Transit Research Analysis Committee Letter Report: March 10, 2006

DETAILS

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Mr. Ronald Hynes
Deputy Associate Administrator
Office of Research, Demonstration and Innovation
Federal Transit Administration
U.S. Department of Transportation
400 Seventh Street, S.W.
Washington, D.C. 20590

Dear Mr. Hynes:

We are pleased to transmit this second letter report of the Transit Research Analysis Committee (TRAC). The committee was convened by the Transportation Research Board (TRB) in response to a request from the Federal Transit Administration (FTA). The members are listed in Enclosure A. The committee is charged with advising FTA as the agency develops a strategic agenda for transit research and with identifying roles that FTA and industry should play in carrying out that agenda. The committee also advises FTA with regard to (1) the federal role in research, relative to the roles and activities of others involved in transit research; (2) high-priority opportunities proposed by the agency; and (3) processes that should be in place to ensure that FTA receives the input and cooperation of transit research stakeholders in developing the federal research program.

Since issuing its first letter report in June 2005, TRAC has focused on assisting FTA as the agency develops its strategic research plan. At the third TRAC meeting, held on July 7–8, 2005, in Woods Hole, Massachusetts, the committee discussed a draft of the plan with FTA staff and a representative from the Oklahoma Transportation Center (OTC), who was charged with assisting FTA in developing the plan. Following the July meeting, FTA and OTC staff modified the plan, and the revised draft was discussed by a subgroup of the committee, FTA staff, and OTC representatives at an informal working meeting in Washington, D.C., on August 26, 2005. Following further revisions, FTA released a version of its plan dated September 30, 2005, and this version was reviewed by the committee at its fourth meeting, which was held on December 5–6, 2005, in Washington, D.C.

At FTA's request, TRAC has also sought to help the agency identify research opportunities linked to the plan's high-level goals. To this end, the committee held panel discussions on transit ridership research and electric drive for transit applications at its third and fourth meetings, respectively.[1] The objectives of the panel discussion on transit ridership were to establish what is known about different aspects of transit ridership, identify areas where further research could help resolve uncertainties and answer questions about future demand for transit, discuss ways in which further research could lead to increased ridership, and identify areas where FTA could contribute to research aimed at fulfilling the agency's high-level goal of

[1] The presenters and panelists from the third and fourth TRAC meetings are listed in Enclosure B.

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increasing transit ridership. The purpose of the panel discussion on electric drive technologies for transit applications was to identify research needs in this area and opportunities for FTA to contribute to this research in pursuit of its high-level goal of protecting the environment and promoting energy independence. The committee thanks all the panelists who participated in the July and December meetings for their valuable contributions to the committee's work.

This letter report presents the committee's response to the September 30, 2005, version of FTA's strategic research plan, including recommendations for disseminating and updating the plan and putting it into practice by linking it to FTA's annual program of research. The need to influence earmarked and designated research is addressed within the context of FTA's efforts to identify and conduct a balanced portfolio of research to meet the agency's strategic goals and serve the transit community. The final section of the report addresses opportunities to pursue research in support of three of FTA's high-level goals, namely, increasing ridership, improving capital and operating efficiencies, and protecting the environment and promoting energy independence. The discussion in the latter category focuses on transit applications of electric drive technologies.

The committee's work throughout the past year has been most ably assisted by FTA staff, including Barbara Sisson, you, Bruce Robinson, Lewis Clopton, Rita Daguillard, and Walter Kulyk. We appreciate the staff's responsiveness to our comments and particularly commend Bruce Robinson for his hard work and commitment in developing the preliminary version of the plan into a substantive document.

STRATEGIC RESEARCH PLAN

The committee commends the Office of Research, Development and Innovation on the very substantial progress reflected in the September 30, 2005, version of FTA's strategic research plan. The plan has come a long way since FTA shared a preliminary version with the committee in April 2004, and the improvements over the draft discussed at the July 2005 TRAC meeting in Woods Hole are particularly noteworthy. The committee is pleased that FTA adopted the recommendation from the first TRAC letter report to add as a goal that the agency provide national leadership in transit research. The September 30 version of the plan clarifies the objectives under that goal and sharpens the list of the specific strategies FTA will follow. In the committee's view, the plan could be further strengthened by adding a fourth objective under the leadership goal to influence the direction, content, and quality of the full range of transit research going on nationally (at University Transportation Centers, in the Transit Cooperative Research Program, and by earmarked recipients and others) through information, communication, and example.

Another notable improvement to the plan is the addition of the research strategy to "experiment with pricing, parking, [and] yield management strategies" under the goal to increase ridership. As the committee has discussed in previous meetings and noted in its first letter report, influences beyond the control of transit agency managers, such as the price of fuel, parking prices and availability, and regional land use strategies, may be more effective in increasing ridership than strategies that transit properties can generally deploy. We also reiterate the observation made in our previous report that the goal to increase ridership is not an end in itself but a means to other ends, such as alleviating traffic congestion, improving access, and reducing air pollution.

The committee also observed marked improvements in the lists of research strategies for the goals to improve capital and operating efficiencies and improve safety and emergency preparedness, although, as discussed later, the discussion of research priorities under the latter goal could benefit from a more thorough treatment in the light of recent events.

Sharing the Plan with Stakeholders

The plan has already resulted in at least one important benefit for FTA. By highlighting the strategic objectives articulated in the plan, the agency was successful in obtaining an additional $14 million in discretionary research funding during the Fiscal Year (FY) 2006 congressional appropriations process. This funding will allow FTA to continue some of its highest-priority research efforts.[2]

Now that FTA has an effective plan, it is important for the agency to actively share this plan with stakeholders to elicit their suggestions for research that FTA should conduct and to influence their own plans for research. Some specific ideas for sharing the plan with stakeholders are provided later. It may also be useful for FTA to share its plan and the results of its research investments with key congressional committees annually.

> ***Recommendation 1*** **FTA should move aggressively to brief a range of stakeholders on its strategic research plan. These stakeholders should include Congress, the American Public Transportation Association, the Transit Cooperative Research Program Oversight and Programming Committee, the Community Transportation Association of America, University Transportation Centers, Project ACTION, and other groups concerned about or engaged in transit research.**

A Living Document

The committee shares FTA's view that the strategic research plan should be a living document that is reviewed regularly and updated as appropriate. The committee offers to assist in this process by devoting some time at one of its two annual meetings to review and discuss proposed modifications. The high-level objectives of the plan are not expected to change much from year to year, but the projects that flow from these objectives will evolve as knowledge develops and issues change.

Future reexamination of the plan may well be stimulated by national and world events. As a result of the evacuation and coordination problems from Hurricanes Katrina and Rita in 2005, for example, the transit industry has a heightened awareness of the need to be better prepared for emergency evacuations. Research in this area can identify both needs and strategies for dealing with them. The committee is particularly concerned about institutional coordination issues within and between regions and about highway access and capacity.

Similarly, the bombings of transit systems in Madrid and London highlighted the vulnerability of transit as a leading target for terrorism worldwide. Thus, the plan could benefit from an expanded discussion of FTA's role regarding terrorism. Such a discussion could describe the agency's working relationship with the Department of Homeland Security (DHS) and identify gaps in DHS activities that need to be addressed by FTA specifically for the transit industry.

[2] The remainder of FTA's FY 2006 National Research and Technology Program budget is for earmarked or designated projects.

Recommendation 2a **FTA should review its strategic research plan annually in light of current events and accomplishments.**

Recommendation 2b **When the plan is next updated, FTA should add more in-depth discussion of**

- **Research to assist transit agencies in better preparing to respond to natural disasters, and**
- **FTA's role with regard to terrorism and related research needs.**

Putting the Plan into Practice

FTA staff are currently preparing for the Office of Management and Budget's (OMB's) upcoming assessment of FTA's research program using the Program Analysis Rating Tool (PART). Specific actions that FTA is taking include implementing processes to ensure consistent research management across FTA units, notably through the development of a *Research Project Management Handbook*; developing research program performance measures; and increasing competition within the research program by soliciting research project proposals from the transit industry. The committee believes that these actions are likely to be well received by OMB.

FTA staff informed the committee that the agency's research program activities cannot achieve the highest possible PART score. Such a score requires research proposals to be selected competitively—something that is rarely possible within the highly earmarked FTA research program. Because of a combination of authorization and appropriation earmarks and authorized programs, FTA has discretion over only $14 million of its $55 million National Research and Technology Program (NRTP) for FY 2006. In view of this extensive earmarking, FTA has set itself the goal of ensuring that its research program achieves a "moderately effective" PART score. Because the level of earmarking in FTA's budget is beyond its control and because of FTA's renewed vigor in developing and managing its research program, it is disappointing that a "moderately effective" PART score rating is the most that the agency can aspire to.

In addition to the actions listed above, FTA proposes creating a 3- to 5-year research program plan that identifies priority research topics and links the strategic research plan with FTA's annual program of research. The committee considers it important for FTA to identify compelling research topics that FTA can invest in to meet its objectives. Doing so will round out and complete the strategic research plan and make clear the lost opportunities when FTA does not have sufficient discretion over its research funding. As noted above, the strategic research plan sets forth good objectives and research strategies to meet those objectives but has yet to develop a compelling list of specific research topics. Developing these topics is not a trivial exercise and requires considerable intellectual effort. There is also a considerable body of literature to review and analyze in the area of transit. Moreover, defining researchable topics that could contribute to the attainment of FTA's high-level goals requires careful thought and insight. Possible research opportunities identified during the third and fourth TRAC meetings are discussed in the final section of this report.

Development of the 3- to 5-year research program plan, together with efforts to influence the earmarking process and earmark recipients (see next section), may enable FTA to obtain a higher PART rating.

Recommendation 3 **FTA should, as a matter of priority, develop a 3- to 5-year research program plan identifying priority research topics and linking the strategic research plan with FTA's annual program of research.**

Influencing Earmarked and Designated Research[3]

The committee recognizes Congress's role and prerogatives in earmarking recipients and designating funds. Designating funds to specific institutions to carry out research, however, bypasses the role of merit review and competition in ensuring scientific quality and reduces the ability of funding agencies to carry out a coherent research investment strategy (Brach and Wachs 2005). As noted earlier, FTA has discretion over only $14 million (approximately 25 percent) of its $55 million NRTP for FY 2006. About $1.9 million (about 5 percent) of the funds earmarked from FTA's R&D budget is not even transit related, further eroding FTA's ability to carry out its duties.

FTA staff shared with the committee the results of a preliminary analysis linking the earmarked (or designated) and discretionary projects in the FY 2006 NRTP budget to the five high-level goals articulated in the strategic research plan. (This preliminary analysis excluded approximately $9.2 million for activities not linked to any of the five goals and approximately $4.3 million for unprogrammed activities.) As the results in Table 1 show, the high percentage of earmarked funds causes difficulties for FTA in redressing any imbalance of funding among the five goal areas by using its very limited discretionary funds.

In the case of Goal 5, virtually all the funding is earmarked or designated for an assortment of research and demonstration projects on hybrid-electric and fuel cell buses. The lack of coordination among these projects makes it extremely difficult for FTA to develop a coherent program of research.[4] This example provides further evidence to support the committee's observation that earmarks and designated funding are curtailing FTA's ability to conduct a balanced portfolio of research to meet its strategic goals and serve the transit industry.

In light of FTA's success in using its strategic research plan to obtain some discretionary research funding for FY 2006, the committee encourages the agency to take a proactive approach regarding future earmarks and designations. For example, the 3- to 5-year research program plan described earlier could include a list of research topics that Congress could be encouraged to draw on when it earmarks or designates research funds. FTA-commissioned expert review of statements of work developed by earmarked entities could help ensure that work to be conducted will be of maximum benefit, and FTA could require earmark recipients to have their work products peer reviewed and include in their reports statements concerning how their research supports the strategic plan and the specific benefits derived. Finally, the committee urges FTA to evaluate the outputs of all its investments in research, including earmarked research, against the objectives of the strategic research plan. A synopsis of

[3] For present purposes, earmarking of research funds is said to occur when Congress designates a research area or project, a funding amount, and a recipient organization that will receive the funds and conduct the research (Brach and Wachs 2005). If such a recipient organization is not specified, the term "designated research" is used, as opposed to "earmarked research."

[4] An updated analysis indicates that the combined earmarks in the NRTP budget from the authorizers and appropriators in the Goal 5 area total more than $13 million. Three authorization earmarks total about $5.8 million over the life of SAFETEA-LU. The seven appropriation earmarks for FY 2006 total $7.4 million. Appropriators may earmark more funding in subsequent fiscal years during the SAFETEA-LU authorization period.

ongoing and recently completed research as it relates to the plan's high-level goals could then be shared with Congress and other stakeholders on a routine basis.

TABLE 1 Earmarked and Discretionary Funding in FTA's FY 2006 NRTP Budget by Goal Area

Goal	Earmarked Funding, $ millions (percentage for specified goal)	Discretionary Funding, $ millions (percentage for specified goal)	Total Funding, $ millions
1. Provide transit research leadership	0.0 (0)	1.2 (100)	1.2
2. Increase ridership	10.7 (84)	2.0 (16)	12.7
3. Improve capital and operating efficiencies	11.5 (91)	1.2 (9)	12.7
4. Improve safety and emergency preparedness	2.8 (46)	3.3 (54)	6.1
5. Protect the environment and promote energy independence	8.6 (99)	0.1 (1)	8.7

The committee understands that FTA has few resources to manage earmarked and designated programs. Even though FTA's total R&D program has increased, its resources for managing this program have not increased. FTA apparently cannot draw down a percentage of an earmark for management expenses. The difficulties arising from the shortage of administrative funds might be overcome by asking for discretionary resources to manage projects or by tasking an earmarked entity, such as a University Transportation Center with an open-ended earmark and relevant expertise, with program management.

> ***Recommendation 4*** **Assuming that earmarks and designations will continue in the future at some level, FTA should encourage Congress to select topics that will help the agency reach its strategic objectives by developing, publishing, and marketing a compelling list of research topics. The list, which should be developed as a matter of urgency, should form part of the 3- to 5-year research program plan linking the strategic research plan and FTA's annual program of research.**

RESEARCH OPPORTUNITIES

The following discussion addresses research under three of the five high-level goals in FTA's strategic research plan, namely, Goal 2 (increase ridership), Goal 3 (improve capital and operating efficiencies), and Goal 5 (protect the environment and promote energy independence).

Goal 2: Increase Ridership

The panel discussion concerning transit ridership at the third TRAC meeting explored various aspects of current knowledge and research (see Enclosure B). Key points from the panelists' presentations and the ensuing group discussion follow.

There is an important body of research on ridership, but the work is of uneven quality, and sorting through this literature is a considerable undertaking (Taylor and Fink undated). One approach to identifying research needs would be to list the major topics in transit ridership, such as fare structure and information systems, and then, for each topic, identify areas where further research could help resolve uncertainties and increase knowledge. For example, in the area of fare structure it might be useful to obtain more information on differentiated fares, the potential for applying yield management models, and the data needed to calibrate such models.

A complementary approach would involve identifying and exploring opportunities to increase ridership by using high-, medium-, and lower-cost strategies:[5]

- High-cost options could include expanding rail or bus rapid transit or implementing congestion pricing.
- Medium-cost options could include reducing fares, increasing subsidies, and imposing parking surcharges.
- Lower-cost options could include improving the operational environment for transit by investigating options for transit priority and on-street parking.

For all these areas, evidence of cost-effectiveness is needed, and the prospective yield of each dollar expended needs to be considered. FTA research in these areas could inform policy analysis at the local or regional level where such strategies might be applied.

The committee would be pleased to discuss these research ideas in more detail at a future meeting.

Goal 3: Improve Capital and Operating Efficiencies

At the fourth TRAC meeting, FTA staff talked briefly with the committee about a recent report analyzing capital and operating costs for light rail transit (Paaswell et al. 2005). This report was commissioned by FTA as one in a series of four quick (6-month) analysis studies to inform development of the agency's research portfolio. The committee looks forward to more detailed discussion of opportunities to improve capital and operating efficiencies at a future meeting. In the meantime, it notes three areas of potential interest for FTA's research program.

1. *Transit service procurement*: Throughout the world there are many alternative models in how transit service is procured, and considerable experimentation is under way in contracting out services in the European Union. We should be learning about successes and failures in this regard.[6] Options for transit service procurement are fairly limited in the United States because of existing law and regulation. Nonetheless, careful

[5] Cost, in this context, refers to both monetary investment and political effort to implement the options described.

[6] A discussion of transit contracting and privatization initiatives in Western Europe is provided as an appendix to a report on U.S. practice and experience in contracting out transit services (TRB 2001).

evaluations of such experiences laying out both the advantages and the disadvantages of contracting out could be useful to policy makers in domestic applications.

2. *Transit vehicle procurement*: The U.S. domestic bus industry is relatively small because the roughly 500 transit operators in the country purchase only about 5,000 buses annually, which limits opportunities for the five domestic manufacturers to achieve economies of scale. Moreover, many purchases are made in relatively small lots and call for many specific vehicle features attuned to local conditions and preferences, which further hampers achievement of scale economies. Operators requesting bids, however, express dissatisfaction with the cost of buses produced domestically compared with buses available abroad and with the perceived slow pace of technological innovation in the domestic industry.[7] Research concerning the nature of the domestic industry, the barriers it faces, its productivity, and the level of innovation relative to leaders abroad could place more facts on the table.
3. *Benchmarking*: Research concerning the development of key operating, performance, and financial indicators is needed to create meaningful benchmarks for all transit properties. The lack of data uniformity on key variables in the National Transit Database often renders these data insufficient by themselves for the purpose of comparative analyses. The creation of benchmarks is a complex undertaking that will require careful research and analysis, as well as support from transit agencies if new data collection is required, but it could have long-run benefits for transit managers.

Goal 5: Protect the Environment and Promote Energy Independence

At FTA's request, a major theme of the fourth TRAC meeting was electric drive technology R&D for transit applications (see Enclosure B). This request was stimulated, in part, by the designation of a $49 million National Fuel Cell Bus Technology Program in SAFETEA-LU. Further details of this designated program are provided later. Summarized below are key points from the panel discussion of electric drive technologies. Reference is also made to the findings of a report from the Northeast Advanced Vehicle Consortium on the current status of electric drive for transit applications (Callaghan and Lynch 2005). This report, which was commissioned by FTA as one of its four aforementioned quick analysis studies aimed at informing development of the agency's research portfolio, is a useful step in transitioning from a general research area (electric drive) to research priorities and practicalities.

Transit Applications of Electric Drive Technologies

Three types of stand-alone electric drive systems are currently being demonstrated or deployed in transit applications: battery-electric, hybrid-electric, and fuel cell buses (Callaghan and Lynch 2005). Battery-electric buses are generally viewed as niche vehicles, and their market share remains small because of battery limitations that constrain performance (notably range), as well as high cost. In contrast, hybrid-electric buses with diesel (or gasoline) internal combustion engines (ICEs) have made important inroads into the U.S. bus market.[8] As of December 2005, more than 650 were operating in revenue service around the United States. The largest hybrid fleets are operated by New York City Transit (over 300 buses) and King County, Seattle (over

[7] Efforts under way at FTA to achieve greater standardization in bus purchases may help in this regard.
[8] Hybrid-electric buses use a fuel-burning prime power source—usually a diesel-fueled ICE—coupled with an electrochemical or electrostatic energy storage device to provide energy for propulsion through an electric drive system (Callaghan and Lynch 2005). Hybrid technologies in development for applications beyond those currently in use in transit have many different combinations of designs, ICE engines, and fuel sources.

200 buses).[9] Meanwhile, despite much attention in recent years because of their potential to reduce both emissions and petroleum-based energy use, fuel cell buses remain at the demonstration stage as manufacturers seek to improve fuel cell performance and reduce cost.

Hybrid-Electric Buses

Hybrid-electric buses with diesel (or gasoline) ICEs have proven attractive to transit agencies seeking to reduce emissions from their bus fleets without investing in the new fueling infrastructure needed for compressed natural gas (CNG) vehicles. Improved fuel economy compared with conventional diesel buses has proven to be an added bonus of hybrids, particularly with rising energy prices. Hybrids are particularly well suited to downtown routes with frequent starts and stops because of their fuel savings at very low speeds and improved acceleration. Results to date indicate that hybrids have lower emissions than and reliability similar to conventional diesels, although the hybrids are newer than the comparison vehicles. Hybrids have also exhibited comparable or better (i.e., lower) emissions than CNG vehicles, which are the most common alternative-fueled vehicles in revenue service.

Driver and passenger responses to hybrid buses have been generally favorable. Drivers appreciate the quicker and smoother acceleration and the ease of transitioning to hybrids from conventional diesels without the need for extensive training, and passengers have reacted favorably to the quieter ride.

Major unknowns that will be clarified as operational experience with hybrid buses accumulates include how long the battery packs last, what their replacement costs are when they are purchased in volume, and how the longer-term vehicle reliability compares with that of conventional diesels and CNG buses. There is also some uncertainty about how well emissions from hybrids will compare with those from buses powered by new clean diesel engines. Panelists offered differing views about whether hybrids will have lower emissions of fine particulate matter and nitrogen oxides than the best clean diesel technologies.[10]

Hybrid-electric buses are commercially available, but at a substantial initial cost premium of $150,000 to $200,000 over the $340,000 average cost of conventional 40-foot diesel buses (American Public Transportation Association 2005, Table 71). At current fuel prices, the improved fuel economy of hybrids is not sufficient to fully offset this initial cost premium, and conventional 40-foot diesel buses have lower life-cycle costs than hybrids.[11] Scale economies in hybrid technologies could bring down initial costs, but the U.S. transit bus market is too small by itself to achieve such economies of scale. A broader range of heavy-duty hybrid vehicles, perhaps including military vehicles and urban pickup and delivery trucks, will likely be needed to increase the use of hybrid technologies and bring down costs.

[9] Data provided by Walt Kulyk, FTA, during a presentation to the committee on December 5, 2005.

[10] Presumably clean diesel technologies for conventional diesel-powered buses could also be used on hybrid buses with diesel engines to supplement the hybrid's electric drive, thereby reducing emissions even more. This would, of course, increase the cost of the hybrid somewhat.

[11] Assuming comparable reliability, the committee estimated that hybrids would have a life-cycle cost comparable with that of conventional 40-foot diesel buses if fuel costs averaged $3.5 to $4.0 per gallon over the life of the vehicle, but with the additional uncertainty about the life-cycle and replacement cost of batteries.

Fuel Cell Buses

Fuel cell buses offer the potential to reduce air pollution, greenhouse gas emissions, and petroleum-based energy use compared with conventional diesels.[12] Fuel cell buses incorporate a hydrogen-powered fuel cell that provides energy for propulsion through an electric traction motor.[13] The fuel cell can operate as a stand-alone prime power source for the vehicle or as the prime power source in a hybrid-electric system. Current fuel cell bus demonstrations are investigating both power train configurations.

Despite their promise for transportation propulsion applications, fuel cells are still a developing technology because of their high cost and concerns about robustness and durability, as well as fuel storage issues (Callaghan and Lynch 2005). Experimental fuel cell buses are currently about 10 times more expensive than conventional diesels. The fuel cell stack lasts only about 2 years, compared with at least 8 years for a conventional diesel bus engine before overhaul, and the fuel cell system accounts for some 90 percent of total vehicle cost. Some experts believe that fuel cells may never be cost-effective compared with conventional diesels. Even supporters expect that commercialization of fuel cells will require at least another 10 to 20 years of development. The transit market alone is unlikely to drive commercialization, and larger markets for heavy-duty fuel cell vehicles or some other form of incentive will be needed to jump-start the commercial fuel cell bus industry.

Earmarked and Designated Programs

Congress has earmarked research on both bus technologies and bus purchases in SAFETEA-LU and in the FY 2006 appropriations. The authorization of the National Fuel Cell Bus Technology Program designates $11 million to $13.5 million annually to fuel cell technology development over the next 4 years, for a total of $49 million. In addition, of the more than 1,000 bus purchases earmarked by the authorizers and appropriators, many are for hybrids or fuel cell buses. A definitive estimate is not yet available, but at least $22 million in funding for such earmarks has been identified, and some of the earmarks in the capital program have research components.

The National Fuel Cell Bus Technology Program will provide a 50-50 cost share with the private sector to encourage development and demonstration of fuel cell buses. A competition will be held to select three geographically diverse consortia or nonprofits, in collaboration with transit agencies, to implement the program.

Research Strategies

With so much research in the Goal 5 area either earmarked or designated, notably for work on advanced bus technologies, the committee recognizes the difficulties faced by FTA in developing and implementing a robust research program aimed at protecting the environment and promoting energy independence. Nonetheless, there may be opportunities for the agency to

[12] The conservation or emissions benefits of shifting from diesel to fuel cell buses should be kept in perspective: transit buses today account for but 0.3 percent of U.S. transportation energy consumption. See Davis and Diegel 2004, p. 2.6. Even so, for urban areas that are not in compliance with the Clean Air Act Amendments, small reductions in emissions can be significant.

[13] The benefits of hydrogen depend on the source of the hydrogen and its cost, and they will only be achieved if the large-scale storage and distribution problems can be solved. See, for example, Ogden (2005) and National Research Council (2004).

influence or leverage earmarked and designated projects as part of a coordinated effort focused on Goal 5 objectives. Three research strategies are proposed.

First, the committee suggests that FTA build on its "quick analysis" study of electric drive technologies (Callaghan and Lynch 2005) by conducting further analyses to determine the most cost-effective way for transit systems to meet FTA's environmental goals. For example, the analyses might consider whether it is more cost-effective to encourage the development of clean diesel or ICE hybrid-electric systems, or both, rather than to invest in fuel cells. Another question for consideration is whether fuel cell buses are ever likely to reach the goals of cost comparable with that of clean diesels and service life comparable with that of conventional buses. The answers to such questions could be useful for policy makers in informing decisions about future research budgets.

> ***Recommendation 5*** **FTA should undertake further analyses to determine the most cost-effective way for transit to meet its environmental goals.**

Second, the committee urges FTA to take a leadership role in encouraging the recipients of earmarked and designated funds for research on fuel cell and hybrid buses to coordinate their efforts in support of a coherent research endeavor aimed at the high-level goal of protecting the environment and promoting energy independence. FTA should also ensure that researchers working on fuel cells for buses are building upon the fuel cell research funded by the Department of Energy and the California Fuel Cell Partnership. Such an approach will help ensure that the maximum benefit is derived from all the research funding in this area. The committee is concerned that the disparate nature of earmarks and designations for research on electric drive technologies presents challenges in establishing a coherent and cost-effective program of research that focuses on appropriate goals and avoids unnecessary duplication.

> ***Recommendation 6*** **FTA should bring together stakeholders and the many and diverse earmark recipients working on electric drive technologies to develop a strategy to minimize duplication and focus efforts on achieving national goals.**

Third, the committee encourages FTA to identify and pursue opportunities to influence earmarked or designated projects on fuel cell buses such that the research results can also benefit the development of ICE hybrid systems. As noted earlier, whether fuel cells will ever be a cost-effective technology for transit applications remains uncertain. Nonetheless, research on fuel cell buses offers the opportunity to investigate not only some of the potential barriers to commercial operation of such vehicles but also technologies for hybrid buses in general. As noted earlier, hybrid-electric buses combine an electric propulsion system with another power plant, which may be a conventional diesel or gasoline ICE (as in current commercial hybrid buses) or a fuel cell stack (as in some demonstration fuel cell hybrid buses). Thus, there is a useful transition path from ICEs through hybrids to fuel cells. Even if fuel cell goals are not reached, FTA's research and development program could assist the development of ICE hybrids.

In the committee's view, FTA's research on electric drive technologies should focus on riskier, long-term research unlikely to be undertaken by industry, such as efforts aimed at improving power electronics for hybrid vehicles, as well as reducing battery cost and increasing service life. There may be opportunities to leverage research in these areas that is already being conducted under the Department of Energy's FreedomCAR and Vehicle Technologies Program (Department of Energy 2005). Certain side benefits of hybrids—quality of acceleration and ride

and reduced noise—could also be pursued. Even if hybrids are not justified by lower life-cycle costs due to fuel savings, they may have benefits in the form of consumer and community acceptance that could help justify the cost premium—for example, if noise pollution from vehicles becomes a higher-profile environmental issue.

> ***Recommendation 7*** **FTA should focus its R&D strategy on a technology transition path through ICE hybrids to fuel cell buses. Wherever possible, projects should be designed so that they have shorter-term payoffs for ICE hybrids as well as longer-term benefits for fuel cell systems.**

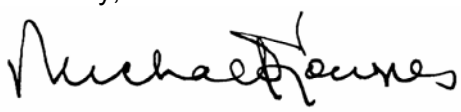
CLOSING REMARKS

The committee appreciates the opportunity to review and comment on successive drafts of FTA's strategic research plan and commends the agency on its progress over the past year in developing the preliminary plan into a substantive document. The committee as a whole has developed a better understanding of research needs and challenges in specific areas through the panel discussions at recent TRAC meetings, and we hope that these events have been useful for FTA's identification and assessment of research opportunities. We look forward to similar discussions of specific research areas and topics at future meetings.

During the course of the last meeting, the committee became aware of the dispersed nature of research management in FTA across multiple units. Apparently FTA offices other than the Office of Research, Demonstration and Innovation are managing research. We are interested in learning more about strengths and weaknesses of this approach and would like to learn more from other FTA program managers at a future meeting. We would also benefit from understanding how U.S. Department of Transportation highway research and initiatives that influence transit performance are coordinated with FTA research and strategic priorities, and we welcome presentations from Federal Highway Administration and Research and Innovative Technology Administration officials on these points.

We offer our best wishes to Barbara Sisson on her call to duty by the U.S. Navy and assignment to the United States Central Command, and we look forward to her safe return in early 2007. In the meantime, the committee looks forward to continuing to assist you and FTA in the development of the agency's research plans.

Sincerely,



Michael S. Townes,
Chair, Transit Research Analysis Committee

Enclosure A: Committee membership
Enclosure B: Presenters and panelists at third and fourth meetings

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ENCLOSURE A

TRANSIT RESEARCH ANALYSIS COMMITTEE

Michael S. Townes, *Chair*, Hampton Roads Transit, Hampton, Virginia
Karen Antion, Karen Antion Consulting, LLC, Stamford, Connecticut
J. Barry Barker, Transit Authority of River City, Louisville, Kentucky
David Bayliss, Halcrow Group, London, England
Ronald L. Epstein, New York State Department of Transportation, Albany
Santo A. Grande, Delmarva Community Services, Inc., Cambridge, Maryland
Delon Hampton, NAE,[14] Delon Hampton and Associates, Chartered, Washington, D.C.
Paul E. Jamieson, Wabtec Corporation, Spartanburg, South Carolina
Brian Macleod, Gillig Corporation, Hayward, California
Clarence W. Marsella, Jr., Denver Regional Transportation District, Colorado
Michael H. Mulhern, Jacobs Civil, Inc., Boston, Massachusetts
Nigel H. M. Wilson, Massachusetts Institute of Technology, Cambridge

[14] NAE = National Academy of Engineering.

ENCLOSURE B

PRESENTERS AND PANELISTS AT THIRD AND FOURTH MEETINGS OF THE TRANSIT RESEARCH ANALYSIS COMMITTEE[15]

Third Meeting, July 7–8, 2005, Woods Hole, Massachusetts

Update on FTA's Research Activities and Budget
Barbara Sisson, Associate Administrator for Research, Demonstration and Innovation, FTA, Washington, D.C.

Development of Crash Energy Management
Ron Hynes, Deputy Associate Administrator for Research, Demonstration and Innovation, FTA, Washington, D.C.

Panel Discussion: Research on Transit Ridership
The Factors Influencing Ridership: What Has the Research Shown?
Brian Taylor, Associate Professor and Vice Chair of Urban Planning, and Director, University of California at Los Angeles Institute of Transportation Studies
Influences on Transit Ridership: A European Perspective
David Bayliss, Consultant, Halcrow Group, London, England (committee member)
Ridership Forecasting and Travel Demand Modeling
Frank Spielberg, Principal, BMI-SG, Vienna, Virginia
Transit Riders and Ridership: A Description of Current Research
Karla Karash, Vice President, TranSystems Corporation, Medford, Massachusetts
Successful Ridership Initiatives Implemented at the Regional Transportation District, Denver, Colorado
Cal Marsella, General Manager, Denver Regional Transportation District, Colorado (committee member)
Future Public Transportation Needs of an Aging U.S. Society
Lisa D'Ambrosio, Research Associate, AgeLab, Massachusetts Institute of Technology, Cambridge

Development of FTA's Strategic Research Plan
Gorman Gilbert, Professor and Head, School of Civil and Environmental Engineering, Oklahoma State University, and Director, Oklahoma Transportation Center, Stillwater

Fourth Meeting, December 5–6, 2005, Washington, D.C.

Provisions of SAFETEA-LU and Implications for FTA's Research Program
Barbara Sisson, Associate Administrator for Research, Demonstration and Innovation, FTA, Washington, D.C.

OMB's Program Analysis Rating Tool
Bruce Robinson, Strategic Analysis Team Leader, FTA, Washington, D.C.

[15] On August 26, 2005, an informal working meeting involving a number of TRAC members, FTA staff, and representatives from the Oklahoma Transportation Center, Stillwater, was held at the Keck Center of the National Academies in Washington, D.C., to review and comment on a draft of FTA's strategic research plan.

Analysis of Capital Costs and Their Effects on Operating Costs
Lew Clopton, Director, Office of Technology, FTA, Washington, D.C.

Panel Discussion: Electric Drive Technologies for Transit Applications
Promoting Energy Independence in Transit
Walt Kulyk, Director, Office of Mobility Innovation, FTA, Washington, D.C.
Activities of the East Coast Hybrid Consortium
Yina Moore, Executive Director, East Coast Hybrid Consortium, Princeton, New Jersey
New York City Transit Experience with Hybrid Buses
Dana Lowell, Senior Consultant, M. J. Bradley and Associates, Manchester, New Hampshire
Operational Experience and Testing of Hybrid Buses
Rick Snyder, Bus Procurement Specialist, Port Authority of Allegheny County, Pittsburgh, Pennsylvania