CENTER FOR TRANSPORTATION RESEARCH

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UPDATE TO THE WORK PLAN FOR THE COMPLETION OF STRATEGIC BUSINESS PLAN

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TxDOT Project 0-6803-01: The Technology Task Force

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WORK PLAN

1. Background

The Texas Department of Transportation's (TxDOT) mission is to provide a safe and reliable transportation system for Texas, while addressing congestion, connecting Texas communities, and becoming a best-in-class state agency. In an effort to help TxDOT achieve its mission, the Texas Technology Task Force (TTTF) was established. The TTTF was formally created in February 2013. After General Appropriations Bill, S.B. No. 1, 83rd Legislature, item 44, VII-31 (2013) was passed, TxDOT and the Task Force were directed to oversee a study on transportation technology. Through guidance from a technology industry expert panel, the TTTF has developed a vision for the future Texas transportation system that furthers these goals via technology-based solutions. The TTTF met from March to August of 2013 (Phase I) to develop a set of recommendations for continuing work in a second phase of a technology study. The recommendations from Phase I are provided in this section; subsequent sections synthesize and discuss work completed in Phase II.

1.1 Phase I of the Texas Technology Task Force

Three objectives were established for Phase I:

1. **Assemble a panel of subject matter experts (SME) drawn from industry and the public sector.** This panel became the TTTF, which ultimately identified key emerging technologies likely to impact transportation over the next 5 to 20 years. Three in-state meetings were held with members between April and July 2013 where they worked to develop a vision and recommendations for furthering emerging technologies.

2. **Convene the Task Force to identify key emerging technologies and outline a path to implementation, addressing policy, economic, and institutional barriers.** Results from the completion of this objective included a list of the key emerging technologies the state should immediately address, preparation of a preliminary analysis of policy, economic, and institutional barriers to be addressed in order to enable and encourage development and adoption of the emerging technologies while minimizing potential negative impacts, and an assessment of the steps necessary to position TxDOT to develop strategies that leverage technology to make transportation safer and more efficient. Based on guidance from the Task Force, three white papers were developed on identified emerging technologies and included details on the state of identified technologies, their applications in Texas, and critical areas for further investigation.

3. **Obtain recommendations for an initial program of work for a public-private consortium and next steps.** The result from objective three included recommendations of initial program of work for public-private consortium that would be supportive of emerging technologies based on findings from first two tasks. It also included recommendation of next steps, continuing research, and further potential legislative and/or policy recommendations.

The following implementation strategies were the Task Force's final recommendations (from Phase I's third objective) and are intended to lay a framework for moving forward toward the vision for emerging technologies in Texas.

- **Incubator** – Create an organization to act as a technology incubator focused on disruptive transportation technologies. The key differentiator for this incubator is the public partnership with TxDOT, where ideas and innovations can be tested and proven in a real-world environment. Technology support services and resources may be offered to emerging technology partners.
- **Public-Private Partnership (PPP)** – Use a range of approaches to create an organizational structure that facilitates economic development in emerging industries via collaboration and coordination among the public, private, and not-for-profit/academic sectors. Such partnerships will create intellectual capital and technology that can be shared to the common benefit or focus on bringing new and evolving technologies to market.
- **Pilot Program** – Conduct a pilot program within Texas to encourage and enable the development of new transportation technologies. The pilot program would collect specific data through testing for evaluating alternatives to the regulations, or create innovative approaches to enhancing safety and ensure that the safety performance goals of the regulations are satisfied for a preselected technology.
- **Legislative and Regulatory Changes** – Identify regulatory and legislative barriers to emerging transportation technologies, and provide guidance on addressing them.

1.2 Phase II of the Texas Technology Task Force

Recommendations from Phase I support the establishment of partnerships and other efforts, which would provide continued support in the pursuit of emerging technology goals. A first step toward partnership and goals is a strategic business plan. Phase II's sole task was to start initial work to create a business plan that would ultimately facilitate partnerships between public and private participants in technology. Such partnerships will be integral to enabling TxDOT's vision of providing a safe and reliable transportation system for Texas, while addressing congestion, connecting Texas communities, and becoming a best-in-class state agency. Phase II of the TTTF project focused on the initial work toward a strategic technology business plan for the state. Additionally, Phase II saw the completion of initial background work for the establishment of the strategic business plan following recommendations from Phase I. The intention is that in later phases of the technology study, the strategic business plan will be completed to fully demonstrate how public and private partners can collaborate in the creation of an economic roadmap to diversify and strengthen the state economy and transportation system though transformative emerging technology adoption. Final contents of the plan will provide an analysis of the state's transportation, information, and communication technology industries, establish state goals and objectives, develop an action plan for implementation, and articulate investment priorities and funding sources.

Preliminary work completed in Phase II includes the following tasks:

- Review of technology development plans
- Development of the work plan to create the strategic business plan
- Environmental scan
- SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis
- Vision and strategy development

1.3 Phase III of the Texas Technology Task Force

The third phase focused on technology discovery and broadening the portfolio of emerging technologies to encompass newly developed ones and those that apply across multiple modes. This phase was conducted over the period of September 2014 to August 2015 with primary tasks including reconvening the Task Force to review and revise Phase I and II work and expanding the list of other highly transformational technologies or integrated systems. New technologies in the portfolio were evaluated using the framework developed in Phase I and new SMEs joined the Task Force to provide insights on new technologies. Using Task Force guidance, critical topics for white paper development were selected and five detailed papers were developed on the following.

1. The Customer of the Future
2. Global Freight and Logistics
3. Small Unmanned Aerial Vehicles
4. Big Data
5. Strategic Communication Planning

Finally, additional work toward the establishment of the Strategic Technology Business Plan was completed and a transition plan for continuing phases was developed.

2. Existing Transportation Technology Strategic Plan

Research and planning activities conducted or ongoing at the national level were reported in Phase I. The most notable federal planning efforts stemmed from partnerships from key agencies, such as the USDOT (U.S. Department of Transportation) and its sub-organizations that include the ITS-JPO (Intelligent Transportation System-Joint Program Office), NHTSA (National Highway Traffic Safety Administration), FHWA (Federal Highway Administration), and RITA (Research and Innovative Technology Administration). New developments arising from national efforts are reported in the next section. In addition, new developments from other states undertaking similar, coordinated efforts to develop an implementation plan for new transportation technologies are reported. And finally, new developments and activities from industry are provided.

2.1 New Developments at the National Level

The NHTSA and the USDOT released a plan for connected vehicle research for vehicle-to-vehicle (V2V) safety application in October 2011 *(1)*. Under this research plan a pilot program in Ann Arbor, Michigan, was established with nearly 3,000 vehicles communicating on public roads using dedicated short-range communications (DSRC) technology, which was a key focus of the pilot program. At the end of the pilot program, which was planned for the end of 2013, the NHTSA stated that it would release a decision on whether to start putting DSRC technology into production cars, or to do more research. Recently the pilot program received a 6-month extension to continue research but has stated that this extension will not change the original plan to release a decision by the end of 2013. NHTSA Administrator David L. Strickland stated that a decision regarding DSRC would still be made in 2013 *(2)*. The decision will come in two parts: the first will relate to DSRC for light-duty vehicles and the second will follow in 2014 and relate to DSRC for heavy-duty vehicles. The decision will state whether it will begin the rule-making process to mandate V2V communication technologies in newly manufactured cars. The implication of such a decision is that it may be the first step towards fully automated vehicles that navigate by internal sensing and communication electronics linked to transportation infrastructure, and communication and database systems.

In December 2013, the ITS-JPO stated that it has organized a new affiliation of DSRC infrastructure device makers, operators of vehicle-to-infrastructure (V2I) installations, and developers of applications that use V2I communications *(3)*. The newly announced affiliation will provide a common technical platform for connected vehicle technology and expand test bed options for users. Its establishment is intended to help ensure that all future connected vehicle applications are based on common implementations of the communications technology. Goals of the new affiliation include the following:

- Exchanging information
- Sharing deployment lessons learned
- Developing a common technical platform
- Expanding test bed options for users

The following seven public, private, and academic institutions have entered into a memorandum of agreement with RITA to be involved in the affiliation of test beds:

1. Arada Systems
2. Southwest Research Institute
3. Detroit Department of Public Works
4. Security Innovation
5. Siemens Industry Inc.
6. Cohda Wireless America LLC
7. University of Michigan

Finally, the Government Accounting Office (GAO) released a report in November 2013 titled "Intelligent Transportation Systems Vehicle-to-Vehicle Technologies Expected to Offer Safety Benefits but a Variety of Deployment Challenges Exist" *(4)*. This report investigated the benefits that could be realized with the adoption of connected vehicles and identified five major areas where challenges exist; these challenges need to be addressed before adoption. Finally, the GAO revealed that a current and ongoing cost analysis is being completed that will look at V2V costs in-vehicle and for the communication security system.

2.2 U.S. State Strategic Plans and Activities

Two notable state efforts are underway: one in Michigan and the other in Florida. The Michigan Department of Transportation, in partnership with the Center for Automotive Research (CAR), completed the Michigan Connected and Automated Vehicle Technology Strategic Plan in July 2013 to leverage testing and research that is ongoing in the state. The plan outlines the motivation for and overview of previous activities and research on emerging transportation technologies, and the state's mission, vision, and goals for autonomous and connected vehicles. The plan laid out measures and strategies, divided into the following themes or focus areas: leadership, safety, customer service, partnerships, system linkages, and efficiency. The plan describes how technologies further the goals of strategic plan and state goals. The appendices contain technical information and other useful and references materials; included are two sections from the *Line of Business Strategy for Vehicle Infrastructure Integration*—Part I: Strategic and Business Plan; and Part II: Specific Goals and Activities *(5)*.

In Florida, the Department of Transportation (FDOT), Tampa-Hillsborough Expressway Authority (THEA), and Center for Urban Transportation Research (CUTR) partnered to host the Florida Automated Vehicles Summit in November 2013. The summit explored issues related to autonomous vehicles and facilitated discussions helpful for creating a framework for implementation of automated vehicles in Florida that will ultimately save lives and enhance mobility. Key focus areas of the summit were automated vehicle technology and prediction of implementation roadmaps, engagement of public and private partners, key regulatory issues to enable the safe deployment of automated vehicles, and the identification of a framework for multi-phased implementation of automated vehicle systems in the state. The summit brought together scholars, elected officials, automobile manufacturers, equipment manufacturers, transportation professionals, trade and industry organizations, and public agencies to create partnerships for moving forward *(6)*.

2.3 Private Sector Technology Strategic Plans and Activities

No official plans from auto manufacturers have been made available, but information about company plans and involvement related to emerging technology has become available through conference proceedings, press releases, and interviews. The following provides an overview of new developments, activities, and announcements from private sector technology and automobile companies.

- Ford *(7, 8)*: Ford Motor Company revealed a glimpse of its newest research vehicle, a Fusion Hybrid designed to test out new autonomous driving technologies. The vehicles reportedly are using a combined Lidar system and 360-degree cameras, similar to Google's technology. Ford also revealed that it is part of the testing effort in Michigan along with State Farm insurance company.
- Volvo *(9)*: Volvo announced a plan that is more aggressive than its competitors' plans: a partnership with Swedish authorities to initiate trial runs of its self-driving cars, which Volvo is calling Drive Me. One hundred specially selected drivers will be given self-driving vehicles, and their commentary and diagnostic information will be fed back to the company for further development of autonomous vehicles. The Drive Me project will be run on every type of roadway, from congested urban center streets to fast-moving freeways, in order to test the cars in all driving scenarios. For Volvo, 2014 will see the introduction of a new user interface and cloud functionality, and a projected rollout is set for 2017.
- Nissan *(10)*: Nissan announced that it will bring multiple self-driving cars to market by 2020. Nissan also announced that the company is relying on partnerships between its own engineers and a number of universities, including Stanford, MIT, Oxford, Carnegie Mellon, and the University of Tokyo, to help create its autonomous driving technology.
- Mercedes and Nokia *(11)*: Nokia has teamed up with Mercedes-Benz to develop smart maps intended to spur the development of self-driving cars.
- IBM *(12)*: IBM entered into a connected vehicle collaboration agreement with Continental, an automotive supply company, to jointly develop fully connected mobile vehicle solutions for car manufacturers around the world.

3. Implications for Texas Transportation Technologies Strategic Business Plan

The review of the current state of the practice in emerging transportation technologies reveals several critical insights for the state of Texas. Table 1 summarizes the status of different technology development aspects, policy, legislation, R&D (research and development), standards, licensing, pilot studies, market and business development, and testing environment.

As indicated in Table 1, the development of emerging transportation technologies has attracted joint efforts from public, private, and academic sectors, investigating many different aspects. These technologies are currently at varying development stages, and not all aspects have been intensively covered in the existing efforts, leaving opportunities and challenges for the state of Texas.

- **Policies and legislations**: The policy and legislation development for the emerging transportation technologies has been primarily led by USDOT and state DOTs. Although the research and development of technology policies and legislations has been an ongoing process in federal and state government, developing a series of promotional policies and legislations for the state of Texas is crucial to the process of eliminating some of the existing institutional barriers facing the development of emerging transportation technologies.
- **Standards and licensing**: Standards and licensing procedures are prerequisites for successfully implementing and managing new transportation technologies. Some of the technologies themselves are still in their development stages and there have been multiple efforts at federal and state levels to design standards and licensing procedures. For Texas, it may be necessary not to initiate the development of a new set of standards and licensing procedures; a preferred method would be to monitor the existing efforts and adopt "well-accepted" standards and procedures. Such a strategy can help avoid the potential compatibility issues seen in the existing electronic toll systems.
- **Technology development**: One mission of the TTTF is to promote technology development and implementation in the state of Texas. These technologies might not have been originally invented or researched in Texas. Meanwhile, many states have deployed technology test sites or testbeds as a strategy of promote technology development in their state. For Texas to stand out among other states in promoting emerging transportation technologies, the real opportunity is to provide an open and supportive environment for technology developers or industry R&D, addressing some of the key barriers that exist in other states (such as lack of financial support, economic instability, legislative barriers to testing technologies, and the lack of data, infrastructure, and facility support).
- **Market and economic development**: A unique mission of TTTF, in addition to promoting technology R&D in Texas, is to spur economic and market development, taking advantage of the vibrant economy, technology foundation, investment opportunities, and the consumer market. Most existing market and economic development strategic plans for emerging transportation technologies have been proposed and executed by private sectors. If TxDOT and state government can facilitate and collaborate with the private sector in creating a healthy, sustainable, and

economically viable environment, Texas will be in a prime position to promote and lead the efforts in technology development.

In response to the current state of the practice, the task force will develop a strategic business plan to provide a roadmap, strategies, and initiatives for future transportation technology development in Texas.

Table 1. Summary of the Representative Efforts in Technology Development Aspects

	Autonomous Vehicles	Connected Vehicles	Electric Systems	Crowdsourcing and Cloud Computing
Policies	USDOT/ NHTSA policy	Under development	Part of US government green energy/ energy security policies *(13)*	U.S. Department of Commerce policy *(14)*
Legislations	3 states passed, 8 states under consideration, 5 states failed	Upcoming USDOT legislative decisions (CV-DSRC)	State and federal promotion legislations	Under development
Technology R&D	Google cars, automobile industry	CV-cellular led by private sectors and academia, CV-DSRC led by USDOT and academia	Battery technologies, electric charging systems	Private industry
Standards	Under development	Safety message communication standards (CV-DSRC), no standards yet for CV-cellular	Under development by the EVSP of ANSI *(15)*	Under development by IEEE, ITU, and NIST *(16)*
Licensing	Under development	Security network framework, under development	Under development with user fee charging strategies	Non-transportation licensing agency: FedRAMP *(17, 18)*
Pilot Studies	Google cars in CA, FL, and NV *(19)*	6 testbeds, 6 safety clinics *(20)*	Charging system pilot studies; highway electrifications pilots	Limited in planning and transportation agencies
Market Development	Private sector efforts	Joint private and public sector efforts	Established EV market	Efforts led by IT companies and private industry
Consumer Products	In 3–5 years by Google *(21)*	Full-CV products under development	Charging and electrification systems	IBM and Cisco system, WAZE mobile app

Acronym Guide:

- CV-DSRC: connected vehicle using DSRC; CV-cellular: connected vehicle using cellular technology; Full-CV: fully connected vehicle; EV: electric vehicle
- EVSP: Electric Vehicles Standards Panel, ANSI: American National Standards Institute, IEEE: Institute of Electrical and Electronics Engineers, ITU: International Telecommunication Union, NIST: National Institute of Standards and Technology; FedRAMP: Federal Risk and Authorization Management Program

4. Work Plan for Developing TTTF Strategic Business Development Plan

The work plan for developing the TTTF strategic business plan includes three major research stages: background research, strategy development, and roadmap and execution plan. Each phase consists of several subtasks to produce the corresponding sections in the final business plan.

4.1 Background Research

The background research for business plan consists of a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, industry impact analysis, economic analysis, and environmental scan.

Task 1: SWOT Analysis

SWOT analysis is a structured planning method used to evaluation the strengths and weaknesses of, opportunities for, and threats to a project or business venture. It involves identifying both internal and external factors that are favorable or unfavorable to the objective of a project.

- **Strengths**: *The characteristics of a business or project that give it an advantage over others.* In the case of this project, the strength analysis will focus on the major advantages possessed by the state of Texas, TxDOT, and the related transportation and information technology industry compared with other states.
- **Weaknesses**: *The characteristics that may position a project or business at a disadvantage.* TTTF will focus on analyzing the existing barriers for technology development such as technology limitations, organizational issues, funding and resource limitations, institutional barriers, and public relations and education.
- **Opportunities**: *Elements that the project or organization may take advantage of.* In the context of transportation technologies in Texas, TTTF will explore key opportunities in different aspects of transportation technology development such as policy, legislative, funding, and collaborative opportunities.
- **Threats**: *Elements in the environment that may bring trouble for the business or project objective.* TTTF will focus on identifying existing efforts by the USDOT, other state DOTs, and private sector entities so that Texas does not waste resources repeating the previous efforts. Meanwhile, external factors such as federal policies, legislation, regulations, and compatibility with technologies in other states may also be evaluated for potential threats.

Since emerging transportation technologies are at varying maturity levels and have significantly different development needs, individual SWOT analyses are required for each targeted transportation technology.

Task 2: Industry Impact Analysis

This task evaluates the industry and economic impact of developing new transportation technologies in Texas. The targeted industries include but are not limited to the transportation, automotive, energy, information technologies, telecommunication, logistics, and financial services industries. The industry impact will be evaluated in the following steps:

- Needs assessment for emerging transportation technologies.
- Related outcomes/products/services by emerging transportation technologies
- Transportation technology development scenario projection
- Impact assessment under different scenarios
- Summary of the overall impact and strategies

More specifically, the industry impact may include the contributions of new transportation technologies to the advancement of technologies, knowledge, and experiences, operational efficiency, new consumer products, and new market development.

Task 3: Economic Impact Analysis

The economic impact analysis produces a critical section in the strategic business plan. Based on the outcomes of Task 2, the economic impact analysis further quantifies the impact of different emerging transportation technologies on the Texas economy. To account for the potential direct, indirect, and induced impact of new transportation technologies on Texas economy, the following indicators may be used in economic impact analysis:

- Budgeting and forecasting
- Return of investment
- Job creation and employment
- GDP (gross domestic product) contribution
- Market creation and expansion
- Production cost savings
- Congestion cost savings
- Life/property damage savings
- Energy savings

Tools and methodologies to be used for economic impact analysis can be classified into two major categories: transportation economic impact assessment toolboxes and general economic impact analysis tools. The USDOT and the FHWA have developed multiple transportation economic impact analysis tools, such as STEAM, BCA.NET, and MicroBENCOST *(22)*. In the economics sphere, generalized economic impact analysis tools such as RIMS II *(23)* are also available.

Task 4: Environment Scan

As an extension of the SWOT analysis, the environment scan identifies several lists of stakeholders and resources that influence the internal and external factors found in SWOT analysis. In this project, the task force is interested in identifying the following entities and resources related to new transportation technology development.

- Internal Environment:
    - In-state transportation or non-transportation government agencies that may affect or contribute to the development and implementation of emerging transportation technologies
    - In-state private companies with potential interest in joining the development program
    - In-state funding and investment companies and organizations interested in technology development
    - In-state academic institutes interested in contributing to the state of research and practice of new transportation technologies
- External Environment:
    - National and federal government agencies and organizations that lead or promote new transportation technologies
    - Out-of-state DOT research centers and organizations
    - International technology development organizations or government agencies

By identifying those specific resources and entities, the task force can most fully address and assess the benefits, opportunities, and challenges in new transportation technology development within the context of the business plan.

4.2 Strategy Development

With the background research conducted in the previous phase, the main purpose of this phase is to complete the sections in the business plan regarding technology development strategies, which includes the development of vision, goals, and detailed strategies.

Task 5: Vision, Mission, and Goals Development

The key of this task is to develop the vision, key missions, and goals for the proposed technology development program in Texas. The vision should incorporate the perspectives from latest long-term highway authorization, MAP-21(Moving Ahead for Progress in the 21st Century) *(24)*, as well as the state and TxDOT strategic goals. The key missions will be developed closely related to the specific visions developed. Program goals will be developed by specifying criteria for determining the success of the transportation technology development.

Task 6: Strategy development

Based on the outcome of Task 5, this task will result in detailed development strategies. Strategic areas to be considered may include funding and investment strategies, organizational structures and procedures, PPP strategies, service offering strategies, client selection strategies, evaluation and pilot testing strategies, legislative- and policy-supporting strategies, and public relation and education strategies. The strategic development will lead to key business initiatives and subsequent policy research to be conducted in future phases of this project.

4.3 Roadmap and Execution Plan

With the completion of strategic development in the previous phase, in this phase the task force will focus on creating roadmaps and a work plan towards achieving the established vision and goals of transportation technology development in Texas.

Task 7: Roadmap and Work Plan

In this task, the task force will develop short-term, mid-term, and long-term roadmaps that consider the inherent uncertainty in resource availability and technology innovations. The short-term roadmap will focus on achieving the most urgent tasks and initiatives to jumpstart the transportation technology development in Texas. The medium-term roadmap will cover the strategic steps towards the large-scale testing and pilots. The long-term roadmap will provide perspectives on addressing the implementation and preparation for new technology breakthroughs. The overall work plan also includes specific work plans for key initiatives, such as creation of the public-private consortium and testing platforms.

Task 8: Organizational Structure and Staff Plan

To ensure the execution of the developed work plan in future phases of the project, the development of an efficient organizational structure and staff plan is critical. The task force will specify the detailed organizational structures, staff requirement, internal boards and responsibilities, work flows, legislation and bylaws, and other aspects to ensure the key initiatives of the project can be carried out.

5. Timeline and Schedule

The development of the strategic business plan is expected to require 18 months. The detailed timeline is summarized in Table 2.

Table 2. Timeline of the TTTF Strategic Business Plan Development

FY	FY 13			FY 14		
Month	**1–2**	**3–4**	**5–6**	**7–8**	**9–10**	**11–12**
Task 1*						
Task 2						
Task 3						
Task 4						
Task 5*						
Task 6*						
Task 7*						
Task 8*						

*Indicates tasks with preliminary research conducted in the previous and current phase of the project.

APPENDIX I. Business Plan Creation Process

PRELIMINARY BACKGROUND RESEARCH

SWOT (Strengths, Weaknesses, Opportunities, Threats) Analysis

The preliminary SWOT analysis for Texas transportation technology development focuses on general social needs as well as economic, policy, legislative, and funding aspects. The task force attempted to identify the unique characteristics that differentiate Texas from other states. The insights of the general SWOT analysis form the basis for the more detailed, technology-specific SWOT analysis to be conducted in the next phase of the project.

Strengths

- **Innovation propelled by transportation needs:** Texas is the second-most populous state in the U.S. with four major metropolitan areas. The state suffers from the ever-increasing travel demand that leads to significant safety, congestion, and energy issues in transportation systems. The land use limitations in urban areas make it impossible to address those issues by simply expanding the existing transportation infrastructures. The state calls for new technological innovations that can alleviate those issues by maximizing the potential capacities in the existing infrastructures.
- **Economic strength:** The Texas economy stayed strong during the recent economic recession. The strong economy makes Texas attractive to investors and start-ups looking for sites with long-term economic stability. This stability is crucial for developing new transportation technologies such as autonomous vehicles, connected vehicles, and electric vehicles that need not only a large consumer base but also a sustainable economy that can support technological innovations.
- **Technology development:** Texas is the home of high technology companies such as Dell, Texas Instruments, AT&T, AMD, Google, Apple, Samsung, etc. NASA's Johnson Space Center and Lockheed Martin's *(25)* aeronautics division are both located in Texas. Texas has also provided generations of researchers and engineers through its large and successful university systems.
- **Government strength:** The state government in Texas has tremendous leadership and solid organizational structure. As one strong component of the state government, TxDOT has a vital interest in investing in transportation infrastructures and is aggressive in addressing transportation issues. Meanwhile, the distributed structure of TxDOT ensures that transportation issues can be addressed with localized methods and solutions.
- **Tradition of funding and investment:** Texas has a tradition of supporting technology innovations, transfer, and commercialization. Texas has multiple technology incubator and accelerator programs that have assisted many young talents in converting their ideas into successful business.

Weaknesses

- **Decline in public funding:** Due to the conservative taxation policies and the increase of automobile fuel efficiency, Texas highway funding continues to decline even though the infrastructure and operational needs are increasing over the years.
- **Decentralized government structure:** Although the decentralized organizational structure provides flexibility for each district in addressing local transportation needs, it does create barriers to the testing and implementation of new transportation technologies across the state.
- **Auto-centric society:** Texas has long been an automobile-centric state with passenger vehicles dominant among other, more sustainable public transportation modes. Although this scenario provides a robust testing environment for vehicle-based technologies such as connected and autonomous vehicles, it can create barriers to the testing and implementation of emerging sustainable transportation solutions inspired by new transportation technologies.
- **Resource limitations:** With the increasing population, Texas also faces resource limitations, especially in terms of water and energy. Such limitations may discourage certain technology development that relies on those resources.

Opportunities

- **National and international technology trend:** TTTF was established in light of the latest wave of innovative transportation technologies triggered by the progress in information, communication, and automobile technologies. If appropriately positioned, Texas can take advantage of the current wave and be among the leading states in developing and implementing those new technologies.
- **Forward-thinking government:** The state government's willingness to promote new technologies and innovative funding strategies, such as PPPs, drives the development and implementation of new transportation technologies.
- **Outbreaks of transportation issues:** Traffic congestion issues in Texas cities over the recent years have significantly worsened and drawn a lot of attention from the general public. Such attention can serve as strong motivations for the introduction and adoption of emerging transportation technologies.
- **Stakeholder support:** The initial conversations between the task force and stakeholders in transportation technology development—including the public, private, and academic sectors—revealed strong interest in participating in and contributing to the program.
- **Economic development in technology development:** A unique opportunity for Texas to excel in the technology development is the ability to combine technology development with long-term economic development. By combining these two aspects, Texas can be at a prime position to attract technology developers, investment, and collaborations.

- **Existing USDOT efforts:** The USDOT has been leading the research, pilot, and policy development for DSRC-based connected vehicle technologies. The NHTSA has also been leading the legislative efforts towards the implementation of connected vehicle devices and the testing of autonomous vehicle technologies. Those efforts can provide the foundation for Texas to develop its own technology development strategies.
- **Lessons learned from other state DOTs:** Many state DOTs have also pursued technologies such as autonomous and connected vehicle technologies and made available significant documentation of the lessons learned in promoting those technologies. Texas can take full advantage of the past experiences and identify a feasible and suitable path for technology development.

Threats

- **Duplication of existing efforts by the USDOT, other state DOTs:** These entities have devoted a great deal of resources to technology research, testing, standardization, and policy research. Texas should not try to replicate those efforts.
- **Private industry R&D development:** Many private companies in the automobile or IT industries have their own R&D agenda and facilities. They are not necessarily interested in collaborating with public agencies if the TTTF cannot significantly assist with their R&D agenda.
- **Legislative barriers:** At the national/federal level, the USDOT may create legislative or policy barriers if milestone decisions, such as the enforcement of DRSC devices and the promotion of public testing of autonomous vehicles, are made according to the original agenda *(2)*. Meanwhile, the related legislative decisions from other state DOTs may also cause confusions and debates for similar technology-related decisions in Texas.
- **Compatibility issues with other states:** Another potential threat is related to the R&D of major emerging transportation technologies: simultaneous technology development efforts may lead to compatibility issues among different systems, similar to the issues that have arisen with electronic tolling systems.

Technology Evaluation Matrices for Preliminary SWOT Analysis

Since transportation systems are complex and embody varying goals and barriers across various modes and user groups, a multidimensional evaluation framework is needed to understand how technologies could impact the system across multiple dimensions and is an initial step for the SWOT analysis. It begins by assessing performance of transportation systems, which requires consideration of safety, mobility, environment dimensions, etc., and along each dimension, measurable and quantifiable indicators are needed. The remainder of this section focuses on a framework that allows for an analysis of the technology across multiple dimensions.

Step 1. Framework Definitions: This framework starts off by defining all technologies within the portfolio in need of evaluation in the SWOT analysis.

- ***Autonomous Vehicles,*** which may include specific applications in the following areas: autonomous freight technology, platoons, and pilots; personal autonomous vehicles including neighborhood/low speed and non-neighborhood vehicles; commercial uses (taxis); and autonomous parking in urban cores. For the evaluation process, these are broken into two categories: levels one and two automation and levels three and four automation.
- ***Connected Vehicles,*** including current and prospective applications, trials, and pilots; V2I implementation/wrong-way driver detection; and studies of human behavior and driver interface with CV applications. For the ranking process, these are broken into two categories: vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) technologies.
- ***Electric Vehicles and Systems,*** including smart highways, solar highways, or roadway energy storage and transmission; battery technology; distributed nuclear energy; alternative fuels, inductive charging or wireless energy transfer; DC fast charging systems, and smart grids.
- ***Unmanned Aerial Vehicles (UAV)*** including surveillance applications and logistics.
- Information and communication technologies, including ***cloud computing*** with big data, distribution and analysis (automotive cloud), and super-fast computing for V2I, and ***crowdsourcing***, *which* includes smartphone applications and surveillance or emergency management examples and applications.
- ***Infrastructure and construction technologies,*** including infrastructure enhancements such as fiber optics and ITS technologies, and construction techniques and equipment (such as truss sliding and vacuum consolidation).
- ***Materials,*** including self-healing pavements and nanotechnologies.
- Additive manufacturing for vehicles and infrastructure (***3D printing***).
- Service-based technologies, which are divided into the following: ***location-based services*** (e.g., ridesharing and social networking applications for transportation) and ***transportation subscription services*** (e.g., shared vehicle fleets).

These technologies are carried forward into Step 2, which is described in the next section.

Step 2. Technology Assessment: Step 1 resulted in an initial technology list, which became the initial technology portfolio. Step 2 was designed to assess individual technologies, as a basis for comprehensive evaluation for selecting preliminary critical technologies for further inspection. The assessment focuses on four primary dimensions:

- **Strategic Goal Alignment:** Ability to meet or further national and state transportation goals, which mainly consists of safety, congestion, and environment.
- **Deployment Barriers:** Presence of barriers to adoption and implementation, which include the regulatory, cost-effectiveness, and safety aspects.

- **Mode-Specific System Enhancement**: Ability of technology to improve transportation in different modes, which cover not only highway traffic, but also bicycle/pedestrian, freight, transit, aviation, port, etc.
- **User Group Enhancement:** Ability of technology to enhance or improve transportation user group experience. User groups will closely align with trip purpose and mode combinations. For example, passenger vehicle travel for home-based work trips may use technologies differently than passenger vehicle trips for leisure travel, or interregional freight travel may receive benefits from technologies that are different for intraregional freight travel.

For each evaluation, each member of the research team was asked to rank technologies in matrix of technologies across columns against each evaluation dimension (rows) on a scale from zero to five. Each integer on the ordinal scale corresponded to each individual's belief about how each dimension represents each technology, with lower values indicating less relevance in a dimension and higher values indicating more relevance. For example, when considering the benefits that lower levels of vehicle automation could have on travel, a rank of zero would indicate no benefit and a rank of five would indicate a monumental impact on travel. A full summary of assessment along these four dimensions and corresponding factors considered are listed in Tables 1a-d. After individual rankings, results from each team member are to be combined to form one final set of evaluation matrices to reflect the consensus of the team.

The final combined rankings will be used to inform a trade-offs analysis to compare technologies along common dimensions. The final evaluation (radar chart) allows for the assessment and comparison of technologies along various dimensions so that a final set of critical technologies may be chosen for further analysis in subsequent steps. A diagram of this full ranking and combining process is shown in Figure 1.

Table 1a: Factors in ranking considerations for goals evaluation

Proposal Goal	Factor Consideration
Economic development	• Quantity and quality of jobs directly created in Texas
Safety	• Crash frequency reduction • Crash severity reduction
Congestion	• Decreased hours of congested travel • Improved traffic flows during congestion • Improved travel time reliability
Connect Texas communities	• Enhanced access to goods and services • Increased Texas gross state product • Public relations and dissemination of information to Texas communities
Best in class agency	• Agency able to deploy resources more efficiently
Infrastructure condition	• Direct improvement to infrastructure condition • Indirect improvement to infrastructure condition
System reliability	• Improved system efficiency
Environmental sustainability	• Reduced fuel and energy consumption • Reduced air pollutant emissions, to meet EPA standards
Reduce project delivery	• Reduced project delivery delays due to shortened time during construction

Table 1b: Factors in ranking considerations for barriers evaluation

Proposal Issues & Concern	Factor Consideration
Institutional	• Internal public transportation agencies changes • Potential new agency positions and duties • Technology standardization and coordination • Cross-agency and private institution collaboration
Infrastructure	• Extent of new infrastructure required • Existing infrastructure repurposed
Regulatory	• Legislative regulatory changes (may be helpful or necessary) • Administrative regulatory changes (may be helpful or necessary)
Policy	• Public agency direction and support
Cost, public	• Direct public agency costs
Safety	• New crashes or incidents otherwise avoidable • Increased crash or incident severity • Electronic security vulnerabilities
Energy	• Energy consumption of new technology greater than potential savings
Public concerns	• Disparate impacts across income groups • Privacy concerns • Neighborhood concerns • Other non-safety or energy concerns
Cost, private	• Consumer technology purchase costs • Corporate technology development costs
Time (develop & deploy)	• Timeframe required to complete phase after entering
Technology	• Technical barriers technology development

Table 1c: Factors in ranking considerations for modal enhancement evaluation

Mode	Factor Consideration
Surface Transportation **Transit** **Freight** **Ports, marines, waterways** **Air/Aviation**	• Increased safety • Increased mobility • Decreased cost on system • Operations and maintenance benefits

Table 1d: Factors in ranking considerations for user group enhancement evaluation

Mode	Factor Consideration
Freight (interregional) **Freight (intraregional)** **Personal (commute)** **Personal (Recreational)** **Emergency** **School/students**	• Increased safety • Increased mobility • Decreased cost on system • Operations and maintenance benefits

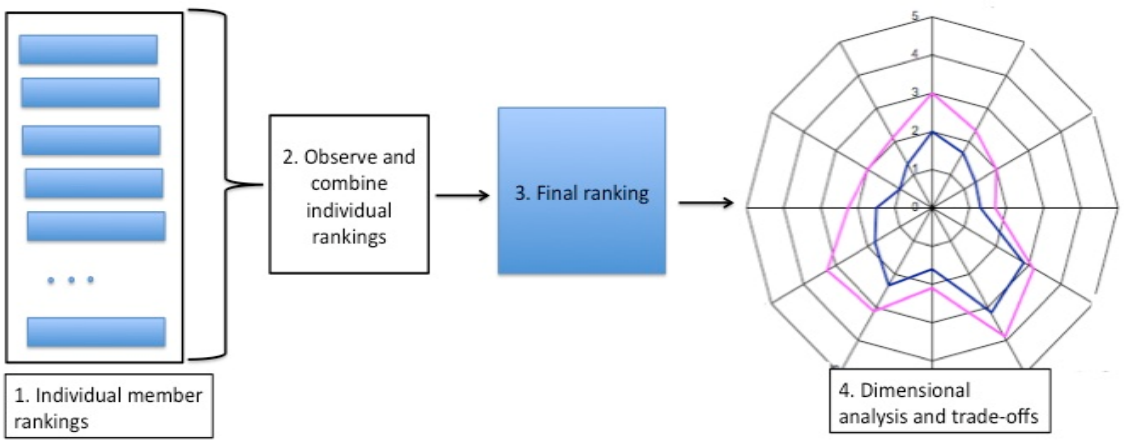


Figure 1: Overview of technology assessment

Step 3. Portfolio Assessment: This third and final step, which will be carried out during the next stage with the help of the TTTF, will take a deeper, more technical look into the technologies and build on Step 2. Due to resource limitations, agencies need to strategically allocate the available resources to technologies under consideration. As a final step, a comprehensive portfolio assessment framework will be used next to gain a deeper, more technical understanding of the technologies. The key difference between this step and the previous ones lies in a more comprehensive perspective—based on the attributes of and forecasts for individual technologies, we consider the technology life cycle; short- and long-term institutional, technological, and economic uncertainties; and the synergy of technologies. To be specific, we will examine the following aspects:

- **Technology Life Cycle:** This analysis will provide a better understanding the development phases and trajectory of technologies, and highlight opportunities for synergy. Life cycle curves will be used to visualize the evolution phases of technologies.
- **Scenario Generation:** The team will forecast possible technology adoption scenarios for the analysis of portfolio benefits in safety, congestion, and environment.
- **Technology Synergy:** This analysis will formally analyze the synergy effect that can be realized by pairing technologies. The possibility of synergy and potential benefits will be analyzed together.
- **Performance Metrics:** Different portfolios will be compared to select and prioritize individual technologies within the portfolio. Three sub-steps will be taken:
    - Convene the Task Force and use Delphi-like process to further rank the technology portfolio and obtain feedback from TTTF members.
    - Combine individual Task Force input to support development of critical list.
    - Select technologies based on highest rankings among technology-dimension intersections weighed against Task Force member input.

The above steps constitute a tentative evaluation framework to apply to the technologies in the portfolio. The framework is intended to be illustrative, as it will become refined continuously based on Task Force guidance. The completion of this analysis will inform the final SWOT analysis.

Observations from Application of Step Two: Technology Evaluation

Observations on strategic goal alignment

For each of the technologies on the radar chart, the total area was calculated with the idea that technologies that align more closely with goals would have larger coverage areas. The total area (area score) is shown in the final row of each matrix. The technologies with the highest area score were ***vehicle-to-infrastructure technologies*** (47.7), ***cloud computing*** (48.4), ***crowd sourcing*** (40.3), ***transportation subscription services*** (40.0***), location-based services*** (32.9), and perhaps ***automation levels three and four*** (32.2). Electric systems technologies show the lowest alignment with goals overall even though it ranked the highest in the environmental sustainability dimension.

Observations on deployment barriers

The results of technology barrier rankings are shown in Figure 2a-d. In the interest of minimizing barriers for transformative technologies, those with low area scores are highlighted. The lowest scores were for ***automation levels one and two*** (10.3), ***crowd sourcing*** (14.5), ***materials*** (18.7), ***transportation subscription services*** (19.8) and ***vehicle-to-vehicle technologies*** (19.1). Note that crowd sourcing, transportation subscription services, and location-based services showed high goal alignment and simultaneously low barrier to implementation. Note that technologies that are less transformational and unlike any existing technology have higher barriers to overcome, whereas technologies with marginal enhancements over existing ones face lowers barriers to adoption and diffusion.

Observations on mode-specific system enhancements

Results from the modal enhancement analysis show that ***automation of all levels***, connected vehicles (***V2V and V2I***), and ***cloud computing*** provide the most benefit across modes with area scores as follows; automation levels one and two (31.5), automation levels three and four (37.5), V2I (31.5), V2V (37.5), cloud computing (34.3). For surface transportation, location-based services and transportation subscription services would also greatly enhance travel. For transit, the same is true. For freight, automation and connected vehicles showed the most enhancements along with the diffusion of 3D printing, which could have great impact on freight travel. For ports, marines, and waterways, the greatest enhancements could come from automation levels three and four, vehicle-to-infrastructure technologies, cloud computing, and infrastructure and construction enhancements. Finally, the single largest impact on air and aviation could be seen from UAVs/drones.

Observations on user group enhancements

Results of the user group enhancement rankings show that all levels of ***automation, connected vehicles, cloud computing, crowd sourcing, and location-based services*** have the greatest ability to enhance travel across user groups with area scores as follows; automation levels one

and two (36.8), automation levels three and four (49.5), V2I (33.6), V2V (46.0), cloud computing (31.1), crowd sourcing (34.6), and location-based services (31.8).

Ratings 0-5: 0 = Does not address goal, 5 = Disruptively beneficial solution

		Autonomous Vehicles		Connected Vehicles			Information and Communication							
Goals		A1/A2	A3/A4	V2I	V2V	Elec. Sys	UAVs	Cloud Comp.	Croud Sourcing	Infrastra. & Const. Enhance	Materials	3D Printing	Location Based Services	Transp. Subscription services
Texas Goals	Safety	5	5	5	5	1	2	4	4	3	4	3	3	3
	Congestion	2	4	4	4	1	3	4	5	3	2	3	4	5
	Connect TX communities	2	4	3	4	1	3	5	4	2	1	3	5	5
	Best in class agency	3	4	5	3	2	3	5	4	3	4	3	4	4
Other National Goals	Infrastructure condition	3	2	5	2	2	5	4	4	5	5	3	2	2
	System reliability	3	3	4	4	1	4	4	4	4	4	3	3	4
	Environmental sustain.	3	3	4	3	5	3	4	3	3	4	3	3	4
	Reduce proj. delivery	2	2	3	2	2	3	3	2	3	2	4	3	3
Area Score		22.3	32.2	47.7	31.8	9.5	30.4	48.4	40.3	30.4	30.4	27.6	32.9	40.0

Ratings 0-5: 0 = No Barrier, 5 = Barrier likely insurmountable in

	Autonomous Vehicles		Connected Vehicles				Information and Communication						
Barriers	A1/A2	A3/A4	V2I	V2V	Elec. Sys	UAVs	Cloud Comp.	Croud Sourcing	Infrastra. & Const. Enhance	Materials	3D Printing	Location Based Services	Transp. Subscription services
Institutional	1	4	3	2	2	4	2	2	3	2	3	3	3
Infrastructure	1	4	3	2	3	2	3	1	3	3	2	2	2
Regulatory	2	4	2	3	2	5	3	3	1	1	4	4	3
Policy	2	4	3	2	2	4	3	3	3	2	3	4	4
Cost, public	4	2	3	2	4	1	3	2	4	4	4	2	2
Safety	2	4	3	4	2	4	2	2	1	2	2	2	2
Energy	1	1	2	1	3	1	1	1	3	1	1	1	1
Public concern	1	4	3	4	2	5	3	3	2	2	2	2	2
Time (develop and deploy)	1	4	2	3	3	3	2	2	3	4	3	2	2
Technology	1	4	1	2	4	2	2	2	2	3	3	2	2
Area Score	10.3	42.4	24.4	19.1	23.0	31.5	21.2	14.5	21.6	18.7	25.1	21.9	19.8

Ratings 0-5: 0 = No benefit to mode, 5 = Greatly benefits travel/operations on mode

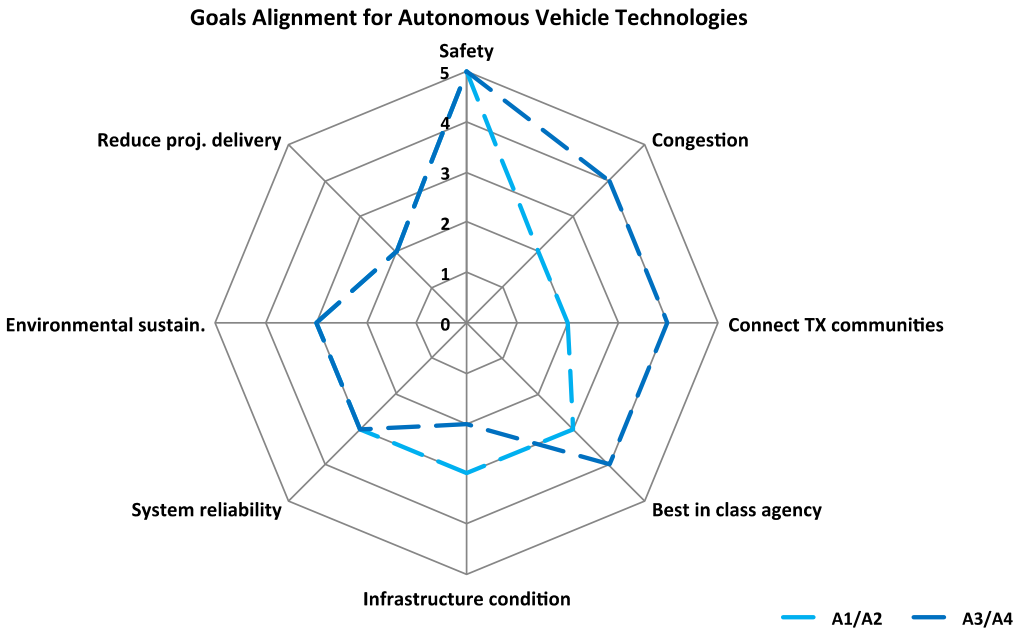
	Autonomous Vehicles		Connected Vehicles				Information and Communication						
Modal Enhancements	A1/A2	A3/A4	V2I	V2V	Elec. Sys	UAVs	Cloud Computing	Croud Sourcing	Infrstra. & Const. Enhance	Materials	3D Printing	Location Based Services	Transportation Subscription services
Surface Transportation	5	5	5	5	3	3	5	5	4	5	3	5	5
Transit	5	5	5	5	5	2	5	4	4	2	2	4	4
Freight	5	5	5	5	3	4	4	4	4	4	5	3	1
Ports, Marine, Waterways	3	4	3	4	1	2	4	2	4	3	3	1	2
Air/Aviation	3	4	3	4	2	5	4	1	4	2	2	1	2
Area Score	31.5	37.5	31.5	37.5	14.5	16.6	34.3	18.0	28.3	16.3	15.2	14.5	14.1

Ratings 0-5: 0 = No benefit to user group, 5 = Greatly benefits travel/operations for user group

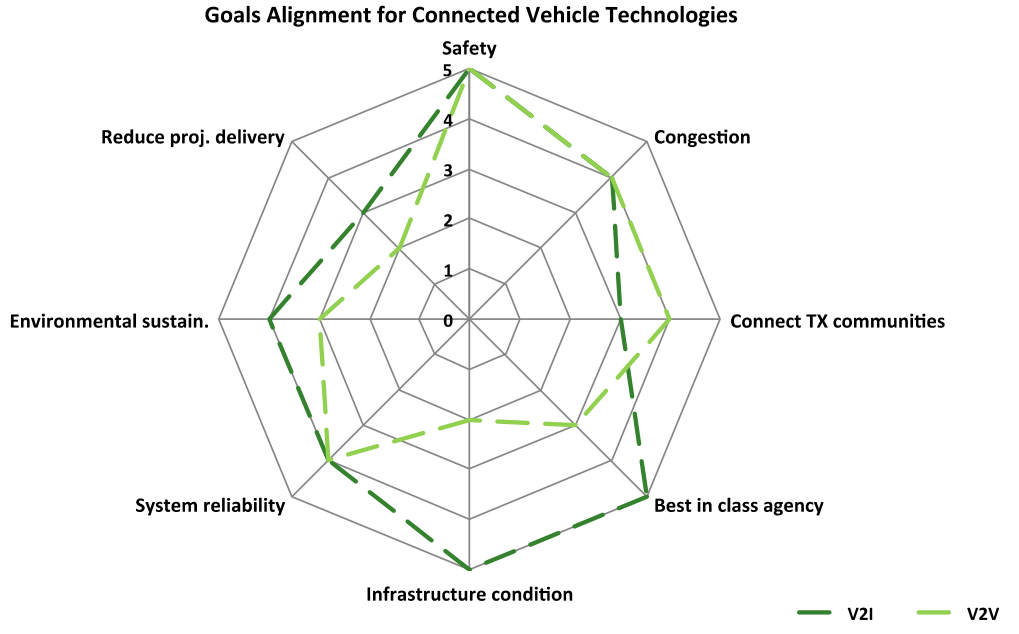
	Autonomous Vehicles		Connected Vehicles				Information and Communication						
User Group Enhancements	A1/A2	A3/A4	V2I	V2V	Elec. Sys	UAVs	Cloud Computing	Croud Sourcing	Infrstra. & Const. Enhance	Materials	3D Printing	Location Based Services	Transportation Subscription services
Freight (interregional)	4	5	4	5	2	4	4	3	3	3	3	3	2
Freight (intraregional)	4	5	4	5	2	2	4	3	3	3	4	4	3
Personal (commute)	4	4	4	5	4	1	4	5	4	4	3	5	5
Personal (Recreational)	4	5	4	5	3	2	4	5	4	4	2	5	5
Emergency	4	5	5	5	2	4	4	5	3	3	2	3	2
School/students	5	5	3	3	3	2	3	3	2	2	2	3	4
Area Score	36.8	49.5	33.6	46.0	14.8	12.7	31.1	34.6	21.6	21.6	15.6	31.8	25.5

Figure 2 (a-d): Matrix Evaluation Results for Four Dimensions

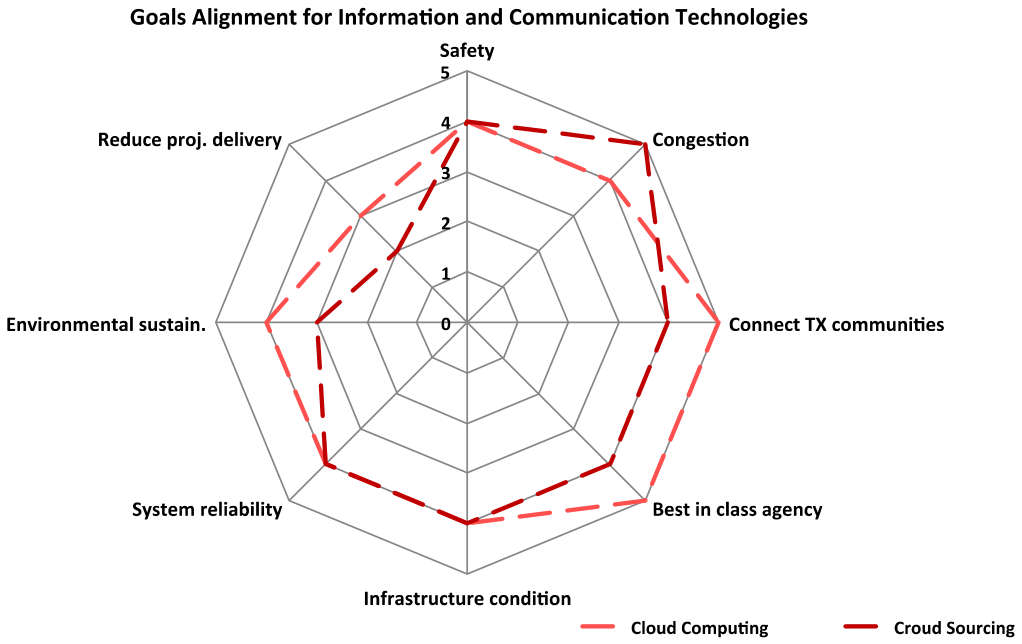
Figures 3 through 6 provide the trade-off results.


Goals Alignment for Autonomous Vehicle Technologies
Safety
Congestion
Connect TX communities
Best in class agency
Infrastructure condition
System reliability
Environmental sustain.
Reduce proj. delivery
0
1
2
3
4
5
A1/A2
A3/A4

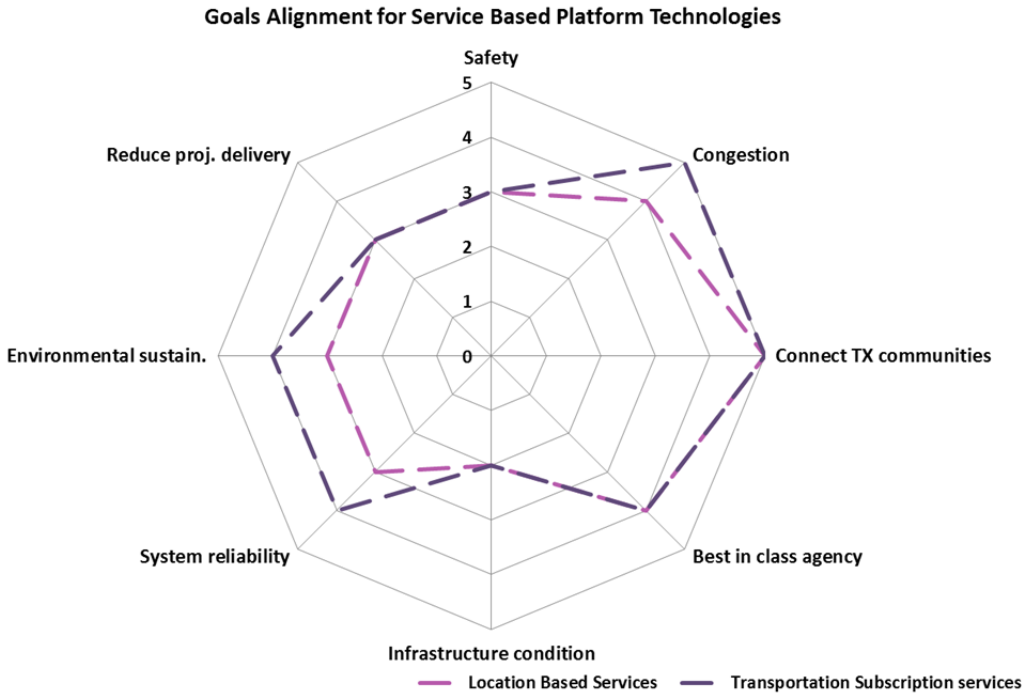
3(a)


Goals Alignment for Connected Vehicle Technologies
Safety
Congestion
Connect TX communities
Best in class agency
Infrastructure condition
System reliability
Environmental sustain.
Reduce proj. delivery
0
1
2
3
4
5
V2I
V2V

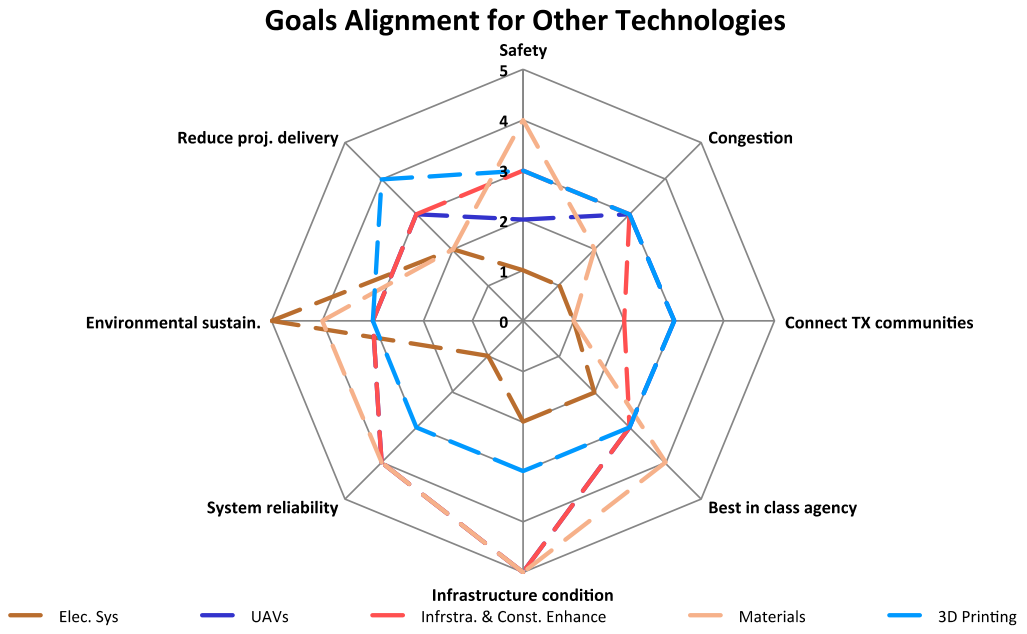
3(b)


Goals Alignment for Information and Communication Technologies
Safety
5
4
3
2
1
0
Congestion
Connect TX communities
Best in class agency
Infrastructure condition
System reliability
Environmental sustain.
Reduce proj. delivery
Cloud Computing
Croud Sourcing

3(c)

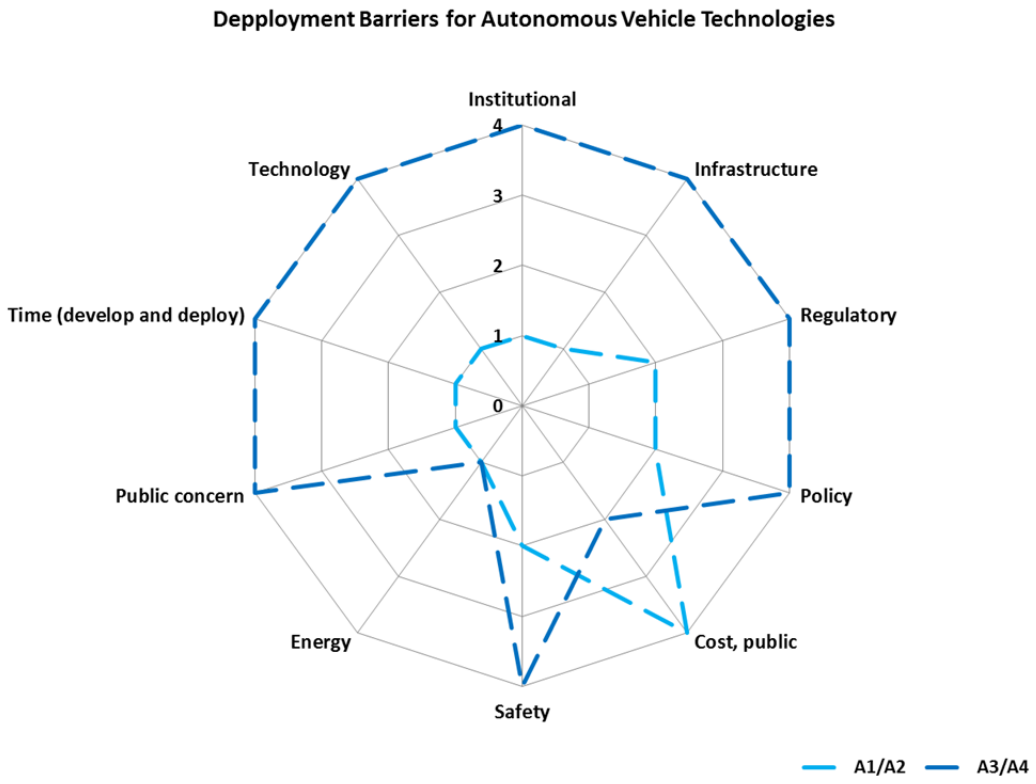

Goals Alignment for Service Based Platform Technologies
Safety
5
4
3
2
1
0
Congestion
Connect TX communities
Best in class agency
Infrastructure condition
System reliability
Environmental sustain.
Reduce proj. delivery
Location Based Services
Transportation Subscription services

3(d)

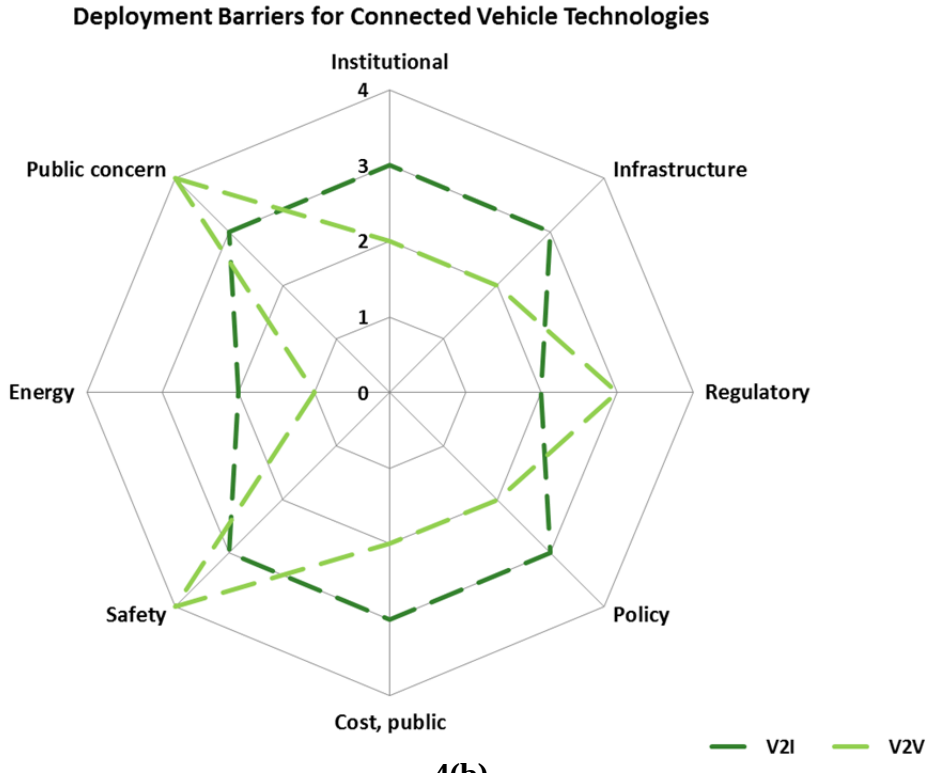


3(e)

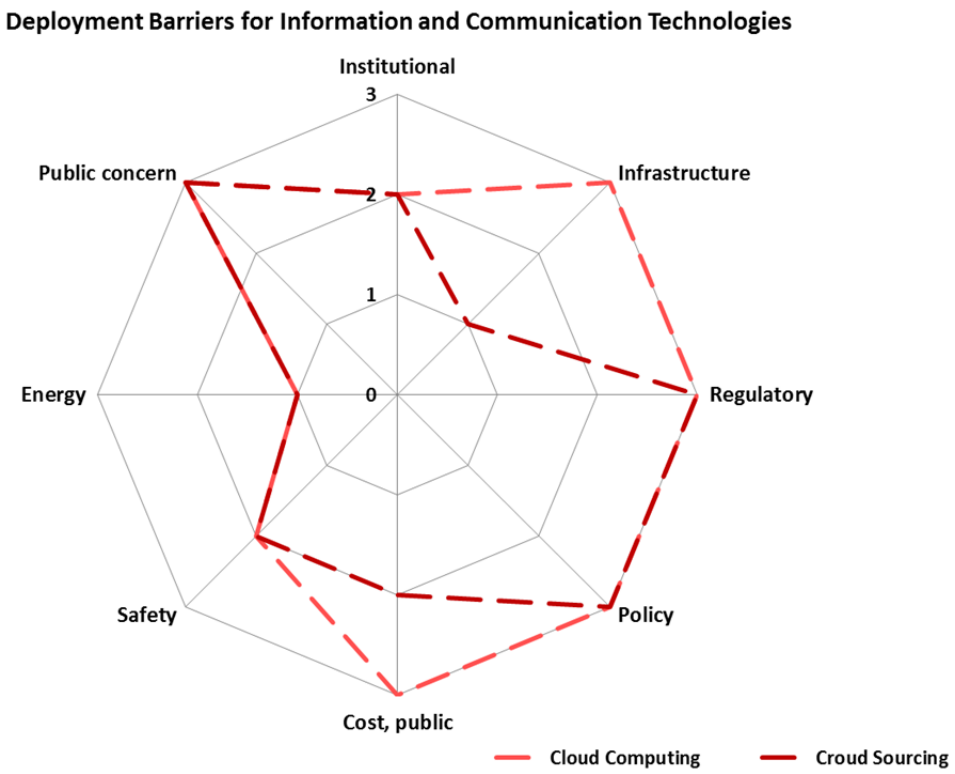
Figure 3 (a-e): Trade-Off Results for Goals Alignment by Technology Group


Depployment Barriers for Autonomous Vehicle Technologies
Institutional
Infrastructure
Regulatory
Policy
Cost, public
Safety
Energy
Public concern
Time (develop and deploy)
Technology
4
3
2
1
0
A1/A2
A3/A4

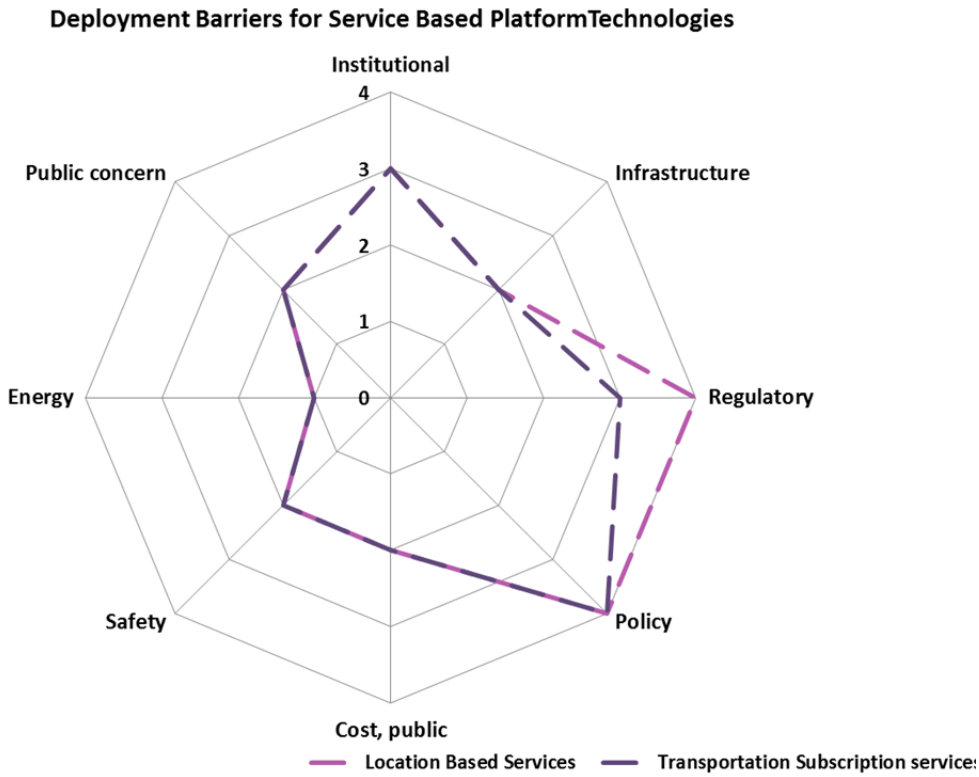
4(a)


Deployment Barriers for Connected Vehicle Technologies
Institutional
Infrastructure
Regulatory
Policy
Cost, public
Safety
Energy
Public concern
4
3
2
1
0
V2I
V2V

4(b)


Deployment Barriers for Information and Communication Technologies
Institutional
3
Infrastructure
Regulatory
Policy
Cost, public
Safety
Energy
Public concern
2
1
0
Cloud Computing
Croud Sourcing

4(c)


Deployment Barriers for Service Based PlatformTechnologies
Institutional
4
Infrastructure
Regulatory
Policy
Cost, public
Safety
Energy
Public concern
3
2
1
0
Location Based Services
Transportation Subscription services

4(d)

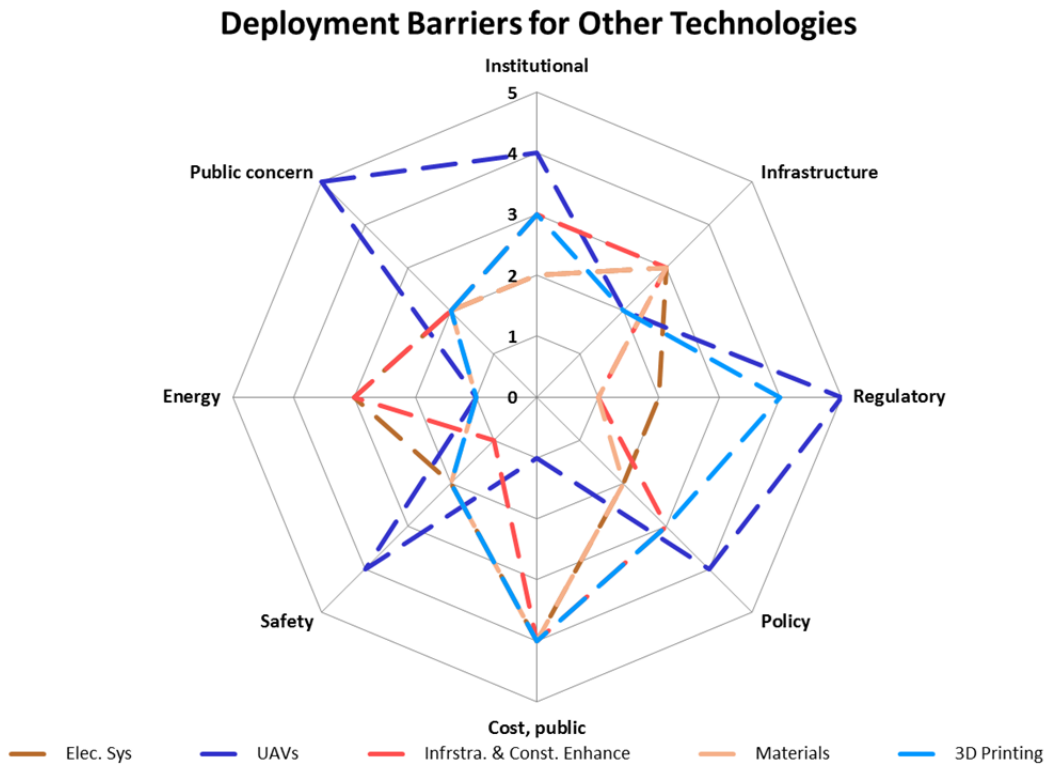
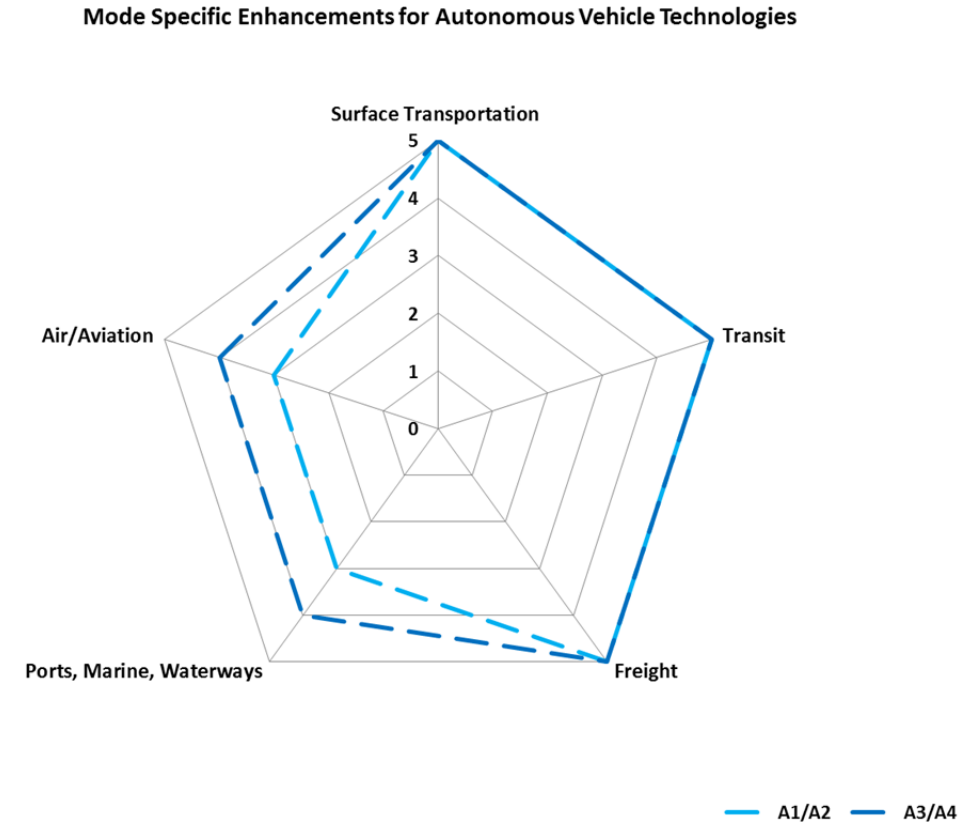
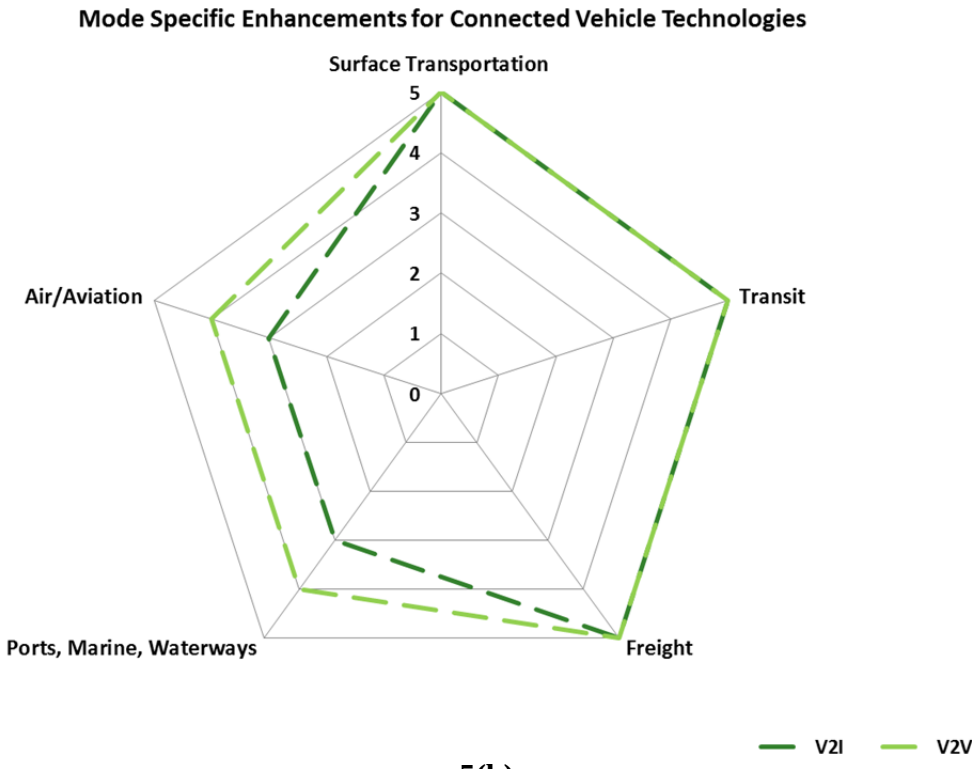


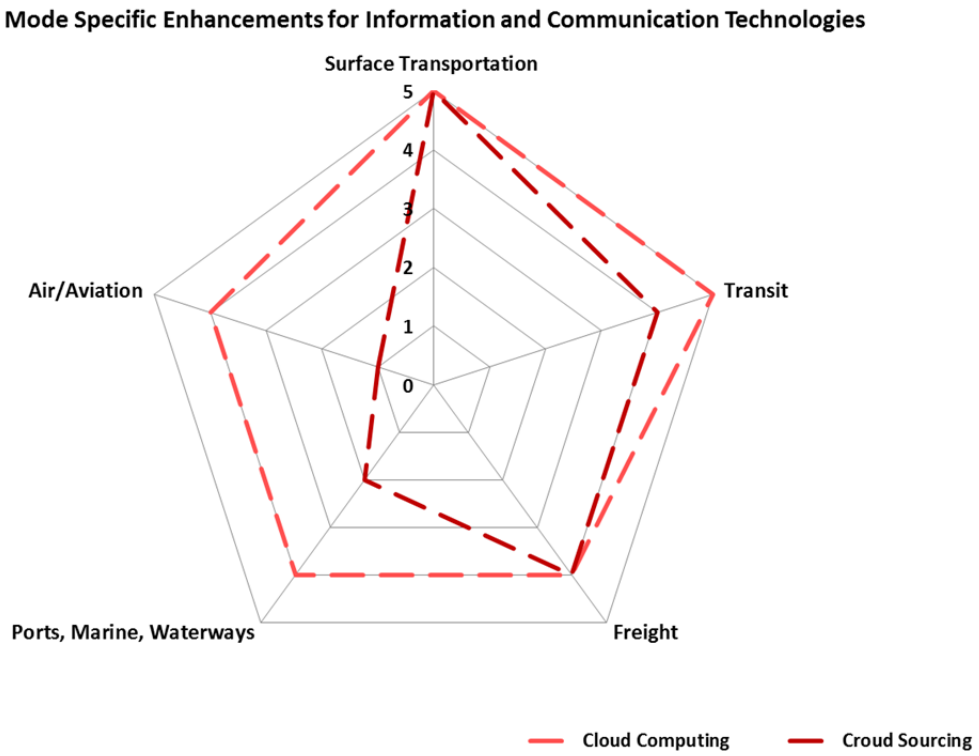
Figure 4 (a-e): Trade-Off Results for Deployment Barriers by Technology Group


Mode Specific Enhancements for Autonomous Vehicle Technologies
Surface Transportation
5
4
3
2
1
0
Transit
Freight
Ports, Marine, Waterways
Air/Aviation
A1/A2
A3/A4

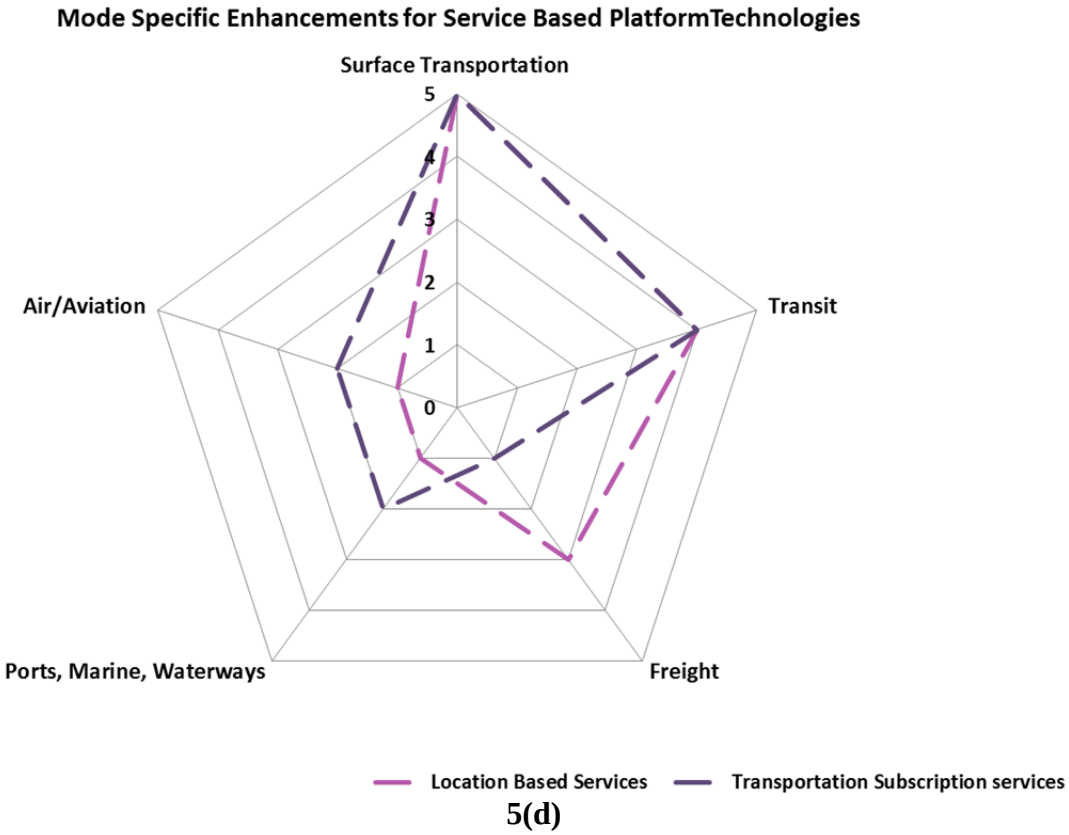
5(a)


Mode Specific Enhancements for Connected Vehicle Technologies
Surface Transportation
5
4
3
2
1
0
Transit
Freight
Ports, Marine, Waterways
Air/Aviation
V2I
V2V

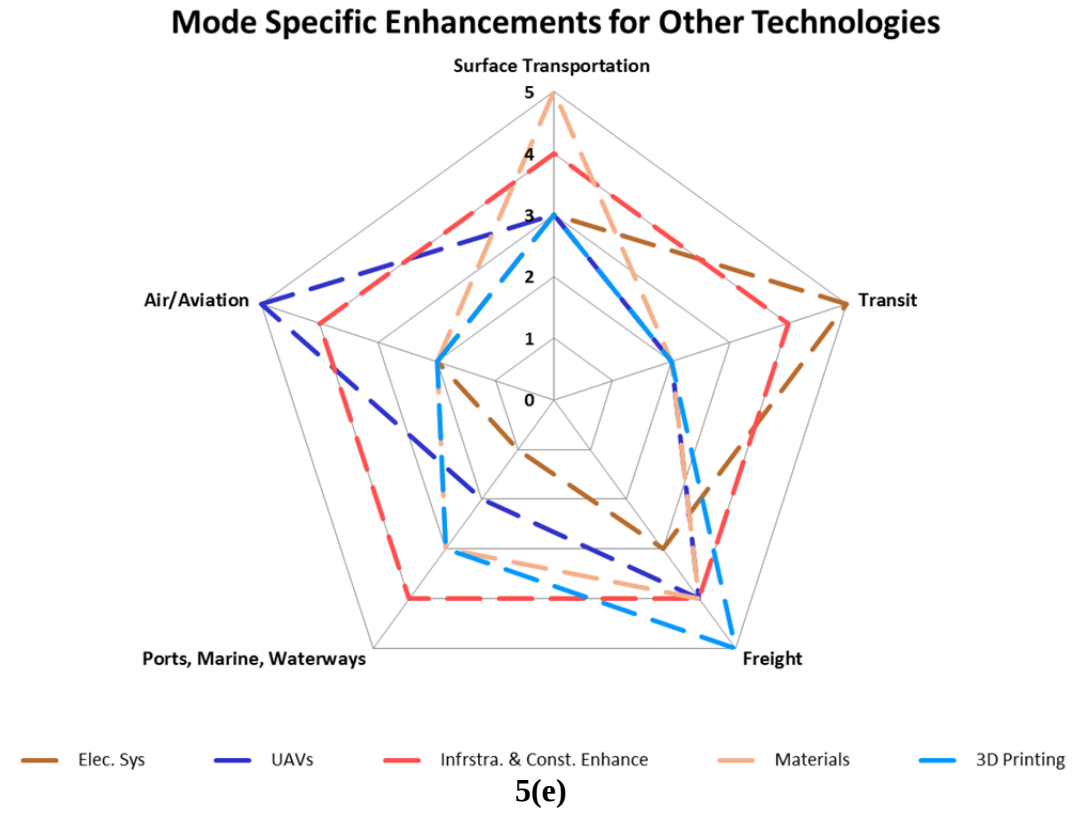
5(b)


Mode Specific Enhancements for Information and Communication Technologies
Surface Transportation
5
4
3
2
1
0
Transit
Freight
Ports, Marine, Waterways
Air/Aviation
Cloud Computing
Croud Sourcing

5(c)

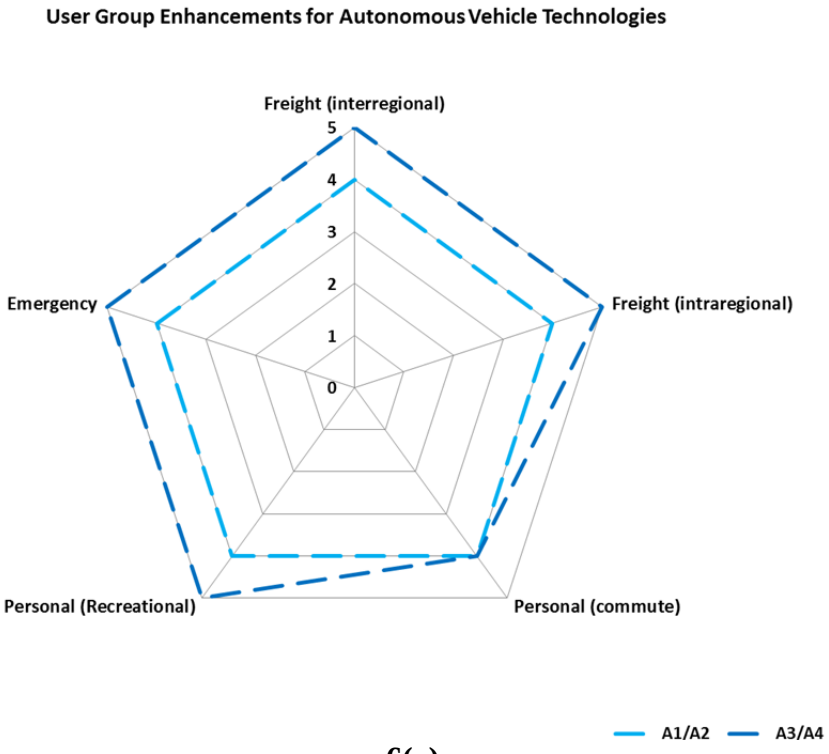

Mode Specific Enhancements for Service Based PlatformTechnologies
Surface Transportation
5
4
3
2
1
0
Transit
Freight
Ports, Marine, Waterways
Air/Aviation
Location Based Services
Transportation Subscription services

5(d)

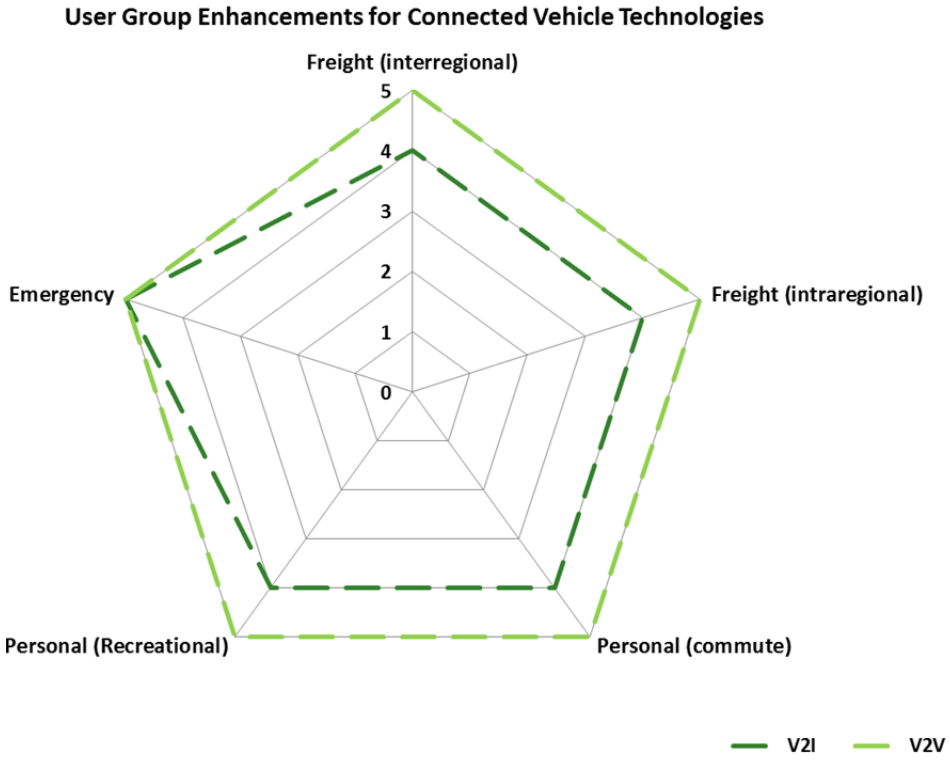


5(e)

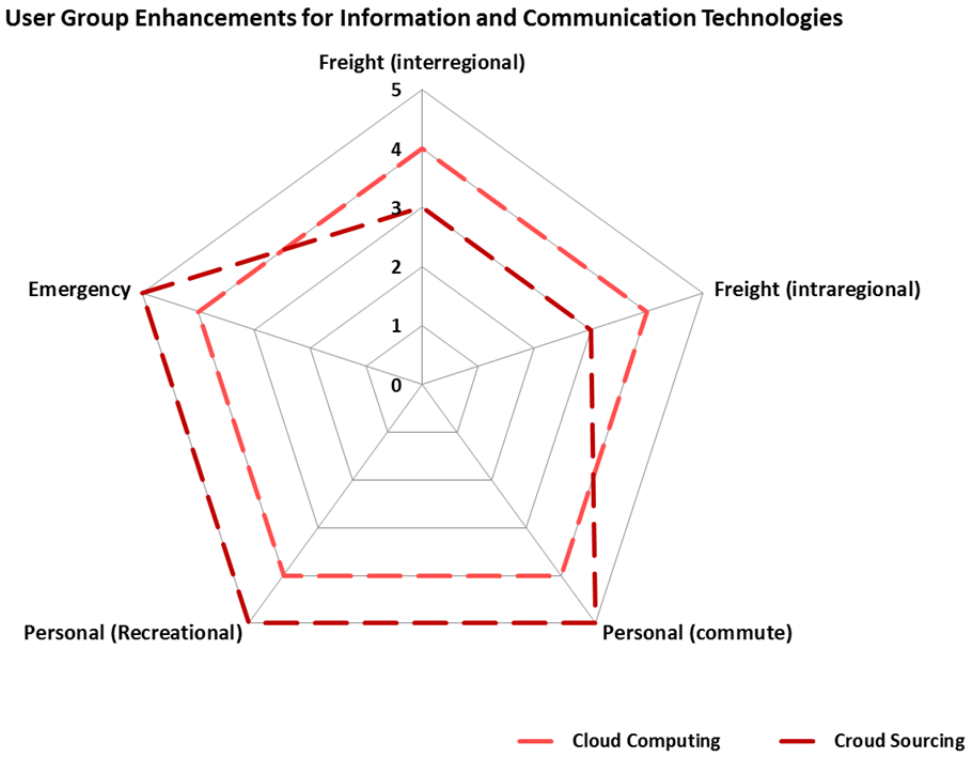
Figure 5 (a-e): Trade-Off Results for Mode Specific Enhancements by Technology Group


User Group Enhancements for Autonomous Vehicle Technologies
Freight (interregional)
5
4
3
2
1
0
Freight (intraregional)
Personal (commute)
Personal (Recreational)
Emergency
A1/A2
A3/A4

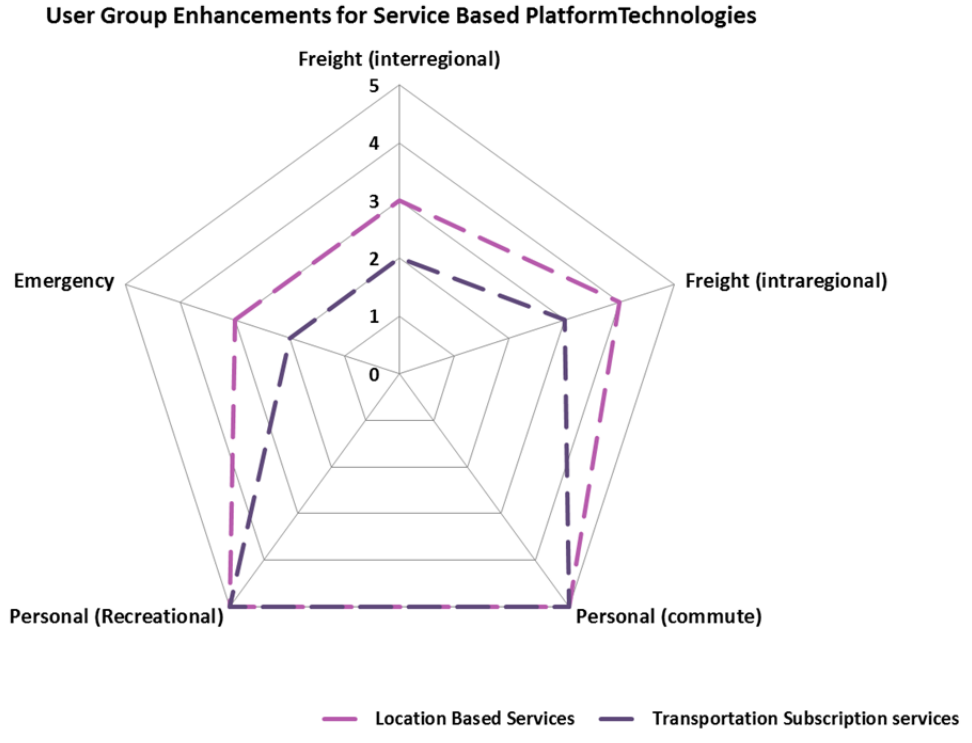
6(a)


User Group Enhancements for Connected Vehicle Technologies
Freight (interregional)
5
4
3
2
1
0
Freight (intraregional)
Personal (commute)
Personal (Recreational)
Emergency
V2I
V2V

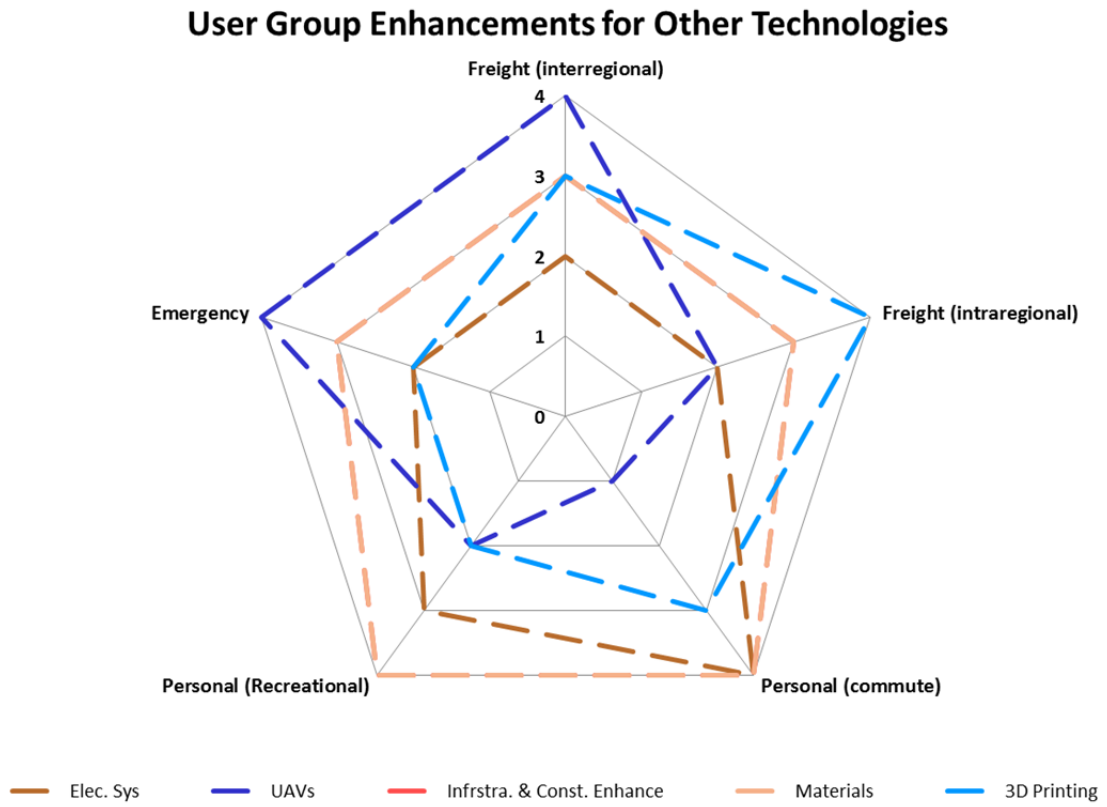
6(b)


User Group Enhancements for Information and Communication Technologies
Freight (interregional)
5
4
3
2
1
0
Freight (intraregional)
Personal (commute)
Personal (Recreational)
Emergency
Cloud Computing
Croud Sourcing

6(c)


User Group Enhancements for Service Based PlatformTechnologies
Freight (interregional)
5
4
3
2
1
0
Freight (intraregional)
Personal (commute)
Personal (Recreational)
Emergency
Location Based Services
Transportation Subscription services

6(d)



6(e)

Figure 6 (a-e): Trade-Off Results for Mode Specific Enhancements by Technology Group

Environmental Scan

An environmental scan serves as an inventory of resources with TxDOT, within the state of Texas, and nationwide that can be leveraged for support in future work and partnerships in transportation technology. As an extension to the SWOT analysis, a detailed scan of the available internal and external resources can lead to a comprehensive understanding of the opportunities and challenges for technology development in Texas. The environmental scan is divided into the in-state internal resource scan and the out-of-state external resource identification.

Resources within TxDOT

The following is an overview of resources within TxDOT that can be used for furthering the TTTF's goals.

- **TxDOT's State Legislative Affairs (SLA)** ***(26)***
  This department within TxDOT is responsible for the department's interaction with state legislative offices and officials, which includes the Texas Legislature, the Governor's office, and other statewide elected officials. SLA responsibilities include responding to legislative requests with timely and accurate information, researching and analyzing legislative and policy issues, attending legislative hearings and preparing the department's testimony for those hearings, providing educational briefings to members and staff, preparing transportation materials for legislative visits, tracking legislation, monitoring legislative actions, and communicating with experts throughout the department. In addition, the SLA facilitates TxDOT's strategic planning process and develops and distributes the department's strategic plan. The office also directs the development and reporting of TxDOT performance measures and results.

- **TxDOT's Federal Affairs (FED)** ***(27)***
  This department within TxDOT is responsible for TxDOT's interaction with legislative offices and officials on the national level, such as Congress, the USDOT, and other national and federal agencies and organizations. The office's responsibilities include responding to Congressional requests, attending Congressional hearings, preparing materials for legislative visits, and providing educational briefings to Congressional members and staff. The office also researches, analyzes, and tracks legislation in addition to communicating with experts throughout TxDOT.

- **TxDOT's Research and Technology Implementation Office (RTI)** ***(28)***
  RTI draws upon the knowledge found in numerous state-supported universities across Texas and combines it with TxDOT's own expertise to benefit Texas drivers. Emphasis areas for research include safety, construction, planning, geometric design, environmental considerations, and hydraulics, among others.

Resources within Texas

Resources within Texas that can be leveraged for support include government research centers and programs, universities and academic research centers, innovative technology companies, and start-up-support organizations. The following provides a preliminary list of such resources and a description of relevant research, project areas, and agency offices.

- **Johnson Space Center (JSC)** ***(29)***
  NASA's Johnson Space Center, located outside of Houston, runs a variety of programs and operations. These include educational, research, and partnership programs that further NASA's goals and innovative technological research. Within the JSC is the Technology Transfer and Commercialization Office (TTO). This office provides support for licensing and partnering for the development and commercialization of numerous technology categories, including clean/green environmental technologies and power, communications, sensors and robotics, software, etc. The TTO encourages partnerships between industry, academia, and other government agencies and researchers at JSC while leveraging the expertise and facilities the JSC has to offer. Each candidate partnership project may fall into one of two categories: a reimbursable where the external party reimburses JSC for JSC's equipment, labor, and facilities, or non-reimbursable, where each party contributes to the project at its own expense.

- **Southwest Research Institute (SwRI)** ***(30)***
  SwRI is an independent, nonprofit applied research and development organization with headquarters in San Antonio. The staff of nearly 3,000 specializes in the creation and transfer of technology in engineering and the physical sciences. Eleven technical divisions offer a wide range of technical expertise and services in such areas as engine design and development, emissions certification testing, fuels and lubricants evaluation, chemistry, space science, nondestructive evaluation, automation, mechanical engineering, electronics, and more. SwRI conducts research in the following areas.

  - Aerospace electronics, systems engineering, and training
  - Applied physics
  - Applied power
  - Automation and data systems
  - Chemistry and chemical engineering
  - Engine, emissions, and vehicle research
  - Fuels and lubricants research
  - Geosciences and engineering
  - Mechanical engineering
  - Signal exploitation and geolocation
  - Space science and engineering

  SwRI is also a founding member and participant in the joint research and educational programs of the nine-member Southwest Research Consortium. In addition the SwRI has established a variety of automotive consortia.

- **Texas A&M Transportation Institute (TTI)/Texas A&M University (TAMU)** ***(31)***
  TTI is a research organization with headquarters in and laboratories on the Texas A&M University campus in College Station and additional offices in cities around the state. TTI employs over 650 professionals, students, and support staff with research focus areas that include transportation economics and policy, environmental issues, freight movement, human and behavioral studies, infrastructure, mobility, safety, security, and workforce development.

- **Center for Transportation Research (CTR)/The University of Texas at Austin (UT)** ***(32)***
  Located at The University of Texas in Austin, CTR is a research institution focusing on transportation research, education, and public service. Its current and ongoing projects address all aspects of transportation, including economics, multimodal systems, traffic congestion relief, transportation policy, materials, structures, transit, environmental impacts, driver behavior, land use, geometric design, accessibility, and pavements.

- **The Center for Innovation (CFI)** ***(33)***
  CFI is a nonprofit organization in Arlington that serves as a catalyst for technology-based economic development. CFI supports a strategic approach to the formation of collaborative partnerships that facilitate and enable the integration of industry, academic, and government research and discovery through venture capital, talent, and expertise. CFI focuses on the commercialization of technology-based research outcomes from universities, industries, and U.S. federal labs that lead to the development of integrated industry clusters. CFI facilitates cooperative or joint activities between federal labs, educational institutions, and industry. Services include patent license agreements, cooperative research and development agreements, material transfer agreements, and educational partnership agreements.

- **Austin Technology Incubator (ATI)** ***(34)***
  ATI harnesses business, government, and academic resources to provide strategic counsel, operational guidance, and infrastructure support to its member companies to help them transition into successful, high-growth technology businesses. Since its founding, ATI has worked with over 200 companies, helping them raise over $1 billion in investor capital. As a program of the IC² Institute of The University of Texas at Austin, ATI fulfills two objectives: promote economic development in Central Texas through entrepreneurial wealth and job creation, and provide a "teaching laboratory" in applied entrepreneurship for UT-Austin students. ATI has over 20 years of experience adding value to technology start-ups. And, based on that experience, the incubation model has evolved as Austin's tech economy has grown and developed. Today, the belief is that the early stage community is best served by offering a broad business building platform, but complementing that with industry-specific capabilities. To that end, ATI has invested in developing domain expertise and market- and technology-specific networks of advisors and investors in four areas:
    - Information technology (broadly defined to cover both software and silicon)
    - Wireless telecommunications (again, covering both hardware infrastructure and software tools)
    - Bioscience (with a human health focus, from device to therapeutics)
    - Clean energy/clean technology (with a strong sub-focus on electric power, although ATI welcomes applications from alternative fuels companies)

- **The Circuit of The Americas (COTA)** ***(35)***
  COTA is a multi-purpose facility that hosts prestigious racing events, including the Formula 1 US Grand Prix. It is the first and only purpose-built Grand Prix facility in the

U.S. The grounds have a state-of-the-art 3.4-mile circuit track and capacity for 120,000. The facility is designed for any and all classes of racing. COTA offers training areas, educational programs, a center with research facilities, services, and amenities to support a broad range of business, technology, and education partners.

National Resources

The following is a list of national organizations and associations made up of transportation professionals that support advanced transportation research and practices. TxDOT has an affiliation, relationship, or connection with each entity listed.

- **The American Road & Transportation Builders Association (ARTBA)** ***(36)***
  ARTBA is an organization of transportation construction-related professionals whose primary goal is to grow and protect transportation infrastructure investment so that public and business demand for safe and efficient travel will be met. In support of this mission, ARTBA provides programs and services designed to give its public and private sector members a global competitive edge. For example, its Transportation Development Innovation Showcase program is committed to helping bring innovative products and services into the transportation design and construction marketplace and to informing the public and their elected representatives how these innovations can provide returns on investment and can be used as a marketing tool. ARTBA also has research staff to complete organization-related research.

- **American Association of State Highway and Transportation Officials (AASHTO)** ***(37)***
  AASHTO is a nonprofit, nonpartisan association that represents highway and transportation departments in the United States, the District of Columbia, and Puerto Rico. The primary goal of AASHTO is to foster the development, operation, and maintenance of an integrated national transportation system, and represents and promotes all transportation modes. AASHTO seeks to educate the public and decision-makers about transportation and the role it plays in securing a good quality of life and sound economy for the U.S. It does so by serving as a liaison between state departments of transportation and the federal government. AASHTO is also an international leader determining technical standards for all phases of highway system development.

- **The Transportation Research Board (TRB)** ***(38)***
  TRB, as part of the National Research Council, is the largest transportation research organization in the world. TRB is organized into committees with specific interest areas. Under the TRB umbrella are several significant research programs that have funded many noteworthy projects and studies on innovative transportation technologies. Such research programs include NCHRP (National Cooperative Highway Research Program), NCHFP (National Cooperative Freight Research Program), and SHRP 2 (the second Strategic Highway Research Program).
    - **NCHRP** ***(39)*****:** NCHRP conducts research in problem areas that affect highway planning, design, construction, operation, and maintenance nationwide. The NCHRP-IDEA program has funded hundreds of innovative ideas with commercialization potentials.

- **NCFRP *(40)*:** NCFRP is another research program focusing on funding the projects related to freight transportation.
- **SHRP 2 *(41)*:** Authorized by Congress, SHRP 2 addresses the significant safety, infrastructure, and congestion issues of the nation's highway system. Its main funded areas include safety countermeasures, renewable energy, facility reliability, and highway capacity.

National Academic and Industry Research Forums

The following section is a list of academic and industry research forums, professional organizations, and other outlets where the Task Force or TxDOT could participate to promote the TTTF project and other emerging technology initiatives.

- **Institute of Transportation Engineers (ITE)**
  The Institute of Transportation Engineers is an international educational and scientific association of transportation professionals who are responsible for meeting mobility and safety needs. ITE facilitates the application of technology and scientific principles to research, planning, functional design, implementation, operation, policy development, and management for any mode of ground transportation. Through its products and services, ITE promotes professional development of its members, supports and encourages education, stimulates research, develops public awareness programs and serves as a conduit for the exchange of professional information.

  Upcoming Meetings: August 14-17, 2016 | Anaheim, California

- **Intelligent Transportation Society of America (ITSA)**
  The Intelligent Transportation Society of America (ITS America) is the nation's largest organization dedicated to advancing the research, development, and deployment of Intelligent Transportation Systems (ITS) to improve the nation's surface transportation system. Founded in 1991, ITS America's membership includes more than 450 public agencies, private sector companies, and academic and research institutions. ITS America's 27 State Chapters are represented across 40 states and includes more than 1200 member organizations.

  Upcoming Meetings: October 10-14, 2016 | Melbourne, Australia

- **International Bridge, Tunnel, and Turnpike Association (IBTTA)**
  The International Bridge, Tunnel and Turnpike Association (IBTTA) is the worldwide association representing toll facility owners and operators and the businesses that serve them. Founded in 1932, IBTTA has members in 20 countries on six continents. Through advocacy, thought leadership and education, members are implementing state-of-the-art, innovative user-based transportation financing solutions to address the critical infrastructure challenges of the 21st Century.

  Upcoming Meetings: August 30-September 2, 2015 | Dublin, Ireland

- **American Association of State Highway and Transportation Officials (AASHTO)**

AASHTO is a nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico. It represents all five transportation modes: air, highways, public transportation, rail, and water. Its primary goal is to foster the development, operation, and maintenance of an integrated national transportation system.

Upcoming Meetings: September 24-28, 2015 | Chicago, Illinois

- **Eno Center for Transportation**
  The Eno Center for Transportation (Eno) was founded in 1921 by William Phelps Eno (1859-1945), who pioneered the field of traffic management in the United States and Europe. Mr. Eno sought to promote safe mobility by ensuring that traffic control became an accepted role of government and traffic engineering a recognized professional discipline. Eno focuses on all modes of transportation, with the mission of cultivating creative and visionary leadership for the sector. We pursue this mission by supporting activities in three areas: professional development programs, policy forums, and publications.

- **Transportation for America**
  Transportation for America is an alliance of elected, business and civic leaders from communities across the country, united to ensure that states and the federal government step up to invest in smart, homegrown, locally-driven transportation solutions. These are the investments that hold the key to our future economic prosperity.

- **Congress for New Urbanism**
  The Congress for the New Urbanism (CNU) helps create vibrant and walkable cities, towns, and neighborhoods where people have diverse choices for how they live, work, shop, and get around. People want to live in well-designed places that are unique and authentic. CNU's mission is to help build those places.

- **Information Technology and Innovation Foundation (ITIF)**
  Founded in 2006, ITIF is a 501(c)(3) nonprofit, nonpartisan research and educational institute—a think tank—focusing on a host of critical issues at the intersection of technological innovation and public policy. Its mission is to formulate and promote policy solutions that accelerate innovation and boost productivity to spur growth, opportunity, and progress.

- **Mobility Lab**
  Mobility Lab is a leading U.S. voice of “transportation demand management – moving people instead of just cars” – and works to create a shared national voice with clear calls to action from TDM agencies across the country.

Upcoming Meetings: September 28-30, 2015 | Chicago, Illinois

- **American Public Transportation Association (APTA)**
  APTA is the leading force in advancing public transportation. APTA’s mission is to strengthen and improve public transportation. APTA serves and leads its diverse membership through advocacy, innovation and information sharing. APTA and its

members and staff work to ensure that public transportation is available and accessible for all Americans in communities across the country.

Upcoming Meetings: October 4-7, 2015 | San Francisco, California & November 15-17, 2015 | Minneapolis, Minnesota

- **American Society of Civil Engineers (ASCE)**
  The American Society of Civil Engineers represents more than 146,000 members of the civil engineering profession in 174 countries. Founded in 1852, ASCE is the nation's oldest engineering society. Through the expertise of its active membership, ASCE is a leading provider of technical and professional conferences and continuing education, the world's largest publisher of civil engineering content, and an authoritative source for codes and standards that protect the public.

  Upcoming Meetings: October 11-14, 2015 | New York, New York

- **Aircraft Owners and Pilots Association (AOPA)**
  With hundreds of thousands of members, AOPA is the largest, most influential general aviation association in the world. AOPA has achieved its prominent position through effective advocacy, safety education and training, enlightened leadership, technical competence, and hard work. Providing member services that range from representation at the federal, state, and local levels to legal services, advice, and other assistance, AOPA has built a service organization that far exceeds any other in the aviation community.

- **Coalition for America's Gateways and Trade Corridors (CAGTC)**
  The Coalition for America's Gateways and Trade Corridors (CAGTC) was established to bring national attention to the need to significantly expand U.S. freight transportation capabilities and to work toward solutions for this growing national challenge. Their sole purpose is to raise public recognition and Congressional awareness of this need and to promote sufficient funding in federal legislation for trade corridors, gateways, intermodal connectors, and freight facilities.

- **United Transportation Union (UTU)**
  The United Transportation Union (UTU) is headquartered in the Cleveland suburb of North Olmsted, Ohio. It is a broad-based, transportation labor union representing about 125,000 active and retired railroad, bus, and mass transit workers in the United States and Canada.

- **American Association of Port Authorities (AAPA)**
  Founded in 1912, the American Association of Port Authorities is a trade association which represents more than 130 public port authorities in the United States, Canada, the Caribbean, and Latin America. In addition, Association members include more than 300 sustaining and associate members—firms and individuals with an interest in the seaports of the Western Hemisphere. AAPA is dedicated to serving deep draft public ports by enhancing port management professionalism, and advocating issues critical to public seaports.

Upcoming Meetings: November 2-4, 2015 in Miami, Florida; October 23-27, 2016 in New Orleans, Louisiana; October 1-4, 2017 in Long Beach, California

- **Transportation Research Board**
  The mission of the Transportation Research Board (TRB) is to promote innovation and progress in transportation through research. In an objective and interdisciplinary setting, TRB facilitates the sharing of information on transportation practice and policy by researchers and practitioners; stimulates research and offers research management services that promote technical excellence; provides expert advice on transportation policy and programs; and disseminates research results broadly and encouraged their implementation.

  Upcoming Meetings: January 10-14, 2016 | Washington, DC

- **Young Professionals in Transportation**
  YPT provides professional development, fellowship, and networking opportunities for young professionals in the transportation field across the country and around the world.

- **American Public Works Association (APWA)**
  The American Public Works Association exists to develop and support the people, agencies, and organizations that plan, build, maintain, and improve our communities. Working together, APWA and its membership contribute to a higher and sustainable quality of life.

  Upcoming Meetings: August 30-September 2, 2015 | Phoenix, Arizona

VISIONS AND STRATEGIES DEVELOPMENT

This section summarizes the preliminary research conducted on vision and strategy development conducted by the task force. Several basic technology development elements are discussed, including the definition of success, funding and investment, organization structure, service offering, client selection, and facility requirements.

Missions, Goals, and the Definition of Success Criteria

The task force was established to identify and plan technological solutions to address TxDOT's key missions, that is, to provide a safe and reliable transportation system for Texas, while addressing congestion, connecting Texas communities, and becoming a best-in-class state agency. Combing TxDOT's goals with the national goals described in MAP-21, the following set of goals were established for evaluating the success of technology development:

- Economic Development
- Safety
- Congestion
- Connecting Texas communities

- Best-in-class Agency
- Infrastructure Conditions
- System Reliability
- Energy Security
- Environmental Sustainability
- Efficient Project Delivery

Based on these goals, the task force further proposes a series of success criteria to guide technology development. The task force considered the success of the transportation technology development program from several different perspectives, such as economic gain, advances in the state of the knowledge and practice, stakeholder engagement, and cooperation and collaborations, prioritized as the following.

- **Economic gain**: The first priority is to promote economic development in Texas; economic gain is considered a crucial indicator. Economic gain can be quantified by return on investment, commoditization, and completion and exiting rates (for incubators).
- **Stakeholder engagement**: Another key factor of defining the success of technology development in Texas is the stakeholder engagement. New transportation technology cannot be successfully implemented without full engagement of all related parties, such as state and local transportation agencies; metropolitan planning organizations; other related non-transportation funding, legislation, policy, and economic development agencies; the private sector; and academia.
- **Advance the state of knowledge and practice**: The newly developed technologies should significantly advance the current planning, operations, management, and maintenance of the transportation systems. The significance of technology advancement should not only be evaluated based on the number of academic papers, patents, and copyrights produced but also the innovative ideas generated and the long-term impact on the development of next-generation safe, efficient, and sustainable transportation systems.
- **Cooperation and collaboration**: There will be multiple parallel efforts by other state DOTs, national or international research and development entities, and private company R&D departments in emerging technology development. The success of the developed transportation technologies should also be evaluated based on their compatibility with similar systems and national standards. The technology development should create opportunities to promote regional, national, and international collaboration and cooperation.
- **User satisfaction**: User response and satisfaction will be more and more important as new technologies move toward field testing and implementation. Feedback from transportation system users, including the car commuters, truck drivers, transportation planners, operators, maintenance crew, and decision-makers, will provide important indicators to determine the success of transportation technologies in the field.

Funding and Investment Criteria

The task force designed funding and investment criteria based on the different development stages of a technology. For unproven ideas, research funding entities such as the DOE (Department of Energy) *(42)*, NSF (National Science Foundation) *(43)*, and NCHRP may be approached about conducting proof-of-concept and field test research. For proven ideas, the task force is establishing PPPs in the form of incubators to help accelerate and commercialize the ideas. For fully developed technologies or methodologies, TxDOT can apply research funds for implementation. Pairing different funding sources with technologies at different development stages can help maximize the benefits and economic returns while minimizing the risks and barriers. Figure 2 illustrates the proposed funding and investment strategies. The technology task force and TxDOT will organize a governing structure responsible for the selection, evaluation, and management of technology development projects. Note: when implementing the commercialized products from the PPP, the proposed funding process requires them to go through the standard TxDOT funding competition procedures in a research program instead of directly entering the research program to obtain funds for implementation. TxDOT and TTTF will be responsible for developing problem statement and performance measures for the process. This additional process will allow TxDOT to maintain the integrity of the research program. Meanwhile, the funding and proposal competition allows competing technologies and products to be considered.

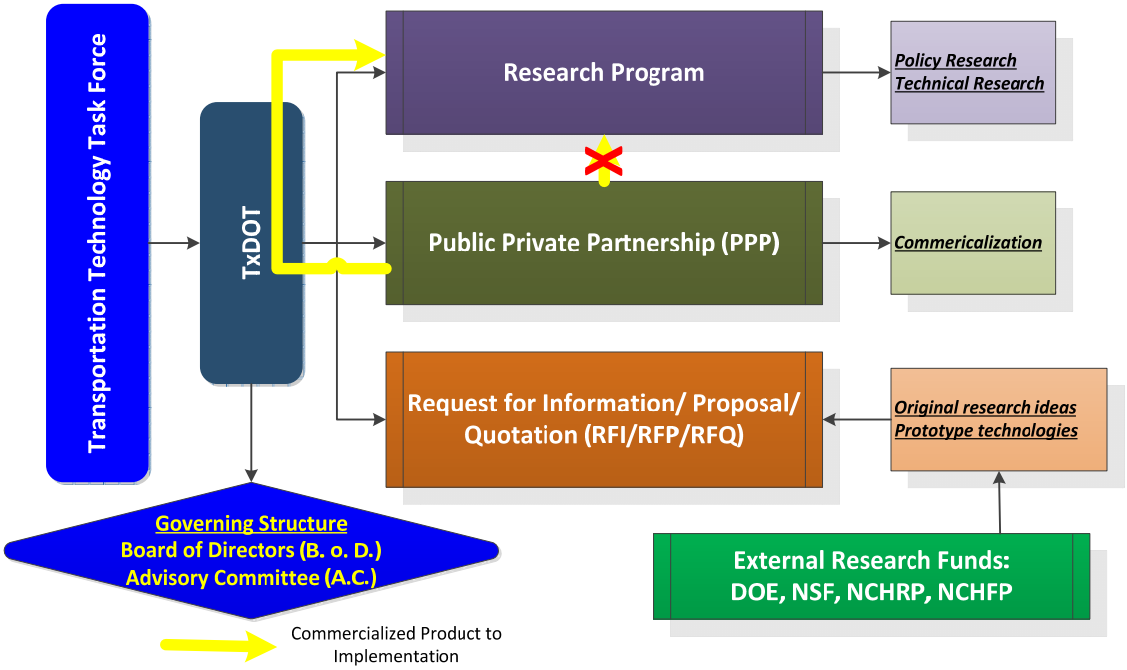


Figure 1. Schematics of the Funding and Investment Strategies

Organizational Structure, Service Offering, and Client Selection

The organization structure of the proposed technology development program consists of two major entities: the board of directors (BOD) and the advisory committee (AC). Figure 3 illustrates the organizational structure and the work flow. The BOD consists of major stakeholders who provide funds for the program such as TxDOT, cities (e.g., City of Austin),

trade groups such as COTA and ARTBA, and private industry and original equipment manufacturers (OEM). The AC is then formed and organized by individuals within the BOD groups and outside experts and specialists. The BOD will organize funding competitions to call from proposals from Principle Investigators (PI) of interested research and development groups. The AC is responsible for selecting among the proposed projects for funding. After being selected, the PIs are then managed by BOD throughout the project period.

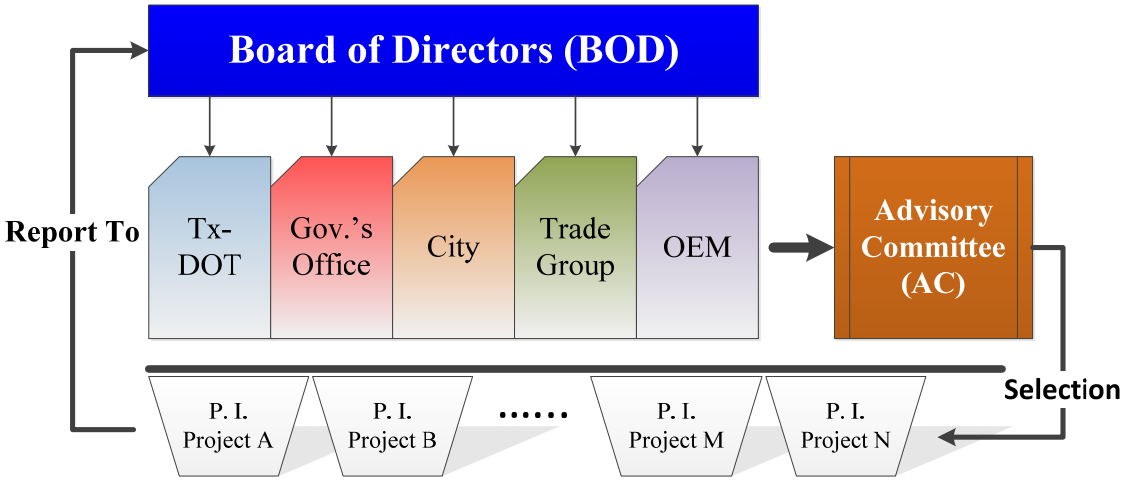


Figure 2. Organizational Structure and Work Flow

The proposed structure is different from a regular funding organization since the selected project may also be incorporated into an incubator program for commercialization in which the BOD and AC have continued advisory and management roles in assisting selected projects. The BOD and AC provide a wide range of service to the selected R&D groups such as direct business development assistance, professional network support, educational programs, facility and infrastructure support, and public relation support. The structure differs from that of a regular accelerator or incubator in its heavy involvement with and impact from the public sector. The hybrid structure allows the technology development program to take advantage of both financial and business support from the trade groups and private industry and the funding, policy, and infrastructure support from the public sectors. The client selection criteria will focus on matching R&D groups with investors while involving the technology development mission and goals set by the public sector members.

FACILITY AND INFRASTRUCTURE REQUIREMENTS

Another important aspect is the facility and infrastructure support for the technology development. Based on the types and ownership, the needed facilities and infrastructures can be classified into the categories provided in Table 3.

Table 3 demonstrates that early-stage technologies such as CV and AV technologies have more significant facility and infrastructure needs than EVS and Crowdsourcing and Cloud Computing technologies. Since the technologies are developed to serve the transportation systems, more public infrastructures needs are identified than the private infrastructure needs. Efficient and

sustainable procedures and business models for providing those public and private infrastructures to the interested R&D groups can play significant role in the success of the technology development program.

Table 3. Facility and Infrastructure Needs for Different Emerging Technologies

Facilities/Infrastructures	AV	CV-DSRC	CV-Cellular	EVS	CS/CC
Public					
Research labs	X	X	X	X	X
Materials labs				X	
Computing centers		X	X		X
Open-road testing sites	X	X	X	X	
Testing corridor or network	X	X	X	X	
Data centers		X	X	X	X
Traffic sensors	X	X	X		X
Access to electrical system				X	
Traffic operations center		X	X		
Driving simulator environment		X	X		
Private					
Closed testing facilities	X	X	X	X	
Testing vehicles	X	X	X	X	
Cellular communication system	X		X		
Private lots and charging stations				X	

X = Facility/infrastructure needed

Acronym Guide:
AV: autonomous vehicles, CV: connected vehicles, EVS: electric vehicle system, CS/CC: crowdsourcing and cloud computing

Summary and Future Work

This appendix presents preliminary background research for the development strategic business plan. During Phase II of the project, the task force mainly focused on the background research with respect to the SWOT analysis, environmental scan, and the vision and strategy development. To complete a workable business plan, a great deal of research and strategic planning remains to be completed, especially in the areas of economic impact and industrial impact assessment, technology-specific policy, and business development strategies. The work plan provides the guidelines for completion of the strategic business plan.

APPENDIX II. Accelerator Texas: Creating Autonomous Vehicle Economic Development

1. Concept

Accelerate Texas (*Accelerate*) will be a public-private partnership established with the intent of developing, commercializing, and implementing new transportation-related technologies with a specific focus on organizations collectively working towards the autonomous vehicle. *Accelerate* ultimately will be an independently operated organization with input and participation of several state agencies, private sector firms, other governmental entities (such as metropolitan planning organizations, cities, etc.) and research institutions (such as Texas universities). The increased use of private-public consortia is attractive as a means for industry to participate in leading-edge research, development, and testing, while maintaining a reasonable cost structure. Texas recognizes the importance that these consortia play in developing next generation transportation technologies and services that are led by industry and supported by government and academia.

2. Context

At least four major external trends align to support the increased integration of technology into the transportation system of Texas.

1. **Texas' role in the global marketplace will only grow over time, as the economy continues to move toward higher value-added production and services.** The transformation of Texas from a center of commodity production to a place that emphasizes adding value through the application of knowledge and technology is virtually complete, notwithstanding the recent surge in energy production. Until recently, the structure of the Texas economy was similar in many ways to that of a developing nation: the state sold basic products such as food and energy, and tended to purchase more sophisticated manufactured goods. That trend has been turned upside down in recent years, as Texas has become a center of research, advanced technology, and high value-added services.
2. **Rapid population growth relative to the rest of the nation will characterize Texas over the next 30 years.** Three main factors influencing Texas' demographics landscape over the coming decades are relatively high birthrates, in-migration, and an aging population; each creates new challenges for the public sector. Strong overall population growth will place greater strain on an already overstressed road and highway network, as well as prompting continued interest alternative forms of transportation.
3. **The physical character of Texas communities continues to evolve**. The traditional model of community development is changing. Urban areas in Texas have long been characterized by relatively low density, as abundant land fostered spread-out cities that relied almost exclusively on the automobile. In recent years, the rate of population and traffic growth has outstripped the road system in many areas, leading to increased congestion. Partially as a result, many communities are now focusing on traditional neighborhood design. The defining characteristics of this development approach are walkability or pedestrian-oriented design; transportation options; a mix of land uses that

integrate housing, shops, civic facilities, and work places; and maintenance or creation of green space.

4. **Public sector funding of basic infrastructure, including the transportation network, has been declining for some time, as the State of Texas spends proportionately less today on highways than it did 20 years ago**. As a result, the focus has shifted toward alternatives to traditional general obligation debt financing of basic infrastructure, with a greater emphasis on tolls, tax-increment financing, development fees, and other alternative financing structures.

Collectively, these factors will require Texas to leverage its existing transportation infrastructure as efficiently as possible, as continued growth runs head-on into evolving development patterns and constrained resources. Meanwhile, the nature and scope of the state's infrastructure is changing. Much of the modern economy's development can be traced to the implementation of networks—highways, rail, telecommunications, and energy. The ability to efficiently move goods, people, capital, energy, and ideas continues to transform the way humans live, work, and play.

Throughout history, transportation was the first network system to be comprehensively deployed, with improvements in the movement of goods and people preceding every stage of industrial development. As outlined by Dr. John Kasarda of University of North Carolina, transportation was a critical ingredient in the four major waves of industrialization that have occurred to date *(44)*:

- The first great cities developed around seaports and along trade routes.
- The second wave of development—and the beginning of the Industrial Revolution—occurred when factories used canals and rivers for power and shipping.
- The third wave of industrial development started with the railroad system, which opened up landlocked resources.
- The fourth wave of development began with massive investments in highway infrastructure that increased traffic, expanded personal mobility, and accelerated metropolitan growth.

According to the FHWA, the current (fifth) wave of industrialization is based on innovations in logistics and manufacturing. Increasingly, components are manufactured offshore, and then they are assembled into finished products near the point of their final consumption or use. This business model depends strongly on a fast and reliable transportation network that minimizes the cost of production. Just as highway infrastructure made the fourth wave possible in the United States, the country's current performance depends heavily on a seamless, intermodal transportation system.

While the future is somewhat uncertain, the sixth wave might well entail the integration of different types of networks into a seamless and invisible underpinning to the movement of goods and people. In particular, the nascent efforts on connected and autonomous vehicles, smart grids, and a general orientation toward minimizing and ultimately removing human beings from a direct operational role in transportation promises a range of social and economic benefits. It is

the promise of these benefits, along with the economic gains associated with first-mover advantage and the pressures outlined above, that make the exploration of better integrating technology and transportation such a timely issue for Texas.

3. Outline for Establishing Accelerate Texas

The work plan for establishing *Accelerate* includes two major phases: 1) near-term preparation, organizational refinement, and announcement; and 2) transition to permanent organization.

Phase I: Near-Term Preparation, Refinement, and Announcement

The objectives of Phase I include 1) seeking and securing initial public and private "founding members" of *Accelerate*, 2) refining the organization's mission, structure, and program of work, and 3) announcing *Accelerate*'s formation. At this point, it appears that TxDOT, the Governor's Office of Economic Development, Texas A&M University, the University of Texas, and Circuit of the Americas (COTA) will be the initial participants, with COTA prepared to offer substantial in-kind resources to the effort. The initial governing board should reflect the founding organizations, though some may choose to participate on an *ex officio* basis. Enabling organizational documents (bylaws, operating procedures, etc.) should be as flexible as possible at this early stage, as they likely will be modified subsequent to Phase II.

Key Short-Term Tasks:

- Secure agreements from initial founding member organizations
- Draft initial enabling organizational documents/structure
- Prepare for organizational announcement
    - Secure facilities at COTA
    - Develop materials to educate and promote *Accelerate* to race attendees, etc.
    - Identify/target key attendees and events
- Continue to brief key officials
- Prepare and implement event-based and soft launch communications plan

To properly create the ongoing structure of *Accelerate*, the following key issues and concerns will be identified: missions and goals, organizational structure, program of work, business plan/funding model, interaction with research partners, and qualifications, regulations, and rights/responsibilities of initial and future participants.
The plan is to have answers to all of the following fully developed over the period from January to November 2014, creating the strategic and operating plan for *Accelerate* in the process.

This will be accomplished via primary research and interaction with analogous organizations, potential participants, and stakeholders that are both informed by and integrated with an external research/outreach program that follows. This strategic communications plan will be built and executed to fit the goals and mission as defined is Phase II.

Timeframe: January 2014 through Summer 2014.

Phase II: Transition to Permanent Operations

The outcome of Phase II should be a plan that prepares *Accelerate* to transition to permanent operations, with policies, plans, and procedures that address the five areas outlined in Phase I in place.

Timeframe: Summer 2014 through the Formula One event in November 2014.

4. Initial Participants/Resources

The proposed initial participants are TxDOT, the Governor's Office of Economic Development, Texas A&M University, the University of Texas, and Circuit of the Americas (COTA). COTA is prepared to offer substantial in-kind resources, including access to portions of the facility for testing and permanent office, meeting, and conference space. These in-kind resources are easily worth more than $1 million (COTA, for example, charges $50,000 to rent the track per day**).** Equally important, both the existing track and the presence of global private-sector transportation stakeholders give Texas a considerable head start on competing states pursuing similar strategies but lacking existing test and office facilities**.**

5. Stakeholder Interaction

We recommend starting Phase II with a review of work-to-date in the wake of the *Accelerate* launch at Formula One 2014. This will be followed by a research process, ensuring that we work with the best data possible to define the strategy and tactics that meet project objectives. Most importantly, it helps us develop the most effective communications strategy because it is based on a clear understanding of our objectives and resources, extensive research, and gaining buy-in from key decision makers at critical steps in the process**.**

Review

We will convene a meeting of the project's key decision-makers to define short-term and long-term success of the project. As a group, we will define the following tasks:

- Review information/contacts gleaned from the *Accelerate* launch;
- Establish key initial metrics—goals and objectives, communications/marketing goals, key dates, and milestones;
- Identify and understand critical issues and the organization's position relative to them;
- Refine target audiences and key stakeholders; and,
- Further structure *Accelerate*'s product offering and marketing efforts.

Analytics

After the initial discovery, we will perform research to identify how specific transportation issues and projects are being framed and who is driving those conversations. The research step is critical as it informs organizations we target, messages and product offerings we create, the routes and strategy we recommend, where the pitfalls may be, where to find the most success, and how to take advantage of it all. This research approach will likely include these aspects:

- We will conduct an assessment of the digital landscape (A Digital Advance™) that looks at key names and organizations that are talking about our issue, a media review of notable earned media coverage, and how the issue is being framed online.
- This step will also dive deeper into the stakeholder and potential partner analysis that was started in Phase I. This includes identification of any emerging voices, organizations, companies, or inventors of transportation technology who would be target partners or collaborators.
- The research will also allow us to identify how (and how often) Texas and Texas-based organizations show up in the national conversation about transportation technology and pinpoint opportunities to own parts of that conversation on a much broader scale.

This initial research phase will also provide a baseline of qualitative and quantitative data that can be used as a reference point after the project launch to compare change in opinion and/or awareness.

Communications Plan for Permanent Operations Launch

We will use the research to develop project messaging (and pair it with key target audience groups) and the initial project launch's communications plan that includes detailed tactics and tools to best meet the goals.

The support team is also available to conceptualize, plan, organize, and execute any external meetings needed in this phase. This may include, but is not limited to, key stakeholder meetings, a speaker's bureau, a rolling road show, and press conferences.

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