Streetcar Capital Cost Estimation

This Best Practice, since it focuses on capital costs has a slightly different orientation. The intent here is to understand the basis of estimating future costs for this transportation infrastructure investment. To do that, the emphasis is on the structure of the federal cost estimating protocol.

> Recent modern streetcar projects have averaged approximately $50M per route mile (inclusive of track in both directions).

Standard Cost Categories

All major transit investments pursuing federal funding through Federal Transit Administration (FTA) grant programs must organize project costs according to FTA's Standard Cost Categories (SCC) structure. This structure ensures that capital cost estimates can be fairly compared from one project to another. The SCC classification includes the following categories:

- Category 10: Guideway and Track Elements;
- Category 20: Stations, Stops, Terminals and Intermodal;
- Category 30: Support Facilities: Yards, Shops, and Administrative Buildings;
- Category 40: Sitework and Special Conditions;
- Category 50: Systems;
- Category 60: Right of Way, Land, and Existing Improvements;
- Category 70: Vehicles;
- Category 80: Professional Services;
- Category 90: Unallocated Contingency; and
- Category 100: Finance Charges.

10 - Guideway and Track Element

> Embedded track (track installed in-street in mixed traffic) costs approximately $10M per route mile (track in both directions).

Guideway and track elements consist of portions of the transit system constructed within the transit right-of-way. Category 10 includes a guideway within a dedicated/exclusive right-of-way or in mixed traffic; required cut and fill; underground tunnels and aerial structures; embedded track; direct fixation track; ballasted track; necessary removal of asphalt, earth excavation, backfill, drilling, mining, finished grading, and retaining walls; and other work needed for guideway or track construction.

20 -Stations, Stops, Terminal, and Intermodal

> Standard stations cost approximately $40-50K each.

Category 20 consists of any cost associated with the stations either above or below ground including: grading, excavation, ventilation structures and equipment, station power and lighting, platforms, canopies, finishes, equipment, ticket vending machines, landscaping, mechanical and electrical components, access control, security, artwork, station furnishings (benches, trash receptacles, etc.) and signage.

Protection and/or relocation of existing underground utilities can be a significant expense.

Modern streetcars cost roughly $4.0-4.5M per vehicle; replica streetcars cost approximately half that of modern streetcars.

30 - Support Facilities, Yard, Shops and Administrative Buildings

Category 30 is comprised of vehicle storage and maintenance buildings; track for storage of vehicles; office support areas; major shop equipment and maintenance facilities.

40 - Sitework and Special Conditions

Included within Category 40 are all of the materials and labor required for construction of the transitway; environmental mitigation and hazardous material/soil contamination removal; required wetland, historical/archeological and park mitigation; sidewalks, public art and bike facilities; fencing; site lighting and signage; as well as any costs associated with mobilization, traffic mitigation and temporary construction.

50 - Systems

Category 50 includes costs associated with communications, train control, train signals, traffic signals, crossing protection, traction power substations, and the catenary power distribution system.

60 - Right-of-Way, Land, and Existing Improvement

Category 60 includes the costs for parcel impacts, including purchase, easements, relocations, real estate fees, and professional services associated with parcels needed for the transit and highway improvements.

70 - Vehicles

Category 70 includes the cost of modern streetcar vehicles using electric propulsion.

80 - Professional Services

Under professional services Category 80, FTA identifies eight sub-categories. These categories represent expenditures related to project engineering; project and construction management; insurance; legal matters (such as permit review fees and surveys); testing and inspections; and technology-related training of personnel.

90 - Unallocated Contingency

Category 90 provides a standard unallocated contingency to account for any items or issues potentially not considered.

100 - Finance Charges

Category 100 includes finance charges expected to be paid by the project sponsor/grantee prior to either the completion of the project or the fulfillment of the federal funding commitment, whichever occurs later in time.

Small Shuttle/Community Circulator

Portland opened the country's first modern streetcar in 2001.

An urban circulator provides a transportation option that **provides district mobility, accelerates pedestrians, connects urban destinations** and fosters the **redevelopment of urban place into dynamic environments**. An urban circulator can be a special bus or a streetcar. Over the last decade, the streetcar became well-known as a catalyst for economic development and enhanced livability.

Features of the Streetcar

Considered by many as an "old" technology, the modern car is anything but old. The new vehicles are sleek in design, quiet and comfortable. Features include:

- Using rails embedded in the street
- Operating with automobiles in shared traffic lanes
- Providing connections within a compact urban setting, not across a region
- Offering low floors that allows easy boarding for seniors, bicyclists, and those with wheel chairs or strollers
- Serving short trips and at low speeds
- Supporting neighborhoods as "walk extenders"

***Top*: Portland, Oregon's Pearl District before streetcar operations. *Bottom*: Same area showing redeveloped properties after streetcar service began.**

Benefits of the Streetcar

The popularity and attractiveness of the streetcar is based on its three specific benefits – being a pedestrian accelerator, a district circulator and development generator. These benefits are crucial to the Strip's continued success.

Pedestrian Accelerator

Streetcars increase mobility options and provide the "last mile" of service to pedestrians. Potential streetcar alignments must "target" streets with consistent pedestrian activity and in locations with potential pedestrian generators, given that the first class passenger of the streetcar is the pedestrian. Streetcars stations are typically spaced in accordance to block lengths and can vary from 600'-1200'.

Put the circulator where the pedestrians will be

Pedestrians are first class riders

Remember "service" does not have to be at the front door

Create visual connections and an overall sense of place to increase walkability

Small Shuttle/Community Circulator

District Circulator

The Strip is a “natural” place for a streetcar, having clear boundaries – the river on the west, the bluff on the east and bridges on the north and south. The potential alignment should be identified based on the project goals, identified transit needs within the Strip District, and public and stakeholder suggestions. When selecting an alignment consideration should be given to the capability of tying in future extensions.

Connect the maximum number of existing destinations

Tie together key existing destinations to encourage ridership from the outset

Follow an easy-to-understand, "readable" route

The circulator route should be clear and direct, particularly for non-regular riders

Position the route for future expansions

Opportunities for connections to future extensions should be considered

Development Generator

Other cities are advancing streetcar design to use this transit alternative as one tool to increase land values in targeted location. Research shows that about 90% of available development potential is realized on blocks directly facing the streetcar line, falling off over the next three blocks.

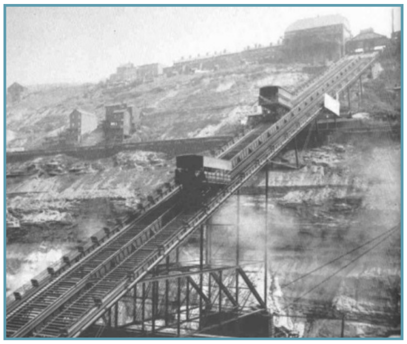
Uncork the most development potential

Serve areas that are primed for redevelopment, not just areas that are already developed

Consider use of couplets

Couplets offer an opportunity to expand the economic impact area

Funiculars and Inclines



Historical image of the Penn Incline from the Strip District to the Hill District at 17th Street.

As a way to connect hilltop residential areas to the downtown and industrial areas, Pittsburgh's developed a series of funiculars or inclines. The first one was the Monongahela or Mon, opening in May 1870. Through the years, Pittsburgh had 16 inclines and two are still in operation. The Penn Incline was located in the Strip District at 17th Street, and it moved both freight and passengers. It closed in 1953 after 80-years of service between the Strip and Hill Districts.

Features of Funiculars

By definition, a funicular or incline is a counterbalanced, cable driven railway traversing a steep slope. There are typically two cars, operating on parallel tracks with stations at the top and bottom. Although most funiculars are used to transport people, they also can move goods and materials. There are traditional and hybrid funiculars.

Traditionally, funiculars were designed with wheels on fixed rail. The wheels could be flanged or unflanged to allow for shared track usage. The track is supported from below with structural bracing. Although the track typically follows a constant slope and direction, some have been designed to allow for grade changes and curvature. The cars are attached by a cable to each other with a pulley at the top of the slope. This is the type used in Pittsburgh.

A **hybrid funicular** is a mix between the traditional rail-based funicular and other forms such as gondolas and cable cars. One feature of a hybrid funicular is the ability for the cars to "self-level" by use of modified chassis systems. This allows passengers to stay level with the ground and allows for non-conventional designs over varying terrain.

Benefits of Funiculars

The use of inclines or funiculars results in multiple benefits for the Strip District:

- **Connectivity** is reestablished between the Hill District and the Strip District. It also complements the Hill District Master Plan.
- Reduces short-length vehicular trips using circuitous routes such as Bigelow Boulevard and Herron Avenue between the Hill and Strip Districts. This results in increased operations at key intersections on Liberty Avenue.
- Coupled with a multi-modal station at the lower terminal, the solution provides **mode choice and accessibility** to mode options such as transit and bicycling. This encourages use of alternative modes and increase in vehicular traffic operations.
- **Hybrid funiculars** can be flexible in design to allow for compact or underground stations, offset stations, obstacle avoidance, and varying slopes.
- The self-leveling system **increases rider comfort** when traversing varying slopes. Thus reducing the need for passengers to lean or brace themselves while in motion.

Funiculars and Inclines

Portland Aerial Tram, an example of a hybrid funicular, runs between the Waterfront District and Oregon Health and Science University.

Hungerburgbahn Funicular located in Innsbruck, Austria is an example of a hybrid funicular.

Photo source: http://gondola project.com

A new incline or funicular in the Strip District will meet specific needs that improve connectivity with adjacent neighborhoods, increase traffic operations, and promote multi-modal options.

Models of Hybrid Funiculars

There are several examples worldwide that could be utilized as models for the Strip District:

- The **Portland Aerial Tram** is an example of a funicular suspended overhead with cables, thus allowing the chassis to be separate from the car. The cables are supported at each station and at an intermediate tower and are pulled by haul ropes. This Tram is operated by the Oregon Health and Science University and was initially conceived to reduce trips to/from the hilltop University via a circuitous route.
- An advanced example, the **Hungerburgbahn Funicular**, located in Innsbruck, Austria operates on a fixed track but has the flexibility to traverse multiple grade changes allowing it to tunnel under existing roadways. The individual cars are encased in a chassis, allowing them to naturally level independent of the chassis.

Operating and Maintenance Costs

Annual operating and maintenance costs comprise all on-going expenses including operator salaries, maintenance and support personnel salaries and supplies, facilities maintenance (including maintenance of overhead wires), vehicle insurance, energy consumption, and related elements.

For conceptual planning purposes, an all-inclusive unit cost of $150-200 per revenue hour can be assumed. This cost is based on actual costs of modern streetcar operations. A more detailed operating cost analysis will be needed as a route and plan are refined. Such an analysis will consider specific components of operations - allocated costs of labor, fuel / power, maintenance, insurance, and other components of on-going operations.

Comparison of Streetcar and Bus Costs

Compared to typical bus operations costs, streetcar costs may be marginally higher when calculated on per hour of service, due to the maintenance of additional facilities that are required for streetcars. However, recognizing the higher ridership that streetcars encourage, operating costs for a streetcar may be lower than those of bus on a per-passenger basis. Furthermore, the life-cycle cost of streetcars is typically lower than the bus, due to the longer service life of streetcar vehicles (30-40 years) as compared to buses (12-15 years).

Total Annual Costs

Annual costs for a typical streetcar circulator may range from $2M to $4M, depending on the route length and service characteristics. Longer routes, longer hours of operation, and more frequent service result in higher operating and maintenance costs.

Staffing Needs

Staffing needs are dependent on the size of the streetcar operation, but include the following resources:

- Streetcar operators
- Maintenance staff
- Street supervisors
- Dispatch personnel
- Fare inspectors and
- Administrative personnel.

Transit Stop Consolidation

Signage from the Metrobus Bus Stop Consolidation Program, Washington, DC

One major concept when planning improvements within a corridor such as the Strip District is the principle of transit stop consolidation. Often, in dense urban or fringe areas, multiple transit routes along a corridor have their stops spaced on alternate blocks or some other "spread" method.

Traditional thinking suggested that spreading out the stops over multiple blocks, and splitting the routes serving each specific stop reduced crowding at stops and provided the best traffic flow. It also nominally provides the most complete "service coverage" for the neighborhood, although any individual passenger might have to walk to get to their specific bus stop. Unfortunately, as congestion increases, the "spread" stop approach breaks down as buses delay not only those using "their" stops but also the other routes using "other" stops.

Transit stop consolidation turns this concept around and believes that more overall community benefit is achieved by concentrating the stops into fewer locations, improving route performance and at the same time adapting the unused space for other uses, a

Features of Stop Consolidation

Stop Consolidation provides a dense neighborhood like the Strip District with the following features:

- Fewer Stops/transit facilities and simpler operation
- More room for other street/sidewalk uses.
- Longer walk access for some, shorter for others
- Streamlined transfer opportunities
- More options for stop placement better suited to the neighborhood
- Opportunity for neighborhood focal points.

Benefits of Stop Consolidation

- While the features of stop consolidation are not necessarily appropriate everywhere, a neighborhood such as the Strip stands to benefit from its implementation in several key ways: **Improved travel speeds and headways** – Fewer stops can lead to faster running times for vehicles, which could result in more frequent headways or the potential to expand service hours. More vehicles available to serve the neighborhood will bring more people to patronize the businesses in the neighborhood without additional parking strain.

- **Congestion removes "spread" stop benefit** – Once a corridor is congested enough that buses stopping on one block routinely slow down those which stop on alternate blocks, the "spread" stop scheme becomes ineffective anyway.
- **Reduced travel times for passengers** – In dense urban areas such as the Strip District, sidewalk use is generally not seen as a negative amenity for passengers, and they can benefit from the faster ride times. Even if passengers have a slightly longer

walk to arrive at a stop, cities find that their quicker rides often more than make up for increased walking time in the urban core areas.

- **Optimum use of premium pedestrian and stop amenities** – Enhanced facilities and amenities such as bus shelters, specialized crosswalks, and safety features are popular, but expensive. With fewer stops, more of the station features could be improved.
- Fewer stop locations simplifies the streetscape, and makes space available for other uses (parking, bike racks, sidewalk features, etc.)—Usable streetscape space is at a premium in the narrow Strip District, and any opportunity to “reclaim” street or sidewalk space for other uses is welcome.
- **Cost savings** – By reducing the number of stops, transit systems could save money compared with current routes and reallocate/reinvest those funds.

As with any stop location decision, careful consideration needs to be done so as not to adversely impact ridership or economic development potential.

The placement of station stops is also an important consideration when planning a streetcar line. Streetcars by their very nature are neighborhood circulators, thus frequent stopping and close spacing of stations (every other block or similar) is the norm. However, there are times when such close spacing is inadvisable for operational, demand, or developmental reasons. An important part of the planning, design, and construction of a streetcar system is determining whether two adjacent stops are truly necessary, or if the same substantial benefits could be seen by a single stop. Questions to ask when considering streetcar stop consolidation include:

- Are changes feasible and advantageous operationally?
- Will changes unduly impact anticipated ridership?
- Will changes adversely affect economic development potential?

Further into streetcar planning, when the fiscal realities of the project come more into focus (such as during implementation phasing and value engineering), it may be necessary to remove a stop or stops or defer them to a later construction phase. At that time the cost savings will be clearer and can be more carefully weighed against (presumably negative) impacts to operations, ridership, and economic development.

Universal Design for Transit

Universal Design can meet ADA compliance while also achieving better design for all populations

Universal design is a broad concept that considers how infrastructure, products, and services can be used by the broadest population possible from the onset, rather than providing add-on elements for specialized populations. Although transit systems, are often most focused on ensuring handicapped access, universal design also applies to the elderly, children, the heavyset, and the frail. With universal design, as wide a swath of users as possible is accommodated seamlessly at all times.

Features of Universal Access

New transit facility improvements must comply with the latest safety standards, including the Americans with Disabilities Act (ADA). However, organizations such as the United States Access Board remind us that ADA regulations are a minimum standard rather than a regulated specification. As such, design can always achieve above and beyond the minimums established by the ADA. An example of the difference is illustrated here:

- ADA compliance is achieved when a transit vehicle lowers a ramp for a wheelchair-bound passenger waiting to board, at which point the passenger wheels him/herself to a secure part of the vehicle, or is wheeled by the driver. Other patrons are made to wait while this is achieved.
- Universal design is achieved when a transit vehicle arrives at a station stop that is level with the vehicle, and a wheelchair-bound passenger rolls on board alongside other passengers, without incurring additional wait time for anyone else.

Level boarding achieves Universal Design.

Handicapped passengers typically prefer universal design concepts because they are treated like everyone else, in a system that everyone can use equally. The goals of universal design with regard to handicapped accessibility are for the same solutions to apply to as many people as possible. **Although the specific components of universal design can vary widely, the following lists some of the key overall features in universal design:**

- **Vehicle Technology**. The same GIS-based technology that feeds mobile apps that tell well-connected users when the next transit vehicle will arrive is the same technology that announces current stops and/or bus identifiers to riders on board or at the station stop, an important benefit for blind or other low-vision passengers.
- **Signage**. Users who are new to the system prefer easy-to-read signage and easy-to-understand maps, just as an elderly passenger with limited eyesight might.
- **Ticketing**. Ticket machines that offer verbal directions graphic instructions can assist average riders, new riders, blind riders, illiterate riders, the elderly, and children.
- **Level Boarding**. Level boarding does more than assist wheelchair-bound passengers – it also facilitates the boarding

of passengers with bicycles or strollers, or even those with bulky items to carry.

On-board GIS technology serves mobile apps while also providing blind and seeing passengers with stop announcements

Benefits of Universal Design for All

The key element of Universal Design is that handicapped accessibility is not the only issue considered. By trying to accommodate as much of the population as possible, the following elements also come into play on board transit vehicles:

- **Vehicle Technology**. Rider confidence is improved among all special populations and everyone has a sense of when the bus or streetcar is coming, where it s going, and how to get on/off.
- **Signage**. Simple, clean, and universal signage design benefits all riders, but especially those groups who may have trouble seeing or understanding the signage otherwise, such as low-vision, elderly, or visitors not familiar with the neighborhood.
- **Ticketing**. Universal design ticket machines offer verbal directions. Also, graphic instructions can assist average riders, new riders, blind riders, illiterate riders, the elderly, and children.
- **Level Boarding**. Level boarding does more than assist wheelchair-bound passengers – it also facilitates the boarding of passengers with bicycles or strollers, or even those with bulky items to carry.