Advanced Small Transit Vehicle Technology Study

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1. INTRODUCTION

In October 2005, the Federal Transit Administration (FTA) and the Small Urban and Rural Transit Center (SURTC) at North Dakota State University (NDSU) held a meeting with several transit industry representatives launching a project to examine the state of small transit vehicles. Originating out of concerns expressed by rural transit providers, the program developed to include a market and technological analysis of all transit vehicles fewer than 30′ in length (for the purposes of this study, a small transit vehicle is defined by a length of fewer than 30′). The goal of this project, named the Advanced Small Transit Vehicle (ASTV) Development Program, is to improve transit service by facilitating the deployment of improvements for small transit vehicle design. This document is the final product of the first phase of the ASTV program.

Based on input from transit industry stakeholders, this paper will meet five objectives in preparation for the next phase of ASTV development:

1. Outline Transit Provider Concerns – As the motivation for this project, understanding the issues transit providers face with the procurement and operation of small transit vehicles is fundamental in determining future actions under the ASTV program. Concerns will be defined, prioritized and clarified as needed. It is important that these issues are understood clearly by operators, manufacturers and government agencies so all stakeholders can effectively work together to resolve them.

2. List Available Vehicles and Technologies – In order to ensure future ASTV program efforts are not duplicative, all vehicles and accessories that are commercially available should be summarized. It is important to include this information not only to aid in guiding the ASTV program, but also as a source for transit providers.

3. Analyze Small Vehicle Market – One of the issues immediately identified as hindering the development of small vehicle technology are the unique aspects of the small urban and rural transit market. A description of this market, and projections for future growth, will provide manufacturers with the information they need to plan their small vehicle production.

4. Examine Developing Technologies – An important component of Phase I of the ASTV program is an analysis of vehicle technologies. This will include cost-benefit information for alternative fuels and ITS components.

5. Recommend Phase II Plan – The final goal of this paper is to identify future actions and make recommendations for the next phase of the ASTV program. A final decision will be made through discussions with industry stakeholders.

The scope of this paper is primarily focused on vehicle design and performance. Discussion of broader areas, such as infrastructure and operating practices, are included mostly on a cursory level. There are many issues, from procurement to service coordination, that are vital to the improvement of small urban and rural transit. These issues are receiving some attention in the research community, and more information can be found in referenced sources.

2. BACKGROUND

In preparation for the first series of stakeholder meetings, a draft scoping paper was created and distributed to define the program and provide background information. The final draft also outlined the work plan for Phase I, and included discussion points and decision factors to be addressed during stakeholder meetings. A copy of this paper, and minutes from stakeholder meetings, can be obtained from FTA or SURTC (http://www.surtc.org/research/reports.php).

The motivation for this project was an advisory committee request to analyze the technological needs of vehicles providing transit service in rural areas. According to the 2000 census, approximately 59 million Americans live in rural areas. Nearly 80% of rural counties have no public bus service, a number which is around 2% in metro counties (CTAA 2005). Additionally, as of 2000, an estimated 59% of rural vans and 41% of small buses were in service past their expected lifetimes (CTAA 2005). A 2002 survey of transit agencies identified vehicle reliability and maintenance costs as the most common concerns in the use of small buses (Hemily and King 2002). Customer acceptance was also a commonly cited concern, arising from poor ride quality, noise, gas fumes and crowding (Hemily and King 2002). Accessibility is also an small vehicles issue as high floors are common and interior vehicle space is limited. A majority of small vehicles used for transit are converted from vehicles designed for other markets. Passenger vans are commonly retrofitted with wheelchair lifts and high roofs to fill transit needs. Cutaway and body-on-chassis vehicles allow transit agencies to benefit from advances in the larger truck market. The uncertainties of the small transit vehicle market lead to a high turnover rate of manufacturers. This compounds not only the improvement of vehicle designs, but also warranty and maintenance.

In 2006, the ASTV program was presented at three transit industry meetings. At each meeting, representatives of manufacturers, transit agencies, human service providers and state departments of transportation (DOT's) were asked to discuss issues and experiences with small transit vehicles. A key point raised during these meetings was that there are essentially three separate markets of transit vehicles under 30′ long: small transit buses, cutaway buses and transit vans. These categories are defined in Section 3. Significant concern was expressed over what is perceived as FTA's requirement for low-bid procurement procedures. Many providers stated they would prefer a higher quality vehicle, and would even be willing to sacrifice quantity to some degree if necessary. This led to discussion of state procurement practices, especially with 5310 and 5311 funding. There is often little or no communication between state DOT's and transit providers regarding vehicle specifications. Small transit agencies generally are assigned vehicles from a single statewide procurement based solely on the number of vehicles needed. Providers would prefer more say in the development of procurement requests.

Maintenance was mentioned as a concern in two different contexts. One was the issue of warranties and assigning maintenance responsibility. Since many small transit vehicles are converted from production vehicles, it is difficult for a transit provider to get service normally covered under a warranty. For example, an original van manufacturer would not expect to repair an axle for a vehicle with a wheelchair lift installed since that increases the load on the axle; the lift manufacturer would not be responsible for the axle of a vehicle they did not produce. A second maintenance issue is the amplified effect of a small transit agency having a vehicle out of service. A transit agency with only ten vehicles would suffer from losing a single bus for a day, whereas the service provision of a 100 bus fleet would likely not be affected. Additionally, providers that are not large enough to support their own maintenance department often rely on a city or county facility. These are often overloaded and slow to respond, and they prioritize emergency services vehicle repairs over transit vehicles.

Vehicle design issues and the adoption of advanced technologies were discussed as well. It was agreed that the major reason advancements are not being made is a lack of funding. Many providers are interested in low-floor or alternative fuel vehicles, but do not have the means to purchase them. The price of a small low-floor vehicle can be two to three times the cost of a traditional cutaway. Since small transit vehicles have a shorter useful life than standard buses, justifying this cost difference becomes more difficult. It was noted that the overall market for small transit vehicles is comparatively small, and cannot motivate manufacturers to improve design features. One recommendation was to link to another market, such as the commercial truck market, and encourage improvements that will benefit both industries. In addition to spreading out research and development costs among different industries, an ASTV with improved performance in fuel efficiency, dwell times and ridership may offset the increase in vehicle prices.

Another issue manufacturers face is component installation and custom orders. Small transit vehicle procurements, regardless of the amount of vehicles being ordered, generally have unique specifications and cannot benefit from decreased manufacturing costs associated with mass production. Transit providers often request specific component brands as well, forcing vehicle manufacturers to work with several different component companies instead of arranging bulk purchases or supply contracts.

Coordination of transportation services was also mentioned as a motivation for this project. Combining resources and funding for transit, human services and school transportation is encouraged and often necessary in rural areas. This will require a vehicle that is flexible enough to meet the needs and requirements of the different applications. An example is the Federal Motor Vehicle Safety Standard (FMVSS) for the Multi-Function School Activity Bus (MFSAB). In order for a vehicle to be used for Head Start transportation, it must meet the same safety standards as a school bus. This includes minimal seat spacing, which generally prevents the same vehicle from being used for adult passengers.

Overall recommendations included sponsoring a “white book” document outlining recommended vehicle specifications for small transit applications. It was suggested that the only way the industry would meet transit needs in the short run is to alter an already mass produced vehicle that would lower costs and provide name recognition to transit agencies. The main contention was that improvements would best be made through some form of standardization of vehicle specifications and procurement.

3. CONVENTIONAL SMALL TRANSIT VEHICLES

3.1 Vans

To better understand small transit vehicles, this study provides an example vehicle representing vans, cutaways and small buses. An example of a van is the Ford E-Series Wagon (Figure 3.1). Vans are fewer than 20 feet in length and usually carry 11 to 15 passengers. Some are equipped with either a low-floor or a ramp for wheel chair accessibility, although this is not a common van feature. A van's fuel source is almost always unleaded gasoline, and they are often used for shorter intercity routes bringing passengers into larger communities from rural areas for work, shopping, medical appointments, etc. Vans have become a popular option in recent years for transit agencies attempting to save money on the initial purchase price of a vehicle to utilize on routes that have low peak demand. Most vans are also much less expensive to operate than either cutaways or small buses. Due to their smaller size, they usually get better gas mileage, are more versatile on narrow roads and therefore, easier for drivers to operate.

However, vans are not as comfortable for passengers, especially elderly or mobility-impaired individuals who must bend over and maneuver to sit in the rear seats of the van. There are also rollover and additional safety concerns regarding the use of passenger vans. National Highway Traffic Safety Administration (NHTSA) research has shown that 15-passenger vans have a rollover risk that increases dramatically as the number of occupants increases from fewer than five to more than ten. In fact, 15-passenger vans (with 10 or more occupants) had a rollover rate in single vehicle crashes that is nearly three times the rate of those that were lightly loaded (with fewer than five occupants). Also, passenger vans cannot transport school children due to safety concerns, and this prohibits their use in coordinating public transportation with school transportation (NHTSA 2005).

Figure 3.1 Ford E-Series Wagon (Ford 2006)

3.2 Cutaway Buses

A prime example of a cutaway bus is the ElDorado Aerotech (Figure 3.2). Cutaway bus bodies are mounted on varying sizes of truck chassis and are usually between 19 and 29 feet in length carrying 14 to 30 passengers. Most are equipped with wheelchair lifts as seen in Figure 3.2. They are powered primarily by either gas or diesel engines and are usually the most common small transit vehicles within agency fleets. Cutaways' primary purpose is to serve the local community, carrying both handicapped and non-handicapped riders and providing rides to community centers, grocery stores, medical appointments, etc. Cutaway buses are often the 'workhorses' in non-urban communities providing the largest percentage of rides to the cliental. Cutaways do have a shorter useful life than unaltered vehicles, and they also have rough ride and reliability concerns as discussed in previous sections.

Figure 3.2 ElDorado Aerotech (ElDorado 2006)

3.3 Small Transit Buses

An example of a small transit bus is the Blue Bird Ultra LMB (Figure 3.3). Small transit buses are between 25 and 29 feet in length and usually carry 22 to 30 passengers. The bus in Figure 3.3 is equipped with a low-floor for ease in entering and exiting the vehicle. Small buses' primary power source is diesel fuel, but some are utilizing hybrid technology to save on fuel costs while lessening harmful fuel emissions. Small transit buses almost always serve more densely populated areas within small urban communities. They are often utilized during non-peak periods in urban settings to save money, as they are less costly to operate compared to larger transit buses, and they also offer drivers greater maneuverability in highly congested and narrow city streets.

Small transit buses represent the most costly segment of the small transit industry, but due to their traditional transit vehicle look, are often preferred by riders as their choice for public transportation use. They also have a longer useful life than vans and cutaways and lower maintenance costs due to similarities with large transit buses. However, they are less versatile than vans and cutaways due to their larger size and the rear hangover behind their back tires, which is a concern in rural and unpaved, mountainous areas.

Figure 3.3 Blue Bird Ultra LMB (Blue Bird 2006)

4. SMALL VEHICLE MARKET CONDITIONS

United States bus manufacturers indicated repeatedly that generating a profit in the transit bus industry is extremely difficult, and there is no room for error (Hidalgo et al. 2006). Most of these manufacturers develop large buses designed solely for fixed-route service in large metropolitan areas. However, similar problems hinder the small bus industry. The lack of large markets and stable demand cycles for transit buses, both large and small, is one of the main concerns leading companies to hold excess capacity in anticipation of large order quantities. As a direct result of this and other issues, manufacturers enter and exit the industry frequently.

4.1 Manufacturers

North Dakota State University's Small Urban and Rural Transit Center (NDSU SURTC) conducted a small vehicle (less than 30 feet in length) manufacturer study. The 2005 American Public Transportation Association (APTA) transit vehicle database including over 21,000 small transit vehicles built between 1990 and 2005 was utilized in the research. More than 60 different manufactures were included in this sample. Many of these manufacturers built only a handful of buses accounted for in the database, while 19 manufacturers (Figure 4.1) were responsible for the overwhelming majority of buses produced. ElDorado National produced more than 4,500 small buses in the database while Ford Motor Company and Goshen Coach represented the next two top manufacturers, respectively. Manufacturers that produced more than 100 small buses present in APTA's 2005 vehicle database are included in this figure.

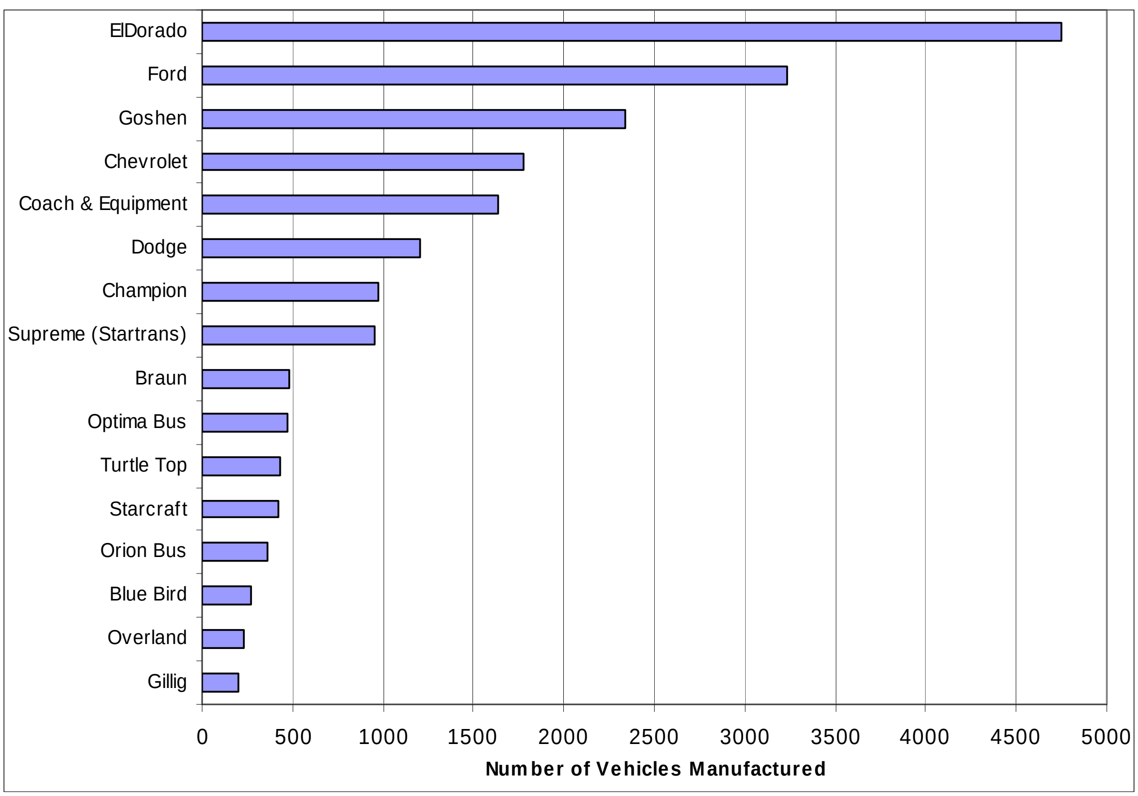


Figure 4.1 Major Small Vehicle Manufacturers (APTA 2005)

4.2 Active Vehicles

Figure 4.2 shows the number of active vehicles per model year represented in the APTA database. The number of active vehicles from model years 1996 (621 vehicles) and 1997 (983 vehicles) are significantly lower compared to model year 1998 (1,541 vehicles). Looking back from 2005, most of these vehicles were between seven to nine years old when the data was collected. FTA's mandated 7-to 10-year life cycle for small transit vehicles is quite evident based on this figure.

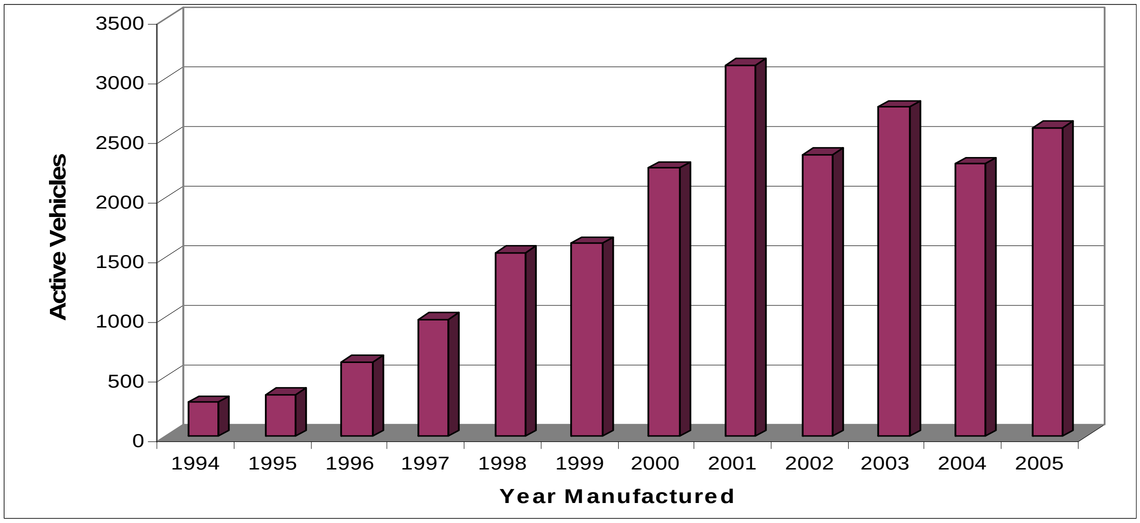


Figure 4.2 Model Years of Active Small Transit Vehicles (APTA 2005)

4.3 Size

When considering the development of a new small transit vehicle, attention should be given to the dimensions of the vehicle compared to industry standards. The majority of small vehicles represented in the APTA database are between 20 and 25 feet in length with the 20- and 25-foot buses being the most common registered lengths by a wide margin (Figure 4.3). ElDorado National and Goshen Coach both sell a large number of 25-foot transit buses, which account for a large percentage of the buses at that length.

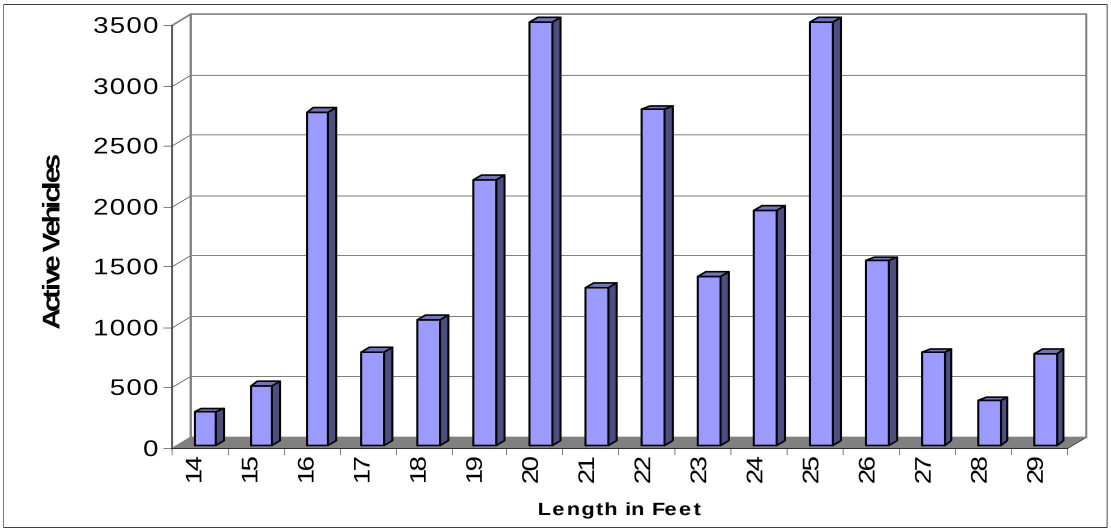


Figure 4.3 Length of Small Transit Vehicles (APTA 2005)

4.4 Cost

The average purchase price of a small transit vehicle also must be given some consideration when developing a new rural transit vehicle. Capital cost seems to be a secondary issue to maintenance. This is probably due to the 80% federal share and affects purchasing decisions. Based on the 2005 APTA database, the average purchase price per small transit vehicle after removing outliers was roughly $57,000 for model year 2005. This purchase price varies widely depending on the size and model of the vehicle procured and on specific features transit agencies stipulate within their procurement parameters. Transit agencies requesting specific features that vary from agency to agency are a source of frustration for manufacturers and prevent them from reducing costs by producing a standard type of small vehicle for the industry.

4.5 ITS

Advanced technology is another area to consider when developing vehicle specifications. Automatic vehicle location (AVL) technology is used by nearly all of the larger transit systems and is becoming more prevalent in both small urban and rural systems as well. On-vehicle audio and video surveillance systems are another popular technology. However, most rural areas would have little need for such systems. Equipping a vehicle with obstacle detection devices would be of greater importance in both small urban and rural areas. Backing a small bus can be very difficult and viewing small or low-to-the-ground obstacles while backing is virtually impossible. An obstacle detection device would serve this purpose and could prevent numerous accidents. Many rural transit agencies are also considering deploying an advanced radio communication system that is more reliable and is part of the national ITS architecture. Technologies such as electronic stop announcements and electronic passenger counters would also be welcome, but less of a priority compared to AVL and obstacle detection devices. The cost of all advanced systems should be considered, along with the market served by a vehicle designed to serve rural areas, before making a decision on the technology.

4.6 Alternative Fuels

The 40-foot transit bus industry offers a variety of different fuels and propulsion systems. The four most common power systems include:

- Diesel
- Compressed Natural Gas (CNG)
- Diesel and Electric Battery (DB)
- Liquefied Natural Gas (LNG)

(Hidalgo et al. 2006).

Many small transit vehicles use gasoline for their propulsion systems. Hybrid engines that utilize gasoline and electric batteries, similar to the diesel and electric battery engines employed in larger transit buses, are a possible alternative to standard gasoline engines. Transit agencies have a real interest in adding alternative fuel vehicles to their small transit vehicle fleets. This is due to the fuel savings that will result from utilizing hybrid technology as well as the improved reputation of the transit agency due to its environmental awareness (ASTV Stakeholder Meeting 2006). Transit systems can market their use of alternative fuels to increase consumer interest and influence ridership.

5. DEVELOPING TECHNOLOGIES

Due to the nature of the market, there rarely are technological improvements developed strictly for small transit vehicles. As with most transit advancements, new technologies tend to be adopted after having been developed and proven in other industries. Two notable exceptions are the adoption of alternative fuels and integrated vehicle based safety systems (IVBSS). The centralized facilities, professional drivers and experienced mechanics provide an excellent forum for testing and adopting these types of technologies.

Among the new technologies entering the market are low-floor chassis and Intelligent Transportation Systems (ITS) components. While these remain cost-prohibitive for the average transit provider, they are expected to become more affordable and reliable in the near future. A short, objective description of technologies with potential to improve small transit vehicles is included below. More information and analysis will be included in the cost-benefits discussion later in this paper.

5.1 Alternative Fuels and Propulsion

Small transit vehicles provide an excellent forum for testing and deploying alternative fuels. These vehicles benefit from the centralized fueling and maintenance of transit providers, as well as industry-funded development of alternative fueled medium- and light-duty engines. As previously stated, gasoline and diesel are the most common fuels used in small transit vehicles. Motivated by environmental and energy dependence concerns, many transit providers may wish to move to alternative fuel and propulsion sources. Alternative fuels derived from biomass (such as ethanol or biodiesel) offer an additional source of income for local farmers, which may drive rural providers more than environmental or energy independence concerns. Changing fuel sources may also lead to quieter operation, improved health and ride quality, and improved public perception. In adopting a new technology, required support and infrastructure costs must be considered during the decision process. Adoption of many new fuels will require a new fueling infrastructure; whereas lower blends of ethanol and biodiesel can be implemented with existing infrastructure. New propulsion methods will also impact training needs and scheduled maintenance.

Compressed natural gas (CNG) has been widely adopted in standard transit buses, with mostly positive experiences. CNG vehicles generally have lower emissions than standard diesel or gas vehicles. Domestically produced CNG is also more common than domestic gas or diesel. Using CNG requires more space for fuel storage than a diesel or gasoline tank. The storage tanks must be pressurized and add significant weight to the vehicle. Another common clean vehicle technology is found in hybrid vehicles. Hybrids combine two power sources to drive the vehicle, either in series (a single drivetrain) or parallel (such as a launch assist). A major benefit to hybrid technology is the ability to recapture energy during braking. Hybrid-electric vehicles (HEV) are powered by both an internal combustion engine (ICE) and electrical storage (batteries or ultracapacitors) provided to electric motors. A medium-duty HEV chassis has already been developed and is available in the transit market. Hydraulic hybrids store recaptured energy by pressurizing fluid in onboard cylinders. This technology is significantly cheaper than HEV technology, and can be retrofitted to existing vehicles. The first medium-duty hydraulic hybrid transit vehicles are still under development.

Other fuels that have been tested in transportation applications include biodiesel, ethanol and hydrogen. These can all be added to standard fuels, or CNG, as additives, or used as the primary fuel in designated engines. Biodiesel and ethanol are produced from domestic agricultural products. This involves the fermentation of carbonaceous material, commonly corn or soy. These fuels tend to achieve improved emissions, although new developments in diesel engines have lessened these effects. Hydrogen can be produced from many different sources. Electrolysis of water, where electricity is passed through water to separate its hydrogen and oxygen components (similar to "reversing" a fuel cell), is thought of as a "green" method of hydrogen production. Some testing sites use only renewable electricity, such as wind or solar power, to power their electrolysis. Hydrogen can also be isolated from coal and natural gas, although these methods produce carbon emissions. However, they are currently the most cost effective and common methods of hydrogen production. Once in the vehicle, pure hydrogen fuel will only emit water vapor, but the source of hydrogen must be considered in a complete analysis.

Fuel cells are an alternative power source attracting interest in the transit industry. A standard ICE vehicle draws mechanical power from continuous combustion reactions and transfers that mechanical power directly to the wheels. Fuel cells produce power through an electrochemical reaction, which is then used to drive an electrical motor. There are many different fuel cell systems, but the most common being tested in transportation applications are hydrogen fueled polymer electrolyte membrane (PEM) fuel cells. A PEM fuel cell combines ambient oxygen and purified hydrogen across a membrane to form water, similar to the combustion reaction that occurs in an ICE. However, the PEM separation prevents a combustible mixture from forming and only allows the reaction to occur by completing an electrical circuit, from which power is drawn. Several private fuel cell vehicles are in development by automobile manufacturers. There are a few domestic fuel cell transit bus demonstrations underway, building on international experience. By 2009, at least ten new demonstration buses are expected to begin operations. Hydrogen storage is one of the major hurdles being examined in these demonstrations. Widespread production of fuel cell vehicles is not expected for several years after those demonstrations are complete.

Both fuel cell and hybrid-electric vehicles require the use of electric motors. This technology is developing along with fuel and power source technologies. Some vehicle designs have included four separate electric motors, one mounted on each wheel. As energy storage capabilities continue to improve, electric drive vehicles will achieve better performance. Many electric drive vehicles have the ability to operate in a "zero emission" electric only mode.[1] This option may have esoteric appeal for some transit services, such as tourist areas or congested business districts.

5.2 Accessibility

Standard transit vehicles have seen vast improvements in accessibility in the last several years. Lifts and ramps have become more advanced, which has decreased dwell times. The use of low-floor buses has increased significantly, and as a result the cost differential of this technology has dropped. Low-floor buses are designed to remove the need for steps to access the bus. The lower floor heights allow accessibility using a ramp instead of a lift. Some low-floor vehicles have a raised section of seating in the back, while others are completely flat. At least one company is producing a medium-duty low-floor chassis for transit use. Kneeling buses are also used by many transit agencies. A hydraulic lift system can be used to lower the bus on one or more tires. This drops the door height closer to the curb, improving accessibility.

[1] "Zero emission" operation of electric and fuel cell vehicles refers only to tailpipe emissions. Upstream generation of electricity or hydrogen generally produce carbon dioxide and other regulated pollutants.

5.3 Intelligent Transportation Systems (ITS)

Intelligent Transportation Systems (ITS) include a wide range of technologies that improve vehicle performance, safety and congestion. Several technologies are very beneficial to transit systems, and can particularly improve demand response and paratransit. Computer Assisted Dispatching (CAD), Automatic Vehicle Location (AVL), Global Positioning Systems (GPS) and on-board navigation systems can vastly improve transit services that require continuous scheduling information. These technologies have become fairly common in transit agencies of all sizes. CAD uses logged data and continuous updates to schedule dispatch services from a central location. Computer software is used to enter all requested stops and routes, which are then assigned to vehicles through radio, text messages or a mobile data terminal (on-board computer). This allows trips to be optimized, minimizing the number of vehicles a transit system must maintain in service. CAD also requires less advanced notice for trip scheduling and can inform drivers of cancellations. AVL is a continuous system of recording vehicle positions and relaying that information to a central location. It can be used to monitor performance and to aid in dispatch and vehicle assignments. GPS complements AVL by accurately identifying and relaying vehicle position. This is accomplished by an on-board receiver measuring its distance from multiple satellites. GPS is also used by on-board navigation systems that use the calculated vehicle position to map out a route to an entered location. These technologies are all complementary in improving vehicle assignments and demand service scheduling. They are widely available both during the procurement process and as an after-market addition for vehicles of all sizes. There are several case studies available in different sized transit agencies and vehicles.

Other ITS technologies are used by large transit agencies, but rarely in small vehicles. Automated Passenger Counters (APC) use sensors mounted at each vehicle door to log the number of boardings and alightings at each stop. Typically these passenger data are downloaded at a central location (i.e., bus garage) and are used in service planning and performance measurement. A wide variety of systems are available, with equally variant capabilities. However, most APC systems are capable of equaling or exceeding 95% counting accuracy.

Traffic Signal Priority (TSP) is a technology in which signal timing is adjusted to give right-of-way preference to a certain vehicle. This can be accomplished through extending signals or pre-emption of the regular cycle. TSP is used to improve travel times in congested areas. Baseline signal timing, when optimized, is as useful as TSP in minimizing wait times for transit vehicles. There are many different technologies used in TSP systems, and can be included during vehicle procurement or added to an existing fleet.

Electronic fare collection allows fares to be collected before entering the vehicle. Passengers are then given electronic media or a proof-of-payment ticket. Electronic media are used to enter the station, or for on-board fare collection. Another fare collection technology is Ticket Vending Machines (TVM). This is an increasingly robust technology, and several suppliers are available for the many different types of electronic fare technology. Proof-of-payment systems are also an option to decrease passenger boarding times. They are generally enforced by roaming fare enforcement officers. These payment methods can drastically reduce dwell times from traditional on-board payment.

Several other available and developing ITS technologies can benefit transit. Security features, such as in-vehicle cameras, can improve ridership and public perception of transit. This is a more important feature in large vehicles where the driver may not be able to monitor all passengers. Offering WiFi (wireless Internet) access can increase interest in transit, especially for commuter services. Vehicle Assist and Automation (VAA) is a class of technologies that provides partial or complete control of a vehicle. This can be used for precision docking or automatic vehicle operations with obvious safety and performance benefits. Integrated Vehicle Based Safety Systems (IVBSS) combine safety and collision avoidance technologies into a single system to warn drivers of imminent crashes. Real time Next Bus information displayed at bus stops is well received and can improve ridership. The necessary technology is currently available and used by an increasing number of transit agencies. Information can also be displayed in the vehicle to improve the transit experience. Next Stop information can automatically be displayed and announced, as well as delays and transfer information.

5.4 Small Transit Vehicles

Over the years, there have been several unique small vehicles designed specifically for transit. The Dutcher PTV and Orion II were built in the 1980's to address paratransit needs. While these vehicles are no longer offered, an increasing number of companies provide purpose-built small transit vehicles. As mentioned above, there are currently low-floor and hybrid-electric chassis available for transit applications. Estimated costs for a hybrid cutaway vehicle are over $100,000. Daimler-Chrysler offers a purpose-built transit vehicle (marketed domestically as the Dodge Sprinter), as does Ford (available in Europe as the Ford Transit). These are essentially production vans modified by the original manufacturer for transit use, and cost roughly the same as after-market conversion vans. However, this mitigates some of the warranty and maintenance issues identified with conversion vehicles.

Ebus, an electric vehicle company based in California, offers a 22′ all-electric or hybrid-electric transit vehicle (PTI 2002). These vehicles are Altoona tested (report available from Pennsylvania Transportation Institute), have 23 seated positions, low floors and the ability to "kneel." According to the Altoona report for the Ebus 22′ trolley, the all electric model has a maximum range of just over 53 miles. The hybrid-electric version is expected to have a range of about 250 miles and be able to run on diesel, propane or natural gas. This Ebus has a short rear overhang of only 43", but a center ground clearance of only 8.3", mainly suited for urban or suburban applications. Ebus is preparing demonstrations of hydrogen fuel cell models of this vehicle as well.
A low-floor, hybrid-electric small transit vehicle is currently in operation in suburban Paris. This vehicle was designed to serve as a feeder bus to larger urban transit systems. The French-based company Gruau built the first 100 of these Microbuses for delivery in 2004, with an estimated price of $145,000 (2003 dollars). The bus has a completely flat, low floor, is about 17.5 feet long and can seat up to 25 passengers, depending on the seating configuration. Information on experience so far is unknown.

A similar transit-specific small vehicle is being developed in Florida. A prototype vehicle is being demonstrated in a rural area of Putnam County, on unpaved and poorly-maintained roads. A local transit provider is planning to fund the construction of five more prototypes, and send one for testing at the Altoona bus testing facility. When the vehicle is ready for commercialization, it will be available from 19-25 feet in length with multiple seating configurations. The commercial version, called the Brevi Bus, has a flat, low floor and may be offered as a hybrid, although the current design is for a standard diesel. The rear overhang is roughly 48", allowing greater maneuverability in rough driving conditions. The projected purchase price is $125,000, and it is expected to meet Buy America requirements.

6. TRANSIT AGENCY PERSPECTIVE

A 2002 study by Hemily and King on the use of small transit buses (fewer than 30 feet in length) highlighted many important issues that can be incorporated to develop the rural bus research plan. Based on a survey of 63 transit agencies, Hemily and King (2002) found that vehicle reliability and high maintenance costs were both the most frequently cited and highest-ranking concerns with regard to small buses (Table 6.1). This indicates the need for a small bus with higher mechanical reliability. More than one-half of respondents operating small buses reported that vehicle reliability was a concern, and 42% reported they had higher maintenance costs than predicted.

Table 6.1 Survey Responses on Concerns with the Use of Small Buses

	Percent of Responses	
Issue/Concern	Cited as Issue/Concern (%)	Cited as Most Important (%)
Capital Cost of Vehicle	17	3
Customer Acceptance	**39**	14
Maintenance Costs	**42**	13
Operator Acceptance	**33**	6
Safety	12	2
Vehicle Reliability	**53**	**25**
Other	33	16

Hemily and King (2002)

The issues of customer concern highlighted by the survey results included poor ride quality, noise, fumes, single door and crowding. Safety was only cited one time as being the most important concern with the use of small buses. The most frequently cited safety concern was for those standing on a crowded bus, which is of little concern during bus use in most small urban and rural areas. Other issues, such as lack of seats and lack of capacity at peak hours, also do not concern most transit agencies within the rural bus industry.

Hemily and King (2002) also collected fuel consumption data from several transit agencies (Table 6.2). This has become a major issue in the past year because of the increase in fuel costs throughout the country. Operational differences were found to have a large impact on the fuel consumption for small buses. Fuel economy was highest when small buses were used in regular linehaul service when average system speed was highest. Whenever significant idling time occurred, fuel economy dropped rapidly. This motivates the development of a small hybrid electric bus. Hybrid buses are optimal to operate in low-speed areas that require substantial dwell time. Some small towns may save a significant amount of money by switching to hybrid vehicles because many of their buses rarely leave the city limits, and they are operated at low speeds, less than 40/mph, throughout most of their service area.

Table 6.2 Fuel Consumption Experiences of Several Transit Systems

Transit System	Service Life Category	Average Fuel Consumption (mpg)
Kansas City Area Transportation Authority	4-5 year	8.75
Charlotte Department of Transportation	7 year	6.7
Port Authority of Allegheny County	7 year	5.25
Kansas City Area Transportation Authority	10 year	4.7
Connecticut Transit	12 year	3.59

Hemily and King (2002)

Transit agencies within the SURTC research states of North Dakota, South Dakota, Minnesota, Montana, Wyoming and Utah have also voiced some concerns regarding the performance and efficiency of their small-bus fleets. Steps were also an item of main concern. The fact that small buses do not kneel like larger transit buses makes it difficult for elderly individuals to board and exit buses. Wheelchair issues included tie-down problems. When a wheelchair is tied down behind the rear axle, where many are located, the ride becomes extremely rough. Strong preference is given to having wheelchairs secured directly behind the drivers. It is also easier to converse with wheelchair passengers located in the front of the bus, and it is much easier to have two wheelchairs on a bus at the same time when located in the front of the bus where there is more room to move about.

Large wheelchairs with leg extenders are also a concern; often the only way to have two such wheelchairs on the bus at one time is to be able to secure them in the front of the bus. It should be noted that Q'Straint makes a new tie-down that allows for full circular motion that eases the wheelchair tie-down process for operators. Many buses are now beginning to employ this new product. Consideration should be made to include these new tie-down specifications for a prototype rural transit bus. Most drivers also feel that the side wheelchair door is the only acceptable option for most rural communities. Rear loading of wheelchairs will not work because there are seldom curb cuts that allow for access from the rear when the bus is parked properly.

Ride quality depends largely on the quality of a bus's suspension system. The leaf spring suspension is conventional in most small buses. One transit fleet manager said an air suspension system would offer superior ride quality and is offered by the International Corporation. A cost-benefit analysis of this suspension system should be analyzed before it is considered for implementation. International is willing to provide demonstration buses to transit agencies so ride quality can be compared to standard leaf spring suspensions. The Sprinter, which has been discussed as a possible rural bus prototype, incorporates the conventional leaf spring suspension system found in most small transit buses. A survey will be sent to CTAA transit agencies to determine what other ride quality problems hinder their small bus operations and need improvement. The survey will cover current small agency vehicles along with their areas of interest in new fuels and technologies. Manufacturers will also be surveyed to gain a better understanding of their concerns regarding this rural bus initiative.

7. MANUFACTURER OUTLOOK

Both transit agency representatives and small transit vehicle manufacturers agree that a market exists for a small transit vehicle (fewer than 30 feet in length) that incorporates advanced technologies. The primary technologies of interest include hybrid propulsion systems and low-floor chassis (ASTV Stakeholder Meeting 2006). Efforts are underway to meet these demands as manufacturers Azure Dynamics and Dallas Smith have already designed small transit vehicles with hybrid electric propulsion systems and advanced low-floor technologies (Azure Dynamics 2007, Dallas Smith 2007).

WestStart-CALSTART (2005) studied the motivations behind the increasing presence of hybrid transit buses in the industry. Although their focus was on 40-foot buses, many of their findings also apply to small transit vehicles. WestStart-CALSTART divided their study into four main sections highlighting the economic, environmental, policy and technology rationale behind the success of hybrid transit buses. The economic motivations for the success of hybrids included improved fuel economy and maintenance savings. Environmental reasons consisted of air quality and noise reduction benefits. The policy reasons for utilizing hybrid transit buses were energy security, due to lessened reliance on foreign oil, and the environmental justice benefits due to improved air quality. The main technological reason stated was that hybrids form an evolutional bridge from the internal combustion engine to cleaner technologies, such as hydrogen fuel cells (WestStart-CALSTART 2005).

A major hurdle to overcome in order to improve the feasibility of an Advanced Small Transit Vehicle (ASTV) is to lower the cost of technologies such as ITS and the alternative fuel propulsion systems used to manufacture like vehicles. This is especially important in making vehicles available to small urban and rural transit providers who have more limited resources compared to their urban counterparts. Increasing the volume of advanced vehicles produced would lower production and procurement costs to transit agencies, as costs are disseminated into different markets.

There is shared market potential available for producing hybrid drive systems that support multiple vehicle types. For example, cutaway transit buses can incorporate the same drive systems as service trucks and light parcel delivery vehicles. Improved operating performance would also be a result of increased hybrid production volumes. With a larger market for manufacturers to serve, more attention would be paid to improving the efficiency of the entire supply chain (WestStart-CALSTART 2005).

8. COST-BENEFIT FACTORS

To begin analyzing the feasibility of developing an ASTV, it is useful to perform a cost-benefit analysis of the vehicle technologies discussed above. As the focus of this paper is small transit vehicles, the analysis will focus on vehicle equipment capital costs not including necessary infrastructure. It is important to note that as these technologies are improving and demand is growing, costs can change drastically over relatively short periods of time. All costs are reported as current value (2005/2006 dollars), though some are based on data from 1995. Also, many of the elements of a cost-benefit analysis will be unique to the application of the vehicle. The analysis provided is meant to be generally informative, but transit providers will have to perform detailed cost-benefit analyses based on their own requirements. Reported benefits are limited in scope, and largely anecdotal, and results are not meant to apply broadly to the entire small transit vehicle market. It should also be noted that only direct economic costs are discussed. Some technologies have the potential to increase collision risk (distracting the driver, etc.), and could potentially have indirect (such as increased insurance rates) or environmental costs.

8.1 Vehicle Type

The benefits derived from different types of vehicles are entirely dependent on the service and demand for which the vehicle is chosen. For low-demand paratransit applications, the smallest accessible vehicle (currently a converted minivan) will likely be the most cost effective. Transit providers that coordinate services with human services providers will find the most benefits in a flexible vehicle with easily adjustable seating arrangements. Of the vehicles described in the Developing Technologies section above, the new chassis and automobile manufacturers' production vehicles fit within the three categories identified by SURTC. Average capital costs for each category is included in Table 8.1. The transit-specific designed vehicles will begin to redefine those categories, offering a smaller purpose-built transit bus (smaller than the current nominal 27′) that can fill the role currently best suited for cutaways or vans. While these vehicles are currently cost-prohibitive, given developmental and market support, they may eventually become the most cost effective vehicle choices.

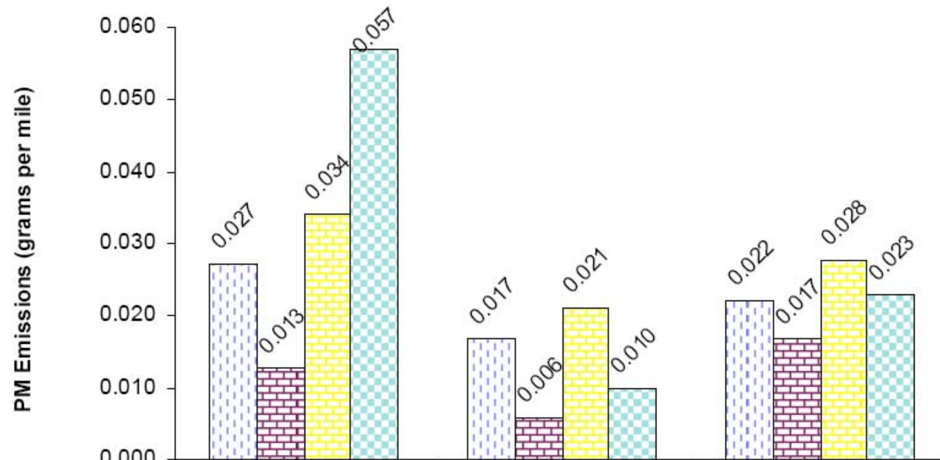
Table 8.1 Average Capital Costs of Small Transit Vehicles

Vehicle Type	Avg Capital Cost	Nominal Length (ft)	Nominal Capacity (seats)
Van	$33,000	17	12
Cutaway	$65,000	23	17
Small Bus	$180,000	27	25

(SURTC 2007)

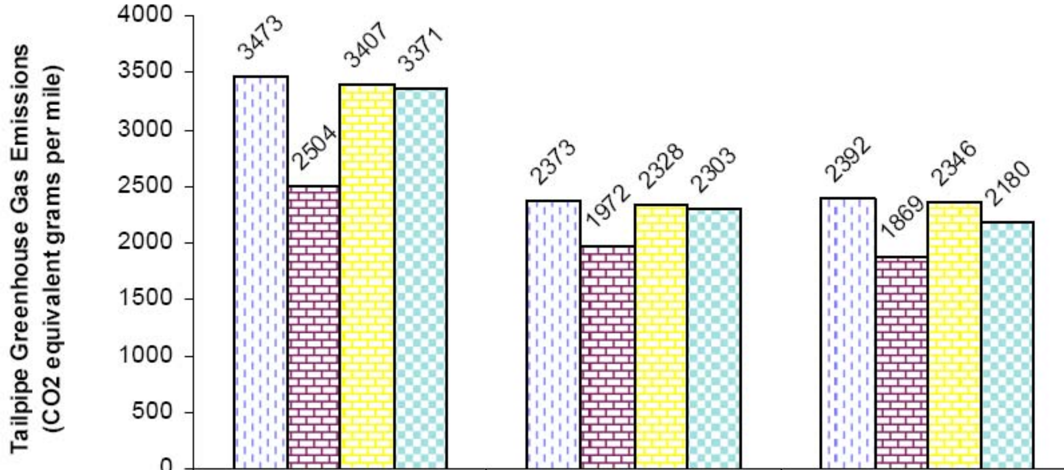
8.2 Fuel and Propulsion

The benefits derived from the use of alternative fuels or propulsion can be as difficult to quantify as those from vehicle selection. For some communities or applications, public perception and green initiatives may justify increased costs for alternative fuels. Other transit providers may find operating and maintenance costs prevent the introduction of new fuels. Multiple research projects currently focus on life cycle costs of alternative fuel transit vehicles. These will provide information that will be very helpful in planning fuel selection. Figures 8.1-8.5 show results from an FTA-sponsored study conducted by West Virginia University (Clark et al. 2007). They show estimated bus cost and emissions data for standard 40-foot buses. Due to limited experience and evaluation of alternative fuels, this information is not currently available for small transit vehicles. Furthermore, it is difficult to obtain reliable averages for the small transit market, due to the broad range of technologies, sizes and applications of small vehicles. Comparisons between fuels can be made from the standard bus data, though total capital costs will differ significantly. Capital and operating costs are based on running a 100-bus fleet. Analysis of these data must be left to particular transit providers to address their specific applications.



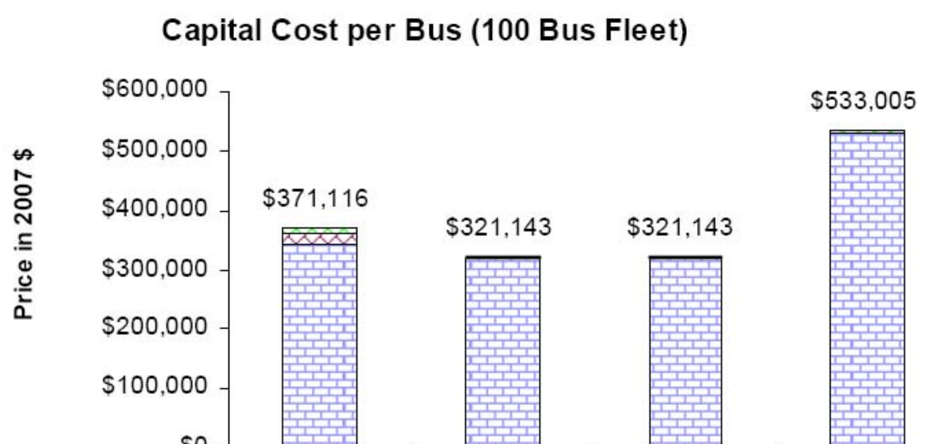
	MAN	OCTA	CBD
B20 Biodiesel	0.027	0.017	0.022
Diesel Hybrid	0.013	0.006	0.017
Diesel	0.034	0.021	0.028
CNG	0.057	0.010	0.023

Figure 8.1 Estimated Model 2007 Standard 40-foot Bus Particulate Matter Emissions



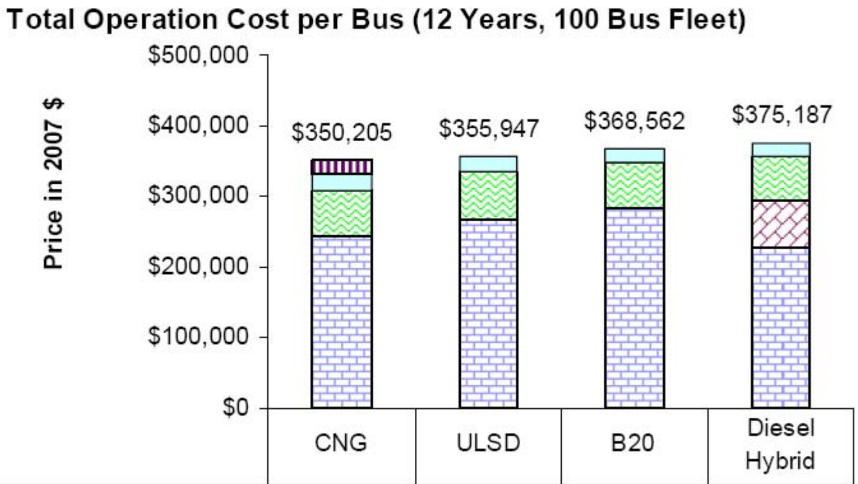
	MAN	OCTA	CBD
B20 Biodiesel	3473	2373	2392
Diesel Hybrid	2504	1972	1869
Diesel	3407	2328	2346
CNG	3371	2303	2180

Figure 8.2 Estimated Model 2007 Standard 40-foot Bus Greenhouse Gas Emissions



	CNG	ULSD	B20	Diesel Hybrid
Total	$371,116	$321,143	$321,143	$533,005
Emissions Equipment	$0	$1,434	$1,434	$0
Depot Modification	$8,750	$0	$0	$1,400
Refueling Station	$20,000	$0	$0	$0
Vehicle Cost	$342,366	$319,709	$319,709	$531,605

Figure 8.3 Average Capital Cost per 40-foot Bus in a 100 Vehicle Fleet



	CNG	ULSD	B20	Diesel Hybrid
Total	$350,205	$355,947	$368,562	$375,187
Compression Electricity	$19,003	$0	$0	$0
Facility Maintenance	$24,433	$20,723	$21,039	$17,470
Propulsion-related System Maintenance	$62,588	$66,394	$62,706	$63,589
Battery Replacement	$0	$0	$0	$67,500
Fuel Costs	$244,181	$268,830	$284,818	$226,629

Figure 8.4 Average Operating Cost per 40-foot Bus in a 100 Vehicle Fleet

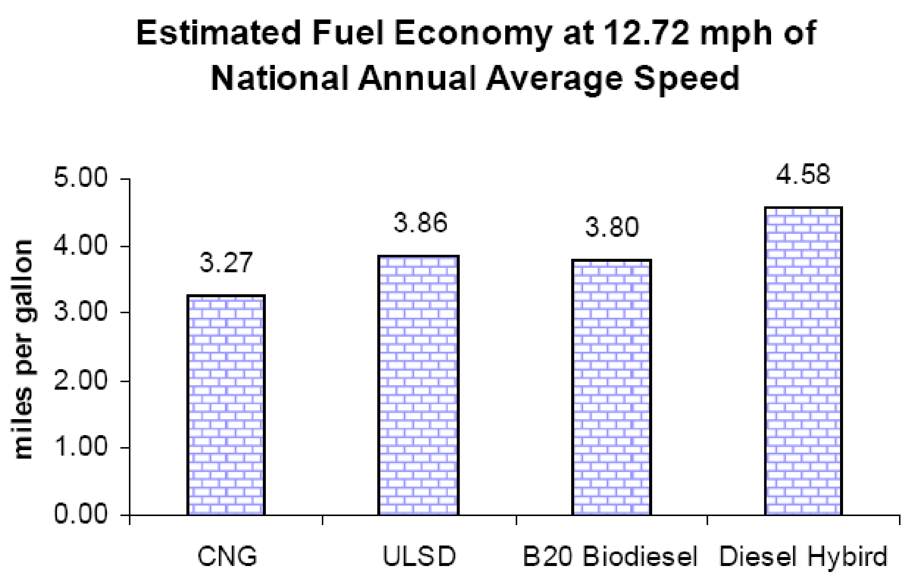


Figure 8.5 Average Fuel Efficiency in Standard 40-foot Bus

Table 8.2 Average Fuel Prices

Fuel	Avg. Cost per Gallon
Gasoline	$2.22
Diesel	$2.62
CNG*	$1.77
E85	$2.11
Propane	$2.33
B20	$2.66
B2-B5	$2.75
B99-B100	$3.31

*CNG price reported per gallon gasoline equivalent (GGE).
(DOE 2006)

8.3 Accessibility

Analysis of accessibility technologies will be restricted to floor height and wheelchair equipment. It is estimated that the cost differential for a low-floor small transit vehicle is $100,000 over a standard high-floor model. Based on the results of one report examining the experiences of five different transit agencies, ambulatory passenger boarding times decreased almost 20% (avg = 0.83s, s = 0.63s), and alighting times decreased almost 40% (avg = 1.1s, s = 0.71s) on low-floor compared to standard buses (King 1998). These data are reported for standard 40' buses, and must assume differences in maneuverability within the vehicle, to be applicable to small transit vehicles. Averaging two stops per mile throughout a 200,000 mile vehicle lifetime, this works out to about $0.125/s in reduced dwell time.

Boarding times for non-ambulatory passengers vary widely based on the individual and operator as well as the vehicle. For the purposes of this report, a cost-benefit analysis will be included for ramps and lifts. To meet ADA requirements, the necessary length of a ramp for standard floor vehicles is often too large to be practical. The choice of a ramp versus a lift is directly related to the height of the vehicle floor. Additionally, issues such as number of doors, and presence or lack of a curb, will affect these decisions. The current average capital cost of a lift is about $8000, and the cost of a ramp averages around $3500. Based on a study of transit during the 1996 Paralympics in Atlanta, powered operation of a lift and ramp both averaged about 11s for deployment or stowage. Manual operation of a ramp showed slight improvement, averaging about 8s for deployment and 9s to stow. This was a very limited study (some data only included two observations) and does not provide enough information to compare total boarding or alighting times. However, it is unlikely there is a significant difference in dwell time between automated lifts and ramps. Since there are many other factors to consider when choosing accessibility options, a more complete analysis must be performed by the transit provider.

8.4 ITS

Cost-benefit data for ITS equipment are reported in detail by the US Department of Transportation (DOT) ITS Joint Program Office. Table 8.3 shows a list of transit related components. These technologies are described in detail in the Developing Technologies section earlier in this report. The capital costs included in the table are for on-board vehicle equipment only, and do not include necessary infrastructure costs. Lifetimes for the listed equipment varied from seven to 10 years, which is longer than the average lifetime for small transit vehicles. Again, finite quantitative cost-benefit analysis must be performed for each procurement. In selecting multiple ITS technologies, the vehicle's electrical system must be able to handle the increased demand. This can be met with different alternators and multiplexer systems, the costs of which, if required, would need to be considered as well. Integrating too many components onto a vehicle will also decrease space available to the driver and passengers and increase capacity.

Table 8.3 ITS Component Costs-Benefits

Technology/ Equipment	Avg. Capital Cost	Estimated O&M Cost per year	Benefit Example
CAD Terminal	$400	$108	Kansas City, MO reduced required fleet size 10% without a reduction in service after the introduction of AVL/CAD technology. The Denver, CO RTD decreased late arrival by 21% with the same technology.
GPS	$1,250	$24	See above.
TSP	$1,650	$7	Experience in 10 cities show a -2% to 20% decrease in bus travel times.
Security (CCTV + Emergency Button)	$4,600	$180	Ann Arbor, MI passengers noticed the introduction of surveillance equipment, but only reported sensing an increase in security at night.
Electronic Farebox	$850	$45	Ventura, CA estimated savings of $9.5 million per year through decreased fare evasion, $5M in data collection costs and $990,000 in decreased use of transfer slips.
APC	$5,625	$3	Employing dynamic scheduling (including radio use and APC's) San Jose, CA, paratransit increased shared rides from 38% to 55% and decreased fleet size from 200 to 130 vehicles.
Navigation	$2,400	-	Turin, Italy reported travel time decreases of 10% in personal vehicles equipped with navigation systems.
Radio	$185	$9	See APC example.

9. LIFE-CYCLE COSTING

The estimated life-cycle costs of ownership for advanced cutaways and for conventional vehicles are projected in Table 9.1. These projections are based on a combination of known factors (current fuel economy and current maintenance costs) and estimated factors such as purchase cost and battery pack life. Table 9.1 shows the total cost, including the full value of the purchase cost, and the cost to a specific state agency, assuming that the current purchase cost subsidy by the federal government (80%) remains in effect. The table also makes comparisons between the life-cycle costs of hybrid, low-floor, hybrid low-floor and conventional cutaway vehicles.

(Please note that the data presented in Table 9.1 is based on projections obtained by the Small Urban & Rural Transit Center through committee meetings, surveys, and related research. The cost projections will vary from state to state and from transportation provider to transportation provider and are only meant to serve as a means for further discussion.)

9.1 Comments on Cost Estimates

Purchase Price

The numbers listed in the table are approximate current costs. It is expected that the ASTV purchase costs will decrease as production volumes increase. For the "Total Cost" columns, the full purchase prices are listed. For the "Cost to State" columns, the prices are based on the current federal subsidy of 80% on transit vehicles.

Brake Maintenance

The numbers shown are based on brake service performed on a conventional cutaway over a six-year period in a rural service area and the expectations for new ASTV vehicles.

Fuel

The numbers shown are for 150,000 miles of service at eight MPG for the conventional cutaway and 12 MPG for the hybrid model, at a fuel price of $3 per gallon.

Table 9.1 Life-Cycle Cost Estimates (5-7 years, 150,000 miles)

	Total Cost		Cost to State	
	Conventional Cutaway	**Hybrid Cutaway**	**Conventional Cutaway**	**Hybrid Cutaway**
Purchase Price (80/20)	$50,000	$150,000	$10,000	$30,000
Brake Maintenance	8,000	6,000	8,000	6,000
Fuel ($3/gallon, conventional 8mpg, hybrid 12mpg)	55,000	37,000	55,000	37,000
Battery Replacement	0	10,000	0	10,000
Other Normal Miscillaneous Maintenance	17,000	15,000	17,000	15,000
Increased Revenues				
Ridership Increase (3%/yr due to improved public perception) (Assuming 50,000 base rides/yr at $3 per ride)	0	27,000	0	27,000
Total Cost	**$130,000**	**$191,000**	**$90,000**	**$71,000**

	Total Cost		Cost to State	
	Conventional Cutaway	**Low-Floor Cutaway**	**Conventional Cutaway**	**Low-Floor Cutaway**
Purchase Price (80/20)	$50,000	$100,000	$10,000	$20,000
Brake Maintenance	8,000	6,000	8,000	6,000
Fuel ($3/gallon)	55,000	55,000	55,000	55,000
Battery Replacement	0	0	0	0
Other Normal Miscillaneous Maintenance	17,000	15,000	17,000	15,000
Increased Revenues				
Ridership Increase (3%/yr due to improved accessibility) (Assuming 50,000 base rides/yr at $3 per ride)	0	27,000	0	27,000
Total Cost	**$130,000**	**$149,000**	**$90,000**	**$69,000**

	Total Cost		Cost to State	
	Conventional Cutaway	**Hybrid Cutaway**	**Conventional Cutaway**	**Hybrid Cutaway**
Purchase Price (80/20)	$50,000	$175,000	$10,000	$35,000
Brake Maintenance	8,000	6,000	8,000	6,000
Fuel ($3/gallon, conventional 8mpg, hybrid 12mpg)	55,000	37,000	55,000	37,000
Battery Replacement	0	10,000	0	10,000
Other Normal Miscillaneous Maintenance	17,000	15,000	17,000	15,000
Increased Revenues				
Ridership Increase (5%/yr due to improved accessibility & public perception) (Assuming 50,000 base rides/yr at $3 per ride)	0	45,000	0	45,000
Total Cost	**$130,000**	**$198,000**	**$90,000**	**$58,000**

Battery Replacement

The current expectation is that the battery pack will need replacement once during the life of the hybrid cutaway. Only time will tell if this is realistic, but the reliability for batteries of this type (nickel-metal-hydride) has been improving in hybrid automobiles.

Other Normal Miscellaneous Maintenance

The numbers shown are estimates based on previous research data from rural transit agencies. This will vary widely and the ASTV models are assumed to incur less of this cost due to their advanced technologies.

Ridership Increases

Increased ridership assumes an improvement to the transit agency's public image based on its implementation of hybrid and low-floor technology in its transit fleet. The low-floor technology will improve accessibility to vehicles, allowing for ease of loading and unloading passengers, increasing the overall service efficiency within the agency. Throughout this research effort, transit agency managers highlighted the marketability of implementing advanced technologies in their vehicles. They felt it would improve their public image and lead to an increase in ridership.

10. ASTV FEASIBILITY

Based on the above estimates, within the current market, any low-floor alternative fuel small vehicle is going to cost more than $125,000. With that large a differential, the benefit most needed to justify the cost would be increased useful life. An ASTV would need to operate about three times longer than current small transit vehicles to justify the cost differential. This is reasonable to accomplish if an ASTV could be designed to reach the 12-year useful life of standard buses. While including ITS technologies, infrastructure and maintenance will increase the cost, benefits gained from service and operating improvements could potentially create an economic argument for ASTV deployment.

In determining the potential for a new ASTV design, there are many issues to consider in addition to a basic cost and benefit analysis. It is important to consider previous experiences in which a new vehicle was designed independently of market driven development. In the last 30 years, the FTA (formerly as UMTA) has twice supported the design of advanced vehicles to improve domestic bus production. Neither of these attempts was successfully adopted by manufacturers. However, many of the features of these buses have become integrated into the transit industry. With the ASTV, the desired technologies are already available but need to be commercialized in the small transit market. The three divisions within this market present further complications. To fill the needs of the whole market, a vehicle would have to be flexible enough to carry 20 passengers but still be accessible and affordable enough to effectively serve paratransit needs. The necessary advancements have been made, with both Brevi and Ebus designing 22' vehicles with the flexibility of a standard bus layout. These designs also have the potential to meet the problems associated with service coordination. Standard flip-up transit seating can be installed to allow a single vehicle to serve as a suburban feeder bus or on a paratransit route. There would be more difficulty in providing after school transportation, due to the inflexibility of FMVSS requirements. The most restrictive standards are the seat spacing and crash-worthiness requirements. The MFSAB dictates short spacing between seats to provide compartmentalization restraint for passengers. This restricts accessibility of the standards for full grown adults. The construction of an MFSAB differs from most transit vehicles in order to meet rollover and crashworthiness standards. In an already funding limited industry, developing a production vehicle that is flexible enough to coordinate school and transit services is greatly hindered by these requirements. FTA is encouraging ongoing vehicle development projects to address the FMVSS requirements.

Overall, this analysis shows the technology necessary to make an ASTV feasible is already available. With some assistance and coordination between transit providers and manufacturers, an ASTV could become readily available in the near future.

10.1 Phase II Analysis

Three concepts have been identified as options for Phase II of the ASTV project:

1. Federally guided coordination of procurement practices, design considerations and vehicle selection.

   Deliverables: Recommendation Guide for State DOT distribution of 5310/5311 funds; ASTV Design Features; Guide/Workshops for Writing Small Transit Vehicle Procurement Specifications, Evaluations of Current Advanced Small Transit Vehicles, Comprehensive Vehicle Component Cost-Benefit Study, Analysis of Including FMVSS School Transportation Requirements in Transit Vehicles

   Estimated Cost: $100,000 per report

   Notes: As part of an industry wide standards development effort, APTA has begun developing a "white book" of procurement specifications for transit vehicles under 30' in length.

2. Federally supported demonstration and evaluation program of several vehicles as potential prototypes for an ideal ASTV.

   Deliverables: Evaluation report for each demonstration; Report comparing demonstration experiences

   Estimated Cost: $500,000 per demonstration

3. Federally supported design and demonstration of unique ASTV, meeting MFSAB FMVSS requirements, in cooperation with manufacturers to speed commercialization.

   Deliverables: Prototype ASTV and Demonstration Evaluation Report

   Estimated Cost: $1,000,000

11. SUMMARY AND CONCLUSIONS

When this research effort began nearly two years ago, advanced technologies in large transit buses were becoming widely available while similar technologies in small transit vehicles were lagging behind. Presently, advanced technologies are becoming more readily offered in small transit vehicles, although at a much higher price compared to their standard counterparts. The lack of procurement standards or guidelines for small vehicles has played a part in the development of a wide assortment of vehicles and technologies currently offered. Rural transit operators have neither the budget nor the time to stay updated on the changes that are occurring. There is an element of fear in that buying new technologies for their vehicles will not benefit their agency or clientele.

This research has concluded that a “white book” should be developed for small transit vehicle procurement. APTA is currently working on such an effort. This document would provide guidelines for small vehicle procurement that could be utilized by small and large transit agencies alike. Its availability would lessen the fear smaller agencies encounter when attempting to procure new vehicles. Also, state DOTs that handle much of the procurement for smaller agencies would be aided by such a document. Manufacturers could also look to the document for recommendations associated with new vehicle development.

Stakeholder meetings were very helpful throughout this research in determining the current market for small transit vehicles and the needs of transit professionals. Additional meetings should be held to discuss the applicability of small transit vehicle standards to the industry. APTA may already be planning this for one of their upcoming conferences. If a demonstration project is developed to use advanced transit vehicles within different markets, a group of professionals should be assigned to determine the proper markets in which to conduct such an endeavor.

The idea of advanced technologies in small transit vehicles is beginning to take hold throughout the industry. The initial cost is the largest barrier most agencies face when trying to implement new technology. Increasing production volumes of advanced technology vehicles will lead to a decrease in current procurement costs. The increasing cost of energy will only speed the transition to hybrid drive technologies. All agencies will begin to see the benefit of such technologies and incorporate them wherever and whenever they are available.

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13. ACRONYMS AND ABBREVIATIONS

ADA – Americans with Disabilities Act
APC – Automatic Passenger Counter
APTA – American Public Transportation Association
ASTV – Advanced Small Transit Vehicle
AVL – Automatic Vehicle Location
B20 – Biodiesel (20% diesel blend)
CAD – Computer Assisted Dispatching
CBD – Central Business District
CNG – Compressed Natural Gas
CTAA – Community Transportation Association of America
DOT – Department of Transportation
E85 – Ethanol (85% gasoline blend)
FMVSS – Federal Motor Vehicle Safety Standards
FTA – Federal Transit Administration
GPS – Global Positioning System
HEV – Hybrid Electric Vehicle
ICE – Internal Combustion Engine
ITS – Intelligent Transportation Systems
IVBSS – Integrated Vehicle Based Safety Systems
LNG – Liquefied Natural Gas
MAN – Manhattan Bus Operating Cycle
MFSAB – Multi-Function School Activity Bus
MPG – Miles Per Gallon
NDSU – North Dakota State University
NHTSA – National Highway Traffic Safety Administration
OCTA – Orange County Transit Authority
PEM – Polymer Electrolyte Membrane
PTI – Pennsylvania Transportation Institute
SURTC – Small Urban and Rural Transit Center
TSP – Traffic Signal Priority
TVM – Ticket Vending Machine
ULSD – Ultra-low Sulfur Diesel
VAA – Vehicle Automation and Assist
WVU – West Virginia University