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Bus Rapid Transit

Vehicle Demand and Supply Analysis

September 2002

U.S. Department of Transportation
Federal Transit Administration
Office of Research, Demonstration and Innovation
Office of Mobility Innovation, Service Innovation Division

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FOREWORD

This report represents one part of an effort to provide information to the U.S. transit authorities on activities related to Bus Rapid Transit (BRT).

NOTICE

Preface

This report was prepared by CALSTART, Inc., the California operating division of WestStart. The data contained in this report includes planning information that carries a degree of uncertainty. While it may reflect current thinking of transit properties relative to Bus Rapid Transit, the specific quantities or timing may not occur and the preferences identified now may change in the future. Likewise, data from the U.S. manufacturing sector reflects current information that also may be subject to change in the future.

Acknowledgements

The Federal Transit Administration (FTA), Office of Mobility Innovation, sponsored the report. CALSTART would like to acknowledge the contributions that made this report possible. The study was conducted through telephone interviews, face-to-face interviews and email questionnaires. The authors would like to express their sincere appreciation to the many people that made time in their busy schedules to provide their insights, data and observations that are the heart of this report.

The participants included FTA officials, community transit representatives, manufacturers and suppliers, and other industry stakeholders. All participants contributed valuable information, ideas, suggestions, viewpoints and perspectives on BRT plans and topics. CALSTART paraphrased comments, aggregated data and compiled numbers to profile the community demand and the manufacturers' perspective. CALSTART also appreciates the reviews and clarifications provided by the participants.

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1.0 Introduction

1.1 About the "Vehicle Demand and Supply Analysis" Study

Signature vehicles and related technologies have been slow to emerge from the U.S. bus-manufacturing sector. The "Action Plan for a Thriving BRT Market" is a set of planned activities, developed through a series of FTA Workshops with industry, which addresses the impediments to Bus Rapid Transit (BRT). The "Action Plan" deliverables relate to the five major aspects suggested by the industry: 1) Marketing, 2) Proactive Vehicle Deployment, 3) Data Collection and Evaluation, 4) Streamlining Project Development and 5) Partnerships with U.S. Manufacturers.

The focus for "Partnerships with U.S. Manufacturers" is on the domestic bus-manufacturing sector in a global context. Through those partnership-activities, the FTA intends to identify more effective ways to encourage the supply of U.S. made vehicles to the U.S. BRT Communities. Industry stakeholders requested that a study be performed to characterize the U.S. "demand" for vehicles suitable for use in BRT service settings. On the manufacturing side, the stakeholders requested that the study address the U.S. manufacturers' intentions and capabilities to "supply" the requisite vehicles and technologies. This report is a response to that request.

The report documents data from interviews with transit properties and from public documents about their plans for implementing BRT corridors. The "demand" portion compiles information about the quantities of vehicles, delivery timing and vehicle preferences such as vehicle type, dimensions, floor style, propulsion, image and appearance, as well as supporting technologies such as automated vehicle location (AVL), signal priority, cashless fares, and other infrastructure. The data is classified as "firm," "near firm" or "planning," depending on the degree of certainty the respondents felt about the data provided. The results are based on aggregating and cumulating the data over the period from 2002 to 2012.

CALSTART staff then contacted and met with vehicle manufacturers to discuss their development activities, current and future vehicle production plans and capabilities. The discussions with manufacturers emphasized the vehicles as part of a BRT system. The vehicle and technology preferences, as expressed by the BRT communities studied, guided the manufacturer interviews. From those interviews and also from public documents, an aggregate view is developed about the ability to supply vehicles for BRT now and in the near future.

Implications are drawn from the combining of the community and the manufacturer study results. The implications concentrate on the preferences for vehicle characteristics, and what issues the manufacturing sector may face with these preferences. What emerges is a perspective on the vehicle features desired to support BRT plans, the factors affecting availability of the vehicles with these features and a set of proximate topics that overlay the availability issues. These overlaying topics are not a set of conclusions or recommendations but are topics that, the manufacturers' suggest, may be important for future industry dialogue.

1.2 Organization of this Document

Section 2 of this document is an Executive Summary with major findings reflecting the Community Study Results, Manufacturer Study Results and the Study Implications.

Section 3 documents the background for this work, amplifying the three-fold purpose in terms of 1) the Community Study, 2) the Manufacturers Study and 3) the Study Implications. Section 3 also delves into the goals and approach to the Community Study.

Sections 4 and 5 present the detailed results from both studies. First, Section 4 documents the Community Study Results plus provides a concise summary of the vehicles and community preferences. Section 5, the Manufacturers Study Results, deals with the study of the U.S. manufacturing sector. The leading sub-sections of Section 5 discuss the goals and approach for the Manufacturers Study. The results of the Manufacturers Study are in the later sub-sections of Section 5.

The final Section 6, Study Implications, combines the results of the studies and analyzes the implications from the two studies. More detailed information can be obtained on this Study and analysis by contacting CALSTART or the principle investigator.

2.0 Executive Summary and Major Findings

2.1 Study Purpose and Approach

Public transportation as the mode of choice is a key element of the Bus Rapid Transit (BRT) Vision. A family of BRT systems is envisioned as a high-quality transit service featuring high-capacity, modern bus-type vehicles. These vehicles, combined with ITS technologies and operational improvements, offer a speed and capacity service-expansion alternative for public transportation. The desire is to lower the capital and operating costs of service expansion while enhancing the image of bus transportation.

The three-fold purpose of this study and analysis is to: 1) characterize the U.S. market demand for vehicles by BRT Communities (Community Study), 2) study the domestic bus manufacturers' ability to meet that demand (Manufacturers' Study), and 3) identify issues and implications of the Studies (Study Implications). An interview approach was used to capture the data. Aggregation and analysis of the data leads to a discussion of implications based on the participants' perspectives.

2.2 Major Findings

2.2.1 Community Study Findings

The Community Study compiles and aggregates data from the BRT communities on their BRT plans with the objectives of quantifying vehicle deliveries and timing as well as vehicle and supporting technology preferences. Data capture is through interviews with transit properties and through review of public documents. Communities selected for contact are listed in the Table 1 below. Information has been compiled on twenty-two of the twenty-eight.

Table 1 - Transit Communities Contacted for the Study

AC Transit	**Cleveland**	**Honolulu**	**New York**	**San Diego**
Albany	**Denver***	**Las Vegas**	**Dulles Corridor**	**San Juan ***
Atlanta *	**El Paso**	**Louisville**	**Orange County**	**Santa Clara**
Boston	**Eugene**	**Los Angeles**	**Orlando***	**Seattle**
Charlotte *	**Fort Collins**	**Miami**	**Phoenix**	*** No detailed data available for study**
Chicago	**Hartford**	**Montgomery Cty.**	**Pittsburgh ***	

<u>Vehicle Type and Number.</u> The aggregate total of 5004 vehicles is anticipated for potential delivery in the period 2002 to 2012. These vehicles are broken into three basic categories, based on information provided by the community participants:

•	Articulated vehicles	60-65 feet	3,117
•	Non-articulated vehicles	40-45 feet	1,244
•	Non-articulated vehicles	30-35 feet	643

Artic Delivery Rate. The highest average number of Articulated vehicle (Artic) deliveries is 400 per year during the study time period of 2002 to 2012. These vehicles, as well as the shorter vehicles, represent a service expansion and are expected to add to the present annual replacement of transit vehicles.

Artic Vehicle Propulsion. Interest is growing in vehicles with hybrid drive systems and a preference for low emissions compared to previous years:

- Two-thirds (2,104) are planned for diesel internal combustion engines
- One third (1,013) are planned as hybrid powered
- Low sulfur diesel is specified for over 70 percent of the diesel-fueled vehicles
- CNG is planned for 1,340 (44%) of the Artics with 15 considering LNG

Artic Floors, Doors. Most preferred are continuous low-floor and 3 doors:

- 782 (25%) vehicles - no door preference at this time
- 613 (20%) vehicles - 2 door openings
- 1,512 (48%) vehicles - 3 door openings, two double-stream
- 210 (7%) vehicles - 4 or more openings and both right and left side
- 3,081 (99%)vehicles - continuous-low floor preferred

Articulated Vehicle Appearance, Features. Responses revealed:

- A preference for a "rail like, sleek, modern, futuristic" look by over 3.7 to 1 relative to "paint, branding and logo" (2,457 to 660).
- Low noise is a priority for 42 percent (1,321) of the Artics.
- Docking "guidance" is considered for 37 percent (1,139) of the Artics.

Non-articulated 40-45 foot Vehicle. Conventional external appearance, with branding and logos, is preferred. Propulsion system selections are traditional but fuel choices are more open. Door and floor selection also are largely open. Passenger comfort and amenities are also important. The preferences are more conventional for this length vehicle:

- Most (1,204) plan "branding/logo" with only 40 desiring "unique image"
- Internal Combustion Engine (ICE) dominated the 1,244 buses planned with only 30 open to hybrid power and 3 were planned for fuel cell power
- Fuel is not specified for 667 vehicles
- CNG (260), diesel/low sulfur diesel (125) and LNG (159) are planned
- Door selection for 780 out of 1,244 is open; while 40 prefer 1 door, 404 prefer 2 doors, and 20 desired 3 doors
- 425 had not selected floor height; 512 plan for continuous-low floor, 267 a step-low-floor and 40 a standard floor

Non-articulated 30-35 foot Vehicle. One community may plan to support their BRT expansion with 30 foot feeder vehicles using an estimated 600 vehicles. Preference is for a unique image, low-floor-with-step vehicle with 2 wide door openings.

Infrastructure. Many of the communities were already implementing or are planning some form of AVL (61% of corridors), signal priority (64%), off-board fare collection (55%), on/off board information signage and audio call out systems (30 – 51%). Exclusive, dedicated or reserved guide ways, plus HOV or BAT-share lanes, are prevalent (57%); and mixed combinations of these and mixed traffic brings the number to 89% of the corridors. Queue jump or exclusive ramps are planned for only a few corridors (8%).

For about one third of the corridors, only limited planning information was available so all of these numbers many well increase. For the most part, stops and shelters are planned with branding but not necessarily with rail like amenities except for information and fare collection.

2.2.2 Manufacturer Study Findings

The Manufacturers' Study explores U.S. manufacturers' supply capabilities in the competitive, global market context from data developed through meetings and interviews. Key points of discussion are present and future production plans and the Community Study preferences. Not all manufacturers contacted in Table 2 responded.

Table 2 - Manufacturers Contacted for Study

Chance Coach, Inc.*	**NEOPLAN USA Corporation**	**Nova Bus***
GILLIG Corporation	**New Flyer of America**	**Orion Bus Industries Inc. ***
Motor Coach Industries*	**North American Bus Industries, Inc**	**TransTeq**
*** Contacted and only partial information provided for this preliminary report.**		

The Community Study data indicates that the vehicles desired by the communities represent a service expansion rather than replacement vehicles. The manufacturers have the capacity and the growth flexibility to respond to the quantities. For example:

- Current Backlog is typically 15 months, ranging from 8 to 20 months
- Backlog Growth is mixed - some are at industry growth rate, some flat or negative
- Manufacturing Capacity is more than 6,000 vehicles per year with 1 shift
- Manufacturing Capacity can grow, preferably through addition of fractional shifts

The manufacturing sector has an increasing number of models available. Research and development is also creating a growing selection of propulsion systems and fuels, electronics, comfort and amenity options plus styling, materials and maintainability changes. Highlights of the models available for order include:

- Three 60-65' Step-Low Floor Articulated Vehicles

- Eight 40-45' Step-Low Floor Non-articulated Vehicles
- Three 40-45' Continuous-Low Floor Non-articulated Vehicles
- Nine 30-35' Step-Low Floor Non-articulated Vehicles
- Three Artics offer diesel power, two CNG, one LNG and one Dual-Mode Hybrid

Research into noise reduction and hybrid propulsion or reduced emission propulsion systems is definitely a priority with the dominant manufacturers. The following are in some stage of development by the U.S. manufacturers:

- 4-5 New Articulated models plus 2-3 40-45' models
- 4 Parallel and 2 series-hybrid Non-artics (7 R& D supplier partners available)
- 3 Fuel cell bus programs

2.2.3 Study Implications

The Implications Section combines the results of Community preferences and the Manufacturers responses to answer the question: can the manufacturers supply the vehicles for BRT community plans? The answer depends on the type of vehicle:

- Domestic manufacturers are not now delivering a Community preference - 60-65' Continuous-Low Floor Artic, with Sleek, Modern, Futuristic or even Rail-like appearance (suggesting "speed" or new), Quiet, and with Docking Guidance
- Some properties seeking such vehicles have gone overseas
- This is a "product" issue not a "capacity" issue
- For 30-35' and 40-45' vehicles, models are currently being delivered by the domestic manufacturers that will satisfy the majority of the transit properties

The analysis of the demand and the supply, from both perspectives, defines some implications. Listed briefly here are the highlights for future industry dialogue:

- **Appearance.**

  Communities Prefer - Sleek, Modern, Futuristic or even Rail-like appearance suggesting "speed".
  Manufacturers' Response - Sleek, Modern, can be supplied whereas Futuristic or "Rail-like" can be supplied but the style changes are in the "beholders' eye" and so needs more definition or convergence to minimize customization.

- **Continuous-Low Floor.**

  Community – adds to appearance, bus appeal, and door placement options.
  Manufacturers – reduces seating capacity, affects components selection and creates a maintenance access issue, but can be available with industry input.

- **Quiet.**

  Community – interior **and** exterior noise reductions are definitely important.
  Manufacturers – all are addressing noise control, EPA rules may require added engine cooling increasing fan noise; hybrids can help but will take time and aggressive sound control is possible with engineering and investment.

- **Docking Guidance.**

  Community – adds to system speed and bus image/appeal.
  Manufacturers – some test program experience, development is being spurred by bus collision avoidance systems, potential for a low cost system with a little time.

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3.0 Study Plan and Design

3.1 Purpose of the Vehicle Demand and Supply Analysis

The study purpose is to characterize the U.S. demand for vehicles by BRT communities and the capability of the U.S. manufacturers to meet that demand or implications. The study three-fold purpose is broken down into three elements that are highlighted as goals in the Table 3 below. The goals are to gather data from both transit properties and the domestic manufacturers and to develop implications about the demand and supply from the community and manufacturing sector perspective.

Table 3 - Study Three-fold Purpose

BRT Community Vehicle Demand and Supply Study Elements	
Study Element	**Element Goal**
Communities Study	**Characterize the U.S. Transit Properties' demand for vehicles to support BRT Corridor service plans**
Manufacturers Study	**Explore the ability of the U.S. Bus Manufacturing Sector to meet the transit properties' demand for vehicles**
Industry Implications	**Develop implications about the issues and a perspective for possible future dialogue**

After characterizing what the communities want in the vehicles for their BRT plans, the Manufacturers' Study data will help answer the question: Can domestic bus manufacturers meet the community demand? Answering this question entails exploring the concerns and issues raised by the bus-manufacturing sector. The intent of the implications section is to show an aggregate view of each issue from both the community and manufacturing perspectives. Implications so developed may suggest some answers or provide a focus for future dialogue or actions. Note that defining or even suggesting future actions **is not** part of this task.

3.2 Community Study Goals, Objectives and Approach

Accomplishing the over-all purpose starts first with the capture of data from the communities. An interview approach is the main tool for this study. This subsection details the goals, objectives and approach for collecting the information from the BRT communities.

The specific goal of the Community Study task is to compile information about each transit property's BRT corridor plans and strategies for the time period 2002 to 2012. This task accumulates the following information by identified BRT corridors (if available) as shown in the Table 4 below.

Table 4 - Community Study Goals: Capture BRT Plans and Vehicle Information

- **Quantities of vehicles – by corridor for each community**
- **Vehicle delivery timing – by corridor**
- **Vehicle characteristics – by corridor**
  - **type, dimensions, doors and interior design, propulsion and fuel, image and exterior requirements**
- **Supporting technologies and infrastructure – by corridor**
  - **vehicle guidance, vehicle location (AVL), signal interface, information display, fare collection, lane/right-of-way and design features, station requirements**
- **Respondents rate information as – "firm," "near firm" or "planning" numbers depending on the estimated certainty of project elements.**

This study uses an interview format and, at times, will have limited or incomplete data. Some transit properties are not far enough along in their planning to provide detailed data for the study. The rating of firm (80-100% certainty), near firm (50- 80% certainty) or planning numbers (50% or less certainty) was compiled but was not used to discount the numbers. The results are not a statistical "projection" but rather a simple cataloging of data.

The objective of capturing this data is to determine the quantities and what types of vehicles the communities' desire to complete their BRT plans. The "what" is culled from "preferences" expressed in the interview data. In some cases, more than one choice was being considered but for the data compilation here, the primary selection is used.

The data is cast in charts, to suggest the rough trends in the size and character of the BRT demand for vehicles over the years 2002-2012, from the communities studied. Specific objectives for the formulation and presentation of this data are listed in Table 5.

Table 5 - Community Study Objectives for Results

- **Aggregate the number of vehicles planned for delivery each year from 2002 to 2012, by type**
- **Cumulate potential vehicle deliveries by type (2002-2012)**
- **Quantify demand for specific vehicle characteristics (propulsion, fuel, doors, floors and appearance), by vehicle type**
- **Identify and quantify, by corridors, specific BRT support technologies and infrastructure**

This study task is a direct result of an "Action Plan" line item. The approach was to execute the steps shown in Table 6. At earlier BRT Workshops, meetings with the FTA officials, U.S. bus manufacturers and transit properties helped identify some important data items recommended for inclusion in the initial study.

Table 6 - Approach to the Study

- **Discuss stakeholder analysis interests at workshops**
- **Formulate the Community Study goals and objectives**
- **Select the Communities for the study**
- **Compile BRT corridor background data on communities**
- **Interview key BRT contacts at the communities**
- **Compile data into spreadsheets with narrative notes**
- **Create trend charts, analyze and evaluate the data**
- **Prepare a narrative report**

Based on these meetings and workshop participation, the CALSTART staff formulated the community study goals and objectives resulting in a set of questions for transit communities. Next, after selecting a set of communities, data was captured through review of public documents and direct interviews or meetings with transit properties. The data was reviewed and analyzed resulting in this preliminary report.

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4.0 Community Study Results

This Section provides an initial "snapshot" in time of a very dynamic and evolving process of enhancing transportation systems in the U.S. by adding BRT system technologies. The data contained in this section includes planning information that carries a degree of uncertainty. While it may reflect current thinking of transit properties relative to Bus Rapid Transit, the specific quantities or timing may not occur and the preferences identified now may change in the future.

4.1 Transit Properties in the Study

The Transit Properties pursued for responses for the study are identified alphabetically in Table 7. The potential total vehicle quantities identified for each respondent are shown in the columns on the right. The quantities represent the sum over the years 2002-2012 of potential deliveries by vehicle type for all corridors discussed with the responding community contacts. For some of the listed "communities," more than one transit property may be planning BRT corridors in the "region" of the listed community. The vehicle types are defined simply as 60-65' Articulated vehicles (Artics), and Non-articulated vehicles with lengths of either 40-45' or 30-35'. Some information was unavailable at the time of this draft for some of the communities contacted leaving blank cells in Table 7. The timing of these quantities of vehicles will be provided in later charts and graphs.

Table 7 - Communities, Contact(s) and Vehicle Totals from the Study

Community	Contact(s)	Potential Vehicle Quantities		
		Artics	40-45'	30-35'
AC Transit	Alameda-Contra Costa Transit District (AC Transit)	82	60	
Albany	Capital District Transportation Authority (CDTA)		20	
Atlanta *	Metropolitan Atlanta Rapid Transit Authority (MARTA)			
Boston	Massachusetts Bay Transportation Authority (MBTA)	146	117	
Charlotte *	Charlotte Area Transit System (CATS)			
Chicago	Chicago Transit Authority (CTA) and Chicago Dept of Transportation (CDT)	80	355	
Cleveland	Greater Cleveland Regional Transportation Authority (GCRTA)	88		
Denver*	Denver Regional Transit District (RTD), U.S. 36 Transportation Management Org			

Community	Contact(s)	Potential Vehicle Quantities		
		Artics	40-45’	30-35’
El Paso	Sun Metro	10		
Eugene	Lane Transit District (LTD)	15		
Fort Collins	Transfort Dial-a-Ride, City of Fort Collins	12		
Hartford	Connecticut Department of Transportation	44	10	10
Honolulu	Department of Transportation Service, City and County of Honolulu	45		
Las Vegas	Regional Transportation Commission of Southern Nevada (RTC)	40		
Louisville	Louisville Transit Authority River City (TARC)	22		
Los Angeles	Los Angeles County Metropolitan Transportation Authority (LACMTA)	1158	143	
Miami	Miami-Dade County Transit Agency		10	600
Montgomery County	Public Works and Transportation, Division Transit Services, "Ride On"	166	357	33
New York	MTA Long Island Bus	550		
Northern Virginia (Dulles Corridor)	Virginia Department of Rail and Public Transportation	107		
Orange County	Orange County Transportation Authority (OCTA)		114	
Orlando*	Central Florida Regional Transportation Authority			
Phoenix	City of Phoenix	15	58	
Pittsburgh *	Port Authority of Allegany County Planning Department			
San Diego	San Diego Metropolitan Transit Development Board (MTDB)	60		
San Juan *	Puerto Rico Highway and Transportation Authority (Metro Bus Authority)			
Santa Clara	Santa Clara Valley Transportation Authority (VTA)	120		
Seattle	King County Metro Transit and Seattle County Sound Regional Transit	357		
*No information available for the community in this preliminary report				

The potential quantities are developed from a number of sources. In some regions, multiple organizations are collaborating on plans. In other cases, study information about future needs was available and also incorporated. Some of the communities have some large quantities identified. For example, in Los Angeles, LACMTA has two Requests for Proposals with a total quantity of 816 Articulated vehicles for delivery in future years plus an identified need for a greater amount. That combined quantity results in a total of 1,158 Artics for LACMTA.

The numbers for New York on Long Island are very preliminary and may well be understated since some of the planning documents suggest a need for up to 1,270 vehicles. A total of 550 are estimated for delivery in the 2002 to 2012 time period. Miami is interested in doubling the number of their BRT feeder vehicles (30-35' buses) to support their BRT growth plans, and a total of 600 are included in the compiled data.

The quantities attributed to the various communities should be kept in mind when reviewing the trends depicted. The aggregate numbers reflect the present thinking in the community and preferences. The absolute quantities are presented without discounting in this preliminary document. This document is under review so any number below or in subsequent chapters is subject to change.

4.2 General Observations

The underlying factors motivating the communities to explore BRT alternatives are growing population and roadway congestion. The economics of transit and success stories from communities who have tried implementing BRT systems also contribute. For the most part, the BRT systems add capacity along existing routes or can create whole new routes. It is an added capability to move people, or mobility, as part of a regional transportation system. In some cases, this added mobility is planned to displace people from single occupancy vehicles and into public transportation.

The numbers of vehicles represent a growth in the transit system service capacity. The BRT service can overlay the planned growth in the community transit and local transportation system. For the most part, these numbers represent a Service Expansion.

4.3 Types and Numbers of Vehicles

The communities studied selected three basic types of vehicles for their future BRT system plans. Although not all communities have reported in, the data shows some interesting trends.

The annual number of potential or planned deliveries of Articulated bus-type vehicles (60-65'), Non-articulated buses (40-45') and Non-articulated buses (30-35') can be added year by year for a cumulative annual total. This cumulative, annual total (number of potential deliveries) is plotted, by each type of vehicle, over the years 2002 to

2012. Figure 1 plots the cumulative total for each of these types of vehicles by calendar year which totals to a quantity of 5,004 vehicles by 2012.

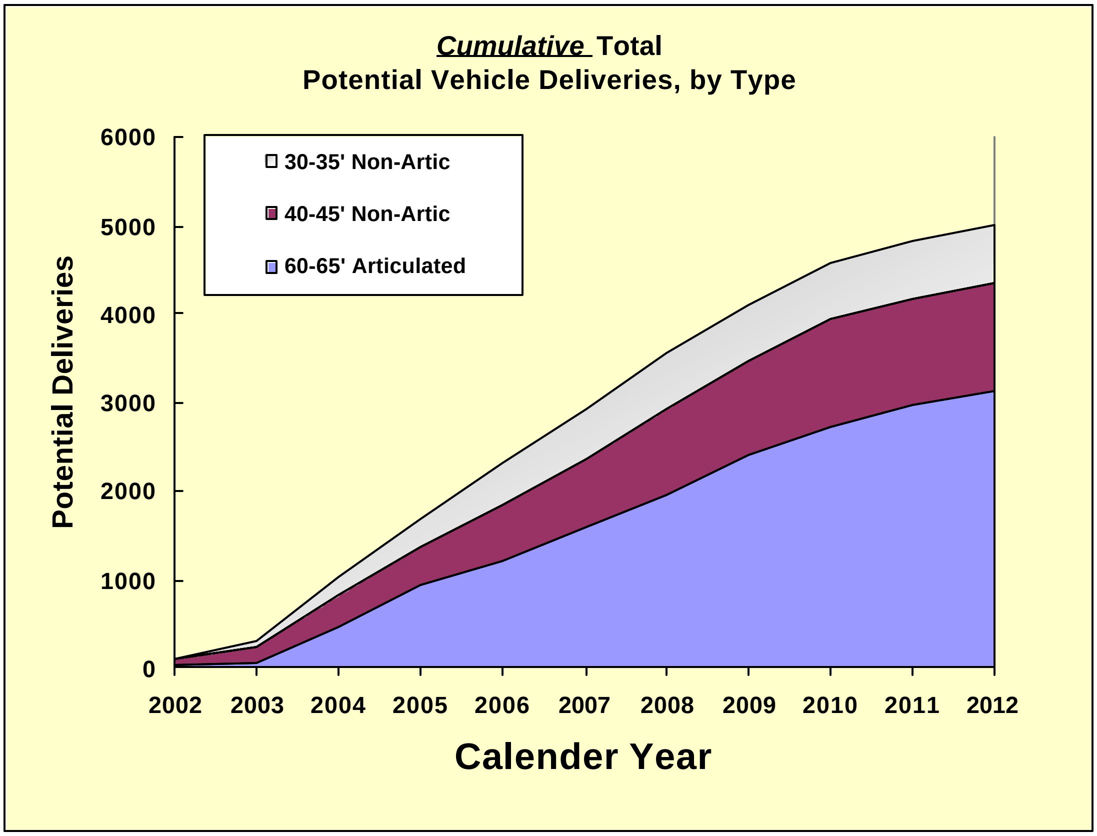


Figure 1 - Cumulative Total Potential Vehicle Deliveries per Year by Type

The data in Figure 1 represents planned deliveries looking forward from July 2002. It does not reflect all of the deliveries of vehicles necessarily ordered prior to 2002. Only four communities were planning to receive vehicle deliveries actually in 2002. The data for 2002 and 2003 is preliminary and will be refined through follow-up interviews with communities. The potential deliveries beyond about 2009 fall off from the growth in the earlier years. This effect relates to the number of communities and the timing planned for their vehicle deliveries.

The effect of the delivery timing is shown by a plot of the cumulative number of communities contributing to the potential deliveries. By adding the number of communities the year that each one ***begins*** taking vehicle deliveries and plotting the cumulative total an interesting effect can be seen. Figure 2 is a plot of the cumulative number of communities plotted the year they begin taking deliveries of their vehicles.

For example, in 2002 in Figure 2, a total of four communities plan to begin receiving the vehicles for their BRT corridors. In 2003, an additional four other communities plan to begin accepting planned deliveries resulting in the cumulative number of eight. By 2008, all the communities responding to this study will have entered the pool and will continue receiving vehicles for other corridors, but earlier

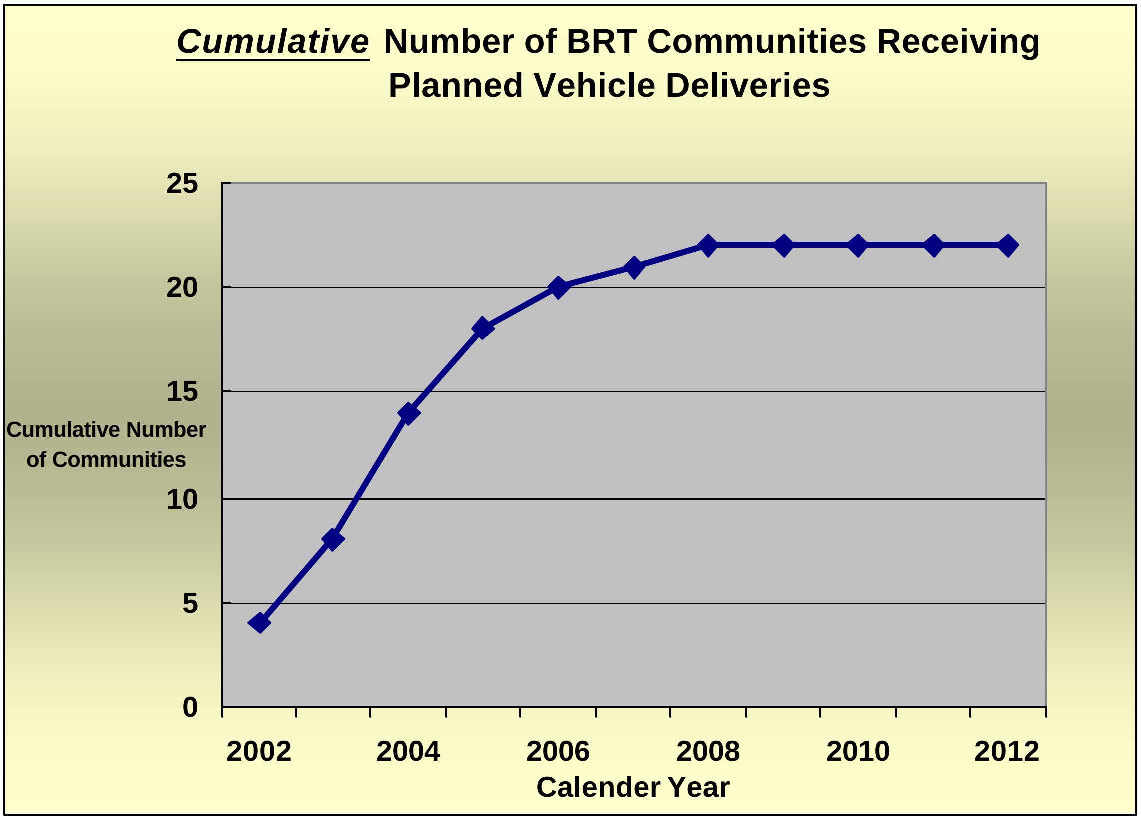


Figure 2 - Cumulative Number of BRT Communities

entering communities will have completed delivery of their vehicles. The trend in Figure 1 shows a corresponding fall-off in cumulative deliveries after 2009. Perhaps, with other communities becoming BRT participants in the next few years, that trend may be reversed and the cumulative growth in vehicles sustained.

An important note is that Figure 1 represents potential orders that have been rated a firm, near firm and planning numbers. The degree of certainty was discussed with the respondents interviewed and who provided the data. A "Firm" rating represents 80-to-100 percent certainty, "Near Firm" a 50-to-less-than-80 percent certainty and "Planning Numbers" are rated at roughly 50 percent certainty. Figure 3 illustrates these numbers by year of delivery for Articulated Buses for each rating (Firm, Near Firm and Planning Numbers). Figure 3 illustrates that as one moves farther into the future, the certainty of an estimated delivery quantity moves from primarily Firm to primarily Planning Numbers, i.e. less certain, which is to be expected.

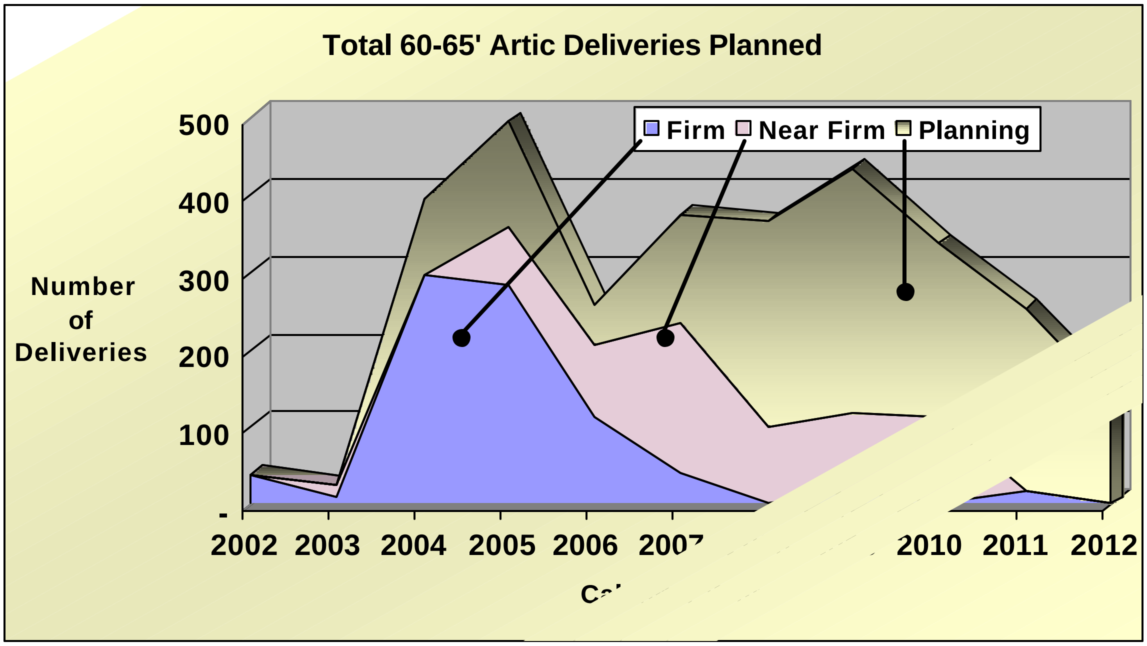


Figure 3 - Articulated Vehicle Deliveries - Firm, Near Firm, and Planning Numbers

As mentioned previously, the vehicle quantities in this analysis represent a Service Expansion and not replacement vehicles for transit properties. Data for total potential Artic orders out to 2006, obtained from APTA, shows a quantity of 1,387 Artics. The APTA data represents a larger group of transit properties than in this study. From Figure 1, the total cumulative number of Artics in this study for 2006 is 1,212. These quantities are "close" but the 1,212 Artics are planned for the BRT communities whereas the 1,387 Artics are a **larger** group of properties that include replacement Artics as well as the artics for the BRT Communities, according to APTA. There is an overlap in the two data sets.

The extent of overlap was determined by comparing the total Artic quantities property by property between the APTA potential orders and potential deliveries in this Community Study out to the year 2006. Of the 1,212 Artics in this study, 733 vehicles designated for BRT corridors were not included in the APTA data indicating a service expansion. This Community Study also identifies an additional 479 Artic service-expansion vehicles that were included in the APTA data as potential Artic orders. The balance of 908 vehicles in the APTA data is considered "replacement Artics."

The implication is that replacement Artics quantities may average from 200 to 250 per year and the Service Expansion Artics for emerging BRT corridors may add an additional quantity of 400 per year. The number of 400 per year is the average annual total in Figure 3 during the years 2004 to 2009. The total of both Artic types could grow to 600 to 650 per year.

4.3.1 Vehicle Type Breakdown

The balance of the vehicle preferences discussions uses the total potential deliveries for each type of vehicle over the time period 2002 to 2012. Figure 4 below

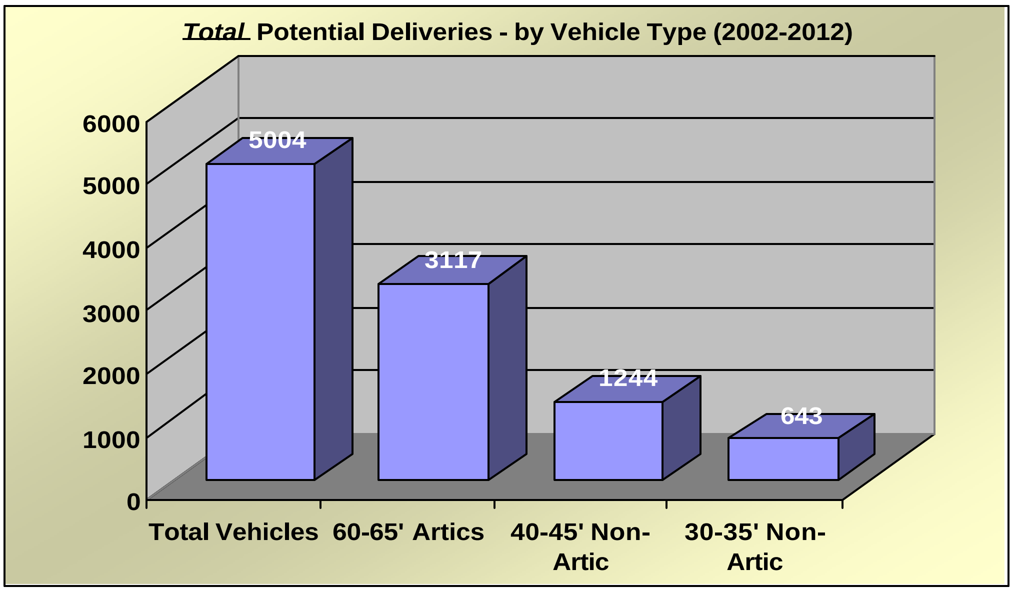


Figure 4 Vehicle Type Breakdown, Total Potential Deliveries 2002-2012

shows the total deliveries by type and Figure 5a and 5b compares the data from this study and from APTA in terms of percentages. The BRT communities plan on more

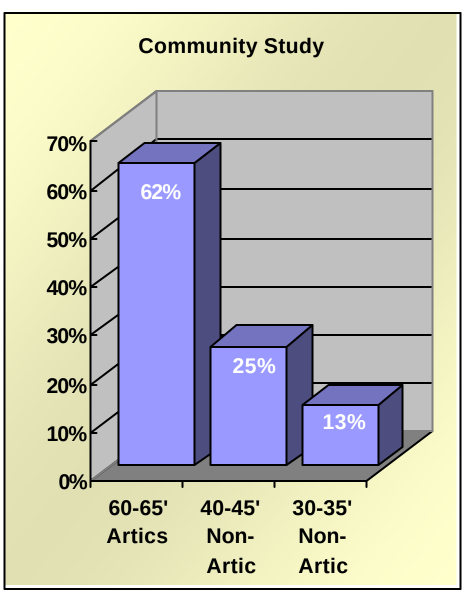
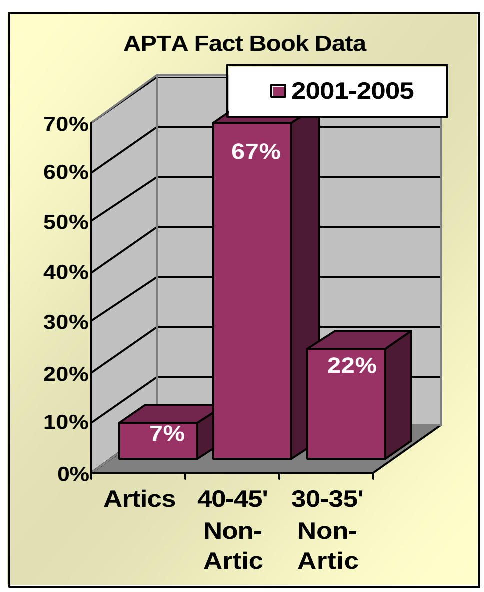


Figure 5a - Community Study Breakdown



5b- U.S. Transit Industry

high-capacity vehicles than the bus transit industry as a whole in the United States. The public bus transportation system supports a multi-tier system of vehicles and service. The BRT service makes use of higher capacity vehicles as shown by comparing the percentages of vehicles in Figure 5.

4.4 Vehicle Propulsion

This sub-section discusses the types of propulsion systems and fuels that communities are beginning to include in their plans. The data and discussions are organized under the vehicle categories described in Section 4.3, namely, 60-65' Artics, 40-45' Non-artic and 30-35' Non-articulated Buses. Some communities are farther along in their selections than others but for the purpose here, the values of Firm, Near Firm and Planning Number quantities and selections are aggregated. For some communities where a selection was still pending or open, the choices were noted. In this section, when such a choice situation arises the data used reflects the current choice (for example, the type of fuel in use presently by that community) and then the alternate will be explored in the future.

4.4.1 Articulated Bus Propulsion and Fuel

The Articulated buses selected by the communities studied had propulsion systems that include the internal combustion engine (ICE), various types of hybrid-electric drives and dual-mode drive. Dual-mode drive systems typically use an electric traction motor and an ICE as generator on-board, but the vehicle can switch to an off-board electric power source such as an over-head catenary electric power distribution system. A diesel-electric trolley-bus, for example, can be powered by an overhead catenary. Some properties have dual-mode trolley-buses which allow the vehicles to run without the over-head power (on the generator) for part of the route.

The fuel types planned by the communities for potential Artic deliveries are shown in Figure 6 include diesel, low sulfur diesel, compressed natural gas (CNG) and liquefied natural gas (LNG). Dual mode buses that use an ICE are included in the totals and are typically diesel powered in the generator mode. Some of the hybrid-powered vehicles had battery packs and would use one of the fuels. The battery electric hybrid totals are also included with their generator/ICE fuel type. The "all fuels" category reflects the same number of potential Artic deliveries discussed in earlier sub-section 4.3 in Figure 4.

Although bio diesel was a study category, none of the communities polled were considering that fuel for use. This data can be compared again to the APTA historical data for fuels for the time period 1990-2000. Diesel fueled 90 percent of the

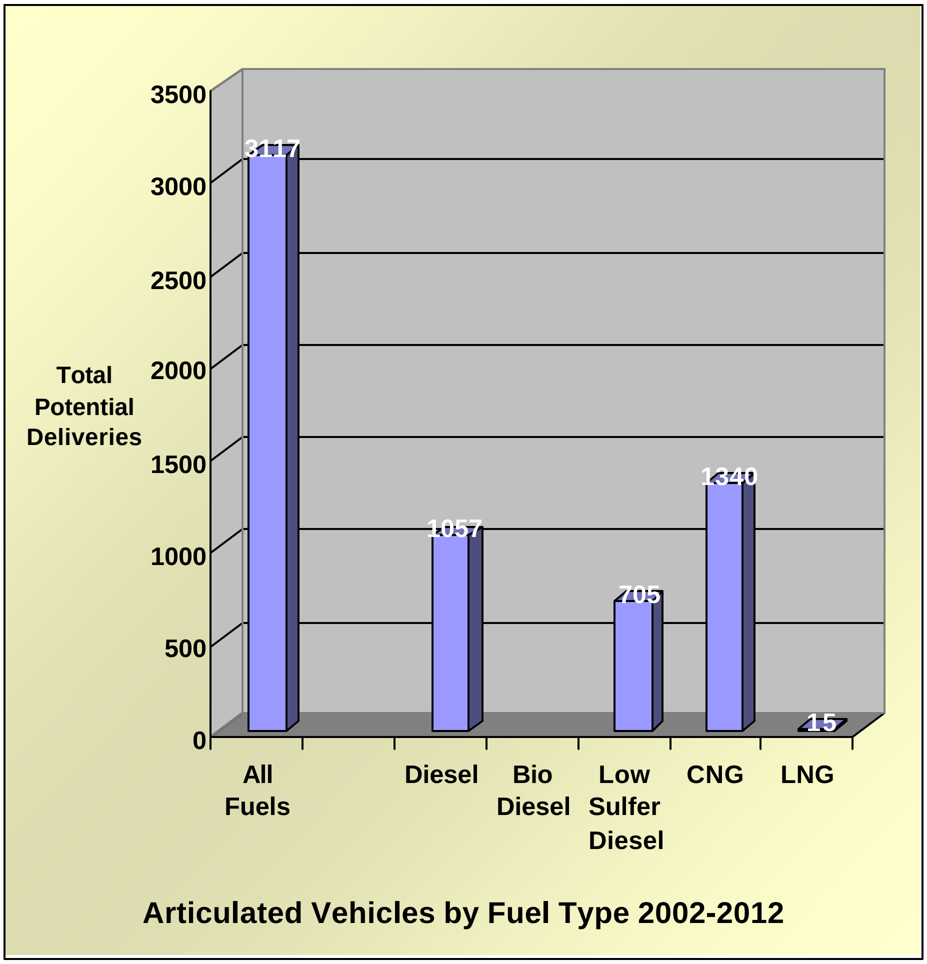


Figure 6 - Propulsion Fuels for Artics

transit buses in 2001. Use of CNG and blends steadily grew during the decade, being used in 7.5 percent of the buses in 2001. LNG fueled 1.5% of the buses in that year also. As can be seen from Figure 6, Artics planned for BRT corridors may well use more cleaner burning fuels in the next decade.

The growth of Hybrid Electric drive-trains for propulsion of the Articulated vehicles is evident when comparing data from this study data to historical data provided by APTA. Based on APTA data for 1990-2000, hybrid electric systems represented less than a tenth of one percent of the transit buses when trolley buses are excluded. Figure 7 shows that almost a third of the potential Artic deliveries may sport hybrid electric drives in future years. This is ten times the number in transit in 2000. These hybrids will be powered by largely either low sulfur diesel or CNG as shown in Figure 8.

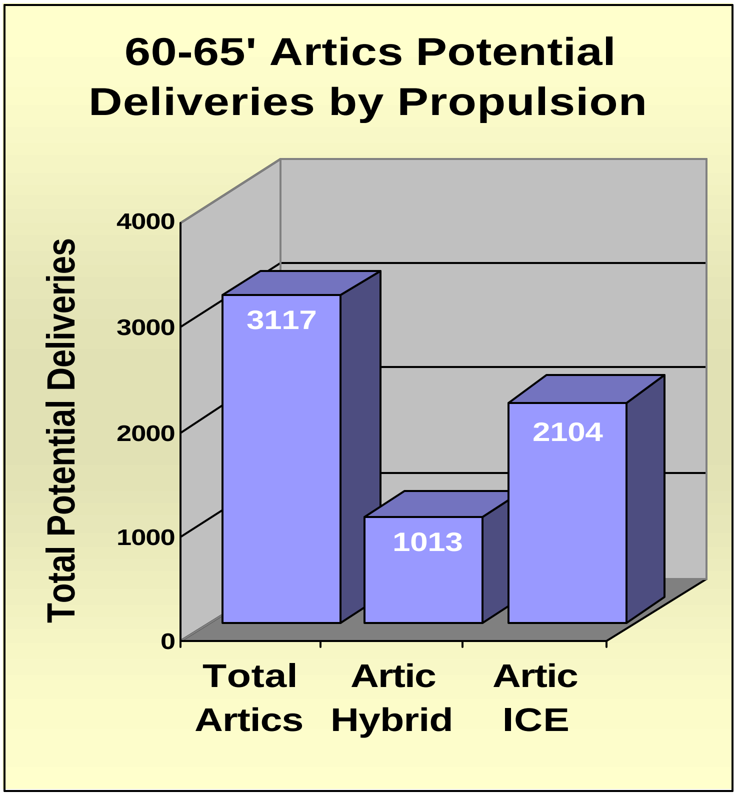


Figure 7 - Artic Hybrid and ICE Drive Systems

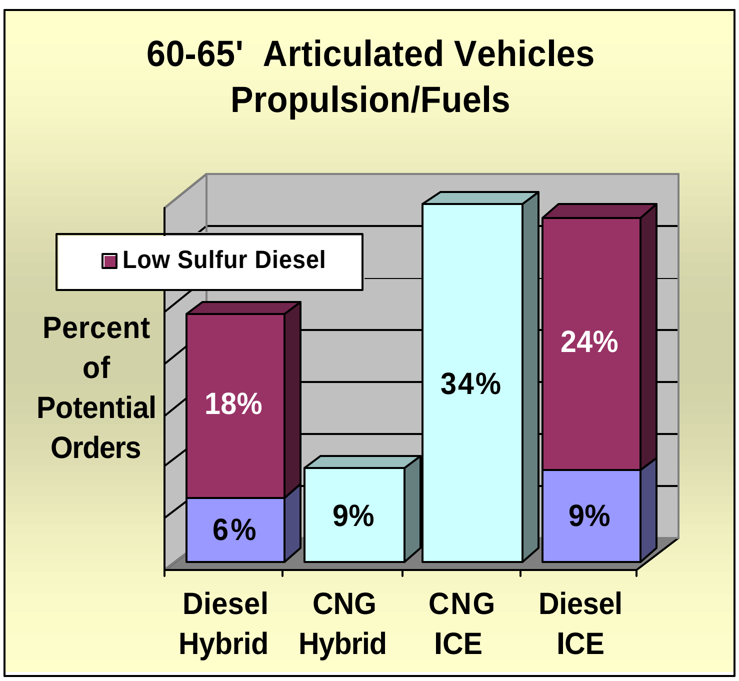


Figure 8 - Fuel Comparison for ICE and Hybrid Artics

4.4.2 Non-articulated 40-45' Vehicles Propulsion and Fuel

The propulsion and fuel selections for the 40-45' buses are shown in Figure 9. The ICE is the propulsion system of choice except for 30 vehicles where one community is open to considering a hybrid propulsion system. Also, one community is planning to take delivery of 3 fuel cell buses (not shown in Figure 9). Surprisingly the fuel choice is still open for over 50 percent of the vehicles (667).

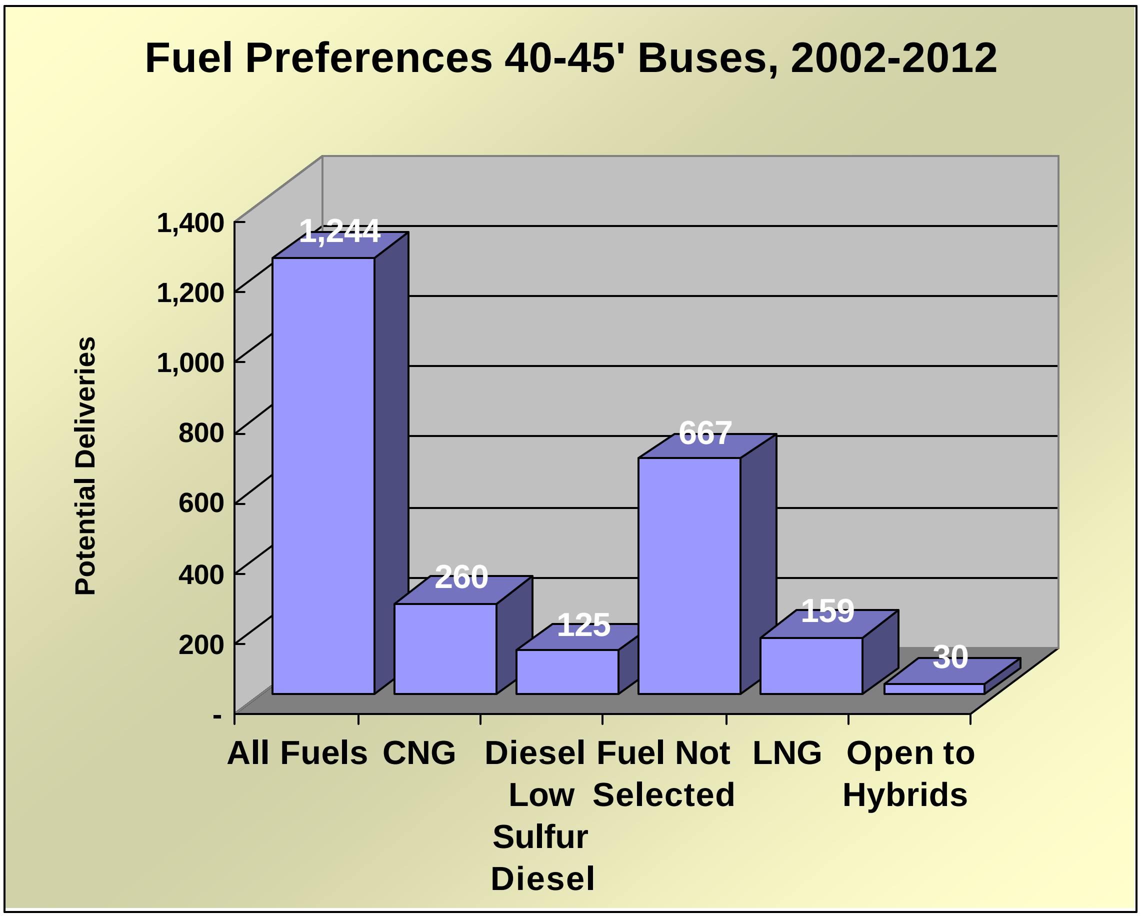


Figure 9 - Propulsion and Fuel Preferences for 40-45' Non-articulated Buses

4.4.3 Non-articulated 30-35' Vehicles Propulsion and Fuel

The 30-35' Non-articulated buses are BRT feeders in the planners' alternatives. Primarily one community accounts for 600 of these vehicles. The propulsion choice is conventional ICE and the fuel of choice is diesel as shown in Figure 10.

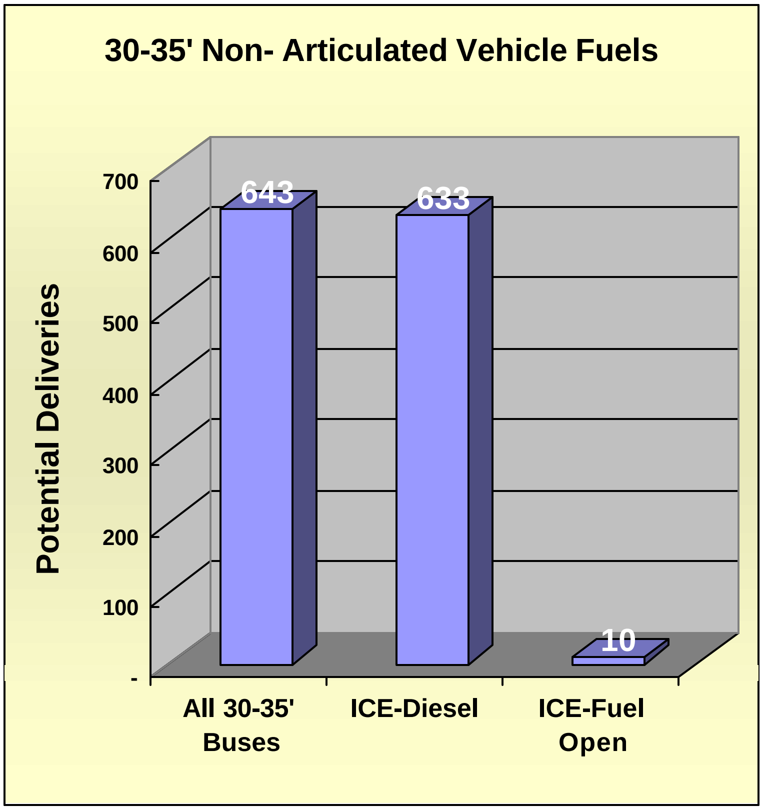


Figure 10 - Non-articulated 30-35' Vehicle Propulsion and Fuels Selection

4.5 Vehicle Body Preferences

This section covers doors, floors, appearance and interest in advanced features such as guidance for the three types of vehicles. Charts are organized by vehicle type in this subsection.

4.5.1 Articulated Vehicle Feature Preferences

Door preference in terms of numbers, types of doors and their placement reflected community ridership, stop/station design, fare collection and seating interest as well as basic type of route. For the most part, on Articulated vehicles, 3 doors was the preference for 48% of the potential deliveries as shown in Figure 11. Almost 800 were undecided at this time but typically were looking at 2 and 3 door designs. Some center-located 2 door vehicles were a preference for about 20 percent of the potential deliveries. Some, about 210, were interested in 4 doors, and in one instance 5 doors with an opposite side single door as the fifth door.

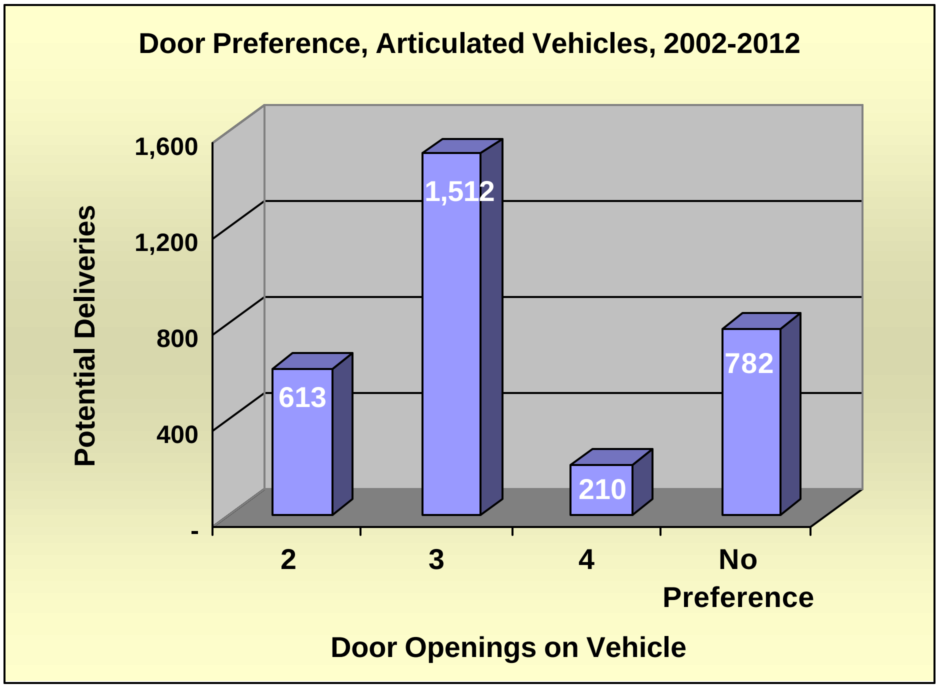


Figure 11 - Door Preferences for Articulated Vehicles

Floor preference was low floor without a step for Articulated vehicles as shown in Figure 12.

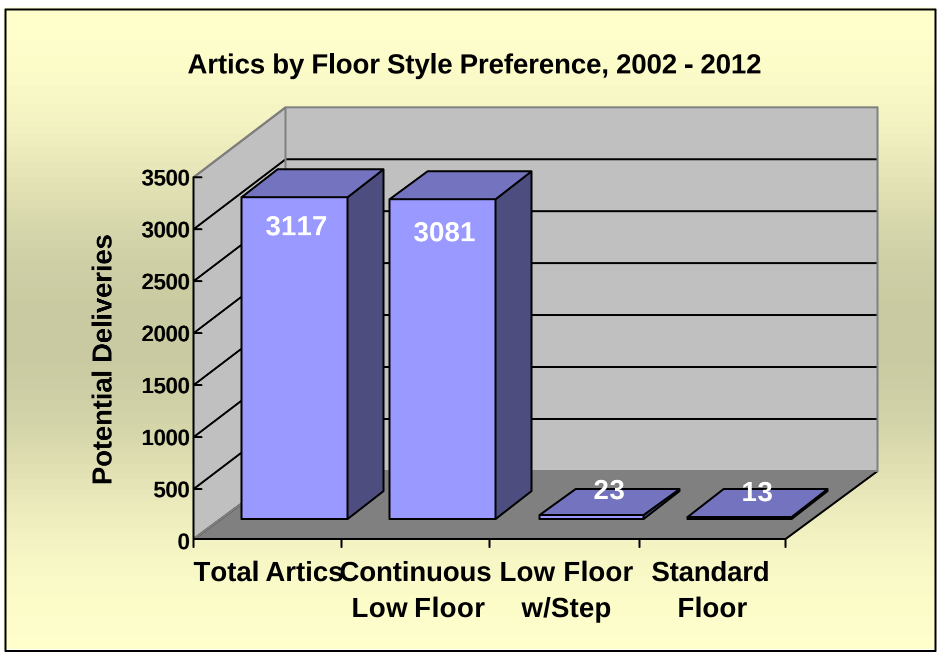


Figure 12 - Preferences for Floor Styles in Articulated Vehicles

Articulated vehicles were often characterized in appearance as "sleek, modern, futuristic, rail-like" and anything that denotes speed and new. This includes the interiors as well. This is reflected in close to a 4:1 preference for "sleek, modern, futuristic, rail-like" over "paint, branding and logo" as shown in Figure 13. The meaning of the adjectives is clearly in the eye of the beholder but these adjectives were mentioned consistently in the interviews by the respondents.

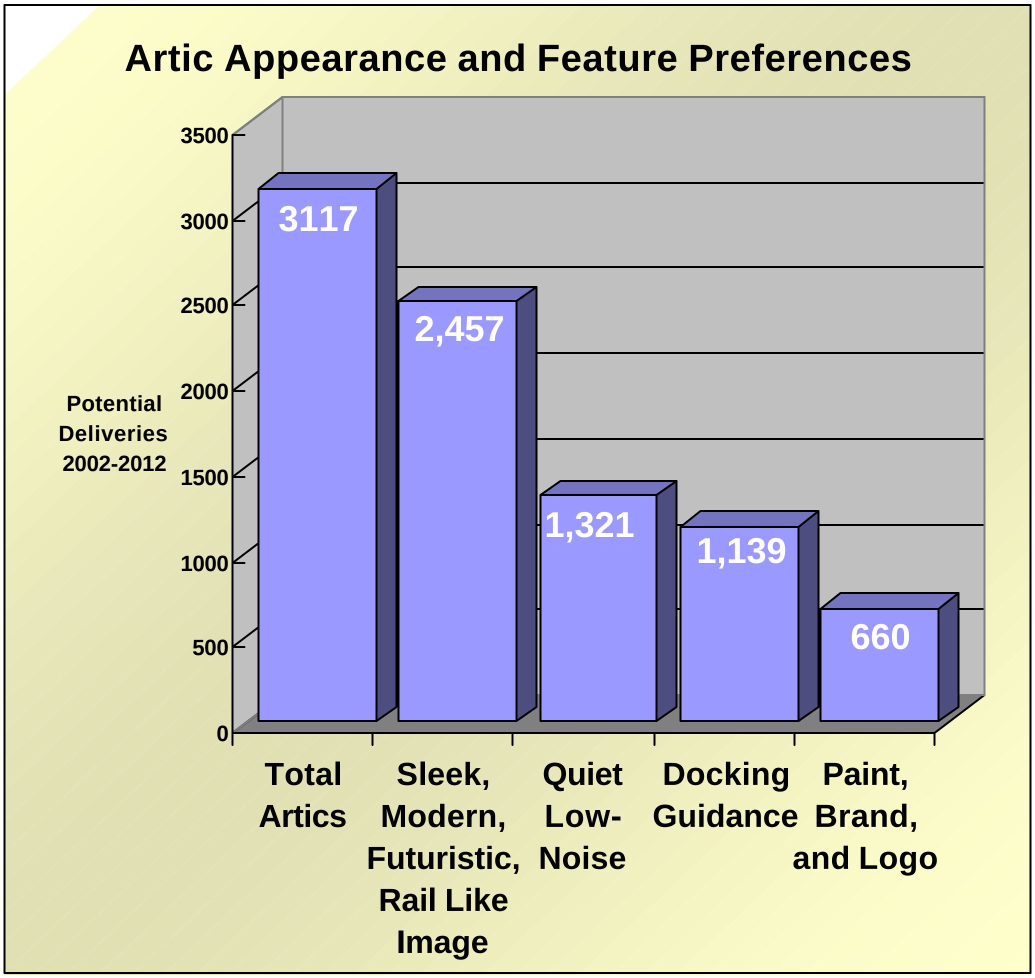


Figure 13 - Vehicle Appearance and Feature Preferences, Artics

Low noise drive systems were another advanced feature mentioned in conjunction with "sleek, modern, futuristic or rail-like." As shown in Figure 13, well over half of the potential deliveries were interested in "sleek, modern, futuristic or rail-like" vehicle with a "quiet, low-noise" propulsion system. Only one property had a specification relating to noise (10 dBA lower requirement for exterior noise). Interestingly, when looking at the communities who preferred the sleek, modern, futuristic or rail-like appearance, almost half were interested in considering or specifying guidance capability.

4.5.2 Non-articulated 40-45' Vehicle Feature Preferences

This section captures the preferences for doors, floors and appearance for 40-45' Non-articulated Vehicles. Figure 14 indicates that door-opening count is still an issue for some communities. Likewise, floor height, shown in Figure 15, is open, but almost half are leaning toward continuous low floor.

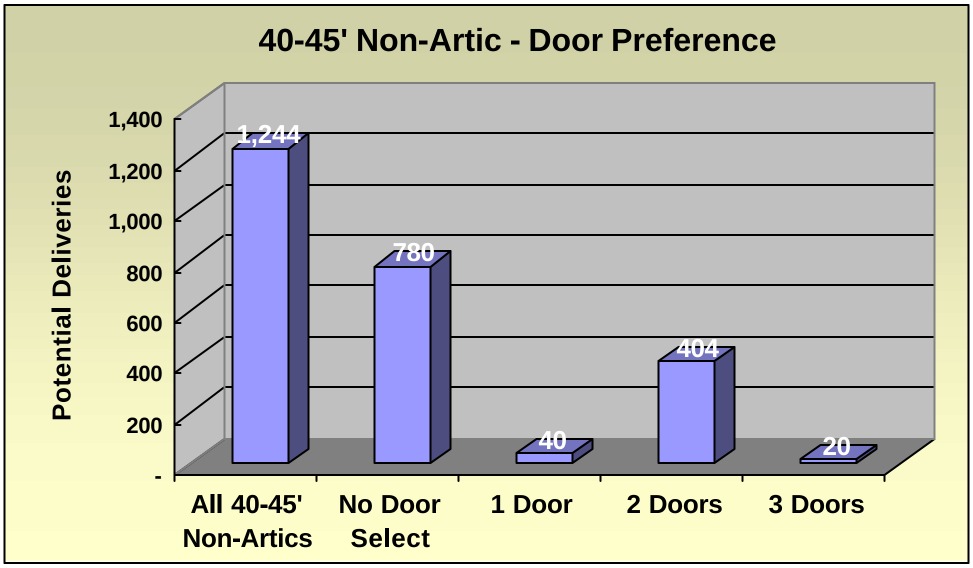


Figure 14 - Door Preferences, 40-45' Non-articulated Vehicles

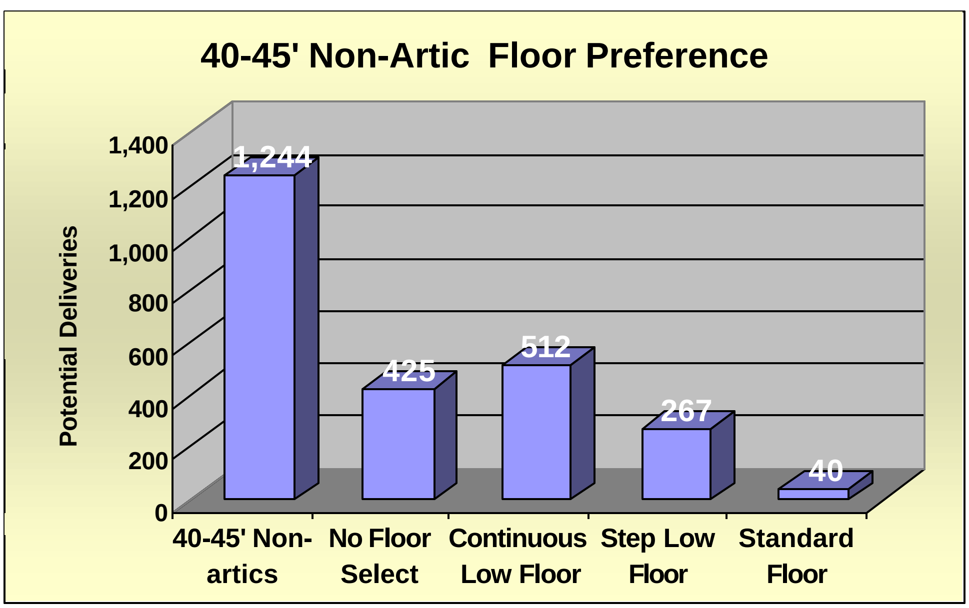


Figure 15 - Floor Preferences, 40-45' Non-articulated Vehicles

The communities accept branding and logos to signal a BRT system vehicle in the 40-45' lengths as shown in Figure 16. Likewise, only one community out of the twenty-two contacted was interested in considering guidance for the vehicle. Noise was not highlighted as an issue.

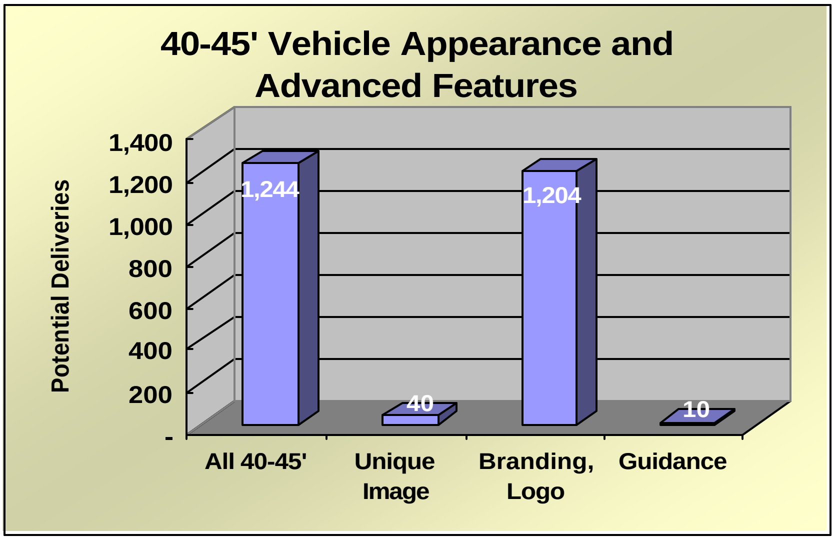


Figure 16 - Appearance and Feature Preferences, 40-45' Non-articulated Vehicles

4.5.3 Non-articulated 30-35' Vehicle Feature Preferences

One community was interested in adding vehicles to their "BRT" system in a 30 foot length. As shown in Figure 17, their preference is for 2 wide doors and a stepped

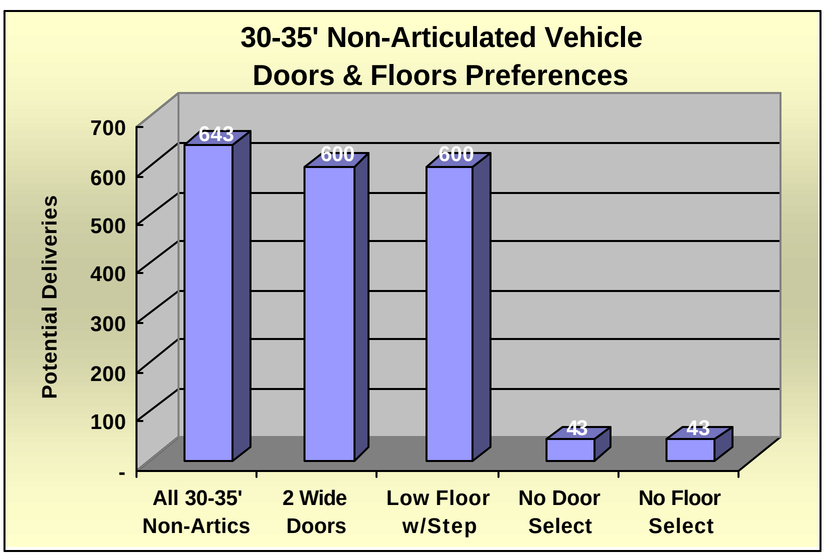


Figure 17 - Door and Floor Preferences, 30-35' Non-articulated Vehicles

low floor is acceptable. Other communities were interested in small quantities and had not yet selected door opening requirements or floor height. When considering appearance, again a single community dominates in this study with a 600 vehicle planning requirement. But the desire is to have a unique, speedy image even at 30 feet in length. Likewise, there is interest in guidance for docking to help with system speed.

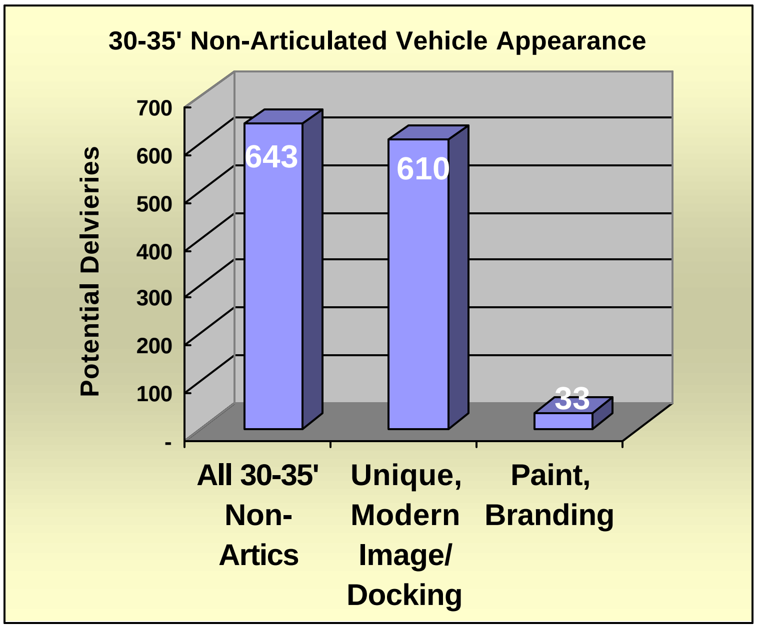


Figure 18 - Appearance and Feature Preferences, 30-35' Non-articulated Vehicles

4.6 Support Technologies and Features

The communities have a variety of support technologies that they are implementing or planning to implement for BRT. Table 8 identifies the category of technology and the types or classes of technology being used by the communities.

Table 8 - Supporting Technology Preferences

Support Technology	Community Selections
Automatic Vehicle Location (AVL)	**GPS, radio, roadway sensors, combinations; AVI tags**
Traffic Signal Interface	**Priority, preemption**
Information	**On-bus – automatic audible stop call outs, LED signage; Off-bus – LED signage, count-down monitor, bus arrival signal, NextBus, interactive info**

Support Technology	Community Selections
Fare Collection	Off-board - Proximity Cards, Proof-of-payment, Ticket Vending Machines On-board – conventional with passes
Roadway Infrastructure	Exclusive ROW, mixed HOV, fixed guideway, mixed traffic, queue jump, exclusive ingress/egress, business and transit lanes, reserved lane, dedicated tunnel, geometric intersection improvements
Stations/Stops	Shelters, dedicated stations, convertible (to rail) stations, service amenities

The Community preference "trends" for the technologies in Table 8 are indicated in Figure 19 as a percentage. Although not all communities had selected specified a

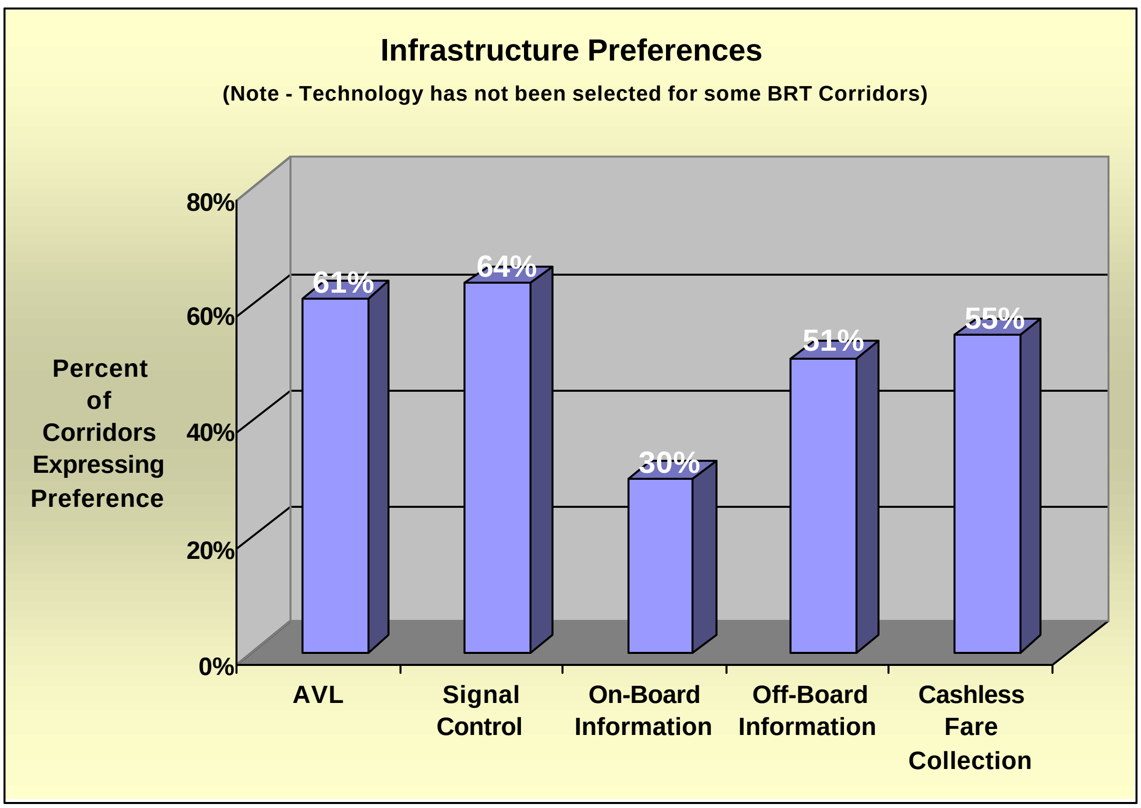


Figure 19 - Aggregate Preferences for Infrastructure Technologies

technology selection or preference for a particular corridor, the preference is expressed as the number of corridors out of the total number of corridors (as a percent) that preferred or selected a technology. For any corridor, for example, a community might select or prefer any one of a number of AVL technologies to implement. The number of those corridors are added together and divided by the total number of corridors in the study (77). The results are shown in Figure 19. Many of the communities are already implementing AVL, signal priority or preemption, on-board information signage or audio call out systems, off-board information signage and off-board fare collection or cashless fare collection.

Another important feature of BRT systems is the route treatments for their impact on system speed. Figure 20 provides a "snapshot" of the reporting communities' busway or bus lane selections as a percent of the total number of BRT corridors. The Study

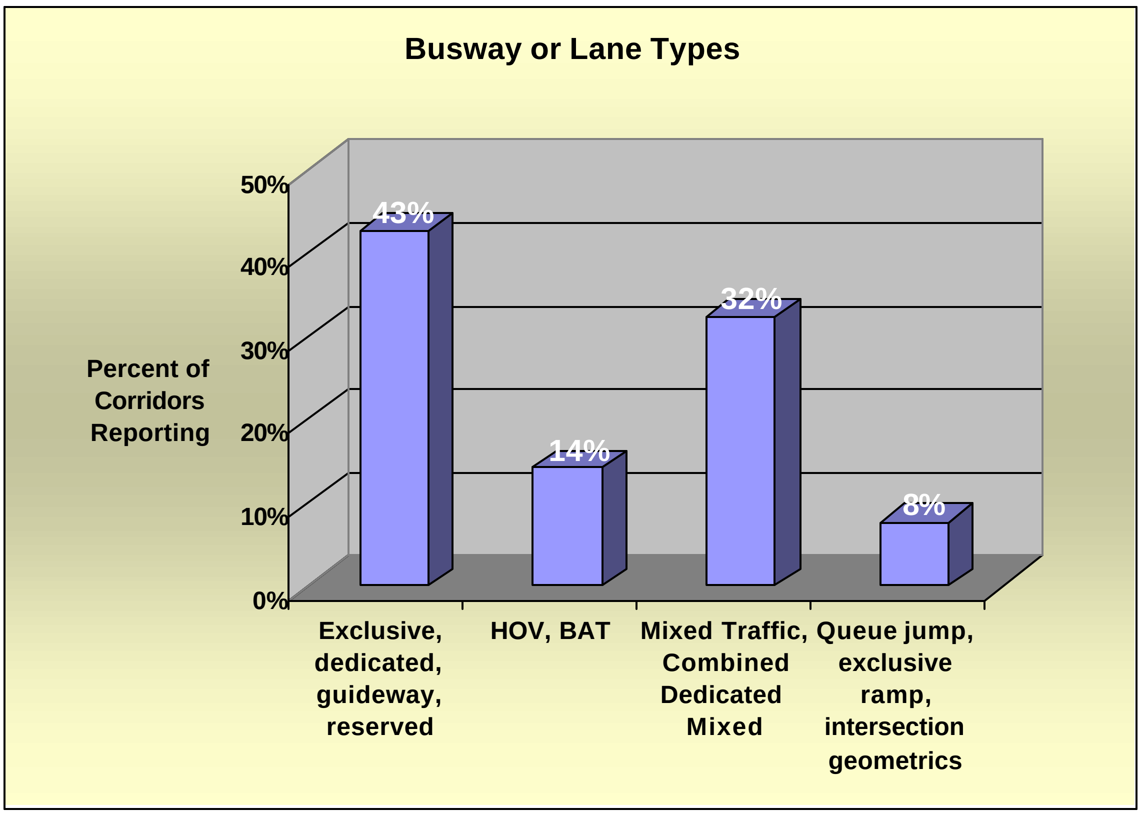


Figure 20 - Busway Infrastructure Types

results show that up to 43 percent of the corridors can be classed as "exclusive, dedicated, guideway or in some way a reserved lane." HOV, mixed HOV or a "Business And Transit" (BAT) curb-lane type of lane was planned for 14 percent of the corridors. Over 30 percent of the corridors involved some route portion that was mixed traffic combined with some form of exclusive or HOV lane. Some local geographies and city development have led to selection of a dedicated tunnel to implement a BRT system. Queue jump and exclusive or limited-share lanes are less prevalent in the corridors reported.

Consideration is being given to stations that can be converted at a later date to rail stations for a couple of corridors. But, for the most part, stops and shelters are planned with branding but not necessarily with rail like amenities except for information and fare collection.

4.7 Summary of Community Study

This subsection summarizes the key results of the Community Study. Some findings of the Vehicle Demand and Supply Analysis are not unexpected:

- BRT mode planning represents a Service Expansion
- Higher capacity vehicles, 60-65' Artics (62 %) and 40-45' Non-artics (23%), together are 85% of the mix

The preferences for the Articulated vehicles are highlighted in Figure 21. The communities indicate that continuous low floor is a clear preference. The appearance

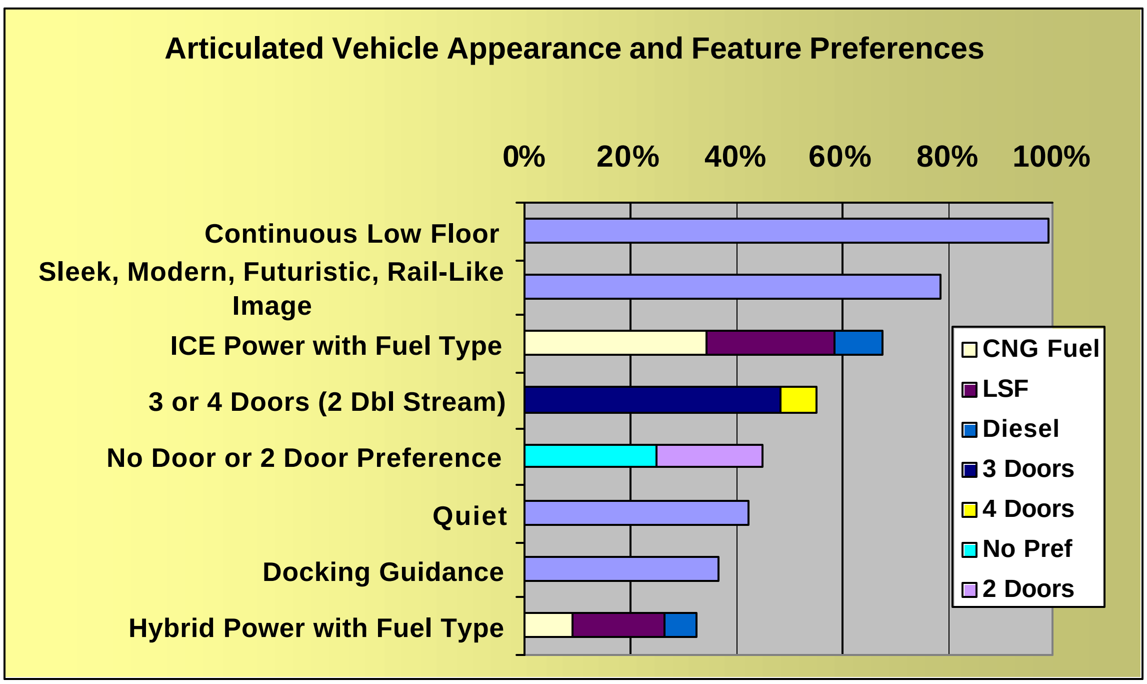


Figure 21 - Ranked Preferences for Articulated Vehicles

of the vehicle is described in terms that suggest speed and something new, ranging from sleek, modern to futuristic and rail-like. Almost 80 % of the vehicles are described in such terms and just counting communities the number is over 75%. Over 65 percent of the vehicles are planned as ICE powered and fueled with CNG (34%), Low Sulfur Diesel (24%) or Diesel (9%). Door preference is mixed with 3 doors representing 49 percent but some communities not expressing a selection yet (but were leaning to 2 or 3 doors) were fairly high. Over 40 percent of the Artics in the study are desired in a "quiet" or "low noise" configuration. Surprisingly, almost an equal number were interested or considering specifying a docking guidance technology (no specific technology). About a third of the Articulated vehicles were preferred in a hybrid drive system configuration with CNG (9%), Low Sulfur Diesel (18%) or Diesel (6%) as the generator fuel.

The 40-45' Non-articulated Vehicles were planned as a conventional bus based on the key preferences as summarized in Figure 22 below. The appearance, an issue for the Artics, was dominated by a paint, branding and logo preference. Likewise, the propulsion power was also conventional with the ICE the clear preference. Fuel selection

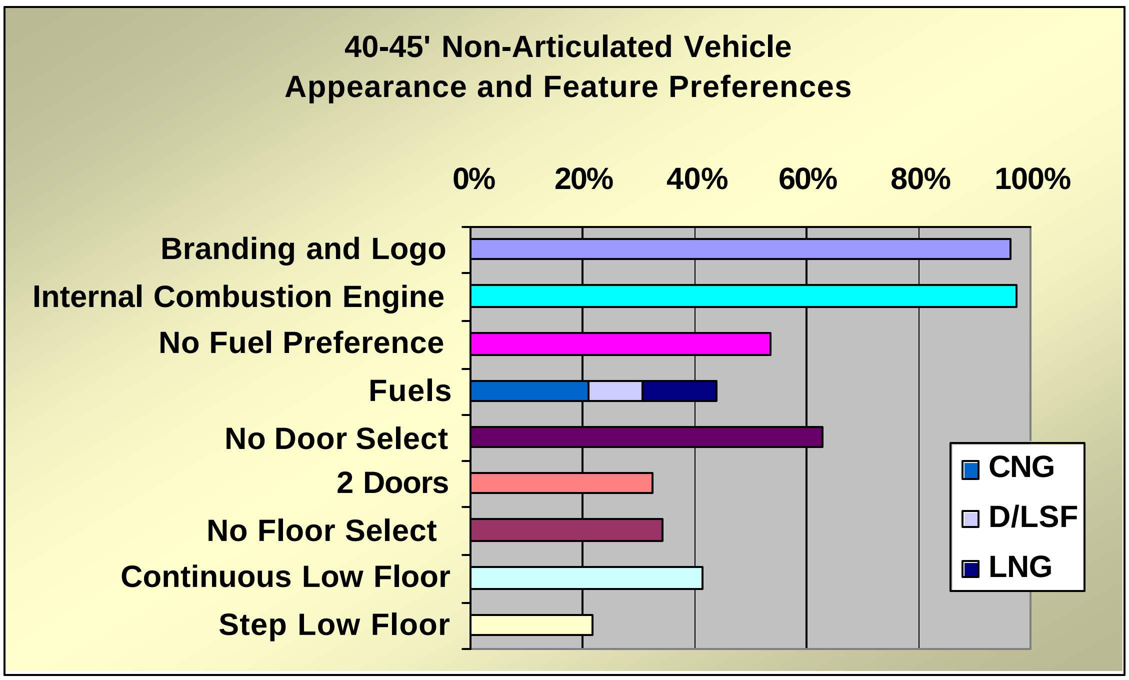


Figure 22 - Summary of Non-articulated Vehicle Preferences

was not settled on for over 50 percent of the 40-45' vehicles. Of the fuels preferred, CNG and LNG accounted for over 30 percent and diesel/low sulfur diesel accounted for almost 10 percent. Doors and floors also showed a large number of the communities are still undecided. When door selection preference is indicated, the preference is for 2 doors on the 40-45' vehicles. Floor preference shows continuous-low floors preferred in at least 40 percent and step-low floor for about 20 percent of the vehicles.

In regard to the 30-35' vehicles, respondents show a preference for step-low floor, two doors and, interestingly, a sleek, modern look. Miami is contemplating possibly doubling their BRT feeder routes with these vehicles and, therefore, prefer the sleek, modern appearance.

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5.0 Manufacturers Study

5.1 Purpose, Goal and Objectives

The purpose of the Manufacturers Study is to provide a perspective on the U.S. domestic manufacturers' readiness and potential response to the BRT communities growing demand for vehicles and the preferences in those vehicles. This is merely a snapshot and not intended as a projection. Fundamentally, the fulfillment of the future supply requirements will be based on the business case as it evolves for the individual companies. A number of industry factors can influence and affect the individual business case.

The goal is to capture information about current domestic manufacturers that supply the U.S. transit properties. The objective is to compile the bus manufacturer's information in a way that characterizes the sectors' capabilities, in an international context, to supply of the vehicles preferred by the BRT communities. This will be done by identifying industry metrics and capabilities listed in Table 9.

Table 9 - Manufacturers Study Objectives

• **Current Backlog** • **Manufacturing Capacity** • **Capacity Growth**
• **Present Models Available for Order** • **Vehicles or Technologies in Development** • **Technology Partners**

• **Response to Community Priorities**
  ▪ **Propulsion, Fuels,**
  ▪ **Appearance, Doors, Floors**
  ▪ **Noise Control**
  ▪ **Guidance**

5.2 Approach

The approach is data gathering and aggregation through interviews, both in-person and via telephone, to refine publicly available data. Data and observations, based on the data, are reflected in comments in the aggregate to overcome competitive sensitivities yet provide a faithful representation of the U.S. bus manufacturing sector. Various reports, such as APTA Fact Book, and other public sources provided information about the various companies and their products. This data was aggregated, keeping in mind the results of the community study, to provide the industry "supply capability."

5.3 Domestic U.S. Suppliers Studied

The dominant, domestic U.S. suppliers of transit vehicles, as identified in the APTA 2001 Fact Book based on deliveries are as shown in the Table 10 below. AVS, EBus and TransTeq were added to the list to round out the study. Some specialty

Table 10 - Domestic Bus Manufacturers in the Study

• **Chance Coach, Inc. ***
• **GILLIG Corporation**
• **Motor Coach Industries ***
• **NEOPLAN USA Corporation**
• **New Flyer of America**
• **North American Bus Industries, Inc.**
• **Nova BUS ***
• **Orion Bus Industries Inc. ***
*** Contacted and only partial information provided for this preliminary report.**

suppliers such as TransTeq, AVS and EBus are contacted because they have seized on select technologies such as hybrid-electric drive systems, low noise and low floor vehicles to supply highly visible service in select communities.

5.4 Manufacturer Study Results

Backlog. A collective look at U.S. manufacturing capacity is shown in the Table 11. The top 8 of the domestic manufacturers collectively are carrying an 8 to 20 month backlog in orders totaling from $ 1.5 to $ 2 B in orders in U.S. transit bus deliveries (even more if options are included). This could represent approximately 7,000 to 8,000 buses.

Table 11 - Manufacturer Perspective on Production Capacity

Industry Study Element	Manufacturers' Response
Backlog as of 2001	• Ranges from 8 to 20 months (Typically 15 months) • ~ 7,000 to 8,000 units • ~ $ 1.5 to 2.0 Billion
Growth in Backlog	• Somewhat mixed across industry • Steady for dominant suppliers, one negative • Niche suppliers – modest growth
Manufacturing Capacity	• > 6,000 per year with 1 shift • For prototype models or new customers, time to initial delivery is growing, typically - 400 days • Capacity and engineering are in place to deliver the types of vehicles preferred by the BRT communities
Manufacturing Capacity Growth	• Add shifts or fractional shifts, easy but risk is morale • Add manufacturing space, non indicated any plans, risk is over-capacity • Industry has sustained a ~ 5 - 8% per year since advent of TEA-21 • Reauthorization could be important to the industry

Growth in Backlog. The growth in backlog of the individual suppliers appears mixed, as noted in Table 11. The growth in backlog for the largest suppliers (in 2001) appears to be holding steady except for the apparent exit of Nova Bus. The niche suppliers show some modest growth in backlog.

Manufacturing Capacity. Manufacturing or assembly space was expanded by some suppliers and has accommodated industry growth in transit bus deliveries since 1993. Currently, the industry delivers over 6,000 vehicles per year, essentially, operating with one production shift per day as shown in Table 11.

Length of time to first delivery has been an issue. The industry feels that the pressure to "custom" design vehicles for individual properties can increase time to the first article, which as a prototype requires additional engineering and test. Another effect is the bid process itself. The bid process tends to make deliveries to "new" customers seem longer when compared to the time for existing customers who exercise options and receive the delivery, sometimes ahead of schedule. Multi-year contracts with options provides more control over delivery schedule but "new" customers for bus manufacturers that win a new bid may find the first delivery times are longer than desired. The net effect of either situation is a growth in first article delivery times with an acceleration of the time for subsequent deliveries.

The growth in manufacturing capacity and engineering to deliver the vehicles for the BRT communities, especially the Articulated vehicles, is definitely there according to the manufacturers interviewed. The product and design preferences are an issue which will be discussed in the Study Implications, Section 6. The information from APTA underscores the manufacturers view as suggested in Figure 23 below.

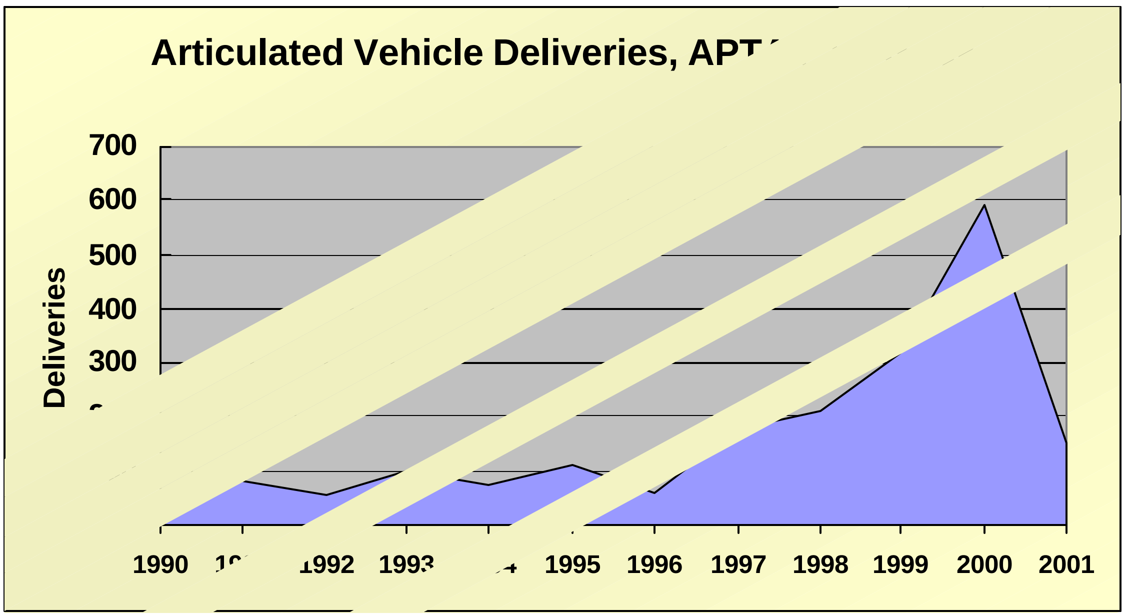

Figure 23 - Articulated Vehicle Deliveries 1990 - 2001, APTA Data

During the time period 1990 to 2001, as shown in Figure 23, the U.S. manufacturers delivered close to 100 Artics per year early in that time frame. Later, from 1997 on, the deliveries climbed up to a peak of 591 in 2000 then dropping back to 151 in 2001. These Artics, according to APTA, were replacement Artics. As noted from the Community Study Results in Section 5, the average production rate anticipated for the combined BRT and replacement Artics may be 600 to 650 per year.

<u>Manufacturing Capacity Growth.</u> Despite the assurances of capacity to respond to increased production of Artics, the question of options for adding capacity was also asked of the manufacturers. As noted in Table 11, growth in production capacity can occur in two ways: adding shifts or adding assembly space. Current production appears accommodated by essentially 1 shift and capacity can be increased by adding shifts. Respondents felt that adding shifts or partial-shifts is risky to morale but less risky than adding more space. Some feel that there may even be an over-capacity in manufacturing assembly space at the present.

Finally, the industry as a whole has been able to continuously grow in annual deliveries at a rate of 5 to 8 percent, steadily from 1993 to 2000. The advent of TEA-21 and subsequent reauthorization contributed to this growth as did the response of the public to improvements in transit. The current Reauthorization will also have an effect on BRT.

Current Vehicle Mix. Table 12 below highlights the current mix of vehicles and technologies available from the U.S. bus manufacturers for the BRT communities. The most noticeable issue is that the current model 60' Articulated vehicles are not available from the domestic manufacturers with Continuous-Low Floor or special appearance options. There are some models in development that might well address both issues to some extent but are not available for ordering currently (although possibly for bids). The current mix of 40-45' and 30-35' vehicles available from domestic bus manufacturers should meet the vehicle requirements for the BRT communities.

Table 12 - Vehicles and Technologies Available or in Development

Industry Study Element	Manufacturers' Response
Current Vehicle Mix	• 3 Step-Low Floor 60' Artic Models in Production • 4 Step-Low Floor 60' Artic Models in Development with Potential for New Features or Appearance • 11 40-45' Non-artic Models in Production, Step-Low and Continuous-Low Floor • >10 30-35' Step-Low Floor Non-artic Models in Production
Advanced Development	• 2 Series hybrids in production • 4 Parallel Hybrids Models in Development • 2 Vehicles with Composite Structure • 2 New Model Artic • 1 New Model Standard (appearance, amenities) • 2 Fuel Cell Models in Development
Hybrid-Drive System R & D Partners	• BAE (HybriDrive); Allison (EP Drive); • ENOVA, Dana/Alstom, Siemens, Solectria (series hybrid drive); • ISE Research; Capstone, TransTeq (Various)

Development and Partners. As shown in Table 12, in the overall industry, new models with advanced hybrid propulsion and technologies are on various drawing boards. Plus, some strong technology partners with well-known names are developing hybrid drive systems to supply domestic manufacturers.

Finally, the Manufacturers Study addresses the specific domestic manufacturers' perspective on BRT technologies and specific Community vehicle preferences expressed in Section 4. Table 13 highlights the domestic bus manufacturing sector responses.

Table 13 - Manufacturing Sector Reponses to Community Vehicle Preferences

Industry Study Element	Manufacturers' Response
Technology Priorities	• Reduced maintenance – design and materials • Lighter weight – subsystems, components • Corrosion control • Passenger comforts – lighting, A/C, door options • Intelligent Transportation Systems - AVL, signage, • Cashless fare subsystems
Fuels	• Diesel - low sulfur w/traps • Alternative Fuels: CNG; LNG
Engine Technology	• Diesel and Alt Fuel ICEs in production; • Development – Series/Parallel hybrids (near term) • Fuel cell (long term)
Appearance and Styling	• Prefer a three stage program • Technology now is primarily second stage • Prefer "on-road" experience prior to next (third) stage • Preference for Commonality and/or industry dialogue to focus "Stage III" models
Low Noise	• Acoustic treatments, working with vendors on subsystems • Series/Parallel hybrids reduce noise (near term) • Fuel cell can substantially reduce noise (long term)
Guidance System	• PATH Magnetic RSG System for Docking

Technology Priorities. The U.S. bus-manufacturing sector is working on technologies to reduce the cost of maintenance and to enhance the BRT service. New subsystems, components and materials offer weight savings to accommodate community design, styling and propulsion preferences. Passenger amenities and comfort items are being offered by all manufacturers and clearly preferred by some communities. The manufacturers embrace the BRT technologies for Intelligent Transportation Systems (ITS) such as AVL and display subsystems that contribute information and combine with cashless or proof-of-payment fare collection to increase system speed.

Fuels. All manufacturers provide diesel power trains and fueling systems. Low sulfur diesel including soot filters and other traps will be offered. Alternative Fuels of CNG and LNG are offered or manufacturers respond to requests with compatible engine and fuel systems.

Engine Technology. Hybrid technologies, both series and parallel, are also becoming more robust as a few manufacturers are completing revenue service trials with new systems/subsystems. At least four bus manufacturers have hybrid drive powered vehicles in development, and one has an order for production quantities of an early production drive system. Full production with hybrid systems may well have to wait a few more years for hybrid-drive vehicle deliveries to reach acceptable pricing. Some dual-mode systems are available and poised for delivery next year.

Appearance and Styling. Changing the appearance of vehicles appears as a priority among the manufacturers, but more importantly, they prefer to minimize the variations. The preference would be to put vehicles on the road that provide the service necessary for BRT corridors. This will allow time for industry dialogue about what constitutes suitable advanced styling for a vehicle, in particular, the Articulated vehicles. From the manufacturers' perspective, such an approach would lower industry risk while growing the "image."

Low Noise. Manufacturers are seriously considering lower noise techniques with some working with acoustic treatments. Some are looking to hybrid designs to achieve lower noise levels.

Guidance. Specialty subsystems such as guidance options are being seriously considered by manufacturers. While this is primarily considered a future technology, some trial demos or tests have been completed in the past. At least two manufacturers have an interest in the Berkeley PATH Magnetic Marker Reference Sensing and Guidance System for docking application.

Fundamentally, the U.S. domestic manufacturers have technologies available (fuel systems, hybrids, appearance items, passenger amenities, etc.) with the partners and the manufacturing strength to compete effectively in the global marketplace for production of vehicles for BRT service settings. The economics of the business case for these deliveries will have more to do with the availability of suitable vehicles than specific requirements.

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6.0 Study Implications

The purpose of the Study Implications Section is to bring forth the issues that have arisen from the two Studies discussed in Sections 4 and 5. This Section combines the U.S. BRT Community preferences in vehicles and the response in terms of vehicles and technology from the U.S. Bus Manufacturing sector, in a discussion format. In providing this juxtaposition, the intent is to reflect the demand and supply side perspectives in a convenient format for the ***reader to draw implications***. Following that are some companion suggestions for future courses of action or desires, provided again by the U.S. Bus Manufacturing sector. Perhaps this Section will stimulate future industry dialogue and pave the way for courses of action to overcome some of the issues and shortfalls. This Section is ***not*** intended to develop conclusions or recommendations.

6.1 Vehicle Supply

6.1.1 Key Questions

The intent of the this Analysis is to answer the questions shown in Table 14 – what is vehicle demand from the U.S. BRT Communities and can the U.S. bus manufacturers supply these vehicles? The Community vehicle demand is largely for high capacity vehicles. But the preferences expressed for features and the vehicles available from the manufacturers make the question easier to answer by re-phrasing as in Table 14.

Table 14 - Key Vehicle Demand and Supply Question

The BRT Study Questions are - • **What is the vehicle demand from the U.S. BRT Communities?** • **Can the U.S. bus manufacturers supply the vehicles for BRT Community plans?**
The Combined Study Results suggest a two-part question - • **Can U.S. bus manufacturers meet community demand for 40-45' and 30-35' Non-articulated Vehicles?** • **Can U.S. bus manufacturers meet community demand for 60-65' Articulated Vehicles?**

6.1.2 Response to the Key Questions

The first study question, as shown again in Table 15, is yes the U.S. Bus manufacturers are in a position to supply the majority of the communities. For the most part, the Communities seek vehicles that can be branded or clearly identified with BRT type service. Some uniqueness and styling features are offered by the manufacturers. Industry production capacity can deliver the modest increase in quantities for these "Service Expansion" vehicles. The demand for vehicles can be satisfactorily met even in a competitive, global context.

Table 15 - Demand and Supply for Non-articulated Vehicles

First Vehicle Demand and Supply Question is - • **Can U.S. bus manufacturers meet community demand for 40-45' and 30-35' Non-articulated Vehicles?**
The Combined Study Results suggest - • **Yes, current models are available from the domestic manufacturers that respond to the preferences of the transit properties.** • **The demand focuses on available product, available fuels and drive trains.** • **Appearance demand is Paint Scheme and Logo primarily but manufacturers are offering more styling options.** • **Production expansion up to 200 Vehicles a year does not represent a challenge to the existing supplier base.**

The Community vehicle demand for high-capacity, 60-65' Articulated vehicles raises some issues. As highlighted in Table 16, all of the U.S. manufacturers provide Step-Low Floor Artics. But the gap increases when other feature preferences are detailed. Appearance and styling changes, noise control, docking guidance and hybrid drive systems, while in various forms are on the drawing-boards, these features are considered unavailable now by the Communities. This has led to some Communities going overseas for early implementation of their BRT plans. These vanguard implementations will be watched closely by the industry as other communities seek vehicles for their BRT systems.

The issue here appears to be product and image. Clearly, domestic manufacturers can produce high-capacity, Articulated vehicles in sufficient quantities. The Community Study indicated some clear changes that would make the Articulated product appealing for their BRT service. These details are in sub-section 6.2

Table 16 - Demand and Supply for Articulated Vehicles

Second Vehicle Demand and Supply Question is -

- **Can U.S. bus manufacturers meet community demand for 60-65' Articulated Vehicles?**

The Combined Study Results suggest –

- **Not now – no such models that are currently being delivered by the domestic manufacturers that reflect the community preferences.**

Community Preference	Percent of Vehicles
Continuous Low Floor	~ 100 %
Sleek, Modern, Futuristic, Rail-like Appearance	~ 80 %
Quiet	~ 45 %
Docking Guidance	~ 40%
Hybrid Drive System	~ 35 %

- **Some properties seeking such vehicles have gone overseas.**

- **This is a product issue not a capacity issue.**

6.2 Perspective on Articulated Vehicle Issues

This subsection is a series of discussions that reflect the two study viewpoints on each individual issue. The information is extracted from notes from interviews with the study participants. Every effort has been made to objectively portray the points regarding each issue.

6.2.1 Continuous-Low Floor

From the interviews with BRT Community respondents, the choice of continuous-low floor is a clear preference for almost 100 percent of the Articulated vehicles. As the interviews with the manufacturers proceeded, this was discussed with each manufacturer.

The manufacturer interview results is compiled and presented as a bullet list in the accompanying Table 17.

Table 17 - Combined Study Results on Continuous-Low Floor Artics

Community Preference	**Continuous Low Floor throughout the Vehicle** • **Requested for almost 100% of the Artics**
U.S. Manufacturers Response	• **Domestic Models available now are Step Low Floor** • **Low Floors were tried by US, didn't succeed for various reasons, component selection was part of the issue** • **One model in development, others – wait and see** • **Seating capacity reduction is a concern** • **ICE Power, seating and maintenance access concern** • **Alt. Fuels and axle loading is also an issue**

The domestic manufacturers all currently provide step-low floor Articulated vehicles. In the past, domestic suppliers delivered continuous-low floor models, but for various reasons, such as component selection, the models "did not succeed." The industry returned to supplying step-low floor vehicles.

One 60' low floor Artic is in development but the other manufacturers are waiting to have more dialogue with communities. The chief concern is that continuous-low floor affects seating capacity. Power by internal combustion engine can also affect seating capacity and makes engine maintenance access a more difficult issue. Alternative fuels such as CNG can also be an axle-loading concern with continuous-low floor design. ICE location also affects door placement.

Summarizing, the manufacturers can deliver a continuous-low floor Articulated vehicle but seating and maintenance requirements need to be compatible. Industry discussion on the options may well helpful to provide what the BRT Communities prefer.

6.2.2 Sleek, Modern, Futuristic, Rail-Like Appearance

Probably the broadest and least defined issue is that of the preferred appearance of the Articulated vehicles indicated by the Communities Study. The issue here is that the BRT communities are seeking vehicles that convey an appealing impression of "speed." A short list of adjectives continued to be provided by the Community participants interviewed for this study. Almost 80 percent of them, as noted in Table 18, used words like "sleek, modern, futuristic, or even rail-like" to describe the appearance of the Artics they desired.

Again, this topic was discussed in depth with each of the manufacturers and the highlights of their collective response are shown in Table 18. Styling changes are coming out of R & D groups in the manufacturers. They describe available changes in terms of "Sleek or Modern" by changing front and rear designs on vehicles. These changes could be made available on Artics now. More futuristic treatments are on the drawing boards, but their concern is that "Rail-like" appearance elements need to be defined. "Rail-like" right now is in the "eye of the beholder" and aspects of appeal elements are not well defined. The desire is that the industry pursue a phased, staged or evolutionary approach with a goal of reaching the ultimate collection of competitive designs in the future.

Table 18 - Combined Study Results on Artic Appearance and Image

Community Preference	**Sleek, Modern, Futuristic, Rail-like Appearance** • **Requested for almost 80% of the Artics**
U.S. Manufacturers Response	• **Sleek, Modern, are probably available** • **Futuristic or Rail-like needs more definition for manufacturers** • **Rail-like may be "in beholder eye", may be related to Continuous Low Floor issues** • **Manufacturers would like a staged or phased approach to reach "Rail-Like"**

6.2.3 Quiet, Lower Noise

Concern for the vehicle exterior acoustic profile as well as interior noise level was expressed by between 42 and 45 percent of the BRT communities. This concern was often mentioned voluntarily and not as a response, although noise levels were discussed with all respondents. The results were discussed during the interviews with the manufacturers.

Noise control is a well-known issue with domestic manufacturers. Often noise control and acoustic treatments are included with present models for control of interior noise. Drive train noise reduction, both exterior and interior, is a more difficult issue, but all the manufacturers are striving for improvements in this area.

The reduction or noise control issues from the manufacturers' vantage point are spotlighted in Table 19. The first point that the manufacturing sector makes is that emission control requirements by the EPA may well increase engine cooling requirements. The result may actually require changes in cooling designs and fans that could tend to increase noise levels, exacerbating the noise reduction problem.

Hybrid drive systems are expected to assist in noise reduction. Near term solutions, especially through hybrid propulsion are doable. The reductions take engineering time and funding. The long range solution could be fuel cell powered vehicles. Some manufacturers are testing such systems in 40-45' vehicles.

Table 19 - Combined Study Results on Low Noise Artics

Community Preference	**Quiet, Lower Drive Noise and Interior Control** • **Requested for 42 % of Artics**
U.S. Manufacturers Response	• **Acoustic treatments help interior noise control** • **EPA requirements may exacerbate Drive System fan noise** • **Hybrids will help but production may be 2-3 years away** • **Aggressive noise control will take Engineering, $$, Time** • **Fuel cell drive trains may be the long range solution**

6.2.4 Docking Guidance

Almost 40 percent of the 60-65' Articulated vehicles in the Community Study were preferred or were considered for a docking guidance configuration. Docking guidance experience or developments were discussed with each of the manufacturers responding to the Study. The response is summarized briefly in Table 20.

At least one manufacturer has had test experience with 40' buses using the Berkeley PATH (Partners for Advanced Transit and Highways) RSG System. PATH's Magnetic Marker Reference Sensing and Guidance System was designed by PATH researchers specifically for vehicle guidance and control. Others are also working with the PATH system which uses magnetic markers in the roadway which are sensed and tracked by sensors, providing steering guidance signals to a vehicle. Integration of electronics such as a docking system has become much easier with the transit vehicles now being designed to be compatible with digital electronics.

While successful tests have shown much promise, the bus transit industry does not have docking specifications that can direct bus manufacturers or industry station/stop designers for an implementation of a "docking system." Manufacturers feel development of such standards would hasten the advent of docking systems in their vehicles.

Interestingly enough, a different but related system for bus collision avoidance is developing with technologies that may support a docking system. The heart of the collision avoidance system is the PATH technology. These developments could lead to a low cost docking guidance system. There are foreign developed docking and guiding systems that may soon be tested in the United States.

Table 20 - Combined Study Results on Docking Guidance for Artics

Community Preference	**Docking Guidance** • **Requested for almost 40 % of Artics**
U.S. Manufacturers Response	• **Some domestic manufacturers have test experience with PATH Magnetic RSG System for Docking** • **Industry development of specifications is needed** • **Developments in bus collision avoidance systems expected to provide low cost technology** • **Low cost anticipated for production**

6.2.5 Hybrid Drive Systems

The Communities Study suggested that almost 35 percent of their 60-65' Articulated vehicles are preferred with hybrid-electric drive systems. Many of these are to be fueled with alternate fuels (CNG). Hybrid-electric drive may accommodate or even facilitate continuous-low floor and noise reduction also; so the topic was discussed at length with the manufacturers.

There are a number of suppliers that offer Hybrid-Electric drive systems to the transit industry. BAE Systems and Allison Transmission both have pre-production systems on trial through various manufacturers on revenue-service test programs. Configurations included diesel-electric, CNG-electric and LNG-electric.

The manufacturers' key concern currently is with the cost of the pre-production systems, as noted in Table 21. However, as with most development programs the production versions will be lower in cost. Some of the systems are on the third generation with more improvements to come. As mentioned previously, noise control may be another benefit that has the manufacturers' interest. Domestic diesel-electric and dual-mode Artics will soon enter service, but most manufacturers see hybrid-electric Artics as 2 – 3 years in the future. Fuel economy and emissions benefits are being documented on shorter, Non-articulated vehicles. Fuel cell vehicles may be in the future with some power systems being developed in some Non-articulated 40-45' vehicles now.

Table 21 - Combined Study Results on Hybrid Drive Systems

Community Preference	**Hybrid Powered Vehicles** • **Requested by almost 35 %**
U.S. Manufacturers Response	• **Diesel Hybrid, CNG Hybrid, LNG Hybrid in development or 'pre-prod' systems** • **Pre-production cost is significant, production costs will fall** • **Hybrid drive systems are 2-3 years away** • **Fuel economy and emissions benefits documented (for 40'45' Non-artics)** • **Fuel cell power source in development**

6.3 Manufacturing Sector Suggestions

The Manufacturers' representatives offered some candid thoughts on the various study topics. This is a study that is meant to provide a set of results that characterize the vehicle demand and supply for the BRT communities. This subsection closes the Study Implications with some collective suggestions from the manufacturers' that relate to vehicle preferences, issues and shortfalls that might serve as talking points for future industry dialogue.

The Manufacturers' suggestions naturally coalesced into the topics in Table 22 below. The first topic addresses all the Artic issues in a sweeping fashion. Issues such as continuous-low floor and appearance are intimately tied to seating capacity and door placement as an example. So the first desire would be to converge on a compatible set of these preferences by a number of communities and take some of the element of "customization" out of procurements. The manufacturers indicate this may speed the availability of "futuristic" looking Artics, would allow for more piggy-backing and move the industry towards a model menu that adds some "new Standard models" that meet BRT Community needs for stylish, high-capacity vehicles.

Table 22 - Suggestions Provided by the Manufacturers

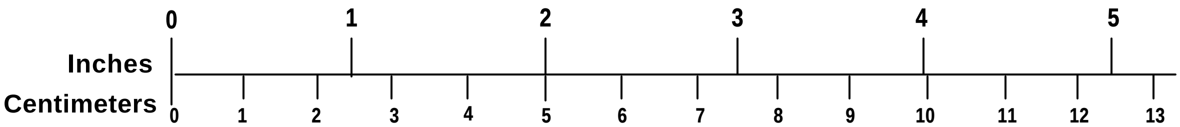
Suggestions from the Manufacturers
• **Communities convergence on Preferences to minimize customization** **Benefits of convergence** • **Speeds development of "futuristic" appearance and other features** • **Allows more Piggyback Orders** • **Work towards New Standard Models** • **Prioritize on Features and Appearance** **Benefit would be a phasing of** • **Powertrains, fuels** • **Low Noise** • **Low Floor** • **Appearance and Appeal** • **Docking Guidance** • **Use a Staged approach to build on the success of increasing BRT System Capacity and Speed, get vehicles on the road!** **Stage One: Brand and Logo-Stage** **Stage Two: Sleek and Modern with speed, capacity & amenities** **Stage Three "Speedy" Appearance full preference satisfaction** • **Docking Guidance** • **Develop Specifications, Work with Communities and Industry**

Short of convergence, a set of priorities for appearance and features could guide the manufacturers and, in turn, accelerate the availability of appealing vehicles for the BRT Communities. A phased approach is a pragmatic way of building on the success of current BRT systems such as Miami or Los Angeles but get high-capacity vehicles on the road quickly. A final note is an appeal for industry docking guidance specifications.

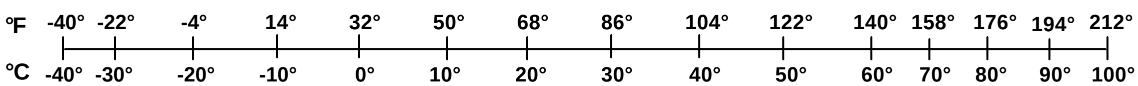
METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC		METRIC TO ENGLISH	
LENGTH (APPROXIMATE)		**LENGTH** (APPROXIMATE)	
1 inch (in)	= 2.5 centimeters (cm)	1 millimeter (mm)	= 0.04 inch (in)
1 foot (ft)	= 30 centimeters (cm)	1 centimeter (cm)	= 0.4 inch (in)
1 yard (yd)	= 0.9 meter (m)	1 meter (m)	= 3.3 feet (ft)
1 mile (mi)	= 1.6 kilometers (km)	1 meter (m)	= 1.1 yards (yd)
		1 kilometer (km)	= 0.6 mile (mi)
AREA (APPROXIMATE)		**AREA** (APPROXIMATE)	
1 square inch (sq in, in^2)	= 6.5 square centimeters (cm^2)	1 square centimeter (cm^2)	= 0.16 square inch (sq in, in^2)
1 square foot (sq ft, ft^2)	= 0.09 square meter (m^2)	1 square meter (m^2)	= 1.2 square yards (sq yd, yd^2)
1 square yard (sq yd, yd^2)	= 0.8 square meter (m^2)	1 square kilometer (km^2)	= 0.4 square mile (sq mi, mi^2)
1 square mile (sq mi, mi^2)	= 2.6 square kilometers (km^2)	10,000 square meters (m^2)	= 1 hectare (ha) = 2.5 acres
1 acre = 0.4 hectare (he)	= 4,000 square meters (m^2)		
MASS - WEIGHT (APPROXIMATE)		**MASS - WEIGHT** (APPROXIMATE)	
1 ounce (oz)	= 28 grams (gm)	1 gram (gm)	= 0.036 ounce (oz)
1 pound (lb)	= 0.45 kilogram (kg)	1 kilogram (kg)	= 2.2 pounds (lb)
1 short ton = 2,000 pounds (lb)	= 0.9 tonne (t)	1 tonne (t)	= 1,000 kilograms (kg) = 1.1 short tons
VOLUME (APPROXIMATE)		**VOLUME** (APPROXIMATE)	
1 teaspoon (tsp)	= 5 milliliters (ml)	1 milliliter (ml)	= 0.03 fluid ounce (fl oz)
1 tablespoon (tbsp)	= 15 milliliters (ml)	1 liter (l)	= 2.1 pints (pt)
1 fluid ounce (fl oz)	= 30 milliliters (ml)	1 liter (l)	= 1.06 quarts (qt)
1 cup (c)	= 0.24 liter (l)	1 liter (l)	= 0.26 gallon (gal)
1 pint (pt)	= 0.47 liter (l)		
1 quart (qt)	= 0.96 liter (l)		
1 gallon (gal)	= 3.8 liters (l)		
1 cubic foot (cu ft, ft^3)	= 0.03 cubic meter (m^3)	1 cubic meter (m^3)	= 36 cubic feet (cu ft, ft^3)
1 cubic yard (cu yd, yd^3)	= 0.76 cubic meter (m^3)	1 cubic meter (m^3)	= 1.3 cubic yards (cu yd, yd^3)
TEMPERATURE (EXACT)		**TEMPERATURE** (EXACT)	
[(x-32)(5/9)] °F	= y °C	[(9/5) y + 32] °C	= x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286 **Updated 6/17/98**

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