Department of Transportation
Transportation Research and Development Strategic Plan
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1. **What research strategies and priorities should the U.S. DOT adopt to achieve the primary purposes cited in the FAST Act?**

   a. *FTA’s Research Program should continue focus on zero emission transportation technologies*

   Over the past few years, FTA has shifted focus on zero emission buses from research and prototype development programs to deployment programs. Thanks to FTA’s support through the Low or No Emission Bus Program (LoNo), Transit Investments for Greenhouse Gas and Energy Reduction Program (TIGGER), National Fuel Cell Bus Program (NFCBP), and Clean Fuels Program, FTA has helped move the needle for zero emission bus technology readiness and better educated transit operators on how to operate and maintain this new and rapidly developing technology.

   However, more research is needed in zero emission technologies and the infrastructure to support them. Additionally, more research is needed to transfer successful zero emission bus technologies, like batteries and fuel cells, to other transit modes, including streetcars and light rail. FTA should also enhance research programs for applying Intelligent Transportation Systems (ITS) to transit applications. As Europe and Asia continue to invest capital in transit research, the U.S. will fail to keep pace if we do not do likewise.

   b. *Utilize transit industry as a test-bed for advanced technology vehicles*

   The transit industry is an ideal test-bed for advanced technology vehicles and other transportation technologies. Transit fleets operate on fixed routes with central fueling and professionally operated and maintained vehicles. Transit fleets are also recipients of federal funding. These characteristics provide an ideal test environment for deployment and demonstration of pilot technologies supported by funding through DOT. Once the technology is proven, it opens up opportunities for deployment in other medium- and heavy-duty markets. We encourage DOT to recognize such opportunities for piloting technologies and develop programs to support testing and demonstration within transit fleets.

   c. *Provide easier path for new adopters of advanced technology vehicles*

   FTA should consider polices that incentivize and are supportive of transit agencies’ efforts to deploy advanced technology vehicles to help relieve some of the risk associated with being an early adopter. For example:
   
   - Allowing new adopters to exceed their standard 20% spare ratio when purchasing clean,
advanced technology vehicles would help alleviate the potential risk of reduced availability

- Allowing technical project managers to be project partners beyond the LoNo Program: Inclusion of non-profits on project teams helps transit agencies not familiar with the new technology plan for the deployment. Such firms can encourage and emphasize selection of the right technology for the right duty-cycles and provide support for transit agencies to perform planning and analysis in advance of deployment. This results in much more successful deployments.

2. How can the issues raised in the U.S. DOT document “Beyond Traffic 2045: Trends and Choices” be strategically addressed by RD&T activities over the next five years?

   a. Support for technical training and outreach

   Beyond Traffic acknowledges that “Emerging vehicle technologies are providing opportunities for continued improvements to the safety and fuel efficiency of new transit vehicles.” However, the investment in the deployment of advanced technology vehicles has outpaced the investment in the training for operations, maintenance, and safety procedures required to support these vehicles and required infrastructure. Lack of an adequately trained workforce could result in improper maintenance that could damage these systems, result in injury, and/or result in financial loss. In addition, first responders need to be educated on the proper response to incidents involving these vehicles. Furthermore, a more educated public that understands the advanced technology and advocates for deployment in their communities can bolster the industry. Such an approach is evident in the current LoNo Program NOFO with the availability of funding for workforce training. FTA, and DOT as appropriate, should continue to find ways to support the industry in technical training and outreach.

   b. Autonomous vehicles

   Prioritize autonomous vehicle demonstrations within the transit and freight industries. Both industries offer ideal characteristics for early stage pilot programs with professionally trained drivers and maintenance staff, consistent routes, and central fueling. Adoption by these industries will illustrate the viability of the technology for more widespread deployments. Specifically for transit service, these demonstrations will also help FTA determine the role transit will play in a driverless, ride-on-demand future.

3. What emerging challenges or opportunities in transportation warrant additional Federal RD&T activities or investments?

   Technology advancements in the transportation sector are occurring at a rapid pace and the U.S. needs to be poised to contribute to and become a leader in this field. Areas which we believe warrant investment include, but are not limited to:

   a. Electromagnetic suspension for bus rapid transit: This technology reduces energy consumption, wear, and maintenance requirements compared to traditional suspensions. It also improves the quality of ride experienced by BRT passengers making the mode a more attractive option to the riding public—BRT with electromagnetic suspension will offer a ride similar to that of light-rail.
b. Wireless streetcar and light-rail: As urban populations grow, many transit agencies are looking at streetcar and light-rail systems to provide an alternative transportation mode between bus and heavy-rail services. Researching and investing in wireless rail systems (rail systems without the traditional overhead catenary system) can help transit agencies implement rail on routes that may otherwise be unserviceable because of restricted right-of-way above the road. Wireless systems can also be cheaper than the traditional catenary systems by reducing construction costs associated with the catenary and power supply infrastructure. Wireless rail vehicles would rely on much of the same technology as zero-emission transit buses, and research and investments in wireless rail technology, including lithium-ion batteries, opportunity charging (both inductive and conductive), fuel cells could carry over to the bus market, and vice versa.

c. Autonomous vehicles (on- and off-road): Benefits of autonomous vehicle technology can include reduced driver error, decreased congestion and improved traffic flow, increased fuel economy, improved safety, real-time and widespread transportation data collection, reduced operations cost, and improved mobility for the young, elderly, and disabled. Applications include every transportation mode, such as light-duty personal vehicles, transit systems, freight operations (on-road and rail), and air services. Hardware and software require RD&T attention and potential deployment applications must be studied, including using modeling and simulation techniques to ensure that early demonstration and deployment programs are as effective as possible. Furthermore, DOT must contribute to solving regulatory, legal liability, and security issues before the technology can be deployed at commercial scale.

d. Integration of zero emission fueling infrastructure within existing fueling network (e.g., natural gas pipeline, electric grid): Efforts must be made to fully understand the impact of widespread alternative fuel vehicle adoption on existing fueling networks, such as gas pipelines and the electrical grid. For example, commercialization and widespread deployment of battery electric vehicles may create a demand for electricity that the utility grid is unprepared to supply effectively and/or efficiently. This presents an opportunity for interagency coordination with DOE and allows DOT to engage with vehicle OEMs and utility providers to insure that the U.S. energy system is capable of supporting large-scale alternative fuel vehicle deployment.

e. High Power Wireless Charging: Wireless induction charging for battery electric vehicles has been limited to low power demonstrations and deployments. Currently, only 50kW induction charging is commercially available and this power level is inadequate to provide the range extension needed for medium- and heavy-duty vehicles, such as transit buses. Furthermore, wireless charging system installation locations are limited by dedicated traffic lanes, underground utilities, and restricted over-head access. Additional RD&T is needed to investigate solutions to installation limitations and improve the power capabilities of induction charging systems. For example, a 200-300 kW charging system is needed to allow for sufficient range extension in today’s battery electric buses. A high powered charging system like this would decrease the battery capacity the bus needs to complete its service requirements, reduce the weight of the bus, and ultimately, bring battery electric vehicle cost down.

f. Dynamic Wireless Charging: Existing battery electric transit bus charging methods require the bus to be stationary while charging. These dwell periods can interfere with the transit agency’s
service schedule and present a real challenge to the widespread adoption of zero emission battery electric buses. Dynamic wireless charging can address this challenge by allowing the electric bus to charge while still in motion. The potential to charge battery electric buses “on the move” gives the transit agency more flexibility when evaluating deployment options, and allows the agency to operate battery electric buses more similarly to traditional diesel and CNG vehicles.

g. Development of highly-effective, automated tools for managing mixed zero-emission technology fleets: Transit fleets may have a mix of all electric (cheaper, more efficient) and fuel cell (longer range, faster refueling) buses to meet their zero-emission operational needs. Automated tools are needed to assist transit agencies with 1) purchasing decisions, 2) long-term fleet planning, and 3) day-to-day fleet operational planning associated with effectively managing these fleets of varying capabilities.

h. Wayside energy storage using second-life batteries for opportunity charging: Even though traction batteries are no longer able to serve the demanding duty-cycle on a transit bus, they can still be used in grid storage applications. This use not only has environmental benefits, but it can bring down the lifecycle cost of the battery. Further, opportunity charged vehicles are being charged on-route during peak demand times when electricity costs are at their highest. Using the second life batteries at the location of the chargers to store energy during off-peak times can significantly reduce the operational costs of electric vehicles.

4. What current and planned RD&T activities sponsored by the federal government should be continued or revised in the future?
   a. Follow FTA’s LoNo Program model for development and demonstrations of other advanced technologies

   The LoNo Program has proven to be a successful model for providing the support necessary to transition emerging technologies into mainstream transportation options. This is demonstrated by the transition of the LoNo program into a capital discretionary program under 5339. We encourage DOT to consider this model for other programs that can help bridge the gap between demonstration and deployment projects.

   b. DOT should continue to assist with standardization of zero emission bus power supplies

   Standardization for electric bus charging and hydrogen fueling equipment is a key hurdle for the industry. Healthy efforts to establish battery electric transit bus charging standards, especially for opportunity charging, are underway. DOT should stay involved with these efforts and provide assistance in the way of additional research or implementation funding.

   With regards to hydrogen fueling, standards for fuel cell transit bus fueling have been established and implemented successfully. However, the ability to utilize existing light-duty hydrogen fueling stations by limited fleets of transit buses until deployment of a dedicated station can be justified would help eliminate a barrier to deployment. With hydrogen infrastructure in short supply, it would be most efficient and cost effective to coordinate efforts for fueling deployments to ensure access for both light-duty and medium/heavy-duty vehicles.

   c. Continue to focus on FTA’s new Low and No-Emission Component Assessment Program

   We applaud FTA’s commitment to the new component testing program. The industry will greatly
benefit from a testing program that fully characterizes zero emission bus technologies.

5. What strategies could improve the cost-effectiveness of U.S. DOT research investments?
   a. Allow non-profit technical project managers to serve as lead applicants on research and advanced technology projects

Providing this role will allow the non-profit technical project management firms to work directly with DOT and will speed up advanced technology adoption. The involvement of experienced non-profit technical management consultants will help inexperienced fleets plan for the new technologies. Such firms can encourage and emphasize selection of the right technology for the right duty cycle, and provide support for fleets to perform planning and analyses in advance of deployment. This will help avoid deployment of poorly matched technologies that result in wasted investments. Experienced technical management firms are adept at effectively and efficiently dealing with risks and issues that arise with implementation of new technologies.

6. How can U.S. DOT best coordinate its RD&T activities with Federal, State, local, private sector, non-profit institutions, and international partners?
   a. Identify appropriate private sector entities and engage in collaborative research projects that will assist in the development and deployment of advanced transportation technologies

The private sector has made advancements in technology-based deployments and DOT could leverage the success to date to further availability of advanced transportation technologies and move them along the commercialization continuum. Non-profits have been successful in leading consortia that bring private-sector industry and the public sector together to collectively address areas of common interest. For example, 1) opportunities exist to leverage the experience of the light-duty OEM vehicle market for fuel cell deployment in the medium- and heavy-duty markets, 2) opportunities exist to coordinate with private sector service providers to leverage resources to promote greater access to transit through efficient first mile/last mile connection, and 3) more actively engage with the utility industry to develop favorable rate structures for fleets deploying battery electric vehicles.

7. What knowledge gaps merit additional exploration by the USDOT?
   a. Pre-deployment vehicle, route, and utility rate modeling and simulation

Advanced technology vehicle procurement and deployment risks can be mitigated by accurately predicting how the vehicle will perform in a specific application before deployment. Vehicle, route, and utility rate modeling and simulation services can help the fleet understand:

- How similar an advanced technology vehicle will operate as compared to traditional technology (e.g. gasoline, diesel)
- How the vehicle’s performance is impacted by the specific deployment environment (e.g. roadway grade, driving speed, cargo, local climate)
- How vehicle characteristics change with age (e.g. decreased in range as batteries age),
- Cost-effective optimal charging/fueling strategies,
- True life-cycle costs, and
- The vehicle fuel economy and driving range in the fleet’s specific application, among many other performance and deployment characteristics.
All of this information allows the fleet to make data driven decisions that lead to a successful deployment program. Investing to virtually deploy and test a vehicle in a modeling and simulation package before procurement is much more cost-effective than purchasing and deploying a vehicle in an application that has not been vetted and may not be suited for the given technology.

DOT should support advanced technology vehicle adopters to utilize vehicle, route, and utility rate modeling and simulation services as part of DOT-funded programs to help mitigate deployment risks and increase the cost-effectiveness the investment. DOT should explore options to help ensure these services are accurate (by increasing the availability of empirical vehicle and component data to modeling/simulation service providers), repeatable (by standardizing inputs, outputs, and methodology), and impartial (by relying on independent, non-profit organizations to perform the services and report results).

b. Advanced technology vehicle component supply chain

Advanced technology vehicles are introducing new materials and components into the transportation supply chain and ultimately the waste stream. These materials must be properly sourced, manufactured, and disposed of to ensure a sustainable life cycle. Gaps exist in the following areas: 1) understanding the clean vehicle component supply chain and guaranteeing the U.S. is competitive in the market; 2) understanding available alternatives to foreign-sourced and/or rare earth materials used in the production of zero emission components; and 3) coordinating with other federal and/or state agencies to identity appropriate end of life strategies for components (e.g., second-life batteries).

c. Effective strategies to improve the efficiency and lower the emissions associated with zero emission bus heating systems

Many zero emission bus manufacturers are already relying upon, or moving towards implementing, on-board diesel fired heaters to heat the vehicle cabin in cold weather deployment conditions. These “dirty” heating systems are contrary to the goals of zero emission bus deployment programs; however, clean alternative systems are currently unable to meet the heating requirements in some deployment locations. DOT should to investigate how zero emission buses can better create and maintain a suitable interior environment for passengers.