

Technical Memorandum

Equipment Analysis

Downtown/Riverfront Streetcar Studies

City of West Sacramento

December 13, 2006



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1.0 Introduction

No element of a rail transit system captures the hearts and minds of the public more than the vehicle itself. Both the riding and non-riding public usually interact with the transit vehicle more than with any other part of the transit system, from actually using it to satisfy travel needs to sometimes competing with it in traffic, to recognizing it as a symbol of the transit service. In some cases, such as the cable cars in San Francisco, the vehicle can even become a defining symbol for the metropolitan area. Thus, selection of a vehicle – from the basic type of car to its various specific physical and performance characteristics, cost and aesthetics – is obviously a key decision, or series of decisions, to be taken in the course of a streetcar project.

2.0 Streetcar Characteristics

A wide range of alternative streetcars exists for consideration at the onset of a project. Electric streetcars have a long history, stretching back to the late nineteenth century when they supplanted vehicles whose tractive effort was provided by horses, or by cables propelled by steam engines. For the purpose of this report, streetcar vehicles are first divided into three broad, chronological categories: vintage and replica trolleys, Presidents Conference Committee (PCC) cars, and modern streetcars. Within each category, there are a seemingly endless number of variations and possibilities which will be summarized below. For vintage trolleys, a fundamental decision is whether to rehabilitate an existing vehicle or to replicate a historic design. For modern streetcars, often it is a question of the extent of departure from service proven or “off the shelf” designs.

Particularly for modern streetcars, but also for vintage trolleys and PCC cars, some of the important configuration and operating considerations that factor into selection of a vehicle are:

- basic size (length and width), clearance requirements, and capacity
- performance (top speed, acceleration and braking rates, etc.)
- sided-ness and ended-ness, i.e., single-sided, single-ended vs. double-sided, double-ended
- single unit operation (tow bar or mechanical coupling only) vs. multiple unit operation (mechanical and electrical coupling)
- floor height (low floor vs. high floor) and the means of accessibility

These and other considerations are reviewed in the next sections.

2.1 Vintage Trolleys & Replica Streetcars

The first electrically powered streetcars entered the American city landscape in the late 1880’s; and by the early 1900’s, every large city, as well as many smaller ones, offered extensive streetcar networks.

Early streetcars typically were made with all-wood bodies or composite wood-and-steel bodies with deck roofs and clerestories. The earliest electric streetcars were small, 25 to 30 feet long with a single four-wheel truck, but the popularity of this new technology soon required that operating companies acquire larger cars in the range of 40 to 50 feet in length (Figure 1). These cars typically had two powered trucks, were not articulated, were high floor, were found in both single-sided, single-ended and double-sided, double-ended versions, and normally operated as single units. There were many variations to these generalities.



Figure 1. Vintage Trolley - Dallas, Texas

Most of the early streetcars were retired by World War II, and those that still survive today, the vintage trolleys, are usually found in museums, as historical items at transit agencies, and in limited or special purpose service by private or non-profit institutions. Many are operated as tourist attractions. Restoring a 90-year old vintage trolley is a painstaking process and primarily an act of love. Keeping one operational is also a challenging task. The most extensive example of a restored vintage trolley system in the United States that is still operational is in New Orleans, whose St. Charles cars date from 1924. Of course, San Francisco's cable car system is, in a sense, also an example of extensive use of vintage and wholly or partially re-created vehicles.

Several cities – Portland, Tampa, Little Rock and Charlotte - have opted to replicate rather than rehabilitate a vintage trolley, and New Orleans has a large replica fleet in addition to its refurbished cars (Figure 2). Replicating a vintage trolley could involve, for example, the construction of a steel underframe and inclusion of more modern safety features while retaining an original or vintage looking appearance (Figure 3). This approach helps guarantee consistency of design and parts, and essentially results in a new product



Figure 2. Replica Vintage Trolley - New Orleans

that has a vintage appearance, plus a long economic life ahead of it.



Figure 3. Replica Vintage Trolley - Portland, Oregon



Figure 4. Replica Double Birney - Tampa

Of particular interest for this project, because they are so similar in appearance to cars operated in Sacramento from the 1920s until the streetcar system's demise in 1947, is the replica double-truck Birney car (Figure 4) manufactured by the Gomaco Trolley Company in Iowa. First built for Tampa, additional units have been delivered to Little Rock, Memphis and Charlotte. These cars are 45 to 50 feet in length, 8.5 feet wide, and equipped with about 40 seats

2.2 PCC Cars

From the mid-1930's through the early 1950's, the Presidents Conference Committee car rose to fame throughout North America, and its design was exported to Europe and elsewhere. Again, while there were many variations, the PCC car was basically an all-steel, non-articulated car, approximately 50 feet in length, with two powered trucks and high floors (Figure 5).

PCC's were built in both single-sided and double-sided configurations, and they were operated as single cars and in multiple unit consists. The rounded, more contoured look and several performance and passenger comfort improvements generally distinguished the PCC car from older vintage trolleys. Some transit agencies in the U. S. cities, e. g. Boston and San Francisco, have retained and rehabilitated some of their PCC cars, and still operate them in limited or



Figure 5. Rebuilt PCC Car - Philadelphia

special service. Philadelphia has completed a PCC rehabilitation program (Figure 5) which included substantial changes to the original cars. In New Jersey, NJ Transit has purchased modern vehicles to replace its PCC fleet for the Newark Subway. Many of these cars were purchased to be used on the San Francisco F Line.

2.3 Modern Streetcars

For the purpose of this report, the term “modern streetcar” is meant to encompass new streetcars currently available in the marketplace and generally based on designs, technologies, and product improvements developed within the last ten or so years.

However, there is no precise technical definition for a “streetcar”, and, while there is considerable experience in the U. S. with modern light rail vehicles (LRV's), the actual experience with modern streetcars (as generally understood) in this country to date is limited to the Inekon/Skoda vehicle produced for Portland and duplicated with minor exceptions for Tacoma. A similar car is being developed by Inekon for a demonstration project in Washington, DC, and to provide additional cars for Portland. Most of what is considered modern streetcar experience resides in Europe, and streetcar vehicles there are typically defined more by the characteristics of their rights of way (ROW) than necessarily by the characteristics of the vehicle itself. Thus, distinctions between modern streetcars and modern light rail vehicles (LRV's), particularly in the European context, can often be more blurred than instructive.

In Portland, a conscious effort was made to distinguish the city streetcar service and the streetcar vehicle from the regional light rail service and the LRV. Compared to the LRV, the streetcar vehicle is shorter (66 feet vs. 92 feet) and narrower (8 feet vs. 8 feet 8 inches), thus making it less intrusive and more in scale with crowded urban streets and residential neighborhoods (Figure 6).

Portland chose to avoid multiple unit operation, so all streetcar service is with single cars, further enhancing the feel of a smaller scale, urban rather than regional system. Performance parameters are accordingly reduced compared to those of the LRV's which operate at higher speed and on considerable grade-separated ROW throughout the metropolitan area.



Figure 6. Modern U.S. Streetcar by Inekon/Skoda - Portland, Oregon

In Europe there is a plethora of modern streetcars. All of the major railcar builders in Western Europe produce vehicles that generally fall within the streetcar category. Often, as in Portland, modern European streetcars tend to be three abreast (two plus one) seating, thus resulting in a narrower cross section vehicle more suited for cramped European streets. Top speed is often limited to 40 to 45 miles per hour compared to the 55 to 60 miles per hour more common for LRVs, which require the higher speed for regional service. Most modern streetcars are articulated, and some, built from a modular design, have multiple articulations and stretch to over 100 feet in length. As is now commonplace with LRV's, most modern streetcars are partial or 100% low floor (providing level boarding). Figures 7 through 11 provide examples of modern streetcars in Europe.



Figure 7. Leoliner by Bombardier (High Floor) - Leipzig, DE



Figure 8. Trio by Inekon (70% Low Floor) - Ostrava, CZ



Figure 9. Combino Prototype by Siemens (100% Low Floor) - DE



Figure 10. Tram 2000 by Bombardier (100% Low Floor) – Brussels, BE



Figure 11. Citadis by Alstom (100% Low Floor) - Montpellier, FR

Table 1 provides a summary of U.S. cities that have some form of vintage trolleys, PCC cars, or modern streetcars either in service or in the process of being procured. Also noted are modern light rail vehicles (LRVs) in those cities that have such vehicles as well as streetcar in service. Overall counts of the numbers of cities with various classes of streetcars are: restored vintage trolleys – 10, replica vintage trolleys – 7, restored PCC cars – 5, and new modern streetcars – 3 in service with orders placed by 2 more projects.

City	Vintage Trolley		PCC	Modern Cars	
	Restored	Replica		Streetcar	LRV
Boston	X [a]		X		X
Charlotte	X	X		X[b]	X
Dallas	X		X		X
Kenosha			X		
Little Rock		X			
Lowell		X			
Memphis	X	X			
New Orleans	X	X			
Philadelphia			X		X
Portland		X		X	X
Sacramento	X [a]				X
San Francisco	X		X		X
San Jose	X				X
Seattle	X			X	X
Tacoma				X	
Tampa	X [a]	X			
Washington, DC				X	

a-1 or 2 cars each, for special events. b-Procurement not yet begun.

3.0 Criteria for Vehicle Selection

There are obviously different approaches to purchasing rail vehicles. The approach recommended in this report is that resources initially be devoted to deciding the basic type and configuration of streetcar vehicle and to not focus on a specific vehicle or vehicle details until more general considerations are resolved, and the parameters of the overall streetcar project more sharply in focus. Once the basic type of streetcar vehicle is decided and a procurement process started, the procurement documents would list in detail all the specific criteria for evaluation and selection. Typically these criteria include the following major categories:

- Qualifications and experience of the manufacturer and sub-suppliers
- Manufacturing plant (location and capacity of facilities, Quality Assurance program, testing capabilities)
- Conformance of proposed vehicle to technical specifications
- Price (in various aspects)

Following are a list of screening factors to begin the effort of defining the basic type of streetcar vehicle most appropriate for this project.

3.1 Core Concept & Aesthetics

Is it important or necessary that the streetcar vehicles present a vintage appearance, or, conversely, does the project want the streetcar vehicles to offer a modern appearance? Is there a nostalgia factor that can only be satisfied by vintage trolleys, or is the focus on provision of a contemporary transportation solution?

3.2 Availability & Uniqueness

One difficulty with pursuing vintage trolleys as the entire operating fleet is finding sufficient identical vehicles and parts. Furthermore, as the system expands, the problem becomes more acute. It is always possible to have a mix of hardware and vehicles, but the more unique each individual vehicle is, and the greater the variation in a small fleet, the more that normal costs of maintenance and operational problems multiply. Much of this situation could be overcome with replicated vintage trolleys.

Sacramento already owns one operational vintage trolley – car #35 – that is housed at RT's LRV maintenance facility, and operates in downtown Sacramento for special events. In addition, the region has two potential sources for old trolleys.

The Friends of Light Rail and Transit, an important Sacramento area transit support organization, own five carbodies dating from Sacramento's first era of electric street railway service in the early decades of the twentieth century. These cars were used for a variety of static uses after the streetcar system was abandoned, are in various stages of serious disrepair, and are devoid of trucks or any mechanical and electrical equipment. Restoring them to operating condition would be a major undertaking involving meticulous rebuilding of the bodies as well as searching out, procuring, rebuilding and installing all the mechanical and electrical gear. As others have shown, this can be done; but it is difficult and time consuming, and costly unless done by dedicated and knowledgeable volunteers. In short, this vehicle alternative seems unlikely to be a good fit with the project's initial timetable and budget, although a continuing

program of restoration of these cars could be considered as a subsequent adjunct to the project, eventually producing an operable fleet of delightful historic vehicles for use on holidays, for special occasions, and when added capacity is required for special events.

A second source of old cars is the stock of ex-San Francisco Municipal Railway PCC cars purchased by Gunnar Henriouille more than a decade ago, and since stored on the South Lake Tahoe airport property. Some have since been sold back to preservationists in San Francisco and San Diego. The cars now remaining in South Lake Tahoe must be removed within the next few months. In rough condition after years of outdoor storage, restoration of these cars would require an extensive rebuilding effort to make them suitable and reliable for every day operation.

3.3 Size, Scale & Capacity

It is important to establish the basic, but not exact, size of the streetcar early in the process, not only for interface with civil elements but for fundamental public perception and to bracket the number of vehicles needed for various service levels. Given the scale of the downtown and a rough initial understanding of likely patronage levels, streetcars in the 80 to 90 foot length or longer are probably not going to be warranted for this project on a capacity basis. Instead, shorter vehicles of between approximately 45 and 65 feet seem to be indicated.

3.4 Configuration: Sidedness, Endedness & Coupling Capability

Single-sided, single-ended operation is a fairly substantial restriction for a new system. Virtually all new light rail systems and most new streetcar systems in this country in the last twenty years have chosen a double-sided, double-ended configuration. This report recommends that a double-sided, double-ended streetcar vehicle be initially assumed as the basis for system design.

The next basic configuration question is whether the streetcar vehicles should operate singly or entrain in multiple unit consists. Further discussion is needed to sharpen the focus on this consideration.

3.5 Accessibility

Accessibility of the streetcar for mobility-impaired patrons is a critical requirement in today's world. Since the late 1980's, modern streetcars and LRV's have solved the problem with stepless entry, matching a low floor for a portion or all of the passenger floor area in the vehicle with wayside boarding platforms, both at a height of approximately 14 inches above the rail. While there were a few examples of low floor vintage trolleys in previous eras, realistically this is not an option today, and on-board lifts or some sort of raised platform (on the wayside) and manual, folding ramp would be required for the vintage trolley or PCC option. The modern streetcar would be at least partially low floor, and would be likely to use a small, automatic bridging device to provide wheelchair accessibility fully compliant with the Americans with Disabilities Act. Alternatively, the vehicle might employ a leveling device that maintains a constant floor height regardless of passenger load.

3.6 Passenger Comfort

Almost all modern transit vehicles in the U. S. use a heating, ventilation, and air conditioning (HVAC) system for passenger comfort. While vintage trolleys and PCC cars were

heated in cold weather (sometimes too well heated), they were not equipped with air conditioning. Incorporation of modern HVAC equipment into the older vehicles could be problematic, although an HVAC system has been accommodated in the Tampa and Little Rock replica cars.

3.7 Conformance to Federal Regulations (Buy America)

Since the early 1990's, whenever local agencies use Federal funds to purchase rolling stock, the local agencies must conform to certain Federal regulations, commonly known as Buy America. Basically, the Buy America regulations require that a majority (now 60%) of the components used in the vehicles must be of U.S. origin and that final assembly of the vehicles must occur in the U.S. These requirements can be difficult to meet with a small order from an off-shore supplier. The regulations also set out various audit procedures and waiver conditions. Also, if a local agency does not use Federal funds to purchase the vehicles, the Buy America regulations are not applicable.

Rehabilitation or replication of vintage trolleys or PCC cars would almost certainly utilize U.S. components and be performed in the U.S., and therefore Buy America should not be an issue if the vehicles are to be purchased using Federal funds. However, the picture is not so clear-cut with respect to modern streetcars (Portland, Tacoma, and Washington, DC) have been purchased using local funds, and Buy America has not been applicable. Final assembly of these vehicles has taken place (and will take place for Washington, DC) in the Czech Republic. While most European carbuilders have established final assembly plants in the U.S. for LRV or heavy rail vehicle procurements, it remains to be seen if any would elect to do so for a small order of streetcars.

3.8 California Public Utilities Commission (CPUC) Regulations

As the location of the first "new start" LRT project of the current era, California early on faced the issue of state safety oversight and regulation, and developed CPUC General Order 143 (GO 143) to set standards for new age LRT projects. Recognizing the continued existence of the SF Muni's heritage trolley system and San Jose's project to renovate a few older trolleys, GO 143 (twice updated, and now in force as GO 143-B) established certain variations for "historic" streetcars, defined as those built prior to 1956. Thus, older cars, including PCCs, are not required to meet all of the GO 143-B requirements for new "light rail vehicles;" but new replica cars must, unless a project proponent can convince CPUC to grant waivers. Among requirements is that every new LRV be able to withstand, without permanent deflection, a force of twice its empty weight, applied to the end of the frame. Some replica cars have met this standard; some have not.

3.9 Cost

Last but rarely ever least is the factor of cost. A very rough guideline is that restored or replicated vintage trolleys or PCC cars would probably cost \$0.75M to \$1.5M depending on the extent of restoration and numerous other factors; while modern streetcars similar to Portland's would cost about \$3.0M, with some variability depending on the technical specifics. However, in terms of carrying capacity or per-seat cost, the cost differential begins to narrow given that the modern streetcar vehicle is substantially longer. A representative listing of streetcar costs per vehicle for cars procured since 2000 is provided in Table 2.

Table 2. Cost per Vehicle of Representative New Streetcar Procurements

Year	City	Supplier	Type	\$ Each
1998	Portland [a]	Inekon/Skoda	Astra 50% Low Floor	\$1,350,000
1999	Tacoma	Inekon/Skoda	Astra 50% Low Floor	\$1,350,000
2000	Portland	Inekon/Skoda	Astra 50% Low Floor	\$1,700,000
2000	Tampa	Gomaco	Double Truck Birney	\$620,000
2001	Little Rock	Gomaco	Double Truck Birney	\$755,000
2001	Philadelphia	Brookville	Rebuilt PCC	\$1,200,000
2002	New Orleans	RTA/Brookville	Perley Thomas	\$1,300,000
2003	Charlotte	Gomaco	Double Truck Birney	\$716,000
2005	Little Rock	Gomaco	Double Truck Birney	\$868,000
2006	Washington, DC	Inekon/DP Ostrava	Trio 50% Low Floor	\$2,840,000

a-Base price; total per car was \$1,608,000 with Support Services included.

4.0 Initial Vehicle Comparisons & Evaluation

Characteristics and issues related to the several vehicle alternatives are summarized in Table 3.

Table 3. Summary Comparison of Vehicle Alternatives				
Item	Modern	PCC	Replica	Vintage
Initial \$ Each	\$3.0 mil	~\$1.5 mil	≤\$1.0 mil	~\$1.5 mil
Cost: 5 or 10 cars	\$15 mil / \$30 mil	\$7.5 mil / \$15 mil	\$5 mil / \$10 mil	\$7.5 mil / \$15 mil
Meet project schedule?	Yes	Doubtful [a]	Yes	Doubtful [a]
ADA	Low Floor w/Level Boarding	Lift (Rear Door)	HiBlock or Lift (Front Door)	HiBlock or Lift Major Impact on Structure
LRT Compatibility?	[b,c]	[b]	[b,c]	[b]
Double Ended, Double Sided	Yes	No	Yes	Some
TES	750 vdc	600 vdc [f]	600/750 vdc	600 vdc[f]
Fit Sacramento History	No	No	Possible [d]	Possible [e]
a-Must undergo painstaking and time consuming restoration of Tahoe PCCs or FLRT Sacto carbodies. b-May need to adjust streetcar anticlimber to match LRV anticlimbers if there is shared track. c-Need upgrade carbody compression to 2g per GO 143B, or obtain waiver (does not affect cars built prior to 1956). d-Gomaco Birneys close in appearance to 1920s PG&E American cars. e-Car 35 (operational) and FLRT carbodies all old Sacramento trolleys. f-P propulsion system usually can be modified to work with 750 vdc TES.				

Either replica vintage trolleys or modern streetcars could be made to work successfully in the context of initiating a streetcar circulator in Sacramento and West Sacramento. Vintage trolleys or PCCs, while potentially available, are likely to require a restoration and rebuilding effort that will exceed the project timeline. Primary issues to consider are image, cost, availability and accessibility.

- Cost: Replica cars are likely to cost about one-third as much as modern streetcars
- Regulatory Issues: Conforming to CPUC GO 143-B, or seeking relief therefrom
- Availability: Both replica and modern streetcars can be purchased from existing suppliers, using existing designs
 - Replica – Gomaco (double truck Birney); Brookville (carbody “tbd”)
 - Modern – any of several global suppliers, if willing to build a small order
- Accessibility: Both replica and modern cars can be equipped to meet ADA
 - Replicas – lift in right front door at each end of car (e.g., Gomaco Birney)
 - Modern – level boarding from raised platform at mid-car door; however, raised platforms pose a design issue, especially on any trackage shared with RT Light Rail, which has some downtown station platforms at rail height (street) level.

Whichever approach is chosen, it is recommended that the basic vehicle configuration be double-sided, double-ended and that, for planning purposes, the basic vehicle width be kept as close as possible to RT’s existing LRVs since shared track is contemplated.

Regarding modern streetcars, while the capital cost of the vehicles will be higher compared to those of replica vintage trolleys or rebuilt PCC cars, modern streetcars such as the Inekon vehicle provide improved performance and passenger comfort, higher capacity, greater opportunity and ease in expanding the system beyond a short starter line, and a better long-term accessibility solution.

Finally, designing a streetcar system’s fixed facilities to accommodate modern vehicles – and perhaps even LRVs – may be desirable considering how the region’s rail system is developing over time. Modern streetcars may become a desirable or even necessary addition to a streetcar system in the future. Even upon opening, it may be desirable to have the ability to dispatch trains of LRVs to West Sacramento to move audiences to and from events at Raley Field. Of course, this approach would not preclude the initial use of vintage or replica cars, or the inclusion of one or more vintage trolleys at some opportune point in the future, when the initial line is established and success has been proven.