; and (2) All of the components of the product are of U.S. origin. A component is considered of U.S. origin if it is manufactured in the United States, regardless of the origin of its subcomponents. 49 CFR 661.5(d). FTA has issued a number of guidance letters discussing manufactured goods.

The existing Buy America law will clearly have major impact on the way that AV transit technology advances in its development and deployment within the United States, since Buy America requirements seem unlikely to be reconsidered just for AV technology application benefits under the current U.S Administration.

Industry Discussion Points – During the Transit Industry Stakeholder Workshop conducted on January 11, 2017, there were a variety of thoughts expressed by transit operating agency representatives. The Buy America stipulations are a major element of project management by transit operators for any New Start transit project procurements or any system retrofit/modification or expansion of the system operating vehicle fleet.

The hard reality known by transit operating agencies is that if the minimum percentage content quota is not met, then FTA funding will be withheld – unless a waiver request has been properly submitted, is justifiable and has been approved by FTA. The second hard reality transit operating agencies have learned is that sources of supply for every component made for existing transit vehicles and equipment are frequently uncertain when the bids are submitted for a project, and only after manufacturing is completed can the actual percentage content by calculated with complete certainty.

When planning for future procurements using federal funding there is even more uncertainty where sources of supply and manufacturing will occur for much of the high technology equipment involved in AV transit. The comments summarized below reflect this experience with managing U.S. transit procurement under existing Buy America laws and provide insight

into related considerations that operators must give for future AV technology applications when planning beyond the current early stage of R&D projects.

Exceptions in the Near Term are likely to be needed which can be granted for a whole project without an extensive waiver application process in order to place AV transit systems in revenue service quickly. There have already been processes set in place within FTA to obtain waivers for initial test and demonstration projects to not require compliance with Buy America stipulations. As a way to address the evolution of AV technology and to not constrain innovation, this approach of the federal government granting waivers may be a key path to moving forward in the near term.

U.S. Sources of Vehicle Supply for AV transit vehicles was an area of interest expressed within the industry stakeholder workshop. Current FTA funding requirements of full compliance with Buy America criteria could be a key factor in that stimulates the development of AV technology manufacturing here in the United States. Transit agencies are typically meeting the percentage quota requirements by purchasing rolling stock from foreign suppliers with subsystem equipment from US suppliers, combined with the final vehicle assembly in the US. For example, a manufacturer from Asia recently built a facility in Southern California because no one could purchase their buses under Buy America laws. An attractive alternative would be to solve these Buy America challenges from truly American owned manufacturers of AV transit vehicles by incentivizing American businesses through tax credits, deductions, and other subsidies.

Maintenance and Spare Parts Supply is another factor in which Buy America issues arise when the manufacturers are not U.S. owned companies. Such issues have been faced by owner/operators of automated guideway transit systems such as those commonly deployed in U.S. airports. These automated systems frequently have foreign sources of supply for systems and rolling stock, since FTA Buy America procurement regulations typically have not been applicable for airport projects. What has been learned is that if a transit operating agency decides to maintain the vehicles/systems themselves and not contract it to the system supplier, there can be challenges due to a lack of knowledge of the parts and their foreign sources of supply.

The maintenance requirements and procedures for these high technology vehicles can also be challenging, and dependent on the quality of maintenance manuals and documentation provided by the system/equipment manufacturer(s). As a result, owner/operators are frequently dependent on the foreign OEM vehicle supplier for the maintenance tasks of advanced technology equipment. These issues have also been a common experience for a few of the "early adopter" transit system deployments of all-electric vehicles and AV transit vehicle technologies, even when the vehicles have been procured from foreign suppliers with FTA waiving the Buy America requirements.

Other key issues raised during the workshop discussion are listed below. These matters should be addressed as soon as practicable to keep innovative applications of AV technology in transit service moving forward.

Considering the current situation where most AV transit vehicle suppliers are not U.S. owned sources of supply, a reduction of the minimum percentage of U.S. subsystems and components could be established in the FTA Buy America regulations.

- **Should the federal government consider changing the FTA Buy America minimum percentages** of U.S. supply for equipment and rolling stock when funding is provided for AV transit technology?

Whenever FTA funds are being applied to transit equipment purchases there is focused federal oversight given to ensure Buy America requirements are met.

- **Should FTA establish an official oversight support office** for providing guidance to transit operating agencies and managing the Buy America regulatory constraints as new applications of AV transit technology begin to come into common service deployment?

A related question was raised concerning the possible mandate of Buy America requirements for transportation network company (TNC) contracted services to AV transit operating agencies using FTA funding.

- **Will Buy America stipulations also be applied to TNC contractors**, as well, when funding for these services comes from FTA grants?

Transit System Safety Program – Safety Management Systems

FTA has provided regulations, guidelines and handbooks for safety program management over many decades. Recent updates to these FTA safety programs have included a Safety Management System (SMS) component which has drawn extensively from the safety program experience of the Federal Aviation Administration (FAA). As with other FTA regulatory guidelines, noncompliance with these safety rules by a transit operating agency could potentially jeopardize FTA New Start funding or conceivably even incur fines or other penalties imposed by FTA if unsafe practices and/or designs are determined to be deployed. In addition, it is possible that such fines could be levied whether federal funds have been used in the procurement of the system equipment, facilities and rolling stock (i.e., transit vehicles).

The overall goal of the FTA System Safety Program is described on the FTA website[13] as follows:

> *The goal of FTA's Safety and Security Program is to achieve the highest practical level of safety and security for all modes of transit. In order to protect passengers, employees, revenues, and property, all transit systems are encouraged to develop and implement a proactive system safety program plan. FTA supports these efforts by developing guidelines and best practices, providing training and by performing system safety analyses and reviews.*

FTA's latest Safety Program Plan requirements, with the associated new Safety Management System regulations have been established under the final rule published in the Federal Register 49 CFR Part 670 – now fully in effect as of September 12, 2016[14].

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[13] https://www.transit.dot.gov/regulations-and-guidance/safety/transit-system-safety

[14] https://www.gpo.gov/fdsys/pkg/FR-2016-08-11/pdf/2016-18920.pdf

FTA's Office of Transit Safety and Oversight administers the federal transit safety regulatory program and includes aspects of program compliance. This role primarily addresses oversight for New Starts projects to advance the provision of safe, reliable, and equitable transit service through adherence with legislative, policy and regulatory requirements as established by FTA. It is noted, however, that the primary oversight of continuing safety program compliance has been delegated to the states, which the Office of Transit Safety and Oversight has been charged with "certifying" the state-level oversight program.

There are multiple "program offices" that have been established within FTA's Transit Safety and Oversight organization which have responsibilities associated with supporting the regulatory framework for the safety program, including Office of System Safety, the Office of Safety Review, and the Office of Program Oversight. The office administering the new Safety Management Systems portion of the program is the Office of System Safety.

Safety Management Systems – The FTA website that introduces the SMS program[15] contains the following overview and also provides links to a number of online resources.

> *Safety Management System (SMS) is a comprehensive, collaborative approach that brings management and labor together to build on the transit industry's existing safety foundation to control risk better, detect and correct safety problems earlier, share and analyze safety data more effectively, and measure safety performance more carefully. SMS is about applying resources to risk and is based on ensuring that a transit agency has the organizational infrastructure to support decision-making at all levels regarding the assignment of resources. Some key parts of SMS include:*
>
> - *Defined roles and responsibilities*
> - *Strong executive safety leadership*
> - *Formal safety accountabilities and communication*
> - *Effective policies and procedures*
> - *Active employee involvement*

Overall, the SMS rules establish new requirements for Safety Plans, guidelines for Safety Plan documentation and record keeping, as well as more specific guidance for hazard analyses, hazard management and related risk assessments.

Although the SMS program has applicability for any size and type of transit operating agency, with specific resources and guidelines available for even the small bus operators (refer to the SMS website link cited in the footnote), the overall system safety program requirements are **only mandated by FTA for fixed guideway rail systems**.

With the new design and operational complexities of AV transit, the new safety risks of automation will make the importance of implementing a full safety program in compliance with FTA guidelines applicable to even small transit operating agencies. Many operators that do not have fixed guideway transit and have never implemented such a thorough safety program as part of their bus operations will likely face a reorganization of their decision-making process, as

[15] https://cms.fta.dot.gov/regulations-and-guidance/safety/safety-management-systems-sms

well as enacting policies and procedures to develop, implement and maintain a comprehensive system safety program plan.

Safety Addressed in Other Working Papers and Stakeholder Workshops – **Working Paper #2 *Safety Assurance Considerations – Blending Transit and Automotive Safety Analysis Methodologies*** provides a thorough discussion of the existing safety methodologies, approaches and issues that are faced by deployment of AV transit technology. Essential to the application of the new SMS methodology framework to manage AV transit system design and operational risks will be the incorporation of the automotive industry's functional safety methodology into the overall system safety assurance process. Working Paper #2 discusses how these two methodologies will need to be well integrated as transit systems deploying AV roadway vehicles enter common use.

In addition, **Working Paper #4 *Operating Agency Policy*.** Chapter Four addresses the policy considerations that local transit operating agencies must consider well in advance of deploying AV transit in revenue service.

This topic of safety has remained a part of the continued dialogue at all the project workshops. Throughout the course of this project's investigations there has been firm assertion of the importance of AV deployment safety considerations by key industry leaders. There is clear indication that "safety" is the most important area of concern for the transit industry with respect to AV transit deployment (as it should be). All transit operating agencies large and small will face the requirement of developing new processes, proficiency and organizational structures to address system-level safety programs. Therefore, updated federal law and regulatory frameworks that establish overall transit system safety assurance program compliance – specifically for the advanced technologies comprising AV transit – are potentially the most important item to be accomplished. However, the definition of "transit" is brought to light here. If a demand-response AV TNC can provide "transit-like" service *without* FTA funds (even if contracted to a public transit agency), should it be subject to such SMS and oversight requirements? The applicability of the NHTSA AV model policy and individual state regulations for driver and vehicle licensing and registration begin to intertwine with FTA rules in a complex manner.

State Safety Oversight – Currently, the responsibility of transit safety program implementation oversight has been delegated by federal law to each state's designated Safety Oversight Agency/Officer. The FTA web page that introduces the State Safety Oversight (SSO) Program[16] has this introductory paragraph:

> *The purpose of the State Safety Oversight program is to oversee safety at rail transit systems. The SSO program is administered by eligible states with rail transit systems in their jurisdiction. FTA provides federal funds through the SSO Formula Grant Program for eligible states to develop or carry out their SSO programs. Under 49 U.S.C. Section 5329(e), as amended by the Moving Ahead for Progress in the 21st Century Act (MAP-21), FTA is required to certify each state's program to ensure compliance with MAP-21.*

[16] https://www.transit.dot.gov/regulations-and-guidance/safety/state-safety-oversight-sso-program

This has created a disparity in the state-by-state safety compliance requirements, with many different and disconnected state-level "authorities having jurisdiction." Recent MAP-21 legislation, however, has added the provision that FTA will certify each state's program. Some states have significant experience and sophistication in guiding and overseeing the safety program plans for transit operating agencies under their jurisdiction – typically being those states with multiple rail transit systems in operation. Other states have much less experience or organizational structures in place to perform regulatory oversight of sophisticated safety programs within their state jurisdiction. Further, some states which currently have no rail transit systems have no designated SSO office at all.

This issue raises a fundamental question of how local transit operating agencies that have only operated rubber-tired bus systems will comply with the FTA guidelines when they have never created their own organizational structures or internal programs to deal with the complexity of safety on the level of rail transit systems. The even greater complexity of automation on the level of AV technology will tax the start-up of new safety programs and SMS organizational structure, especially if these operators are located in states currently without SSO safety oversight agencies/offices.

The following SSO questions were raised during the workshops:

1. Will FTA need to develop a specific uniform framework for all state oversight agencies to follow and implement within their state jurisdictions concerning AV transit technology deployment?
2. Should safety oversight of local transit operating agency system safety program plans and procedures be overseen by an entity different from the 50 different state oversight offices when virtually every transit operating agency will be affected?

Key Questions, Issues and Research Needs –As the application, expansion or modification of existing governmental laws and regulations concerning transit system safety are applied to an increasing number and scale of AV transit technology deployments, further research and policy assessments are also needed to determine where safety analysis and oversight responsibilities should be placed.

The items below are representative of the questions, issues and research needs discussed in the stakeholder workshops, but they are not considered complete and comprehensive.

Passenger/Vehicle Interface – Safety of passengers during the boarding and alighting process and the related vehicle control, door control interlocks, propulsion and braking system interlocks, as well as other related safety features have been a major focus of the safety requirements developed by both the ASCE-21 Automated People Mover System Standards committee, and the IEC 62267 Automated Urban Guided Transport Safety Requirements working group. These working groups have developed consensus standards with a strong representation of automated guideway transit system suppliers and vehicle manufacturers.

The attention these international standards have given to safety functions necessary for proper docking of transit vehicle in stations, monitoring of door operations, protection of passengers from possible entrapment, and protection against passengers entering the transitway sets important and relevant criteria that automated roadway vehicle transit systems will also need to

address. Further research on these topics (along with other "non-driving" functions that removal of a human operator from the vehicle will require to be automated) should be high on the priority list of federal and non-profit research organizations.

Remote Operator Involvement – There are a variety of ways that human transit vehicle operators currently ensure the safety of passengers, particularly when passengers have special needs such as elderly passengers with canes or walkers, passengers with seeing or hearing disabilities, and passengers in wheelchairs.

1. Will FTA safety laws/regulations allow operations control center (OCC) personnel to remotely monitor boarding and alighting of disabled passengers sufficiently to adequately mitigate the risks and thereby ensure safe passenger transfers into and out of the vehicle?
2. How much of the safety assurance risk mitigation under these circumstances of remote monitoring will rely on procedural compliance, and how much will it rely on detection and control functions to be automatically executed (e.g., OCC alarms and operator response, or automatic vehicle propulsion interdiction)?
3. Should regulations allow (or necessarily not preclude) remote operators of AV transit vehicles to enable wheelchair lifts or wheelchair ramps, actuate wheelchair securement features, and/or actively supervise the passenger boarding process through remote video/audio links?

Semi-Automated Operations – Over the near to medium term L2 and L3 automation will require that an operations person remain onboard the transit vehicle, specifically to be ready to resume control of the dynamic driving task when the vehicle exits its operational design domain (ODD as defined in the NHTSA AV model policy). This responsibility to monitor the vehicle automated driving operations, including the need to remain alert to quickly resume driving functions when notified of this need by the driving automation system, must be performed in combination with other non-driving functions – e.g., ensuring safety of the passenger/vehicle interface while boarding/alighting is underway, securing of wheelchairs, and other such non-driving functions. Specific hazard analyses should be performed under the auspices of the SMS process which address this overall combination of automated and non-automated functions/responsibilities that onboard and/or remote operators must undertake. In some industry expert opinions, the safety concerns could be as great or greater during the period when vehicles are automated most of the time, but not all of the time or in all of the functions (i.e. L3 operation). Experiences in the aviation industry indicate that these "partially" automated conditions can induce hazards that can result in spectacular failures when certain "corner cases" of combined conditions are encountered (e.g. multiple systems are disabled or malfunctioning, environmental conditions are extreme, and operator stress levels are either elevated or very, very low). Such situations may become less likely once full and mature L4 AV transit technology becomes available, and some suggest that it might be better to avoid such "shared responsibility" situations altogether by not "progressing" through L3 to L4 and directly developing L4 systems. The progression path would therefore be through low speed, small vehicle operations (today's L4 shuttle vehicles) to larger vehicles and higher speeds which would bring AV transit operations closer to the performance of today's standard manually-driven coaches.

5. NHTSA Vehicle Safety Regulations

Federal Motor Vehicle Safety Standards (FMVSS)

The National Highway Traffic Safety Administration (NHTSA) establishes and maintains safety standards known as the Federal Motor Vehicle Safety Standards and Regulations (FMVSS) for the automobile industry in the United States. Other countries around the world have followed suit with very similar safety requirements.

The FMVSS are only one part of NHTSA's responsibility, but the ultimate regulation of AV technology will likely come through new FMVSS regulations. A NHTSA web page[17] that introduces the NHTSA Priority Plan for Vehicle Safety and Fuel Economy, 2015 to 2017 begins with the following statement:

> *The primary mission of the National Highway Traffic Safety Administration (NHTSA) is to "save lives, prevent injuries, and reduce economic costs due to road traffic crashes." NHTSA strives to meet its mission through a wide range of behavioral and vehicle safety programs. NHTSA's mission also includes a commitment to environmental sustainability through setting and enforcing fuel economy and efficiency standards.*
>
> *NHTSA's vehicle safety program seeks to meet these objectives through:*
>
> - *development, issuance and enforcement of Federal motor vehicle safety standards (FMVSS), regulations and fuel economy/efficiency standards,*
> - *development and dissemination of vehicle and equipment performance information to consumers, including through its New Car Assessment Program (NCAP),*
> - *investigation of possible safety defects and noncompliance, and when appropriate, seeking recalls of vehicles and equipment that pose an unreasonable safety risk or do not comply with the FMVSS,*
> - *research to define safety problems and to support the development of standards to address these problems,*
> - *research to aid the development and deployment of advanced technologies that improve safety and fuel efficiency, and*
> - *collection and analysis of crash data to identify potential safety problems and to assess the effectiveness of proposed solutions.*

The three series of automobile safety FMVSS requirements that are best known are as follows:

1. Crash avoidance (100-series)
2. Crashworthiness (200-series)
3. Post-crash survivability (300-series)

FMVSS standards also address the requirements for some specific types of vehicles such as school buses. NHTSA also monitors vehicle manufacturer compliance with FMVSS requirements, and can enforce safety recalls as well as levy fines on manufacturers of vehicular products deemed as noncompliant with FMVSS regulations. There are multiple additional FMVSS standards for items such as fuel standards, manufacturer and vehicle identification

[17] https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/nvs_priority-plan-june2015_final.pdf

requirements, seat belt requirements, dashboard instrument lighting requirements, and so on. With respect to certain the FMVSS requirements, NHTSA also has defined a battery of vehicle tests with associated procedures and test acceptance criteria. NHTSA performs tests and rates the demonstration of compliance of every automobile model sold in the United States though a five-star rating system.

NHTSA has not yet announced how and if these traditional safety requirements and tests will be expanded to include safety tests specific to what the 2016 USDOT/NHTSA Policy Statement identified as "highly automated vehicle" (HAV) technology. Currently, a process is underway to assess the FMVSS standards' applicability to AV technology. Through this ongoing review process, NHTSA is identifying which standards may need to be changed to properly address semi-automated and fully automated roadway vehicles, as well as identifying what new FMVSS standards will need to be added to test and confirm the adequate safe design of both light and heavy vehicle AV products that are brought to the US market place. The Executive Summary of a 2016 FMVSS evaluation report[18] assessing how HAV technology could fit into existing standards begins with these summary points:

> *Current Federal Motor Vehicle Safety Standards (FMVSS) do not explicitly address automated vehicle technology and often assume the presence of a human driver. As a result, existing language may create certification challenges for manufacturers of automated vehicles that choose to pursue certain vehicle concepts.*
>
> *The purpose of this work is to identify instances where the existing FMVSS may pose challenges to the introduction of automated vehicles. It identifies standards requiring further review - both to ensure that existing regulations do not unduly stifle innovation and to help ensure that automated vehicles perform their functions safely.*

Clearly, the decisions of NHTSA concerning the expansion of FMVSS standards to address AV technology in general, and AV transit vehicles in particular, will have a major impact on the designs of automated roadway transit vehicles that are available for deployment in transit service.

With regard to the early deployment prospects of L4 automation in non-conventional AV transit vehicle designs which are actively being tested in campus and very low speed environments, the following summary point has been extracted from the Volpe review of FMVSS standards and their potential impacts on AV technology (refer to footnote 14):

> *Automated vehicles that begin to push the boundaries of conventional design (e.g., alternative cabin layouts, omission of manual controls) would be constrained by the current FMVSS or may conflict with policy objectives of the FMVSS. Many standards, as currently written, are based on assumptions of conventional vehicle designs and thus pose challenges for certain design concepts, particularly for 'driverless' concepts where human occupants have no way of driving the vehicle (e.g., §571.101, controls and displays, §571.111, rear visibility, §571.208, occupant crash protection represent a few examples).*

[18] http://ntl.bts.gov/lib/57000/57000/57076/Review_FMVSS_AV_Scan.pdf

The special environments and enhanced monitoring and crash avoidance features of AV transit vehicles should be given special consideration in order to allow the near-term deployment of AV transit technology in special environments – a step that we believe is critically important to advancing R&D initiatives. The following questions illustrate some of the key issues that should be addressed:

1. Can the crashworthiness criteria be adjusted for AV technology if/when automation can be shown to significantly improve crash avoidance capabilities of the vehicle?
2. Can provisions with less stringent crashworthiness criteria be made in the near term for AV transit vehicles that operate in protected environments dedicated to transit vehicles and pedestrians (such as campuses, parking lots, and guideways)?
3. Can crash survivability criteria be less stringent for AV transit vehicles operating in protected environments (such as campuses, parking lots, and guideways) when interactions with other roadway vehicles only occurs at signal-protected grade-crossings of the transitway with roadways?

The rapid advancement of a several L4 AV transit vehicle designs which do not resemble conventional automobile, truck or bus chassis designs gives an urgency for NHTSA and FTA to identify any decisions on how and where these specialized vehicles will and will not be permitted to operate. Other FMVSS requirements to be placed on AV transit vehicles that generally conform to conventional bus and light truck chassis design will be issued at a point in the future, probably at the same time as standards for HAV automobiles are released by NHTSA.

6. Security and Privacy Laws

Security Regulations

Cyber security is the biggest threat to safety of AVs. As with any other computerized systems with networking capabilities these days, AVs have the potential to be hacked, which could have very serious consequences particularly in the context of transit. Pilot projects across the EU and USA are testing different cybersecurity and privacy measures. Some vehicle manufacturers are giving "hack-a-thon" prizes to test the security of vehicles. Cyber-security must take a multi-pronged approach to preventing, identifying, and stopping thefts and attacks.

The private sector manufacturers of AVs have different proprietary algorithms and codes for automation, as well as software and hardware that are manufactured by multiple vendors. There are multiple sources of cyber-threat within one AV. In addition, V2I networks are a possible source of cyberattack. Another source of cyber-threat is the internal network for the AV's electrical control unit (ECU). Finally, networks within the AV that are linked to external data sources such as radio, navigation, etc. are another source of a potential threat. Because many of the threats to AVs are internal to the vehicle, private manufacturers must take the lead on implementing cybersecurity. However, in the US, in 2014, only two of 16 auto manufacturers had addressed cybersecurity threats by developing the capability to detect hacks in real-time.[19]

Because of the major need and the lack of commitment from AV manufacturers, US legislators are attempting to pass legislation to establish federal standards for security and privacy for AVs. The act, entitled "The Security and Privacy in Your Car Act" prescribes vehicle manufacturers to detect, report, and stop hacks that interfere with personal data or vehicle control.[20] The legislation addresses the types of data including location, speed, owner, and passengers and the location of the data – on-board, in transit from vehicle to another location, and off-board data storage. It proposes a "cyber dashboard" to tell consumers the vehicle's cyber rating above the minimum requirements. It also requires AV manufacturers to notify the owner or user of the vehicle of what data is being collected, how it is stored, for how long, and what the data is used for. It gives the user the ability to opt out of data collection (with specific safety exceptions) without losing AV features. Finally, the legislation prevents the use of data for advertising or marketing without the owner or user's consent. This legislation has not yet become a law in the US.

In July 2016, the Automotive Information Sharing and Analysis Center (Auto ISAC), a group of Automotive Manufacturers, developed a series of best practices for cybersecurity[21], which is endorsed by NHTSA in its September 2016 Federal Automated Vehicles Policy. The categories addressed include:

[19] http://www.markey.senate.gov/news/press-releases/sens-markey-blumenthal-introduce-legislation-to-protect-drivers-from-auto-security-privacy-risks-with-standards-and-cyber-dashboard-rating-system

[20] https://www.congress.gov/bill/114th-congress/senate-bill/1806/all-info

[21] https://www.automotiveisac.com/best-practices/

- Governance
- Risk Assessment
- Risk Management
- Security by Design
- Threat Detection and Protection
- Collaboration and Engagement.

The best practices document recommends identifying and addressing cyber-threats in the design process of the vehicle's systems with an emphasis on limiting network interactions and separating networks and environments where possible. The governance recommendations include creating or purposing a vehicle cybersecurity organization with regulations and policies for vehicle manufacturers. In probably the best case result for the US, this would be a federal agency responsibility such as NHTSA. How such regulations would affect the transit industry are not known at this time, and NHTSA's AV model policy does not discuss any transit specific issues.

The USDOT has adopted a "security by design" principle as it develops the system architecture for connected vehicles—meaning cybersecurity systems will be built in. In the EU, the recommendations of the C-ITS platform are very clear: one common standardized C-ITS trust model and certificate policy all over the EU, based on a Public Key Infrastructure (PKI) and defined in an appropriate regulatory framework, shall be urgently deployed to support full secure interoperability of C-ITS Day 1 services (including any connected transit systems and vehicles). The "security by design" principle applies to both V2V and V2I systems.

NHTSA's Federal Automated Vehicles Policy addresses data recording and sharing[22]. The policy recommends collecting data for testing and for crash events. For crash events, NHTSA should receive the data itself in case of personal injury and significant damage that requires towing. For testing purposes, NHTSA recommends collecting data on positive events including near misses or when the AV successfully avoided an incident, and sharing the data with other third parties. When the data is shared, it should not be personally identifiable with a person or vehicle. NHTSA acknowledges that data sharing and privacy with regard to AVs is still in its infancy and advises the vehicle manufacturers to work with standards organizations for data collecting and sharing. With regard to privacy, the Federal AV Policy states that consumers should expect:

- **Transparency** – the ability for consumers to understand what data is collected and what it is used for. There is a need for clear and accessible privacy agreements consistent with the White House Consumer Privacy Bill of Rights
- **Choice** – consumers should have some control of data sharing. They should be able to have the choice of sharing and retaining data including geolocation, biometric, and driver behavior that may be personally identifiable.

[22] NHTSA Federal Automated Vehicle Policy, Sept 2016.
http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwiGxK0xhL3PAhUG6mMKHdENDT8QFggkMAA&url=http%3A%2F%2Fwww.nhtsa.gov%2Fnhtsa%2Fav%2Fpdf%2FFederal_Automated_Vehicles_Policy.pdf&usg=AFQjCNHSgKVEpfw_sE0cV6VFGd7uefwl6A&sig2=m-GdAFvdtQlYo8mcuZK11A

- **Respect for Context** – Consumers have the right to know that the data they allow access to is only used in ways it was originally anticipated when collected consistent with privacy agreements. For example, if they are consistently visiting a specific market, the consumer has the right to know their location information isn't going to be used by the AV manufacturer to market specific grocery items to them.
- **Data Security** – Consumers have the right to the reassurance their data and vehicle is secure. There is a need to implement data protection measures for security.
- **Integrity and Access** – Consumers have the right to know their data is being transmitted accurately. As such, they have a right to review and correct data transmissions. AV manufacturers must protect the accuracy of personal data and correct any inconsistencies.
- **Accountability** – There is a need for a higher level of accountability for AV manufacturers and data management system providers to ensure these tenets are being addressed. Government review or an oversight body should audit and evaluate data collection and privacy procedures to make sure they are consistent with policies.

In the European Union (EU), data is divided into different categories – vital interest, public interest, and consent.[23] Each category has a legal definition and specific data associated with it. The overarching recommendation is for informed consent to broadcast, use, or store personally identifiable information, unless it is of vital or public interest. In the context of transit, these guidelines become less clear as riders are simply passengers and drivers of L3 AV transit vehicles are employees with limited to no inherent right to privacy while on the job.

There is still more work to be done in the public and private sector internationally in developing specific policies and regulations for cybersecurity and data privacy for HAVs in general, and specifically for AV transit systems. A security framework for all AV transit will need to be developed stemming from the NHTSA actions. Where such regulatory responsibilities for transit operations will lie will need to be determined, and how such activities are coordinated with Auto-ISAC and State and Federal regulations regarding hacking. Strict punishments will need to be established for cyber-security breaches commensurate with the level of threat particularly in the case of AV transit (up to and including attempted and actual murder and terrorism).

Privacy Protection Laws

Automated vehicles process sensor readings of the surrounding environment to travel safely. For AVs to make those navigational and operational decisions, the vehicle will need to collect data about itself and/or the driver; then distribute that data between vehicles, infrastructure, and other drivers. The risks lie not only in the data collection, but how that data is

[23] C-ITS Platform Final Report, January 2016
http://ec.europa.eu/transport/themes/its/doc/c-its-platform-final-report-january-2016.pdf

communicated whether transmitted between technologies in the vehicle (i.e. smartphone) or V2V or V2I.

New vehicles including buses beginning in September 2014 in the US are now required to have an event data recorder (EDR) per the National Highway Traffic Safety Administration (NHTSA)[24]. NHTSA requires the recorder to obtain information related to 15 variables: speed, airbag deployment, application of brakes, seatbelt worn, engine speed, steering, and others. The recorders are not supposed to be recording audio, GPS, or video within the vehicle (although many transit buses have on-board video that is not strictly part of the EDR). The information is used to assess how well the driver responded in a crash and whether or not the vehicle was operated properly.[25]

Another factor is the availability of the EDR data. NHTSA requires the data to be available up to 10 days after the event and then storable up to 30 days.[26] Depending upon the size of the files and the severity of the crash, this amount of time should be sufficient in recreating the crash or assessing the performance of a test vehicle. As data is collected within the vehicles, and personal information is linked to the driver or the user of the vehicle, the processing and communication of this data will need to comply with data protection and privacy laws. This should not pose to be problematic for driverless transit systems, except in the determination of responsibility of the remote "operator" in any crash.

In Europe, the EU adopted the **Data Protection Directive** (95/46/EC) in 1995 as an important piece of the EU privacy and human rights law. Several countries took the directives and implemented them into their own laws. In early 2016, EU passed the **General Data Protection Regulation** which will supersede the Data Protection Directive. Both laws are designed to regulate the processing of personal data. Processing includes the collection, recording, storing, altering, and/or disclosure of the data. The owner of the data is to be informed prior to transmitting or sharing the data to anyone other than the owner.

The US has no one specific data protection law but rather a patchwork of complementary and in many cases overlapping regulations. The US has several data privacy laws and regulations that are specifically dedicated based on specific industries or specific States (Arizona, Alaska, etc.)[27]. For example, there is the Video Privacy Protection Act, Health Insurance Portability and Accountability Act (HIPPA), as well as the First, Fourth, and Fourteenth Amendments of the Constitution. In 2012, the US administration developed the Consumer Privacy Bill of Rights,[28]

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[24] https://www.gpo.gov/fdsys/pkg/CFR-2011-title49-vol6/xml/CFR-2011-title49-vol6-part563.xml

[25] http://www.nhtsa.gov/About+NHTSA/Press+Releases/U.S.+DOT+Proposes+Broader+Use+of+Event+Data+Recorders+to+Help+Improve+Vehicle+Safety

[26] http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&cad=rja&uact=8&ved=0ahUKEwjL2cLfkr3PAhXH4iYKHc55AZYQFggrMAI&url=http%3A%2F%2Fwww.nhtsa.gov%2FDOT%2FNHTSA%2FRulemaking%2FRules%2FAssociated%2520Files%2FEDRFinalRule_Aug2006.pdf&usg=AFQjCNHTIY4Rsshli0nryk1AIYUwH7P0Dw&sig2=AfZhWKSrc3pTOzlaS3F-ow&bvm=bv.134495766,d.eWE

[27] https://www.huntonprivacyblog.com/wp-content/uploads/sites/18/2011/04/DDP2015_United_States.pdf

[28] https://www.whitehouse.gov/sites/default/files/privacy-final.pdf

identifying or recognizing the Fair Information Practice Principals (FIPP). Data privacy and protection laws are designed so that individuals have a reasonable expectation their private data would not be transmitted to another party without their consent. This would be true for both inside and out of the vehicle; including smartphone and vehicle 'black boxes'.

As an extension of the general principles and legal requirements discussed above, there will need to be additional care given to protecting the personal information of individual transit patrons. New types of on-demand dispatch driverless transit services, in particular, may use data from the passenger's smart phone or other such personal device when they request a transit vehicle. This information will likely include their origin and intended destination as well as possibly their personal identity and payment information. Such personal data, combined with likely use of real-time audio and video security surveillance in vehicles and stations present privacy protection issues for transit operating agencies.

Currently, transit agencies that accept contactless smart cards for fare payment face many of these issues already today as summarized in recent TCRP Legal Research[29]. Most existing legacy transit smart cards have no PII expressly loaded on them but only a balance of funds available for transit use[30]. As smartphones have now enabled new ways for merchants to be paid (Samsung Pay, Google Wallet, etc.) through near-field-communications (NFC), this abstraction of PII from location is somewhat removed but is commonly still managed through the merchant payment system. As noted in [29], no legal cases involving privacy violations of transit patron's PII have been encountered to date. In most situations, the transit agency is treated as just another type of merchant. As long as the transit agency has industry-accepted privacy policies and protections in place, there is little argument that driverless transit services will pose any more PII risk than existing payment and service systems.

Similarly, audio and video surveillance and recordings are now commonplace in transit operations. In most States, recording and real-time surveillance is legal since there is no expectation of privacy in a public space (i.e. in the transit vehicle). Such monitoring becomes even more important when there is no driver on board and communications with the remote operator will only be possible through these systems if a problem arises. As long as the transit agency has industry-accepted privacy policies and protections in place, there is little argument that driverless transit services will pose any more PII risk than existing video and audio surveillance systems on transit vehicles today.

[29] http://www.trb.org/main/blurbs/175848.aspx

[30] Except in certain programs where cards are used for discounted fares such as senior and children and pre-paid passes. In these cases, the user's ownership information is linked to the card's use at the time of payment for verification that the pass is valid.

7. Governmental Policy Considerations

The overall policy considerations on L3, L4 and L5 automated roadway vehicle operations which governmental bodies are beginning to address around the world will have major implications for the long term future of our multimodal transportation systems. There are diverging views on how AV technology will transform and impact both our transportation system and the urban centers of population in which the vast majority of people now live. Broad policy positions will need to be defined soon by local, state and federal governmental bodies and associated laws and regulations will have to be put in place if a preferred, planned outcome is felt to be important to achieve.

The dominant view is utopian. With no policy driven actions this "positive" result can only be hoped to come true. This view embraces the concept of a future world in which people can live wherever they want and simply commute to their work/ school/ shopping/ recreation destinations each day in their own personal automated vehicle, enjoying the travel while they eat, sleep, work or play throughout the trip. In this view, transit use will plummet as people opt to have a vehicle chauffer them throughout the day, and then be dispatched away with no occupants until needed again. For many holding this view, the concept of extensive fleet(s) of shared-use, shared-ownership, or pay-by-the-trip (or weekly, monthly, or yearly "mobility" leases) HAV automobiles is a fundamental assumption. Costs for owning your own vehicle will be vastly more expensive than paying for mobility on demand. Traffic crashes are a thing of the past and congestion melts away as AVs seamlessly exchange data on their movements. Mass transit is no longer necessary.

What is not as well-known is the dystopian view[31]. When everyone owns their own HAV automobile, or co-owns or hires on-demand a shared-use HAV automobile which is dispatched back and forth over potentially long distances to service its multiple owners, massive traffic congestion is the result. This "negative" view asserts that this congestion will occur even with the creation of complete V2V and V2I connectivity which increases the roadway throughput capacity and provides much higher safety. The ability to have an automated vehicle safely drive you to work, and then be sent home, or be sent to a remote and inexpensive parking facility or just drive around empty until needed again, seems an attractive option. However, it is possible that this scenario will create many more vehicle-miles traveled as large numbers of empty vehicles (no-occupant vehicles, or NOVs) move through the roadway system alongside occupied vehicles, thereby completely absorbing the newly created additional roadway capacity. In order for such dystopia to be avoided, ride-sharing must become our new reality. Some research indicates that average vehicle occupancy per trip must approach 3 persons per trip to avoid the gridlock of NOV repositioning that now occurs in parking lots (i.e. individual owner's vehicles are parked more than 90% of the time) and to come close enough to the carrying capacity of line haul transit systems.[32]

The policy questions that should be considered by governmental bodies is whether the regulatory management (or intentional lack of regulatory management) elements in their

[31] https://www.theatlantic.com/politics/archive/2016/01/will-driverless-cars-become-a-dystopian-nightmare/459222/

[32] http://orfe.princeton.edu/~alaink/TRB'14/TRB'14_BrownellPaper_0728v2.pdf

toolbox of proactive transportation master planning will foster utopia or drive dystopia in a future HAV-dominated roadway system. Does policy drive the creation of governing laws/regulations which may be needed to accomplish the goals of a master plan? What is the role of transit systems if mobility in individual HAVs can be provided for comparable cost (some models indicate $16-$25 per person per day – footnote 26) to individual vehicle ownership? If a current transit rider's commute can be cut by 50% travel time for double the price, would they pay the price?

The essence of this question is whether shaping this future transportation world is important enough to intervene in a regulatory manner – much like a government planning for a future water supply must impose regulatory provisions through water conservation/management combined with the creation of sufficient reservoirs and water distribution systems. Any such regulatory steps to shape the world, whether affecting transportation or basic water supply, can be very controversial.

An interesting policy brief has been prepared by UITP, the international association of transit operators that is based in Brussels, Belgium and which has a membership of over 1400 transit operating agencies from 96 countries. Working from a position that asserts the Dystopian view of massive congestion if governmental regulation and investment does not occur and AV private auto proliferation is left unchecked, the UITP policy proposal is titled *Autonomous Vehicles: A Potential Game Changer for Urban Mobility* (see **Appendix F**). The policy document proposes the use of regulatory means to advance a dominant use of shared-ride AV systems, comprising both private fleet operations integrated with high-capacity public AV transit service. Figure 1 shows the illustration of the proposed policy objective in which AV transit is a mode the governmental policy would support, fund and enhance.

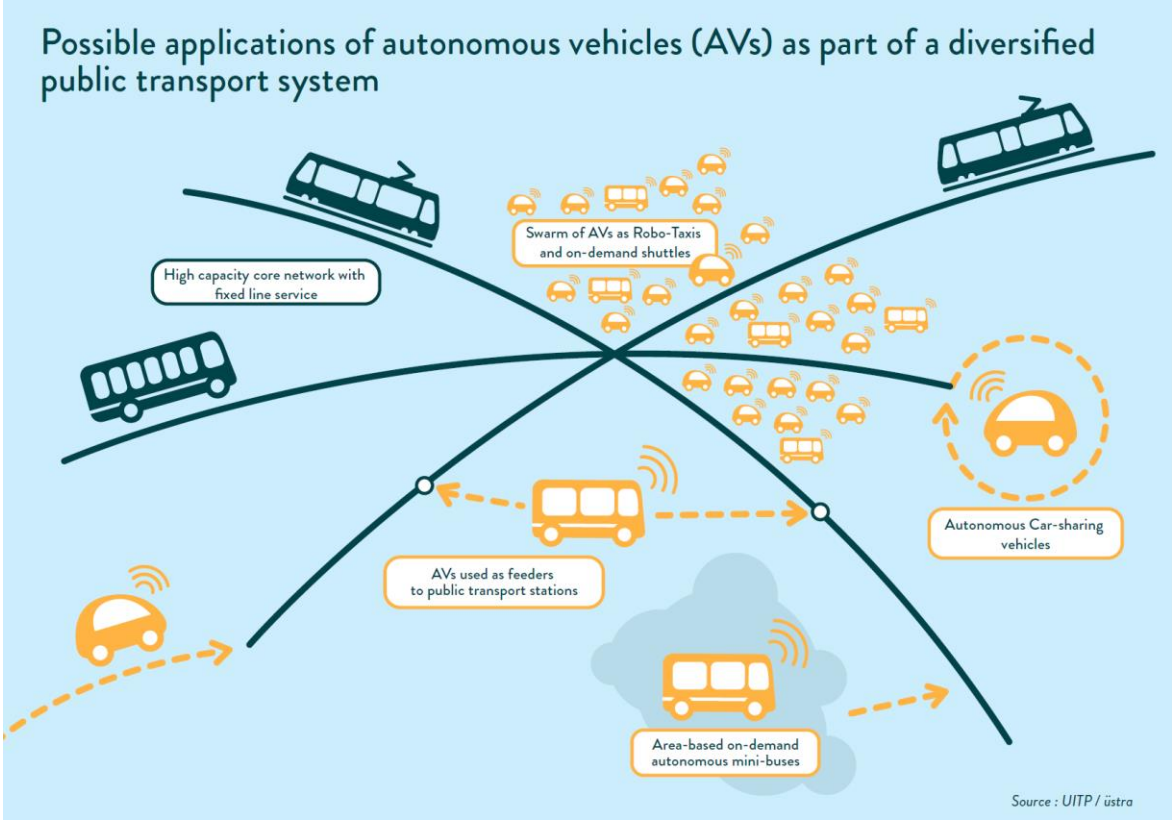

Figure 1. UITP Proposed Concept of Shared-Ride AV Transit and "Robo Taxis" to Feed Mass Transit

A similar Japanese view of a proactive, policy driven future in which the future transportation system with automated roadway vehicles includes a strong public AV transit component created by the government. This comprehensive overview was presented at the 2016 TRB/AUVSI Automated Vehicles Symposium in a presentation by the President of ITS Japan, Mr. Hajime Amano[33]. The policy framework described as the "Cross-Ministerial Strategic Innovation Promotion Program" which includes "Automated Driving for Universal Services" (SIP-adus) involves a level of transportation and urban planning that would certainly be considered "exceptional" in the United States. An extract from the presentation that is most relevant to this policy discussion is included in **Appendix G**. These slides concluded the presentation and provide an introduction of the "ITS Japan Action Plan: 2016-2020." The "key message" presented to describe the purpose of the Action Plan is as follows:

> *Inclusive society, where diverse people in diverse communities actively participate in generating values, will enhance both wellness of individuals and economic development. Automated driving technologies integrated with social innovations should provide everyone with mobility to fully exercise his or her capacity, enabling sustainable development of the society.*

[33] https://higherlogicdownload.s3.amazonaws.com/AUVSI/14c12c18-fde1-4c1d-8548-035ad166c766/UploadedImages/documents/Thurs/0830-0845%20Amano.pdf

The Action Plan leverages AV technology to support an efficient living environment built around a tiered system of urban living and working developments. The illustrations begin by describing "villages" with neighborhoods and walkable communities having a scale of 10,000 in population within which small "personal mobility vehicles" and shared-ride AV transit systems connect people to a central transportation hub. The villages are clustered around and connected to high density larger cities by AV transit systems (called "advanced rapid transit" or ART, which are also referenced as BRT in the presentation). These larger cities are described as "integrated regional hub" cities of 300,000 population that contain medical care, higher education and employment centers, and which are interconnected with other regional hub cities by high capacity rail transit. This network of medium scale regional-hub cities are in turn connected by high speed rail and expressways to SMART, highly automated "mega-cities" which are served by international airports and seaports, creating very large industrial and global trade centers.

Local, regional or federal government agencies may or may not have a formal mission, or even an interest in enacting levels of regulatory control such as described in these international policy visions for the purpose of shaping the future development of our towns and cities. It can be said, however, that policy actions taken now by governmental bodies will directly impact our future transportation and urban living environments. Similarly, taking no action is also a policy decision that will also have a great effect on our collective future.

8. Findings and Recommendations on Governmental Laws and Regulations

Governmental laws/ordinances and the regulatory constraints that they impose will have a major impact on how and when AV transit technology will affect our society and the communities where we live and work. The laws and regulations, and the connections of these regulations to governmental funding mechanisms will without a doubt determine the rate that AV technology enters into public transit service in the United States. Laws and regulations that tightly restrict the innovative development of these advanced transportation systems could delay deployments by many years.

Even more importantly, any delays resulting from laws and regulatory barriers to AV transit technology deployment within the multimodal transportation system may change forever the extent to which transit is considered in long range regional urban planning and funding programs. As discussed earlier, it is unclear if utopia or dystopia will result from a focus on privately owned and operated HAVs and whether such services can truly deliver the mobility that line haul transit systems provide for today's urban cities. Delays in implementation will thereby change forever the extent to which the AV public transit mode is available to be utilized, giving greater probability that public transit may progressively diminish as a key part of the overall transportation system in the years to come.

Employee Protections – A portion of federal laws are intended to protect employees of public transit operating agencies. To some extent, these laws provide for the preservation of jobs and will be critically important to review and possibly modify if AV technology is to have its maximum penetration of this sector of the transportation market.

Section 13c of the Federal Transit Act specifically states "…*must provide for the preservation of rights and benefits of employees under existing collective bargaining agreements, the continuation of collective bargaining rights, the protection of individual employees against a worsening of their positions in relation to their employment, assurances of employment to employees of acquired transit systems, priority of reemployment, and paid training or retraining programs."*

Some involved in our stakeholder meetings believe that this federal law could be one of the most challenging aspects of bringing AV transit technology into the mainstream of public transit service. The involvement and cooperation of collective bargaining unions and impacted staff employees will determine how a mutually acceptable interpretation and application of the law by each transit operating agency.

OSHA Workplace Safety regulations are primarily applicable to industrial workplace protection, and the entry of robotic machines into the manufacturing industry over the past few decades has been a topic addressed by OSHA in the way of guidelines more than regulations. However, the sudden insertion of robotic machines which move within relatively uncontrolled and relative unprotected environments of transit operations and maintenance facilities (when compared to manufacturing plant assembly lines and factories) may require more precise OSHA directives and guidelines that go beyond the existing brief guidelines given in **Appendix B**.

Passenger Protections – Intervention of the federal government to protect the most vulnerable and most dependent of public transit passengers from discrimination and from unsafe operating conditions has been an important area of existing laws and regulations. The two demographics that have had specific federal laws created for their protection are the physically disabled and the racial minority communities.

Title VI Nondiscrimination law has significantly impacted the release of federal funds for transit projects over the past 50 years. There can be decisions made with respect to this aspect of federal funding that has some elements of discretion in determining the nuances of discrimination. The application of AV transit technology for some transit operating agencies could potentially result in negative assessment of discrimination in the project funding review process if the deployments unfairly exclude the portions of the population protected by Title VI. However, there is an equally strong potential that AV technology can *significantly help* transit operating agencies more successfully serve the disenfranchised minority populations if a more cost effective AV transit service can be provided in low density, suburban areas where the population has a high transit dependence.

ADA Transit Regulations are drawn from the Americans with Disability Act in which FTA has developed specific requirements for transit vehicles and transit station facilities. The regulations provide basic criteria that must be accommodated in the vehicle designs, but no regulations are yet in place for L4 AV transit technology vehicles. L3 vehicle automation is probably not a significant challenge with respect to ADA since an operations person will still be onboard every vehicle. However, for L4 transit (which is already possible today at low speeds) a different set of requirements will be necessary since there is no operations person present in the vehicle. Wrestling with these issues cannot begin soon enough as more and more agencies contemplate the use of L4 shuttles for first-mile, last-mile services and circulators.

Existing FTA regulations for conventional rail mass transit and low speed people mover systems have established benchmarks for level platform "gap" criteria (maximum distance between the vehicle and the platform) which may serve to set the standards required for AV transit vehicles. Where level platform boarding is not provided, the safety and operational challenges of deploying wheelchair ramps automatically, versus providing precision docking of vehicles at raised platforms that provide level boarding, should be investigated and appropriate regulations prepared from those research programs.

FTA Regulations – FTA has developed regulations specific to public transit systems which are not derived from other primary law such as their regulations covering Title VI or ADA nondiscrimination laws. These areas of regulation may be the most important with respect to implementing AV transit technology by the local transit operating agency since there are typically quantifiable analyses and calculations involved. Failing to demonstrate to FTA a compliance with the regulations to FTA could directly impact FTA funding grants, or even pose the potential for FTA to levy fines for non-compliance.

Buy America requirements will be a critically important set of regulations directly impact which foreign suppliers of AV transit vehicles can be solicited for proposals/bids once the early phase of R&D is passed and the full FTA regulatory framework is being applied. The Buy America regulations are specifically designed to ensure that transit vehicles and certain raw materials

for facilities construction have their manufacturing source within the United States. Although waivers can be granted by FTA for special circumstances, over the long term foreign vehicle manufacturers will have to establish final assembly plants in the U.S. and procure a majority of their subsystems and components from U.S. manufacturers. The Buy America regulations could also foster the creation of more U.S. owned manufacturers of AV transit vehicles, perhaps accelerated with additional incentives for US companies to enter the market such as tax credits, deductions, or other subsidies.

Transit System Safety Program Plans have been an important part of FTA requirements and guidelines for fixed guideway rail transit systems for several decades. The FTA approach to safety analyses and hazard mitigation has applied methodology developed in the aerospace industry and in related military specifications. Recent updates to the safety regulations adding the definition of a Safety Management System (SMS) to the overall FTA safety program has made the similarities between FTA safety requirements and FAA requirements even stronger. This appropriately aligns the experience of automation in the aviation field with the new automation that is coming to the roadway transit field.

The FTA regulations/guidelines, and the associated State Safety Oversight responsibilities will need careful coordination by FTA over the near to medium term for AV transit systems to have operational safety that equals that of automated fixed guideway transit systems. There may also be a need for expanded guidance and oversight by FTA (or the States) as all transit operators, both large and small, must implement system safety programs for their specific AV transit technology deployments. FTA's safety assurance methodology will need to be coordinated with the automotive industry's safety methodology developed specifically for the AV transit vehicles as manufactured products (Refer to Working Paper #2 for more discussion).

NHTSA Regulations – The Federal Motor Vehicle Safety Standards (FMVSS) comprise the regulatory law that governs the federal government's oversight and control of the automotive industry and the automobile products that are sold in the United States. FMVSS cover basic safety aspects of vehicular crash avoidance, vehicular crashworthiness and crash survivability of passengers. Other FMVSS which require features allowing the vehicle to be driven in a conventional way by a human operator are also included in the regulations.

FMVSS requirements have been under review by NHTSA for several years with respect to the new technology developments of what has been defined in the USDOT/NHTSA 2016 Policy Statement as "highly automated vehicles" (HAV). At this point in time, there have not been any specifically proposed changes or additions to FMVSS to define safety design requirements, test procedures or performance criteria under fully automated or semi-automated vehicle controls. However, it is anticipated that such changes will be forthcoming over the next several years.

The rapid advancement of several L4 AV transit vehicle designs which do not resemble conventional automobile, truck or bus chassis designs gives an urgency for NHTSA and FTA to identify any decisions on how and where these specialized vehicles will or will not be permitted to operate. Other FMVSS requirements to be placed on AV transit vehicles that generally conform to conventional bus and light truck chassis design will be issued at a point in the

future, probably at the same time as standards for HAV automobile standards begin to be by NHTSA.

Security and Privacy Law – Cyber security is the biggest threat to safety of AVs. Cyber-security must take a multi-pronged approach to preventing, identifying, and stopping thefts and attacks. Because of the major need and the lack of commitment from AV manufacturers, US legislators are attempting to pass legislation to establish federal standards for security and privacy for AVs. The act, entitled "The Security and Privacy in Your Car Act" prescribes vehicle manufacturers to detect, report, and stop hacks that interfere with personal data or vehicle control.[34] The legislation addresses the types of data including location, speed, owner, and passengers and the location of the data – on-board, in transit from vehicle to another location, and off-board data storage. It proposes a "cyber dashboard" to tell consumers the vehicle's cyber rating above the minimum requirements. It also requires AV manufacturers to notify the owner or user of the vehicle of what data is being collected, how it is stored, for how long, and what the data is used for. It gives the user the ability to opt out of data collection (with specific safety exceptions) without losing AV features. Finally, the legislation prevents the use of data for advertising or marketing without the owner or user's consent. This legislation has not yet become a law in the US.

In July 2016, the Automotive Information Sharing and Analysis Center (Auto ISAC), a group of Automotive Manufacturers, developed a series of best practices for cybersecurity[35], which is endorsed by NHTSA in its September 2016 Federal Automated Vehicles Policy. In probably the best case result for the US, this would be a federal agency responsibility such as NHTSA. How such regulations would affect the transit industry are not known at this time, and NHTSA's AV model policy does not discuss any transit specific issues.

New vehicles including buses beginning in September 2014 in the US are now required to have an event data recorder (EDR) per the National Highway Traffic Safety Administration (NHTSA)[36]. NHTSA requires the recorder to obtain information related to 15 variables: speed, airbag deployment, application of brakes, seatbelt worn, engine speed, steering, and others. The recorders are not supposed to be recording audio, GPS, or video within the vehicle (although many transit buses have on-board video that is not strictly part of the EDR). The information is used to assess how well the driver responded in a crash and whether or not the vehicle was operated properly.[37]

Policy Considerations – Governmental policy is discussed in its role as the precursor to the enactment of laws and regulations, being a statement of the goal of governmental intervention in the free market process. Two views of the future transportation world that "highly automated vehicles" will bring are the Utopian view in which travel by HAV automobile becomes so safe, convenient and effortless that the attractiveness of public transit falls dramatically as more and

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[34] https://www.congress.gov/bill/114th-congress/senate-bill/1806/all-info

[35] https://www.automotiveisac.com/best-practices/

[36] https://www.gpo.gov/fdsys/pkg/CFR-2011-title49-vol6/xml/CFR-2011-title49-vol6-part563.xml

[37] http://www.nhtsa.gov/About+NHTSA/Press+Releases/U.S.+DOT+Proposes+Broader+Use+of+Event+Data+Recorders+to+Help+Improve+Vehicle+Safety

more people live long distances from where they work. The alternative Dystopian view in which the surge in vehicle-miles travels increases dramatically and congestion increases, in part due to the many empty vehicles that enter the traffic streams and absorb the expected new capacity that V2V and V2I will add to our roadway system.

One prominent example of an international policy proposal is that of UITP in which the dystopian view is asserted and proactive regulatory action is proposed for the purpose of ensuring a well-integrated multi-modal transportation system. In a similar policy proposal, ITS Japan has described a multimodal system in which a large component of AV public transit is included in the future "Strategic Innovation Promotion Program." The Japanese concept specifically includes "Automated Driving for Universal Services" (SIP-adus) which facilitates a completely integrated AV Transit and HAV automobile system, combined with rail mass transit and high speed rail connecting the tiers of urban development in villages, regional hub cities and mega-cities.

It is quite important for local, regional or federal government agencies to establish policies that shape regulatory controls for the purpose of guiding the future development of our transportation systems. It can be said that policy frameworks and regulatory actions taken now (as well as alternative policy decisions not to intervene) by governmental bodies will heavily impact our future transportation and urban living environments.

Recommended Research Projects and Policy Studies on AV Transit Laws and Regulations – The prospects of a transit operating agency losing federal FTA funding due to a compliance issue with the variety of laws and regulations described in this working paper would seem to lead to significant impediments to AV Transit deployment. The following key policy studies are recommended for undertaking based on the considerations and findings of this working paper:

1. **Hypothetical Study of Transit Automation Allowing Withdrawal from Federal Funding** – Assessment of the operational cost reduction prospects for a medium sized transit operating agency (i.e., "typical" local transit agency) will be studied with the objective of withdrawing from all Federal funding support and operational subsidies. The extent of automation will be defined as a series of hypothetical exercises to determine if this premise of financial independence from federal funds is possible and under what combination of service types using only ridership fares and local tax funding subsidies.
2. **Possible Changes to Section 13c of Federal Transit Act** – Investigation of the possible changes to the federal law 49 U.S.C. § 5333(b) known as "Section 13c" will be performed. The work will assess how a progressive process within a transit operating agency for retraining of its employees and a gradual decreasing is total staff could be accommodated under the law. Possible changes deemed necessary to prevent the constraint of AV transit deployment dueto the potential violation of Section 13c will be the key study results.
3. **Applicability of Laws and Regulations to Private Contractors** – Assessment of the applicability of the laws and regulations that apply to public transit operating agencies will be made to determine if these same laws/regulations might be applied to those

companies that provide contracted "transit" services. In particular the applicability of these laws/regulations to transportation network companies (TNCs) will be assessed, and the long term implications for federal funding used for contracted services will be evaluated. Regulations of particular importance appear to be Buy America stipulations, transit employee labor laws, FTA safety requirements and FTA's ADA regulations.

4. **OSHA Regulations for Robotic Vehicles in the Workplace** – Compilation will be performed of technical articles, standards and guidelines relevant to the presence of robotic vehicles in the workplace. This catalogue of materials relevant to robotic machines in the workplace will be assessed for safety procedures and design features applicable to the transit operations and maintenance workplace where AV transit vehicles are present with humans.
5. **Minority Population Involvement** – A working plan is needed by which minority populations can be engaged and involved in the public outreach process as planning for AV Transit deployment begins. Developed for guidance of transit operating agencies, the study documents will establish a framework for any transit agency to accomplish the required public involvement process with minority communities, as well as provide an initial assessment of how AV Transit can be deployed without violating Title VI Civil Rights law.
6. **Title VI Adjustments and Incentives** – A studyshould be performed of the benefits to providing allowances or exceptions to the Title VI requirements for the purpose of advancing the progress of AV technology during the early years of transit deployment. Similarly, the study should assess the use of incentives to encourage AV transit deployment in the combined conditions of low population density and high transit dependency – conditions which are increasingly common in suburban communities.
7. **Automated Boarding Features for Wheelchair Passengers** – This technical study would address the design requirements, challenges and new potential hazards/risks in providing automated ramp deployment and automated wheelchair lift deployment. The study should include an investigation of the means for automated wheelchair securement, and the potential technology required to allow remote operator involvement in the process.
8. **Boarding Requirements and Possible ADA Exceptions** – An assessment of ADA requirements and the apparent required changes to vehicle designs is needed to provide equivalent accommodations and safety as human operated transit vehicles, using features such as precision docking at level-platform station berths. Based on the design and cost implications of the required changes, the project work should evaluate the basis for considering exceptions to the ADA requirements and how those can be addressed within the service needs of passengers with disabilities.
9. **Buy America Challenges** – This study should prepare a report on the current status of viable suppliers of AV Transit vehicles and supporting ITS systems to determine how much of the supplier market will have trouble meeting Buy America regulations. The work should provide an assessment of whether the provisions of the Buy America law should be changed to adjust minimum percentages during the early period of AV Transit deployments, and whether incentives should be considered to improve the

sources of supply from American vehicle suppliers – such as tax credits, tax deductions or other subsidies. The study should also address the need for FTA creating a special oversight support office , specifically dedicated to supporting operating agencies and managing the Buy America requirements during the period when new applications of AV Transit technology are coming on line.

10. **Vehicle/Station Supplemental Systems Necessary for Safe Operations** – A technical study is needed which performs research that begins with a functional definition of the supporting systems necessary for safety in the passenger/vehicle/system interface at station boarding and alighting locations. In particular, the work should address the potential need for new subsystems and associated safety provisions (e.g., propulsion/braking interlocks with door systems) to protect passengers during the period of active boarding/alighting as an integral part of vehicle designs sufficient to meet FTA safety program goals. These provisions may be on the vehicle, in the station, through remote monitoring and intervention by personnel in an operations control center, or some combination of these means and methods.
11. **Semi-Automated Operations Hazards Assessment and Mitigation** – Safety requirements will be studied for the period during which there is partial automation or transitions from automation to human driver/operator control at a point of failure or leaving of the ODD for the AV transit vehicle. The relative safety of AV transit operations under conditions of a human operator onboard the vehicle, a human operator in a remote OCC, and the various conditions when partial automation or transitions form automated operations need to be assessed with respect to hazards and risk mitigation through design features and operating procedures.
12. **Applicability and Implications of FMVSS Requirements from NHTSA** – A combined policy and technical study should be performed to assess the impacts of NHTSA's Federal Motor Vehicle Safety Standards on low speed L4 AV transit vehicles that do not conform to conventional automotive, truck and bus chassis design. As a concession to allow near term operations of these specialized vehicle in special operating environments, the work should assess whether the crashworthiness specifications should be given special provisions in the near term to advance AV technology applications. As an extension of this assessment, the consideration of whether low speed L4 AV Transit should it be granted a more lenient crashworthiness standards on a permanent basis when the vehicles only operate in protected environments such as campuses, parking facilities and dedicated transitways. The study should also assess the design impacts and deployment hindrances of the alternate approach in which full compliance with FMVSS for any L4 vehicle is mandated, no matter what the operating speed or environment – including those vehicles with non-conventional designs and specifically intended to operate within an L4 AV transit system in a semi-protected operating environment.
13. **Development of AV Transit Cyber-Security and Data Privacy Regulatory Framework** – Performance of a policy oriented study is needed which would define a catalogue of issues, perform appropriate research studies and then evaluate draft laws/regulations being considered within the AV technology world. The applicability to

AV Transit should be determined, and a framework of laws and regulations that are probable would then be prepared for reference by transit regulatory agencies, transit operating agencies, transit services contractors and AV vehicle/technology suppliers. The particular importance of protecting personal data of the transit users, and the data processing and storage requirements for local transit operators should also be addressed.

14. **Broad Policy Considerations of AV Transit in Regional Transportation Planning** – A broad policy study is needed which develops a generic regional transportation master plan incorporating the possible scenarios of AV Transit deployment and the associated multimodal transportation infrastructure for metropolitan areas of different sizes and densities. Working also from information gained through surveys of U.S. and international sources on regional transportation master planning concepts (such as described in **Appendices D** and **E**), the study work would then develop a framework of policy issues and information for use in the informing and guiding of decision-making on broad policy positions by transit operating agencies, local municipalities, metropolitan planning organizations and regional transportation policy councils.

Appendix A
Participants in January 11, 2017 Industry Stakeholder Meeting, Washington DC

NAME	ORGANIZATION	PROJECT ROLE
Art Carter	NHTSA	Stakeholder
Brad Thoburn	Jacksonville Transportation Authority	Stakeholder
Marlene Connor	Marlene Connor Associates LLC	Stakeholder
Lou Sanders	American Public Transportation Association	Stakeholder
Rashidi Barnes	Central Contra Costa Transit Authority	Stakeholder
Peter Thompson	SANDAG	Stakeholder
Casey Emoto	Santa Clara Valley Transportation Authority	Stakeholder
Michel Parent	Autokab	Stakeholder
Steve Mortensen	FTA	Stakeholder
Sean Peirce	USDOT Volpe Center	Stakeholder
Eli Machek	USDOT Volpe Center	Stakeholder
Stan Young	Natl. Renewable Energy Lab	Stakeholder
Siva R. K. Narla	Institute of Transportation Engineers	Stakeholder
Barry Einsig	CISCO Systems	Panel Member
Max Azizi	FHWA	Panel Member
Jerry Lutin	NJT	Panel Member
William Rogers	NAS/TRB	Panel Member
Ray Derr	NAS/TRB	Panel Member
Jeffrey Dale	Kimley-Horn	Project Team
J. Sam Lott	Texas Southern University	Project Team
Carol A. Lewis	Texas Southern University	Project Team
Tom Harrington	Cambridge Systematics	Project Team

Chapter 6 – Robotics in the Workplace

Robot Applications

Robots are machines that load and unload stock, assemble parts, transfer objects, or perform other tasks.

Robots are used for replacing humans who were performing unsafe, hazardous, highly repetitive, and unpleasant tasks. They are utilized to accomplish many different types of application functions such as material handling, assembly, arc welding, resistance welding, machine tool load/unload functions, painting/spraying, etc.

Studies in Sweden and Japan indicate that many robot accidents have not occurred under normal operating conditions but rather during programming, program touch-up, maintenance, repair, testing, setup, or adjustment. During many of these operations, the operator, programmer or corrective maintenance worker may temporarily be within the robot's working envelope where unintended operations could result in injuries.

All industrial robots are either servo or non-servo controlled. Servo robots are controlled through the use of sensors which are employed to continually monitor the robot's axes for positional and velocity feedback information. This feedback information is compared on an on-going basis to pre-taught information which has been programmed and stored in the robot's memory.

Non-servo robots do not have the feedback capability of monitoring the robot's axes and velocity and comparing with a pre-taught program. Their axes are controlled through a system of mechanical stops and limit switches to control the robot's movement.

Type of Potential Hazards

The use of robotics in the workplace also can pose potential mechanical and human hazards.

Mechanical hazards might include workers colliding with equipment, being crushed, or trapped by equipment, or being injured by falling equipment components. For example, a worker could collide with the robot's arm or peripheral equipment as a result of unpredicted movements, component malfunctions, or unpredicted program changes.

A worker could be injured by being trapped between the robot's arm and other peripheral equipment or being crushed by peripheral equipment as a result of being impacted by the robot into this equipment.

Mechanical hazards also can result from the mechanical failure of components associated with the robot or its power source, drive components, tooling or end-effector, and/or peripheral equipment. The failure of gripper mechanisms with resultant release of parts, or the failure of end-effector power tools such as grinding wheels, buffing wheels, deburring tools, power screwdrivers, and nut runners to name a few.

Human errors can result in hazards both to personnel and equipment. Errors in programming, interfacing peripheral equipment, connecting input/output sensors, can all result in unpredicted movement or action by the robot which can result in personnel injury or equipment breakage.

Human errors in judgment result frequently from incorrectly activating the teach pendant or control panel. The greatest human judgment error results from becoming so familiar with the robot's redundant motions that personnel are too trusting in assuming the nature of these motions and place themselves in hazardous positions while programming or performing maintenance within the robot's work envelope.

Robots in the workplace are generally associated with the machine tools or process equipment. **Robots are machines,** and as such must be safeguarded in ways similar to those presented for any hazardous remotely controlled machine.

Various techniques are available to prevent employee exposure to the hazards which can be imposed by robots. The most common technique is through the installation of perimeter guarding with interlocked gates. A critical parameter relates to the manner in which the interlocks function. Of major concern is whether the computer program, control circuit, or the primary power circuit, is interrupted when an interlock is activated. The various industry standards should be investigated for guidance; however, it is generally accepted that the primary motive power to the robot should be interrupted by the interlock.

The ANSI safety standard for industrial robots, ANSI/RIA R15.06-1986, is very informative and presents certain basic requirements for protecting the worker. However, when a robot is to be used in a workplace, the employer should accomplish a comprehensive operational safety/health hazard analysis and then devise and implement an effective safeguarding system which is fully responsive to the situation. (Various effective safeguarding techniques are described in ANSI B11.19-1990.)

Appendix C
Federal Environmental Justice Requirements and Interagency Working Group

The Federal-Aid Highway Act (1970) required states and metropolitan planning organizations (MPOs) to develop long-range plans that consider the "overall social, economic, energy, and environmental effects of transportation decisions" (Cairns, Greig, & Wachs, 2003). While Title VI provides equal access to transportation programs and services, additional legislation was needed to ensure that low income and minority populations were extended additional protection and fully engaged in the transportation decision-making process. In the late 1980's Bullard coined the phrase "environmental justice" (EJ) which has the intent of a comprehensive look at how low income and minority communities were affected by environmental hazards, urban renewal programs, and transportation projects.

Even with Title VI of the Civil Rights Act, many scholars believed that additional safeguards were needed to project these special populations. As a response, President Clinton issued Executive Order (EO) 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. The Executive Order, established an Interagency Working Group on EJ, whose charge was to develop agency strategies that protect minority and low income populations.

> *Development of Agency Strategies. (a) Except as provided in section 6–605 of this order, each Federal agency shall develop an agency-wide environmental justice strategy, as set forth in subsections (b)–(e) of this section that identifies and addresses disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations.*

The Executive Order further requires that the environmental justice strategy shall

> *…list programs, policies, planning and public participation processes, enforcement, and/or rulemakings related to human health or the environment that should be revised to, at a minimum: (1) promote enforcement of all health and environmental statutes in areas with minority populations and low-income populations; (2) ensure greater public participation; (3) improve research and data collection relating to the health of and environment of minority populations and low-income populations; and (4) identify differential patterns of consumption of natural resources among minority populations and low-income populations.*

The latest update to these EJ strategies was in 2012. The Interagency Working Group on Environmental Justice further revised and refined the US DOT's 1995 Environmental Justice Strategy giving additional emphasis on the engagement of minority and low income (EJ) communities in the planning, decision-making, and implementing of transportation services. Additional legislation from Safe, Accountable, Flexible, Efficient Transportation, Equity Act: A Legacy for Users 2005 (SAFETEA-LU), and Moving Ahead for Progress in the 21st Century Act 2012 (MAP-21) further emphasized public engagement.

State agencies and Metropolitan Planning Organizations (MPOs) and public transportation agencies are also tasked with adhering to these strategies. In the last few decades, one of the biggest tenants of EJ remains the emphasis on public engagement of minority and low-income populations. Therefore, a major derivative of Title VI law, as enhanced by the Executive Order

and subsequent transit funding Acts of Congress raise a number of policy issues that must be addressed when AV transit is deployed.

EJ Policy Considerations for AV Transit Deployments –Using the four major EJ strategies stated above, FTA and transportation operating agencies must begin thinking about the following:

Promote enforcement of all health and environmental statutes in areas with minority populations and low-income populations – The use of AV technology in EJ communities could prove promising. Agencies must show how these technologies are beneficial to the overall health and environmental of EJ communities, e.g. lower emissions, lower noise levels. Agencies must also identify potential concerns and work to mitigate and impacts to EJ communities. Questions/concerns to address include the following:

1. What are the impacts of using AV buses in low income and minority communities?
2. How can the impact of AV technology improve EJ communities?

Ensure greater public participation - Simply notifying EJ communities about transportation services or activities after the fact is not enough to satisfy the letter of law regarding environmental justice. The International Association for Public Participation's (IAP2) Spectrum of Public Participation (inform, consult, involve, collaborate, and empower) provides guidelines for agencies when engaging the public and involving EJ communities during all aspects of transportation planning. These guidelines will be useful for EJ engagement as FTA and transportation agencies address the following:

1. How will FTA ensure that agencies continue to include EJ communities in the decision-making process?
2. What role and at what level of engagement will occur with EJ Communities?
3. Which public involvement strategies will be employed to ensure that the EJ communities are fully engaged?
4. Will must participate in the discussion of where/when/which communities obtain access to AV buses.

Improve research and data collection relating to the health of and environment of minority populations and low-income populations – Identifying EJ populations requires extensive research, data collection and analysis, and the activities must address the question of:

1. As the population becomes more diverse, what additional data are needed to ensure that agencies accurately identify minority and low income populations?

Identify differential patterns of consumption of natural resources – Understanding how EJ communities use natural resources is important. The advancements of AV means fewer natural resources will be consumed, and EJ matters include:

1. What are the energy concerns relative to transportation services in EJ communities?
2. Will the use of AV technology differ in EJ communities?

Wheelchair Securement – ADA requirements will be a challenge for fully automated systems, since a very important vehicle driver/operator duty is currently to secure/lock down wheelchairs once a passenger has boarded the vehicle. Level 4 automation will need to compensate for this in some way.

1. There are many versions of wheelchairs and standardization of an automated locking device will be very difficult.
2. There are existing products that can assist with docking and securing a wheelchair onboard the transit vehicle, but this is a supplemental system and still needs human attention.
3. Securing wheelchairs within the vehicle before movement along the route assumes means that either:
    a. The transit patron must accomplish this wheelchair restraint using self-actuated systems, or
    b. Remote personnel in the transit system operations control center must be able to accomplish this securement through a remote "drone-type" of action.
4. There is a need for research on a fully automated, mechanical means for securing "any" wheelchair, including automated chairs and other wheeled devices like carts.
5. Ultimately when self-securing wheelchair-vehicle devices becomes available, it will have failure modes and the resulting hazards must be included in the Safety Assurance process.

Boarding/Alighting Accessibility – ADA impacts on the transferring of boarding passengers from the "station" or bus stop into the vehicle (and the reverse process for alighting passengers) were discussed in multiple stakeholder workshops, with many comments addressing not only the issues for public transit operators, but also the private NTC transport providers when unmanned AV vehicles must comply with ADA requirements for their operation in contracted service for public transit entities. The fact is that the federal law and FTA regulations will require that disabled passengers have equal accessibility to public transit service and the priority of serving this segment of the population cannot be dismissed in favor of new technology innovation. The overall AV transit accessibility will probably need level boarding solutions in the near term, and for the medium to long term new some type of provision to replace the role of operators/drivers when the vehicles become fully automated for boarding and alighting locations without level platform/vehicle floor boarding provisions.

Related discussion points from the industry stakeholder workshops are given below:

1. Depending upon the disability, a person with a disability may have problems accessing AV, whether using some automated equivalent for a ramp, or providing a level boarding position complying with ADA regulations.
2. Current AV developers like Waymo or the major automobile OEMs have no apparent development underway that would satisfy ADA requirements. Similarly, level

platform/vehicle boarding stations and AV vehicle designs being developed by the NTCs such as Uber or Lyft do not seem to have any attention being paid to providing accessibility through elevated platforms providing level boarding accessibility.

3. Will there be an acceptable alternative of retaining a third-party contractor whose mission is specifically dedicated to providing ADA compliant vehicle service?
4. FTA needs to formulate suitable criteria for assisting the elderly and disabled in boarding AV transit. It is important that the government recognize its obligation to ensure ADA access equality. This issue needs to be a part of the AV Transit design requirements conversation.
5. GPS can currently be designed to provide adequate docking in order to achieve ADA requirements using supplemental systems like Differential GPS (enhanced accuracy GPS technology) or Lidar (as some have proposed). These complex satellite-based systems can become unreliable, and in particular when one of the higher precision supplemental systems fail, docking accuracy would then be greatly diminished.
6. The Caltran/PATH demonstration BRT project in Eugene, Oregon deployed an automated steering technology based on the vehicle following magnetic markers was able to reliably execute a very accurate station docking maneuver which satisfied ADA requirements at a level boarding platform.
7. One option to handle ADA compliance for the near to medium term is to retrain vehicle drivers/operators drivers who are displaced by AV transit technology, making them customer service ambassadors who can assist with the boarding/alighting process and the securing of wheelchairs.
8. BRT systems and BRT corridors can be a first deployment of AV technology since level boarding can be more easily provided in the BRT corridor design. Therefore highly urbanized transit service must be the first focus to address ADA compliance with AV transit, then suburbs should be addressed, followed by rural, and finally paratransit.
9. ADA is a high priority issue. There will be general dissatisfaction with AV transit if ADA provisions are not satisfied providing accessibility equal to people without disabilities. Some think this is one of the essential issues – especially for rural/suburban service where level boarding is not possible. Others think the funding levels required to make all boarding areas compliant – even at common bus stops – is going to prevent AV transit from happening in the near or medium term.

Overall AV Transit System Design Considerations –In past AV transit symposiums, discussion has addressed the issue of how monitoring of the passenger boarding process in general will be compensated when the bus operator is removed from the vehicle. There needs to be an initiative to standardize the criteria for safe boarding/alighting the vehicle across all variations in vehicle types/service – this is critically important. It is noted that this is a key element of the safety standards which have been written for automated guideway transit systems on both the national and the international levels (ASCE-21 and IEC 62267). These issues of station safety during the boarding and alighting process, especially for the disabled, could relate back to the need to define new operations personnel roles and responsibilities in the near term– whether operations personnel are located on the vehicle, in the station or in a

remote operations center. Further to these issues when a vehicle does not have an operator onboard to monitor and support passenger safety, the ADA requirements in particular may need to be standardized across all AV transit vehicles types.

The industry stakeholder attendees discussed these ADA issues and raised new considerations, as summarized below:

1. ADA Compliance will be impacted differently for different types of transit applications. For service based on fixed route service, there will be different impacts compared to demand-response (or "mobility on demand") service. For first-mile/last-mile applications which are likely to be the initial AV applications, the service type many are anticipating is demand-response.
2. BRT implementation along protected transitways will also be an early type of AV transit application. As has been recommended in other discussions, it will probably be easier implement BRT fixed route corridor designs with fixed station locations that can be configured to meet the ADA station "gap" requirements. Demand response service in urban areas where the design concept may stipulate that passengers can board at the "street corner", or in rural areas where there may not even be curbs and sidewalks, then AV transit systems will have much tougher challenge meeting these ADA requirements.
3. Technology suppliers may need to make adjustments to their design to move toward compliance with these exiting FTA requirements. The example of an early AV technology demonstration utilizing a magnet marker system in the transitway running surface also provided very high precision in vehicle localization and in particular precision in station platform docking maneuvers. This type of simple technology could potentially be a separate subsystem that only engages for station docking. Whatever type of station horizontal and vertical alignment precision a given AV transit vehicle supplier determines is the right solution for their design, each AV technology developer/supplier will need to begin to make design changes to address these functional aspects.
4. Another safety design issue is resolving how the vehicle doors will guarantee the prevention of entrapment if doors close while a person is boarding – designs such as those typically applied by automated people mover technologies and covered in the ASCE and IEC automated transit standards. Protection from entrapment in vehicle doors is essential for the safety of all passengers, and in particular it is critical for protecting the elderly and persons with a handicap – yet this design topic doesn't seem to be one the AV technology developers are currently addressing.
5. Regarding the prospect of remote monitoring of the boarding process, it should be assumed that cameras will be used to monitor the boarding locations. But with the requirements addressing ADA safety, cameras for video surveillance may therefore also need to be made mandatory through regulations in order to support remote operations personnel monitoring the passenger interfaces with the system. Privacy issues may also be important to think through when addressing the remote monitoring of the vehicles, as well as the use of microphones to be able to listen to passenger activity on the vehicle when assessing unsafe situations.

Appendix E
FTA's Buy America Fact Sheet – Buy America 5323(j)

U.S. Department of Transportation
Federal Transit Administration

FACT SHEET:
BUY AMERICA
5323(j)

PROGRAM REQUIREMENT: This provision requires that federal tax dollars used to purchase steel, iron, and manufactured goods used in a transit project are produced domestically in the United States.

Statutory References: 49 U.S.C. Section 5323(j) / FAST Section 3011

Eligible Activities: Buy America applies to all federally funded purchases of steel, iron and manufactured goods, including rolling stock purchases and capital leases.

What's Changed?

1) The FAST Act phases in an increased domestic content percentage requirement for rolling stock, as follows:
   - FY16 & FY17: more than 60% domestic content
   - FY18 & FY19: more than 65% domestic content
   - FY20 & beyond: more than 70% domestic content

2) For rolling stock purchases for which the average cost of the vehicle is more than $300,000, the FAST Act allows the cost of steel or iron produced in the U.S. and used in the rolling stock frames or car shells to be included in the domestic content calculation, regardless of whether the frame or car shell is produced in the U.S.

3) Alters the Buy America waiver process to include a requirement that USDOT/FTA must 1) certify that the steel, iron, or manufactured good is produced in the U.S. in a sufficient and reasonably available amount; 2) certify that the item produced in the U.S. is of a satisfactory quality; and 3) disclose the waiver denial and accompanying rationales on the DOT website.

4) For purposes of qualifying for the General Public Interest Waiver for Small Purchases, the FAST Act defines a Small Purchase as a purchase of $150,000 or less.

For Additional Information on FTA and the FAST Act, please visit: www.fta.dot.gov/fast.html

Appendix F
UITP Policy Brief – Autonomous Vehicle: A Potential Game Changer for Urban Mobility

Source: UITP

Appendix F

UITP Policy Brief –

Autonomous Vehicle: A Potential Game Changer for Urban Mobility

Source: UITP

UITP ADVANCING PUBLIC TRANSPORT

POLICY BRIEF

AUTONOMOUS VEHICLES: A POTENTIAL GAME CHANGER FOR URBAN MOBILITY

INTRODUCTION

Imagine providing affordable, sustainable and convenient mobility options to all citizens including less mobile persons, the elderly, children and people living in suburban or rural areas. Autonomous vehicles (AVs) can help to build that future.

A NEW CHANCE FOR AN EVER-PRESENT PUBLIC TRANSPORT SYSTEM

Cities play a crucial role as engines of the economy, as places of connectivity, creativity and innovation. The arrival of driverless autonomous vehicles represents a unique opportunity for a fundamental change in urban mobility and could lead to healthier, more competitive and greener cities - but only if public authorities and public transport companies take an active role now and integrate AVs into an effective public transport network. If employed as shared 'robo-taxis' and mini-buses as well as used to reduce car ownership through more effective car-sharing schemes, driverless AVs could dramatically enhance public transport. This paper details the challenges ahead and outlines a way forward for the introduction of autonomous vehicles in our cities.

Indeed, a future with autonomous and connected vehicles can have various outcomes depending on how they are to be regulated and used. Will they lead to even more cars on the road, more urban sprawl and more congestion? Or will they contribute to shaping sustainable and liveable cities, the regaining of urban space, less vehicles on the road and a higher quality of life?

Imagine providing affordable, sustainable and convenient mobility options to all citizens including less mobile persons, the elderly, children and people living in suburban or rural areas. Imagine these mobility solutions opening the way for decarbonisation, to enable your city to regain valuable urban space to be reallocated to green zones, economic activities or affordable housing and to provide flexible, around the clock on-demand transport that is safe and cost-efficient. Autonomous vehicles can help to build that future.

LESS TRAFFIC, 80% FEWER CARS

Recent studies by MIT (New York), ITF (Lisbon) and the VDV (Stuttgart) have shown that it would be possible to take every citizen to their destination with at least 80% fewer cars!

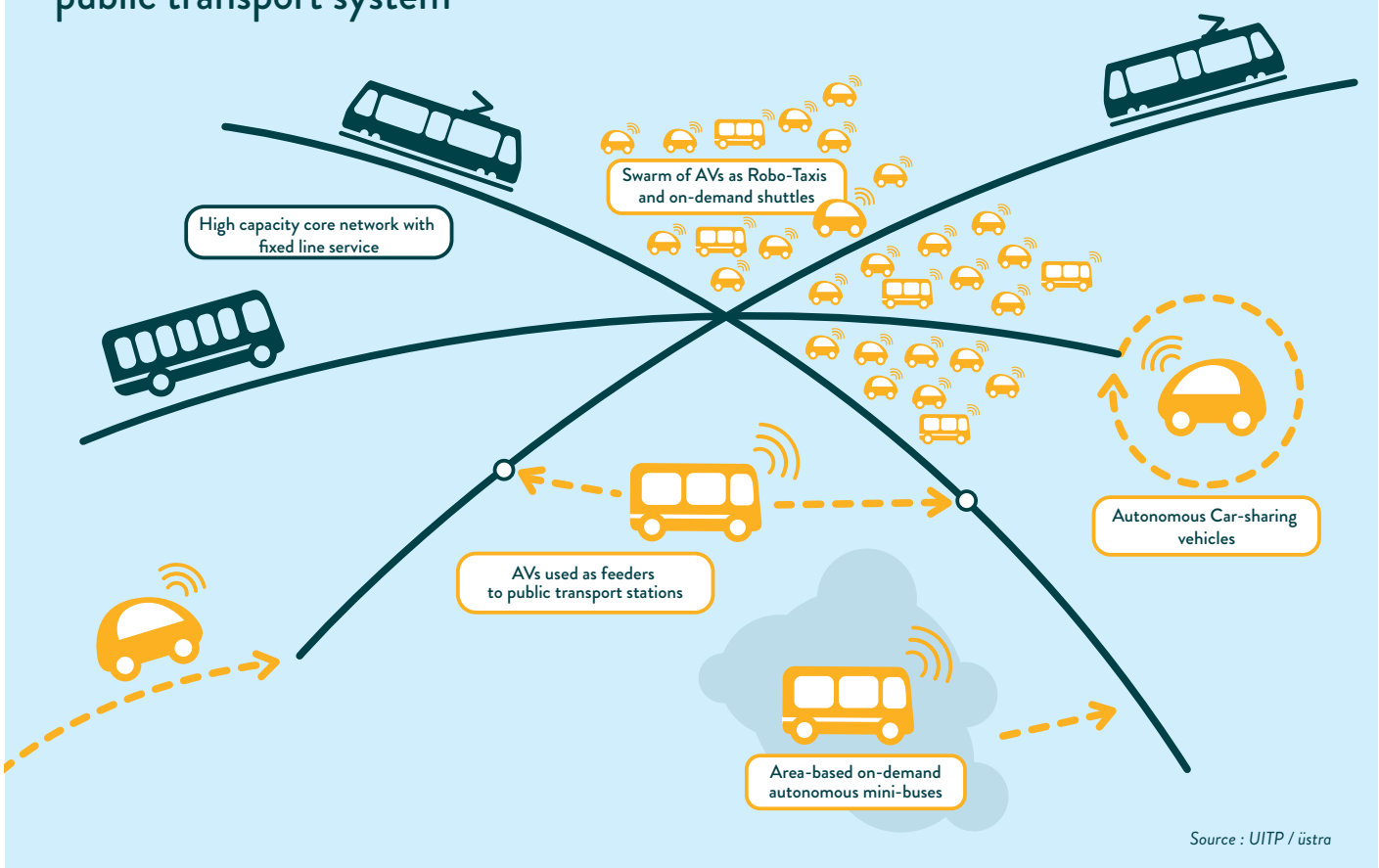
Removing four out of every five cars would have a significant positive impact for cities and affects not only the environment, traffic efficiency, and parking but also frees up a lot of urban space. In many cities, on-street parking accounts for a vast amount of land, which could be freed for other uses. Fewer cars would also lower the cost of building and maintaining roads and generate less noise whilst having a smaller environmental impact.

Driving patterns of vehicles could be algorithmically optimised, but most importantly: self-driving vehicles would also provide much safer roads as today 1.2 million worldwide a year die in automobile-related deaths and 90% of the accidents are due to human error.

BUT this will only happen if AVs are introduced in fleets of driverless shared autonomous vehicles of different sizes reinforcing an efficient high capacity public transport network supporting walking and cycling.

Indeed, the above-mentioned studies clearly state that these results are only obtained if autonomous vehicles are shared and they complement an efficient high-capacity public transport system. Public transport is and remains the only solution able to fulfil the lion's share of trips by using a minimum amount of space in dense urban environments and enabling people to travel in a time-efficient manner.

Possible applications of autonomous vehicles (AVs) as part of a diversified public transport system

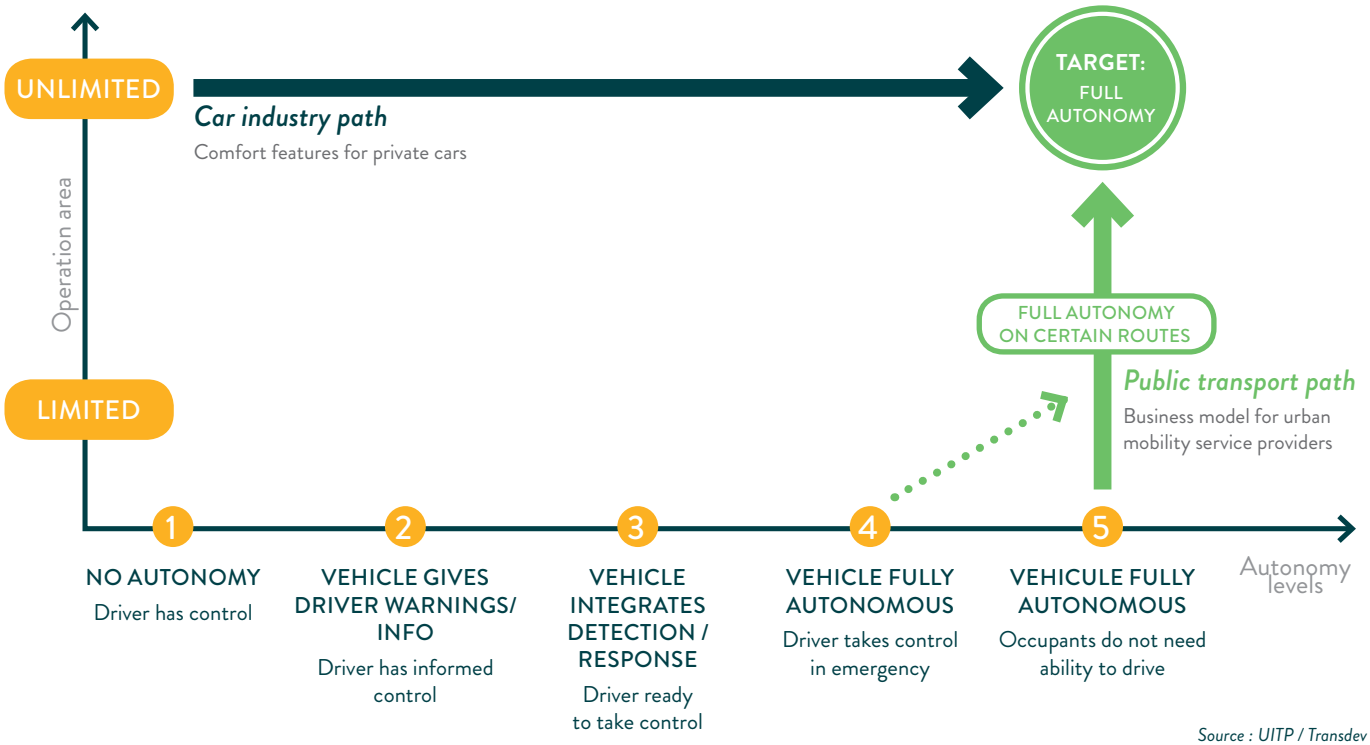


Source : UITP / üstra

The decisive factors that will determine the realisation of the above vision are the shared usage of AVs in fleets and the use of fully driverless operation. If fully automated operation cannot be accomplished, AVs will NOT be able to form a new mode of transport and thus could NOT enhance existing public transport. Therefore cities and countries must actively shape the introduction of AVs now to prepare the authorisation of driverless operation. An integrated effort of all authorities concerned (mobility, road safety, urban planning, traffic control, etc.) must be put in place. Otherwise we will miss the chance for a fundamental change in urban mobility and end up in a scenario where vehicle automation will even further increase the amount of private car and vehicle miles travelled with all the associated negative externalities.

2016 has seen many trials of autonomous vehicles of different sizes and things are moving very fast as – according to various estimations - fully autonomous cars are predicted to become available in the early 2020s.

Public transport offers the quickest development path to full autonomy because it can start operating in a limited area



Source : UITP / Transdev

© Carpostal

Since June 2016, Swiss operator Carpostal – Postauto operates two electric autonomous shuttles for passengers in the city centre of Sion on a 1.5km circuit. Carpostal-Postauto aims to test the public acceptance, the integration of autonomous shuttles in pedestrian zones as well as offering additional services where no public transport services existed before.

© Keolis / Denis Pollard

For Keolis, AVs are a groundbreaking innovation, transforming the city. In Lyon, an autonomous shuttle service has been running on the banks of the river Saône since September 2016, providing easy access to businesses, as well as dining, entertainment, and shopping areas. Designed with intermodality in mind, the shuttle service is situated just a few metres from the tram stops serving the Confluence eco-district.

Although it seems clear that AVs are coming, we do not know yet how they will be rolled out as this also largely depends on how they will be regulated. **The following SWOT analysis shows the strengths, weaknesses, opportunities and threats that shared AVs represent for the future of our cities:**

Strengths

- Provide additional efficient public transport services (high frequency or on demand) during extended operating hours at lower cost
- Social inclusion: more mobility options for all (elderly people, disadvantaged communities, children, less populated areas)
- Solutions for Last-Mile, Door-2-Door, neighbourhood- and feeder services,
- Chance for decarbonisation: introduction of e-mobility
- A chance to re-frame how public transport is used and viewed by the public
- AVs as car- and ride-sharing will reduce parking pressure and car traffic

Weaknesses

- Ability of the public sector to invest in new technologies, lack of speed for innovation and lack of skilled workforce
- Direct services with smaller vehicles could weaken mainline public transport services, walking, cycling
- Significant change only through higher vehicle occupancy
- Special vehicle equipment and development needed for public ride-sharing services (wide doors, room for luggage, communication eg. vehicle to passenger, passenger to control center...)
- Most car-owners are not used to car- and ridesharing and will not accept these forms of car-use naturally
- So far, low speed, low capacity and very "cautious" driving behaviour

Opportunities

- Chance for public transport to become a real mobility provider and the digital integrator with all the opportunities of the value of data, CRM & traffic control
- Enhanced planning of mobility infrastructure
- Chance for new business model for urban mobility, for instance through time-sensitive pricing instead of flat rate
- Increase in jobs with more customer-oriented functions (proactive mobility assistant instead of invisible bus driver?)
- Chance to implement Mobility as a Service Platforms
- AVs as carsharing-cars as a door-opener to increase the number of shared trips
- Regaining urban space through reduced parking needs and shared use of AVs

Threats

- Limits in technology or lack of public acceptance could prevent driverless operation within the foreseeable future
- Traffic volume increase through empty AV cars
- Private cars being replaced by private AVs, making congestion more bearable leading to additional car ownership and urban sprawl
- Reduction in number of driver/chauffeur jobs
- AVs as robo-taxis are a business opportunity for private firms (Uber, Google, Amazon, car-manufacturers). This could lead to the privatisation of urban transport services with a loss of influence for public authorities
- Uncertainty on Life Cycle Costs (LCC), providers, monopolistic or competitive markets, etc.

Now is the time to start preparing the right regulatory framework for AVs to ensure they will serve cities' policy objectives. With current traffic rules, AVs will be seen as comfortable private cars that could well drive around empty to avoid paying parking charges, increasing car traffic and urban sprawl. Public transport, walking and cycling would lose market share and doing nothing is therefore not an option.

Autonomous vehicles will only help to meet public policy goals if they come as shared fleets integrated with public transport

Autonomous vehicles

Privately owned cars

- No effect on car ownership
- No effect on number of parked cars (cars unused most of the day)
- No effects on costs /km
- No effects on mobility for people that do not own a car
- Even more car traffic (as it is even more comfortable and attractive to go by car)

> Unsustainable, even more car traffic

Shared fleet of vehicles

- Strong reduction in number of cars (reduced car ownership, effective use of cars as they operate most time of the day)
- Drastically improved mobility for people that do not own a car

Fleet cars COMPETING with traditional public transport services

- Street reclaiming (less parked cars)
- Improved access to public transport
- Improved mobility for people that do not own a car
- More traffic (strong increase in Vehicle Miles Traveled - VMT)
- Inefficency (small vehicles replacing buses and trains)
- Passenger loss for traditional public transport walking and cycling

> Better mobility, less efficency

Fleet cars INTEGRATED with traditional public transport services

- Large scale street reclaiming
- Highly improved access to public transport
- Highly improved mobility for people that do not own a car
- Strong decrease in VMT
- High gain of efficency (large and small vehicles perfectly mixed)
- Low costs/km

> Sustainable, better mobility and equity

Source : UITP / Martin Röhrleef

Ensuring safe, green, accessible, affordable, equitable and inclusive mobility to citizens are the principles of any city or region. New technologies should be used to help cities reach these policy goals. Therefore, the role of authorities must be to build a regulatory framework to ensure AVs bring benefits to cities and that the above principles are respected. Cities will only be able to shape the future mobility market if they get involved now.

As mentioned before, autonomous vehicles offer the opportunity to provide more public transport options to people and in locations where it was difficult or impossible before because of high operational costs. Shared autonomous 'robo-taxis' and on-demand shuttles will be very cost-efficient since there will be no driver costs and they could solve first- and last mile issues, act as feeders to public transport trunk lines or offer door-to-door mobility. They will be part of a versatile and highly efficient integrated public transport system where citizens will be able to choose the best mobility option through an integrated multimodal mobility platform offering mobility as a service ('MaaS').

© üstra

In February 2016, üstra launched its *Mobility Shop* that offers multimodal registration, routing, booking and invoicing in Hannover, Germany. It is a major step towards becoming a true multimodal provider that offers Mobility as a Service (MaaS) to its customers now and in the future.

© Wiener Linien

In spring 2017 in Vienna, the mobility app WienMobil will offer simple and convenient access via the Wiener Linien app not only to bus, tram and metro services but to all publicly available mobility services such as e-loading stations, parking garages, taxis, Citybike, car sharing, car rental and many more. The result is a one-stop mobility shop that, in addition to accessing real-time information, enables the user not only to buy tickets, but also to book, reserve and pay for other combined transport.

Obviously there are still many questions related to liability, insurance and technology that need to be solved but the introduction of driverless autonomous vehicles has a huge impact on the planning and the investment needed for sustainable urban mobility in the future and this calls for action now to ensure the right decisions are taken.

ENCOURAGING SHARED MOBILITY

The first point is to ensure autonomous vehicles are shared and that people are ready for this idea of sharing and switching between different modes of transport. Therefore, **all forms of shared mobility, mainly car- and ride-sharing, need to be actively promoted and incentivised as of today.** Tax incentives for shared rides or shared ownership of vehicles, shared vehicle zones, promotional campaigns, priority parking places, promotion of pilot projects...: preparing our citizens for shared autonomous vehicles in the future goes hand in hand with more car- and ride-sharing today. Measures to limit single car occupancy need to be taken as well as measures to avoid having empty private autonomous cars on the roads.

CREATING A BALANCED INTEGRATED MULTIMODAL MOBILITY OFFER

The second point is to ensure that these fleets of shared AVs are integrated into a complete mobility solution with high capacity public transport as a backbone in densely utilised areas to fulfil the lion's share of trips complemented by walking and cycling.

In order to become really attractive and form a credible alternative to (autonomous) car ownership, the different sustainable modes need to be coordinated, planned and delivered in an integrated way. From a physical perspective (coordinated network planning, stations, urban planning, and algorithmic optimisation of autonomous fleets) but also from an information perspective: a one-stop-mobility shop acting as a personal mobility assistant offering travel information, booking and ticketing.

The creation of multimodal mobility platforms offering Mobility as a Service is the way to connect urban mobility services now and in the future.

Public transport authorities and operators are experts in organising urban mobility solutions: allow them to lead the transition and take the lead in the coordination of tomorrow's mobility. Moreover, public transport already has experience in the automation of transport services thanks to the automation of metro lines. Indeed, in 2016 there were 803km of automated metro in operation in 37 cities worldwide. This trend is growing as by 2025, automated metro lines are expected to total over 2,300km globally.

Walking, cycling and shared autonomous fleets are excellent options to provide door-to-door transport or act as feeders, but on their own they are not a substitute for public transport, primarily as they lack the capacity to cater for the sheer volumes required in densely utilised urban spaces.

In many cities, public transport companies are leading the transition to offer multimodal mobility to their citizens through partnerships with shared mobility providers such as car- and bike-sharing and they are testing new services with autonomous shuttles. They are also providing Mobility as a Service-platforms to provide combined mobility to their customers and these platforms will also ensure the integration of shared AVs into a complete mobility solution in the future.

AV STRATEGY OF A PUBLIC TRANSPORT OPERATOR: TRANSDEV

Transdev aims to offer innovative mobility solutions and excellent service to its customers. Autonomous vehicles hence were a natural choice since they are flexible in terms of timing and geographical coverage, economical, clean and offer many development opportunities.

"We're convinced of the potential that autonomous vehicles have to extend our current range of services. We're aiming high, and thinking practically. This means going through a key initial stage, on which we are focusing all our energy right now: consolidating our expertise by capitalising on the success of the first operations such as Civaux with Navya and Ladoux with Easymile." Yann Leriche, Chief Performance Officer, Transdev.

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AV STRATEGY OF A PUBLIC TRANSPORT AUTHORITY: LTA

In Singapore, the Land Transport Authority (LTA) considers AV technology an opportunity to help achieve the 2013 Singapore Land Transport Masterplan that aims to promote public transport as the mode of choice. It will help address the challenge of the manpower crunch and AV fleet coordination and control infrastructure will facilitate efforts to improve the reliability of public transport services. On the service provision side, it will offer first- and last-mile connectivity as well as on-demand services through a demand-responsive fleet of shared autonomous vehicles. A massive effort is underway to build up public transport, walking and cycling infrastructure and rally around a car-lite Singapore.

Therefore, Singapore is preparing itself through trials to integrate autonomous vehicles into the public transport network once they are ready.

© LTA

RECOMMENDATIONS

How to get from 0.5 % of shared mobility to 50-60%?

- Public authorities need to take an active role in the roll out of AVs so that they meet policy objectives:
  - Measures to limit single car occupancy: road pricing (to the advantage of high occupancy vehicles), parking management, shared vehicle zones…
  - Measures to avoid empty private AVs idling on the road
  - Urban planning measures:
    - regain urban space from parking facilities to be allocated to other uses
    - integrated urban & mobility planning
    - prevent urban sprawl, rethink urban planning with autonomous shuttles
  - Provide integrated mobility platforms (MaaS) as whoever controls the platform controls the travel behaviour and require all public mobility services to join
  - Regarding data, ensure the different urban mobility services can communicate and are not closed systems
  - Make tendering/concessions for shared AV fleets
  - Any new mobility service should be evaluated against modal split objectives and ensure a better quality of urban life before being supported
  - Promote shared vehicle use in all forms through promotion and tax incentives
- Allow the use of shared driverless autonomous vehicles on public roads, at least in trials to test how to best use them in the mobility eco-system
- Let public transport operators and shared-fleet mobility operators test AVs and take advantage of innovation – adapt regulation to allow testing of autonomous vehicles to be integrated into the public transport offer
- Enlarge the competences of public transport authorities to all urban mobility services
- Support research to understand citizens' acceptance of autonomous vehicles and contribute to create confidence
- Prepare for the consequences on jobs as some driver/chauffeur jobs could disappear and other jobs requiring specific skills will be needed. How will the transition be managed?
- Developments take time: start now because the future is coming
- Boost synergies between public transport & private shared mobility actors

Encouraging shared mobility now will pave the way for the shared use of shared AVs in the future!

This is an official **Policy Brief** of UITP, the International Association of Public Transport. UITP has over 1,400 members in 96 countries throughout the world and represents the interests of key players in this sector. Its membership includes transport authorities, operators, both private and public, in all modes of collective passenger transport, and the industry. UITP addresses the economic, technical, organisation and management aspects of passenger transport, as well as the development of policy for mobility and public transport world-wide.

This Policy Brief was prepared by the Combined Mobility Platform

A digital version is available on Mobi+

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Appendix G
Extracts from ITS Japan Presentation at Automated Vehicle Symposium 2016

Automated Vehicle Symposium 2016
Public Agency Automated Vehicle Initiative

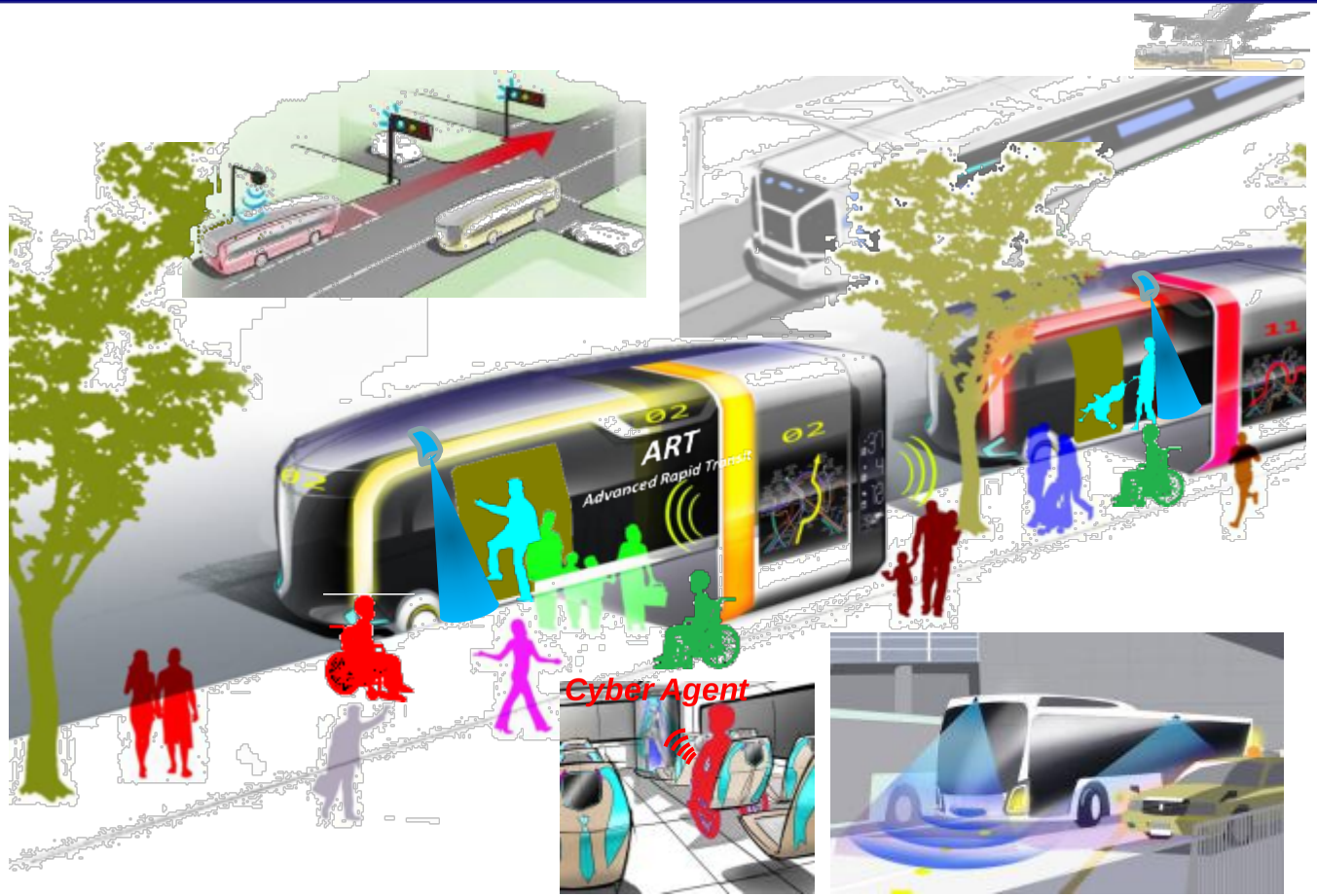
Latest development in SIP-adus and related activities in Japan

Cross-Ministerial Strategic Innovation Promotion Program
Innovation of Automated Driving for Universal Services

July 21, 2016

Hajime Amano
President, ITS Japan
Chair, International Corporation WG, SIP-adus

ART (Advanced Rapid Transit)



Key Message

Cross-Ministerial Strategic Innovation Promotion program
Innovation of Automated Driving for Universal Services

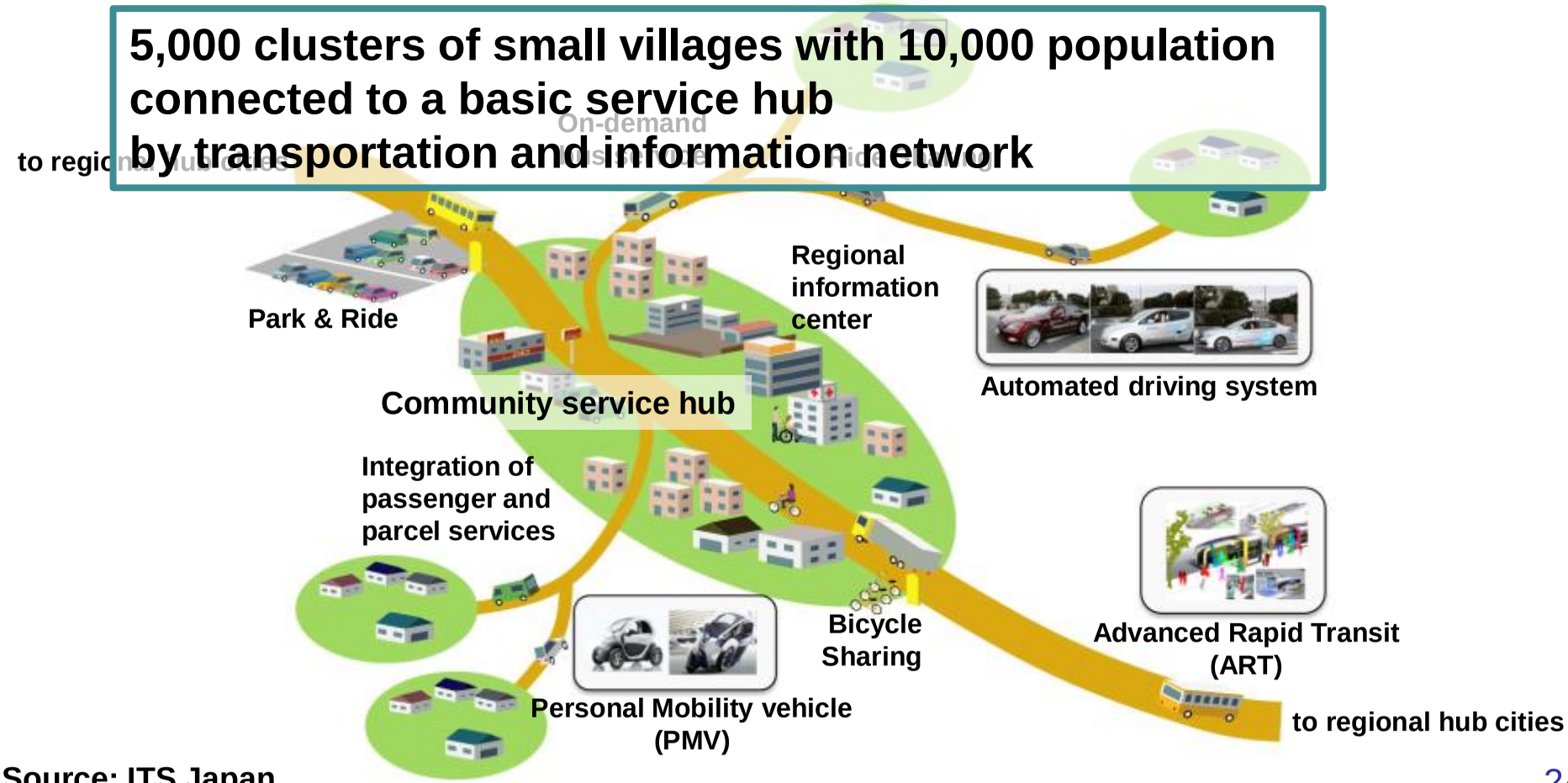
“SIP- adus”

- Mobility Bringing Everyone a Smile -

Inclusive society, where diverse people in diverse communities actively participate in generating values, will enhance both wellness of individuals and economic development. Automated driving technologies integrated with social innovations should provide everyone with mobility to fully exercise his or her capacity, enabling sustainable development of the society.

ITS Japan Action Plan 2016-2020: Cluster of villages

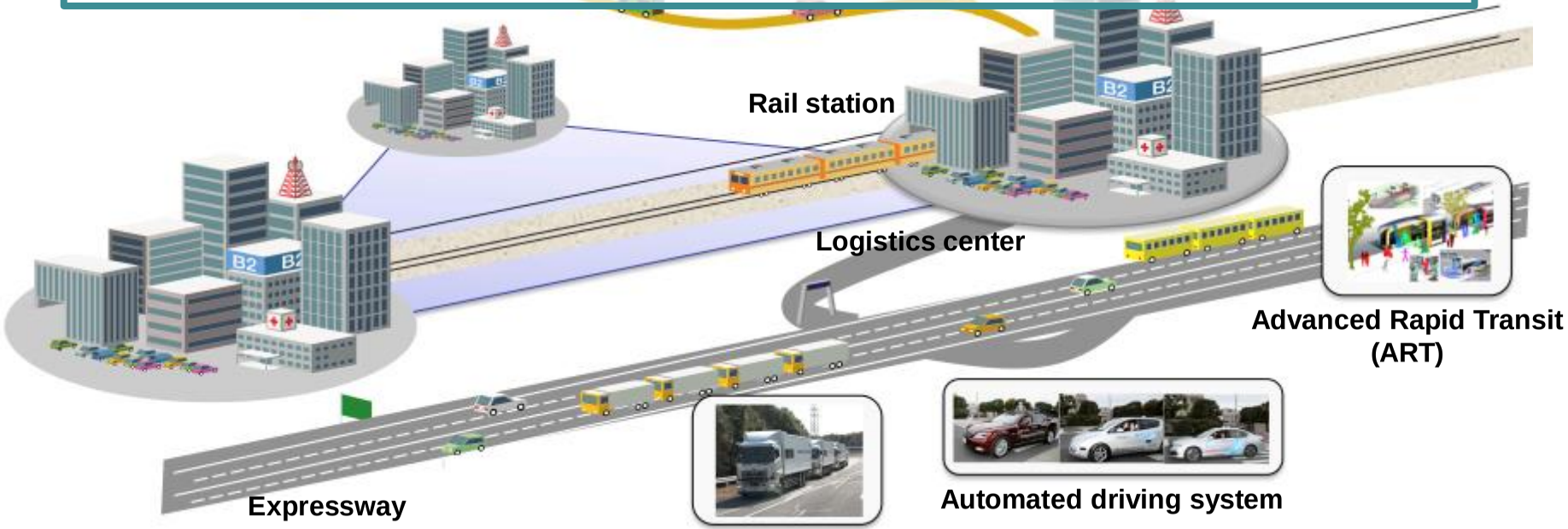
5,000 clusters of small villages with 10,000 population connected to a basic service hub by transportation and information network



Source: ITS Japan

ITS Japan Action Plan 2016-2020: Integrated regional hubs

60 to 70 integrated regional cities with 300,000 population connected to each other within one hour of travel to maintain high level education, medical care and employment opportunities



Source: ITS Japan

ITS Japan Action Plan 2016-2020: Mega city

Center for competitive edge in global economy integrating industries with high capacity and efficient transportation for both domestic and global operations

Source: ITS Japan