# Hercules Aerial Tram/Mobility Study & Report

Prepared by Reconnecting America

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## *I. Report Summary:*

This study seeks to inform City of Hercules Council and Staff about connecting the City's waterfront to a new developing town center. This study gives technical information on the possibility of using aerial ropeways (which includes aerial trams and gondolas) and discusses alternatives such as buses and streetcars.

Aerial ropeways have been transporting people for over half a millennia, however their implementation in urban areas in the United States is rare. This is because they are often used as a niche transport application. Reserved for routes that can not be traversed on land, aerial ropeways serve to connect two points with a straight line. There are three aerial ropeways used as mass transit in the United States today: Roosevelt Island Tram in New York City; Aerial Tram in Portland, Oregon; and the Telluride, Colorado Gondola. In each instance aerial ropeways fly over a natural obstacle including rivers and steep slopes. Three case studies outline these transportation facilities and discuss the reasons for their construction.

Also discussed is the possibility of creating a circulator system using buses and streetcars. Buses can be inexpensive and easily implemented on existing streets. They have advantages such as flexibility but disadvantages like their image. Streetcars have the ability to attract new passengers and development while possibly operating in their own right-of-way but have larger capital costs and construction times. These two options could connect a number of places being created by the City of Hercules and allow citizens to get to destinations without using their own vehicles.

**Technology Overview Preface**
Below is a technology overview of aerial ropeways. Aerial ropeway is the term used by the industry to describe the use of wire rope to transport material and people. This includes aerial trams, gondolas, chair lifts, and funicular technologies, which are all part of the same transportation family.

## *II. Ropeways in the United States*

The first ropeways in the United States were for transporting materials when mining in the West was in a boom. The technology was officially introduced in 1868 when a bicable ropeway was constructed by an engineer named Cypher. Materials tramways had been used to transport work men to high mining encampments, but singular transportation of people was not introduced until just before the turn of the century.[1]

In 1893 a 16-passenger carrier reversible ropeway was used to transport personnel only across the Tennessee River in Knoxville. Passenger ropeways in the United States such as the Niagara Falls Tramway (built in 1912) and the Sunrise Peak Gondola, built in

[1] Dwyer, Charles. Aerial Tramways in the United States – An Historical Overview. OITAF 1988

1907, won international recognition for their designs. The Niagara Falls Tramway is still operating, while the Sunrise Peak Gondola ceased operation in 1911 after transporting over 2,000 passengers.[2]

During the years between the two world wars tramway design continued unchanged until the mid thirties. This lull continued until Cannon Mountain in New Hampshire built its first double reversible tramway in 1938 for skiers and tourists. The number of ropeway applications for skiers exploded in the 1930s and 1940s however costs for large cabin tramways were a deterrent for lots of ski mountains. This led to the development of continuous loop chairlifts developed for this express purpose. The first such installation took a materials tramway and used makeshift chairs to build a ski lift in Crested Butte, Colorado. Major investment and innovations after the war in aerial ropeways led to the first fixed-grip double-chair continuous ropeway in 1946. From then on, alpine skiing increased in popularity and the number of lifts in the United States increased dramatically.[3]

Even though ski lifts were cheaper, people still preferred the enclosed cabin of aerial trams. This was not cheap and limited carrying capacity. A compromise was made in 1957 with the construction of the United States' first detachable gondola system. Individual cabins circulating on the rope allowed skiers to travel up the mountain enclosed from the elements and without their skis on their feet. [4]

The first urban mass transport application of aerial tramways in the United States was completed in 1976 on Roosevelt Island in New York City. In 1984 New Orleans built an Aerial Tram over the Mississippi River for the Louisiana World Exposition. The Mississippi Aerial River Transit (MART) has since been torn down but other studies were done to see if aerial tramways would be feasible in Cincinnati, Detroit, and Denver The Detroit and Cincinnati plans were shelved due to lack of interest and funding, while operating costs for the Denver gondola were so high at over $10 million dollars per year that it was removed as an alternative.[5]

Studies by researchers at the West Virginia University (WVU) on why ropeways are not included as an alternative transit mode have concluded that engineers are generally not familiar with ropeway technology and specifications. Engineers tend to exclude aerial ropeways as an alternative even though there may be advantages in certain applications. While the ski industry is very proficient in understanding the different ropeway technologies available, transit planners and engineers are often not so enlightened. The authors of the WVU study believe this is why until recently only one aerial tram has been used for urban mass transit.[6]

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[2] Ibid
[3] Ibid
[4] Ibid
[5] Bondada, Murthy and Neumann, Edward. *Potential Applications of Aerial Tramway and Gondola Systems for Urban Passenger Transportation*. West Virginia University, Morgantown 1987.
[6] Ibid

## *III. Operations: How do they work and what are the costs associated?*

There are three types of aerial ropeway that have been used for urban mass transit purposes: reversible ropeways; gondolas; and hybrid bicable and tricable ropeways.

**Reversible Ropeway**: Reversible or jig-back ropeways operate with one or two carriers, comprising a carriage, a hanger, and the actual carrier cabin, which travel to and fro between the terminals. It is called a jig back because the power source and electric engine at the bottom of the line effectively pulls one carrier down using the weight to push the other carrier up. Traction is provided via a haul rope that creates a loop from station to station, with the carriage running on single or twin track ropes by way of a truck comprised of wheels tracking on the ropes.[7]

Portland's Reversible Ropeway

Photo by Flickr Photographer Atul66

The cars can be built to carry between 20 and 200 persons at speeds of up to 12 meters per second (~28 mph) and will pass each other mid span each time due to the reversible operation of the ropeway. Depending on the size of the car, line speed, and line length, transport capacities vary between 500 and 2,000 persons per hour.[8]

**Gondola**: Gondola ropeways are the system of choice for feeder services in ski areas, tourism resorts, and the urban environment. Different from a reversible ropeway, the gondola cabin does loops attached to a single ropeway (monocable) instead of reversing along a track wire.[9] The gondolas are attached to the haul rope with detachable grips for safe and easy loading and unloading, with the carriers traveling through the terminals at creep speed after separating from the main haul rope before accelerating to a line speed

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[7] Dwyer, Charles. Aerial Tramways, Ski Lifts, and Tows: Description and Terminology. US Forest Service. 1975

[8] Doppelmayr/Garaventa. Website: Ropeways Page. 2007. < http://www.doppelmayr.com/products>

[9] Dwyer, Charles. Aerial Tramways, Ski Lifts, and Tows: Description and Terminology. US Forest Service. 1975

of up to 6 meters per second (~14 mph) when reattached. Carrier capacity varies from four to fifteen persons, and system capacity can be as much as 3,600 persons per hour. Gondolas have a standard of two stops, however three have been employed in places such as Whistler Ski Resort in Canada.[10]

Telluride Gondola Transport


Photo by Ricardo Sa

**Bicable & Tricable Ropeways**: Bicable and tricable ropeways combine features of both gondola and reversible systems. These detachable circulating ropeways operate with carrier capacities of up to thirty passengers for a maximum transport capacity of 6,000 persons per hour. The advantages of bicable and tricable ropeways derive from their outstanding wind stability, low power consumption, and the use of very long spans. Maximum line speed is 7.5 meters per second (~17 mph).[11]

Val d'Isère, France Tricable Ropeway


Photo by Doppelmayr

[10] Doppelmayr/Garaventa. Website: Ropeways Page. 2007. < http://www.doppelmayr.com/products>
[11] Ibid

**Aerial Ropeways Compared**

| Figure 1. Aerial Ropeways | Top Speed (MPH) | Carrier Capacity | System Capacity (Persons Per Hour) | Average Cost (Per Mile)* |
|---|---|---|---|---|
| Reversible | 28 | 20 to 200 | 500 to 2000 | $65 M |
| Gondolas | 14 | 4 to 15 | Up to 3600 | $18 M |
| Bicable – Tricable | 17 | 30 | Up to 6000 | N/A |

*Costs extrapolated from three systems in each category and are in *millions* of dollars.

Figure 1 shows a comparison between the three types of ropeway that were discussed previously. Costs were derived from 3 systems in each category, two that are or were operating and one planned system. Reversible systems included Roosevelt Island, Portland Aerial Tram and a proposed ropeway in Camden New Jersey. Gondola systems include a now defunct line in New Orleans, Telluride Gondola and a planned Baltimore gondola. The gondola lines were typically longer, therefore reducing their cost per mile figure. Also, terminals for reversible ropeways are much more substantial. Costs were adjusted to 2006 for inflation. Numbers for tricable ropeways were unavailable.

**Capacity**

Line capacity, the amount of carriers that can be used on a ropeway, depends on whether it is a reversible ropeway or a continuously circulating ropeway. This is not person capacity but factors into the calculation of person capacity. Reversible system capacity is dependent on line speed, line length, and station dwell times. Because the trams operate opposite each other, only two stations are recommended. If a third station for picking up passengers is needed, it must be exactly in the center of the line so that the vehicle on the opposite side does not have to stop along the trip.[12]

Continuously circulating system capacity is based on the line length and the spacing between carriers. This is also dependent on whether carriers are detachable (where carriers stop in station areas after coming off the rope) or fixed directly to the ropeway. When discussing person capacity, it is important to note that manufacturers will often state theoretical capacity.[13]

Person capacity is based on the line capacity when each of the carriers is full. Expanding the size or person capacity of systems is not easy due to the carrier size and restraints on the ropes and towers. It is not possible to add or make larger carriers later on, thus system capacity upgrades will require reconstructing the entire system, including towers, cables, and stations. If growth is expected, designing a system to accommodate more gondolas in the future is the best approach. The ropeway can be initially constructed to a higher

[12] TCRP Report 100. Transit Capacity and Quality of Service Manual – Second Edition. Chapter 11. TRB, 2004.
[13] Ibid

standard and carriers can then be purchased later on after the demand has risen. This is not possible on reversible ropeways.[14]

## *IV. Potential Applications in Urban Environments: Advantages and Disadvantages to Aerial Ropeways*

Aerial ropeways have a number of applications in urban areas. They can meet certain market niches that other technologies can not. According to a report done for OITAF (International Organization for Transportation by Rope) by researchers at West Virginia University[15], the greatest potential for aerial ropeway systems exists under the following conditions:

1. Financial resources are severely constrained.
2. Major natural or man-made obstacles exist, which coupled with budget constraints, limit the feasibility of structures for bottom supported systems.
3. Quick completion is desired.
4. A straight alignment is available.
5. Only two stations are needed and there is a clear need to connect the two points by the most direct means available (an intermediate station located ***at midpoint*** is possible for aerial tramways).
6. No extensive expansions are expected in the near future.

The overriding requirement, however, is that a clear need must exist to connect the two points by the most direct means available. When compared to other technologies, aerial ropeways have certain advantages which are discussed below. The following comes from a paper done for the 1988 OITAF symposium by the same authors as the West Virginia University report.[16]

Advantages:

1. Capital costs are low. Aerial cable transit typically has the lowest capital cost (on a per mile basis) compared to other fixed-guideway technologies.
2. Operating and maintenance costs are low.
3. Environmental impacts are minimal. Cable systems leave only a small footprint, require little space for a guideway and towers, and can be easily retrofitted into existing streets.
4. Construction impacts are minimal. Except for a limited number of foundations for towers or terminals, much less site preparation is necessary than for other types of fixed guideway.

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[14] Ibid

[15] Neumann, Peter and Bondada, Murthy. Potential Applications of Aerial Tramway and Gondola Systems for Urban Passenger Transportation. Harley O. Staggers National Transportation Center. University of West Virginia April 1987.

[16] Neumann, Peter and Bondada, Murthy. Aerial Cable Transit. *Where Does it Fit into the Urban Mobility Picture?* OITAF Symposium 1988.

Disadvantages:

1. Expandability is impossible or difficult at best. Since current technology makes it difficult to have systems consisting of more than two stations, future expansion to other areas of the city may not be feasible.
2. Alignment tends to be limited to a straight line. Angle stations both increase costs and consume relatively large amounts of land, the latter being undesirable in urban areas. Concrete or steel guideways carrying self-propelled vehicles are preferable if a curved alignment is needed.
3. Availability, while high, is not as great as for other technologies.
4. High winds and electrical storms force shut downs which would not occur with other technologies.
5. Evacuation techniques are dramatic and unnerving. Cautious public officials are unlikely to feel comfortable with them. Although the techniques are proven safe and effective, media may emphasize their dramatic aspect.
6. Insurance premiums are high. This tends to cancel advantages to low operating and maintenance costs.

The WVU study lists possible applications of aerial tramways as including: transportation over geographic barriers (such as mountains); and connections from parking lots to major activity centers and quadrants of highway interchanges.[17]

**Relevant Standards for Informational Purposes**

The following standards come from the document ANSI B77.1: American National Standards for Passenger Ropeways, which was updated in 2006 by the American National Standards Institute.[18]

*Operating Personnel* – The minimum personnel for an aerial tram is one person to oversee the complete tramway while an attendant must be present at each of the stations. Conductors are generally required in each individual carrier that transports 15 or more people, [19] however, conductors can also operate as attendants at the stations. For a single cabin operation, two people are required at all times. For more than one cabin, the minimum is three operators.[20] For gondola or detachable grip operations, the operator may also act as an attendant, allowing for two people to operate the installation.[21]

*Clearances* – Along the ropeway between stations, the following are the minimum vertical clearances from the bottom of the carriage.[22]

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[17] Ibid

[18] American National Standards Institute. ANSI B77.1: Passenger Ropeways - Aerial Tramways, Aerial Lifts, Surface Lifts, Tows and Conveyors - Safety Requirements. April 2006.

[19] International Organization for Transportation by Rope (OITAF). Technical Recommendations 1965

[20] American National Standards Institute. ANSI B77.1: Passenger Ropeways - Aerial Tramways, Aerial Lifts, Surface Lifts, Tows and Conveyors - Safety Requirements. April 2006. Pg 24

[21] Ibid, Pg 53

[22] Ibid, Pg 7

A. 5 feet between terrain or other possible obstacles.
B. 8 feet when foot traffic is permitted under the line.
C. 15 feet when skiing or controlled vehicle access is permissible under the line.
D. 25 feet where public vehicle transportation is permitted under the line.

*Structures and Foundations* – All structures should be designed appropriately for the site. Design loads should include dead[23], live[24], snow, wind and dynamic loads due to normal and extreme conditions.[25]

## *V: Locations: Where are aerial trams located in the United States?*

Trams are located all over the United States. There are two reversible ropeways in use for urban transit but most are for tourism and ski resorts. The listing below shows some of the more recognizable systems.

<u>Existing Reversible Ropeways</u>
Sandia Peak Tramway, New Mexico
Stone Mountain, Georgia
Cannon Mountain, New Hampshire
Gatlinburg Tram, Tennessee
Mt. Roberts Tramway, Alaska
Roosevelt Island Tramway, New York*
Palm Springs Aerial Tramway, California
Snowbird Aerial Tram, Utah
Portland Aerial Tram, Oregon*

<u>Planned Reversible Ropeways</u>
Jackson Hole, Wyoming
Gore Mountain, New York

<u>Existing Gondolas</u>
Telluride, Colorado*
Vail, Colorado
Mammoth Lakes, California
Aspen Snowmass, Colorado

* In operation as mass transit installations

[23] Dead is when the lift is completely stopped
[24] Live is when the lift is operating as normal
[25] American National Standards Institute. ANSI B77.1: Passenger Ropeways - Aerial Tramways, Aerial Lifts, Surface Lifts, Tows and Conveyors - Safety Requirements. April 2006. Pg 8

## Figure 2: United States and Canadian Aerial Ropeways (2002)[26]

| Location | Primary Function | Length (ft) | Length (m) | Climb (ft) | Climb (m) | Carrier Cap. (p) |
|---|---|---|---|---|---|---|
| **AERIAL TRAMWAYS** | | | | | | |
| Albuquerque, NM (Sandia Peak) | scenic | 14,657 | 4,469 | 4,000 | 1,220 | 50 |
| Alyeska, AK (Tramway) | ski | 3,867 | 1,179 | 2,024 | 617 | 60 |
| Big Sky, MT (Lone Peak) | ski | 2,828 | 862 | 1,450 | 442 | 15 |
| Boston Bar, BC (Hells Gate) | scenic | 1,118 | 341 | 500 | 152 | 25 |
| Cañon City, CO (Royal Gorge) | scenic | 2,200 | 670 | 0 | 0 | 35* |
| El Paso, TX (Wyler) | scenic | 2,500 | 760 | 940 | 287 | 8 |
| Estes Park, CO (Aerial Tramway) | scenic | | | 1,200 | 365 | |
| Franconia Notch, NH (Cannon Mtn.) | ski | 5,139 | 1,567 | 2,146 | 654 | 70 |
| Gatlinburg, TN (Ober Gatlinburg) | scenic | 11,000 | 3,350 | 1,335 | 405 | 120 |
| Heavenly Valley, CA (Aerial Tram) | ski | | | 1,710 | 521 | 25 |
| Jackson, WY (Aerial Tram) | ski | 12,595 | 3,840 | 4,139 | 1,262 | 45 |
| Jasper, AB (Tramway) | scenic | 6,550 | 2,000 | 3,191 | 973 | 30 |
| Jay Peak, VT (Aerial Tramway) | ski | 7,776 | 2,371 | 2,153 | 656 | 60 |
| Juneau, AK (Mt. Roberts) | scenic | 3,087 | 941 | 1,745 | 532 | 60 |
| New York, NY (Roosevelt Island) | urban | 3,100 | 945 | 0 | 0 | 125 |
| Niagara Falls, ON (Spanish Aero Car) | scenic | 1,768 | 539 | 0 | 0 | 40* |
| Palm Springs, CA (Tramway) | scenic | 10,775 | 3,285 | 5,874 | 1,791 | 80 |
| Québec, QC (Chute-Montmorency) | scenic | | | | | 40 |
| Snowbasin, UT (Olympic Tram) | ski | 1,165 | 355 | 510 | 155 | 15 |
| Snowbird, UT (Aerial Tram) | ski | | | 2,900 | 885 | 125 |
| Squaw Valley, CA (Cable Car) | ski | | | 2,000 | 610 | 115 |
| Stone Mountain, GA (Skylift) | scenic | | | 825 | 252 | |
| Vancouver, BC (Grouse Mtn. Red) | ski | | | 2,800 | 850 | 100 |
| Vancouver, BC (Grouse Mtn. Blue) | ski | | | 2,800 | 850 | 40 |
| **DETACHABLE-GRIP GONDOLAS** | | | | | | |
| Aspen, CO (Silver Queen) | ski | | | 3,267 | 996 | |
| Banff, AB (Sulphur Mountain) | scenic | 5,117 | 1,560 | 2,289 | 698 | 4 |
| Big Sky, MT (Gondola One) | ski | 8,530 | 2,601 | 1,525 | 465 | 4 |
| Blackcomb, BC (Excalibur) | ski | | | 1,486 | 453 | |
| Deer Valley, UT (Gondola) | ski | 5,170 | 1,576 | 1,322 | 403 | |
| Gore Mountain, NY (Northwoods) | ski | | | 1,700 | 520 | 8 |
| Heavenly Valley, CA (Gondola) | ski | 12,672 | 3,863 | 2,583 | 788 | 8 |
| Jackson, WY (Bridger) | ski | | | 2,781 | 848 | |
| Joseph, OR (Wallowa Lake) | scenic | 9,650 | 2,942 | 3,700 | 1,130 | 4 |
| Killington, VT (K1 Express) | ski | 6,600 | 2,010 | 1,690 | 515 | 8 |
| Killington, VT (Skyeship) | ski | 13,000 | 3,950 | 2,520 | 768 | 8 |
| Loon Mountain, NH (Gondola) | ski | 7,133 | 2,175 | 2,100 | 640 | 4 |
| Mammoth Mountain, CA (Panorama) | ski | | | 3,100 | 945 | |
| Northstar, CA (Big Springs) | ski | | | 470 | 143 | |
| Panorama, BC (Village) | ski access | | | 3,100 | 945 | |
| Park City, UT (Canyons) | ski access | 2,682 | 818 | 181 | 55 | 8 |
| Silver Mountain, ID (Gondola) | ski access | 16,368 | 4,990 | 3,100 | 945 | 8 |
| Ski Apache, NM (Gondola) | ski | | | 1,800 | 550 | 4 |
| Snowbasin, UT (Middle Bowl Exp.) | ski | 9,494 | 2,895 | 2,310 | 704 | |
| Snowbasin, UT (Strawberry Express) | ski | 9,576 | 2,920 | 2,472 | 754 | |
| Steamboat Springs, CO (Gondola) | ski | | | 2,200 | 670 | 8 |
| Stowe, VT (Gondola) | ski | | | 2,080 | 634 | 8 |
| Stratton, VT (Gondola) | ski | | | 2,000 | 610 | 12 |
| Sugar Bowl, CA (Village) | ski access | 3,202 | 976 | 87 | 27 | 4 |
| Sunshine Village, AB (Sunshine) | ski access | 16,400 | 5,000 | 1,640 | 500 | 8 |
| Telluride, CO (Gondola I/II) | ski access | 13,100 | 4,000 | *** | *** | 8 |
| Telluride, CO (Gondola III) | ski access | | | 0 | 0 | 8 |
| Vail, CO (Eagle Bahn) | ski | | | 2,220 | 677 | |
| Whistler, BC (Creekside) | ski | | | 2,112 | 644 | |
| Whistler, BC (Village) | ski | | | 3,893 | 1,187 | |
| Whiteface, VT (Cloudspitter) | ski | | | 2,456 | 749 | 8 |
| **FUNITELS** | | | | | | |
| Squaw Valley, CA (Gold Coast) | ski | 9,065 | 2,764 | 1,742 | 531 | 28 |

*one carrier only (single reversible tramway)
***from Telluride, climbs 1,785 ft (544 m) to an intermediate station, then drops 995 ft (303 m) to a third station
NOTE: Table does not include the numerous fixed-grip gondola systems.
access = used to transport passengers from remote parking to an activity center.
scenic = used to provide scenic views of mountains, canyons, etc.
ski = used primarily to access ski runs; some are also used for scenic rides during the summer.
urban = used in an urban setting to transport commuters and/or tourists.
SOURCE: Owner data.

[26] TCRP Report 100. Transit Capacity and Quality of Service Manual – Second Edition. TRB, 2004.

## *VI. Construction: What parts make up this technology, and who are the vendors?*

### Construction and Components

Construction of aerial tramways and gondolas is very similar. The installation consists of several different parts: carriers, terminals, towers, and ropes.

***Carriers*** are the structure by which passengers are transported. Included in these structures for aerial reversible ropeways are the carriages (wheel assembly that attaches the cabin to the rope or ropes) and the cabin. The carriage wheels evenly distribute the weight of the carrier across the rope for less stress. For aerial lifts including gondolas and ski lifts, the carrier consists of the chair or cabin and the grip, which attaches the passenger apparatus to the rope.[27]

***Terminals*** are at each end of the ropeway and are made up of two types: the drive terminal and the return terminal. The terminals house bull wheels which are needed to move the haul rope (the rope moves the carrier). The bull wheel in the drive terminal can operate as the drive wheel, and the bull wheel at the return terminal acts as a fixed return mechanism. Either terminal can have wheels, counter weights, or hydraulic or pneumatic cylinders to provide tensioning for the haul rope. The drive bull wheel is attached to the prime mover which is the main power unit operating the ropeway. Ropeways however are required by code to have two power units, one of which can be a rescue power unit with operational parts separate from the prime mover.[28]

For detached grip gondola operations, a separate area for slow down and loading is needed in the terminals and is often electronically monitored for safety. There are very few instances of a mid terminal for dropping off or picking up passengers between the drive and return terminals however, in materials ropeways[29], the tower used to redirect the rope is called an angle station.[30]

***Towers*** are used to support haul ropes and track ropes between terminals. They are often steel framed, and seldom are pylons[31] used. Soil conditions and proximity to bedrock should be assessed when anchoring towers to the ground. The tower's function is to hold and allow haul rope movement through sheaves (wheels) and track rope through saddles (if bicable operation). Towers must also have guides to keep carriages from hitting them

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[27] American National Standards Institute. ANSI B77.1: Passenger Ropeways - Aerial Tramways, Aerial Lifts, Surface Lifts, Tows and Conveyors - Safety Requirements. April 2006.
[28] ibid
[29] A ropeway used for transporting materials such as metal ore
[30] Dwyer, Charles. Aerial Tramways, Ski Lifts, and Tows: Description and Terminology. US Forest Service. 1975
[31] A pyramid shaped support structure

or other objects. Towers must also be numbered successively for passenger awareness and safety.[32]

***Rope*** is the most important part of a ropeway. Individual wires are intertwined together to form a strand, and strands are wound together to form a rope. The end of the rope is generally connected at one end of the ropeway installation to counterweights or anchors by sockets. Two diameter ropes are used for monocable or bicable ropeways. Monocable ropeways consist of one haul rope that supports and moves the carriers and are often thicker than the ropes used for bicable ropeways. Bicable ropeways consist of a haul rope and a track rope for guiding the carriers. The ropes are often smaller in diameter than monocable ropes.[33] [34]

### Vendors

There are only two aerial tram vendors in the United States: Doppelmayr/Garaventa and Leitner/Poma. Doppelmayr has more experience with passenger reversible ropeways in the continental United States; however Leitner has constructed an elaborate tramway in Juneau, Alaska.

Doppelmayr/Garaventa: This company has 30 subsidiaries around the world, including Doppelmayr CTEC, the United States-based division with offices in Salt Lake City. Doppelmayr has constructed over 13,500 ropeways in 77 countries and has constructed reversible ropeways in Portland, Palm Springs, and Stone Mountain, Georgia. Gondolas have been constructed at: Mountain Village, Colorado (Telluride); Heavenly Valley, California; Loon Mountain, New Hampshire; Park City, Utah; and many more.

Leitner/Poma: This company was founded in 1888 and constructs ropeways, ski grooming equipment, and wind power generators. Leitner has constructed over 2,500 ropeways, including reversible ropeways in Alaska, France, Italy, and Austria, and gondolas in Montana and Colorado. Their American offices and manufacturing facility are located in Grand Junction, Colorado, where the majority of parts and steel applications for the ropeways are constructed.

### Capital and Operating Costs

Cost data is limited for urban passenger ropeways in the United States due to their primary use at ski resorts and as tourist venues. But costs can be generalized given that the costs come from a small number of specific pieces of an aerial ropeway system. The majority of capital costs for both gondolas and reversible ropeways will be tied up in the terminals given the simple costs for tower and rope guideway.[35] In the case of Roosevelt

[32] ibid

[33] Dwyer, Charles. About Ropeways. Arthur Lakes Library Colorado School of Mines. 2006. <http://www.mines.edu/library/ropeway/about_ropeways.html>

[34] American National Standards Institute. ANSI B77.1: Passenger Ropeways - Aerial Tramways, Aerial Lifts, Surface Lifts, Tows and Conveyors - Safety Requirements. April 2006.

[35] Nuemann, Edward. Cable Propelled People Movers in Urban Environments. Transportation Research Record 1349. 1992.

Island, 68% of the total cost was for towers and terminals [36] 40% on terminals alone due to urban obstacles at the Manhattan terminal.[37]

A 1992 paper for the transportation research board estimated that a one-mile detachable gondola system costs $5 to 9$ million.[38] Reversible systems can be much more expensive due to larger terminals and massive machinery needed to haul larger cabins. One feasibility study in 1980 showed that a 4,000 foot (3/4 mile) reversible ropeway in Detroit would cost over $10 million ($26.7 million in 2006 dollars).[39] The case study below shows how Portland's design competition led to costs skyrocketing from $15 to $57 million dollars for a 3,300 foot (5/8 mile) system.

Operating costs include power, maintenance, labor, and insurance costs. Insurance costs for ropeway operations are high, however the highest cost to any transit system is often labor. Given the safety requirements of the American National Standards Institute, reversible ropeways and gondolas require three people at all times to operate systems. For gondolas with under 15 passengers per cabin, two attendants at each end are needed. Power costs are expected to be less than typical fixed guideway transit such as streetcars because of the fixed electric propulsion system in a single terminal versus transmission of energy over large distances by wire.[40]

Operating costs for Roosevelt Island are $2.9 million a year, while Portland's tram is estimated to cost $1.7 million per year. Gondola's such as the Telluride Gondola have costs of $3.5 million per year.

## *VII. Case Studies: Three Aerial Tram Operations and/or Planning Processes*

### Roosevelt Island Aerial Tram

This aerial ropeway was the first used for mass transit in the United States. Built in 1976, it was meant to be an interim transportation solution between the new Roosevelt Island redevelopment that began in 1971. The island is primarily car-free, however traffic has increased even though most cars are supposed to park in a garage at the entrance to the Island's only accessible bridge. In 2000, the island had 9,520 residents, however that number has most likely increased with new development. Due to limited access to Manhattan and long commuter trips that require numerous transfers, the Roosevelt Island Development Corporation decided to consider an aerial tram.

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[36] Neumann, Peter and Bondada, Murthy. Potential Applications of Aerial Tramway and Gondola Systems for Urban Passenger Transportation. University of West Virginia. 1987.
[37] N.D. Lea & Associates. Roosevelt Island Tramway System Assessment. US DOT. 1979.
[38] Nuemann, Edward. Cable Propelled People Movers in Urban Environments. Transportation Research Record 1349. 1992.
[39] Neumann, Peter and Bondada, Murthy. Potential Applications of Aerial Tramway and Gondola Systems for Urban Passenger Transportation. University of West Virginia. 1987.
[40] Nuemann, Edward. Cable Propelled People Movers in Urban Environments. Transportation Research Record 1349. 1992.

The Roosevelt Island Development Corporation studied alternatives, including ferries, to connect the island to the Manhattan, but the economic analysis led to a tramway system. Although the tram's direct route made it preferable to rehabilitating streetcar tracks and running buses to Queens and Manhattan, the tram was originally to be installed only as a stop-gap measure until a subway station could be built on the island. The tram would then become a tourist attraction and shuttle people back and forth to the island's numerous sports facilities. However, the subway station was not completed until 1989, and the tram was kept as a permanent transportation fixture.[41]

The tram runs parallel to the Queensboro Bridge, crossing First and Second Avenues into Manhattan. The Roosevelt Terminal contains the engine room for the reversible tramway, while the Manhattan terminal at 60th Street and Second Avenue retains the tensioning and counterweights to keep the tram stable. The Manhattan terminal had to be elevated in order to keep the trams away from car traffic on Second Avenue while also being able to support a tall building above it. There are three intermediate towers to suspend the cables over the East River and cables are anchored at the Roosevelt Island Station.[42]

The Roosevelt Island Development Corporation was formed in 1968 to facilitate development on the island. As a part of the New York State Urban Development Corporation, a bond was made available to the island as long as adequate transportation was provided to the island community. The tram was then included as part of the cost of the island's development and financed by bonds. The total capital cost for building the ropeway installation was $6,250,000, $2 million of which was for the ropeway, testing, and cabins that carry 125 people each while the rest was for towers and terminals.[43] In 2006 dollars the ropeway would cost over $22.6 million.

In 2004 operating expenses were $2.9 million, of which fares covered 41%.[44] This is less than the $2,060,000 (1978 dollars) projected for its first year of operation in 1978.[45] The initial general and administrative costs were much higher and made up 56% of the operating budget due to an $800,000 insurance premium. That premium continued to increase and in February of 1986 had hit almost $9 million dollars.[46] In 1986 residents of the island went on a rent strike after the tram was shut down due to an insurance company's refusal to renew the $150 million dollar policy for the tram. New York State eventually took over the policy as a "self insurance" plan.[47]

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[41] N.D. Lea & Associates. Roosevelt Island Tramway System Assessment. US DOT. 1979.
[42] Ibid
[43] Ibid
[44] 2004 National Transit Database. Other System Operating Costs
[45] N.D. Lea & Associates. Roosevelt Island Tramway System Assessment. US DOT. 1979.
[46] Bondada, Murthy and Neumann, Edward. Potential Applications of Aerial Tramway and Gondola Systems for Urban Passenger Transportation. OITAF NACS and the University of West Virginia. 1987
[47] Lewis, Michael. Rent Strike Set on Roosevelt Island As Tram Protest. New York Times. 24 Feb 1986.

The tram was temporarily closed to install safety measures and upgrade the tram's electric drive after people were stranded for seven hours on April 18, 2006.[48] Since reopening in September of 2006, ridership on the tram has been between 3,500 and 4,000 a day, higher than before the tram closed.[49]

**Marquam Hill Aerial Tram, Portland Oregon**

At the top of Marquam Hill in Portland, Oregon, sits the state's only health and medical research facility. On 116 acres, Oregon Health Sciences University (OHSU) serves 200,000 patients a year and 11,000 employees. It is the largest employer in Portland and the second largest employer in the state of Oregon. By 2003, after rapid expansion, the Marquam Hill Campus had taken up all space that was available. Grant opportunities were being missed because of the campus's size, and the University was considering moving to another location outside of town due to topographical constraints.[50]

City, state, and university leaders rallied to find ways to continue expanding the OHSU facility. They determined that the best solution was to connect the Marquam Hill Campus to a proposed 130 acre area of growth called the South Waterfront. The change in elevation and limited accessibility required a unique solution and planners hit on building a tram line. The South Waterfront had problems as well. Transportation options from the site were difficult and barriers included Interstate 5 to the west, the Willamette River to the east, and the Ross Island Bridge to the north. A transportation plan for the area was completed and it showed that the South Waterfront should be connected north to Downtown with a streetcar extension and connect to OHSU by aerial tram.[51]

The Portland Aerial Tram was completed in December of 2006 and began operating publicly on January 27, 2007 after over eight years of planning. A1998 study of alternatives by OHSU showed that an aerial tram would best be able to provide door-to-door travel between campuses of no more than 15 minutes. A second study performed in 2001 corroborated that finding, allowing the tram to be a part of the city's transportation plan.[52]

Modeled after the successful construction and management of non-profit Portland Streetcar Inc., Portland Aerial Transportation, Inc. (PATI) was formed in 2002 to oversee construction of the tram and then hand it over to the City of Portland when completed. PATI also held an international design competition for the tram and its terminals that set out a budget of $15 million dollars. The team AGPS from Los Angeles and Zurich won the competition with a minimalist design but the final design would prove costly given the necessity for function, safety, and operability over form.[53]

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[48] Barron, James. How a Tram Broke Down, and Riders Bore Up; Options Were Limited After a Power Surge. The New York Times: 20 April 2006.
[49] New York One News. Ridership on Roosevelt Island Tram Higher Than Ever. NY1. 9 Sep 2006.
[50] Gmuender, Joe. *The Marquam Hill – OSU Project. Portland Oregon*. OITAF Ninth Symposium. 2004
[51] Ibid
[52] Ibid
[53] Ibid

Doppelmayr oversaw the ropeway construction, while Arup and GeoDesign Inc. did the heavy engineering for the terminals. During the structural engineering process, the design of the tramway changed due to structural safety issues. The initial design of wood and steel for the upper terminal had to be changed to steel concrete composites given the need to cantilever it away from buildings where microsurgery is performed. The terminal also required drilled pier foundations and seismic considerations that caused costs to rise. Another change was that of the 197 foot intermediate tower. As initially designed, the tower could not handle the torsion that the cables would exert on the tower.[54]

The structural redesigns resulted in a project price tag of $57 million dollars. The two 78-passenger carriers shaped to look like teardrops and painted gray to blend with Portland's often dreary skies also contributed to the cost due to their specialized design. But the cost was not completely born by the City of Portland. 85% of the cost of the tram was paid for by OHSU while bonds issued by Portland will pay the rest. The bonds will be repaid by the increase in property values in the South Waterfront.[55]

On the operating side, the tram is expected to cost $865,000 dollars for the first 6 months of passenger operation. Some of these operating costs include startup costs and it would be expected that the system operating costs will go down following the first few years. The first full fiscal year budget from July of 2007 to June of 2008 is expected to be over $1.7 million.[56] Initially a $2 dollar fare was to be charged to everyone but employees of OHSU but was raised to $4 after officials realized that the costs were going to be higher than expected. Annual and monthly Tri-Met passes are also allowed but transfers and day passes for the streetcar are not.[57] $20,000 (18%) of the estimated $110,000 the city will pay into the operations fund will go to insurance expenses each year.[58]

Vital transportation connections to the two closest destinations (Downtown and OHSU) are expected to produce exponential returns on investment. The South Waterfront is expected to produce $1.9 billion dollars in development after investments in infrastructure that include the aerial tram and streetcars.[59] Early ridership number show the tram is ahead of projections. 5,600 riders took the tram in February of 2007 which was way ahead of the projected 3,080. Farebox recovery is also higher than anticipated with $32,736 being collected versus projected revenues of $29,640. This represents a 22% cost recovery of total operating costs. Given that OSU pays 80% of the operating costs and allows its employees ride for free, this represents a substantial recovery for the city of Portland.[60]

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[54] Ibid
[55] Frazier, Joeseph. Tram Keeps Portland on the Cutting Edge of Mass Transit. USA Today. 3 February 07.
[56] FY07 Tram Budget. City of Portland and Oregon Health Sciences University.
[57] Daily Journal of Commerce. Portland Tram Operators Set $4 Fare. Daily Journal of Commerce. 26 Jan 2007
[58] Mahon, Elizabeth. Portland Department of Transportation. Email Correspondence. Re: Aerial Tram Information. 23 March 2007
[59] E.D. Hovee and Company. North Macadam Urban Renewal Area Return on Investment. Portland Development Commission. August 2003.
[60] The Oregonian. Tram Ridership Doubles February Projections. The Portland Oregonian. 19 March 2007

**Telluride Gondola**

Telluride is a ski resort town in southwest Colorado that is home to about 2,221 people. Its partner city, Mountain Village, is on the other side of a steep ridge and outside of the box canyon in which Telluride lies.[61] The town was deemed a national historic district in 1964, and thus is impervious to the types of development that often typifies similar ski resorts. Since it was designed without the automobile in mind and has not expanded inside its canyon, Telluride is a very walkable place. This is not however the same fate of its partner city Mountain Village. Founded in 1995, the village is known as the bed base for the Telluride ski resort and the need to connect the two while reducing parking and traffic problems was of utmost importance.[62]

Given the constraints of the mountains, weather, pollution from automobiles, and the expense of building mountain roads, the Telluride Ski and Golf Company (Telski) decided that an alternative was needed to connect the two villages together. To address environmental and mobility concerns, Telski would build a three-leg gondola system to serve the resort towns and the ski slopes.[63] The Telluride Gondola Transit Company was then formed to fund and construct a gondola transit system that would reduce travel time from a 20-minute drive to an 11-minute Gondola Ride.[64]

The two-mile $16 million project was completed in 1996 by Doppelmayr and boasts a total of 32 eight-passenger gondolas. Built at the tree line to avoid high winds and weather issues, the gondola maintains a 7am to 11pm schedule 275 days out of the year. Completely different than the bus system which used the eight-mile route between the towns, the gondola increased capacity from 80 to 480 people per hour. Initial rope infrastructure on the 2.5 mile route allows for additional gondolas to be added when the demand arrives.[65] Operating costs are paid for by a 3% tax on real estate transactions which goes to the Mountain Village Homeowners Association. The homeowners association operates under the city services umbrella organization named Mountain Village Metropolitan Services. This entity operates and pays for the gondola and other city services for the town entity named The Telluride Mountain Village Resort Company, a separate entity from Telski. $3.5 million a year goes to gondola operations.[66] The gondola is free except at the mountain station which requires a lift ticket to exit.

## *VIII. Alternative Modes and Routes:*

This section will cover the costs and benefits of other modes of transportation that could possibly be looked at along the chosen transportation corridors.

[61] Telluride.com. Website: Gondola Page 2007. <http://www.telluride.com/about_telluride/Gondola.asp>
[62] Clifford, Hal. Inside the True Telluride. CNN Travel. 5 February 2004
[63] Telluride.com. Website: Gondola Page 2007. <http://www.telluride.com/about_telluride/Gondola.asp>
[64] City of Ogden. Gondola Comparison Document. 2007
[65] Telluride.com. Website: Gondola Page 2007. <http://www.telluride.com/about_telluride/Gondola.asp>
[66] City of Ogden. Gondola Comparison Document. 2007

## Justifying Transit Investments

The justification for transportation investments can be made using a number of different criteria and measures. An example in this justification process are the ratings for the federal new starts program for fixed guideway capital improvements which include measures for cost effectiveness, land use, environmental benefits, mobility improvements, financial stability, operational efficiency, and more. If the community is applying to invest in transit and using criteria laid out by the grantor, that investment should garner certain benefits.

Therefore the basis of justifying a transit investment must be the ability of this investment to meet the community's goals. The community should ask the following questions and more when seeking to invest in their future:

- What are the ancillary benefits of this project to the community?
- Does the project improve mobility for the community?
- What is the likely return on this initial community investment?
- How much value is created in the community from this investment?
- How much money is the community willing to spend on improvements?
- How does this investment fit into the overall community plan for a district or corridor?

Instead of making a decision based on project costs or mobility improvements alone, there must be a look at the bigger picture including how this project will fit into the overall community plan for a district or corridor.

## Tram Routes

The map labeled Map 1 represents three different options for a possible aerial ropeway in the City of Hercules. There are a number of benefits and drawbacks to each alignment that are outlined below.

*Alignment 1 (Yellow)*

Alignment 1 runs from just north of the New Town Center parcel to the commuter rail and ferry terminals, meeting the goal of connecting those two places. It provides the most direct connection for people who park, or in the future live, at the New Town Center site. It is also a comfortable walk for residents of the Hill Town Development, although they would have to cross a busy intersection to get to the aerial ropeway terminal.

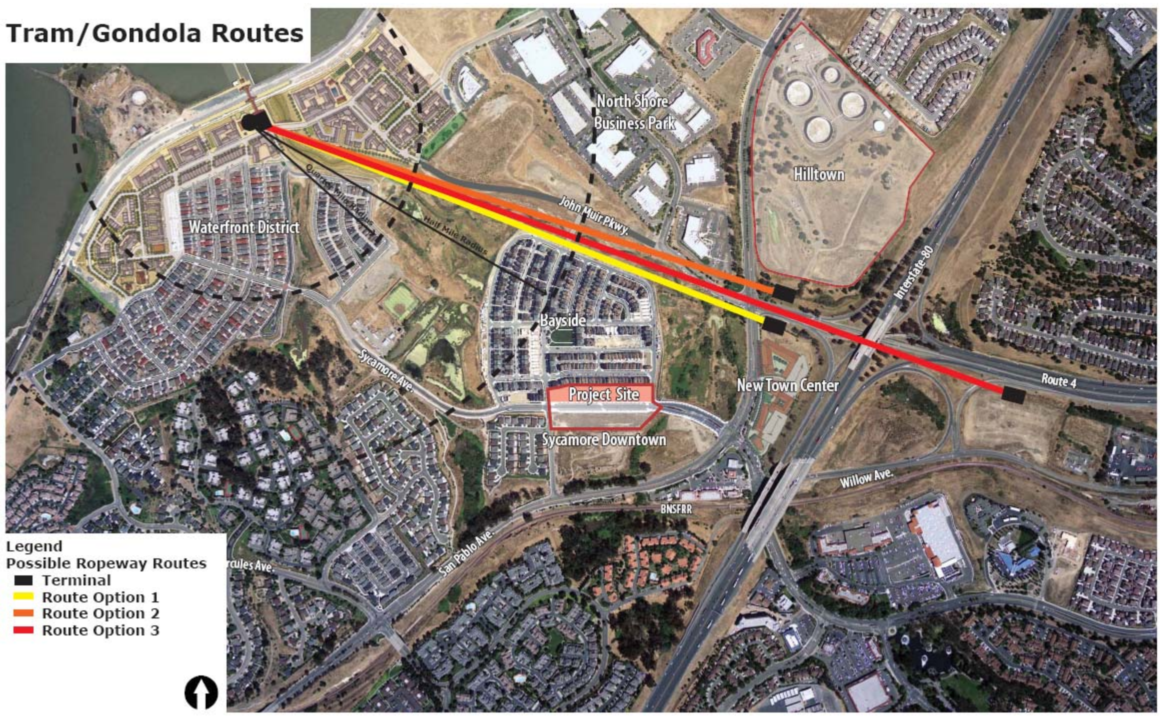
The drawback of this alignment is its proximity to backyards and windows of residents of the Bayside neighborhood. Another issue is where the support towers will be built given the alignment runs over the top of the creek. The route is direct, however there will be no stopping between the two points to pick up residents from Bayside or other future development. Aerial ropeway literature suggests that midway stations are very rare, and expansion is difficult.

*Alignment 2 (Orange)*

Alignment 2 runs from the southern end of the Hill Town development to the commuter rail and ferry terminals. This meets the goal of connecting the New Town Center to the commuter terminals. It provides a direct connection for future residents of Hill Town. It is also a comfortable walk for people who park or will be future residents of New Town Center. A benefit of this alignment is that it moves the ropeway away from the backyards and windows of residents in the Bayside development while perhaps giving more space for support towers.

The drawbacks of this alignment include the street crossing from the New Town Center development area and possible issues with the placement of support towers. Engineering assessments will be needed to fully assess this issue. This route is also direct, but as with Alignment 1, there is no stopping between the two points to pick up residents from Bayside or other future developments. In the long term, neither Alignment 1 nor 2 provide expansion to the future Park-and-ride/town center east of I-80, causing further connection issues.

**Map 1.**




*Alignment 3 (Red)*

Alignment 3 runs directly from future New Town Center parcels east of I-80 to the commuter rail and ferry terminals. Future development residents or parking patrons would have a direct connection to the terminals. The alignment also follows a path further away from the back yards of residents in Bayside.

Drawbacks to this alignment include the amount of time that will pass before development occurs on these parcels. It also bypasses the New Town Center, Hilltown and Bayside neighborhoods en route to the commuter terminals. As with the other two routes, the issue of towers and the creek bed must be addressed as well.

**Bus Alternative**

The local transit authority is WestCAT, which operates buses in West Contra Costa County. Using buses to connect various destinations in Hercules is a flexible alternative that uses existing roads and existing transit authority expertise from WestCAT. There are also drawbacks to this alternative including susceptibility to traffic snarls, the negative image that some people have of bus transit, and the reluctance of developers to use them as an urban development tool.

*Benefits of Buses*

Use Existing Infrastructure – Roads already exist for use in the City of Hercules. If the circulator bus mode is used there will be no need for investment in a guideway, just buses and bus stops.

Flexibility – The flexibility of buses allows them to be rerouted if there is a change in routes to accommodate a higher demand. This flexibility also allows startup to be almost immediate.

Use Existing Services – It is possible to use existing WestCAT buses and operators to run this service. They already have a management structure available to run a circulator bus.

Low Capital Cost – Costs for bus operation are often lower than other modes because of its use of existing infrastructure. Included in the low costs should be wear and tear on the roads from heavier vehicles along with the cost of the buses and stops.

*Drawbacks of Buses*

Existing Infrastructure – While they run on existing streets, they are also susceptible to traffic jams and general congestion. They also contribute to traffic volumes at congested intersections. A circulator bus that will be traveling through the intersection of Sycamore and San Pablo and by the onramp to I-80 south will be slowed by these two traffic points at rush hour.

Flexibility – While it is a benefit of bus service, from a development point of view it is a drawback. Developers see that there is a lack of permanent investment along a route and shy away from building denser projects that are marketed to buyers and renters in part on proximity to transit.

Image – Buses are often seen as the transportation option of last resort for people who can afford to drive. Even though this stigma is improving with the younger demographics, it is still ingrained in the general citizen's consciousness. Bus projects in the United States also tend to not attract new riders to transit.

Energy Consumption – Buses run using internal combustion engines and create carbon dioxide emissions. The newest buses are hybrid diesel electric but still have point source emissions. They are also subject to price spikes in fuel.

*Bus Costs*

The capital costs of operating a new bus route are low. However, all new routes in the WestCAT sytem would need new funding. Based on discussions with staff at WestCAT, the major capital cost of new operations are buses that would cost approximately $350,000 to $500,000 per vehicle. Stops and other costs are minimal, but could involve a concrete slab, shelters, or route posting signs.[67] Buses are equipped with internal ramps for ADA compliance and only need a concrete slab or platform to load and unload persons with special needs. Destinations at the beginning and end of the line can be designed to accommodate the bus while waiting for park-and-ride or transferring passengers.

Operating costs are dependent on maintenance and operations of the vehicles. This is often a factor of the labor cost for each bus running on a given route, overhead costs for operations managers, and continued maintenance of the buses. Buses have a 12-year lifespan according to the FTA. According to the National Transit Database, which collects operating data from every transit system in the United States, costs to run the WestCAT buses in 2004 were $4.30 per trip, $157,703 per vehicle and $4.7 million dollars annually.[68]

**Possible Routes**

Map 2, Bus Routes, represents different options for a circulator bus connecting main destinations in the City of Hercules. There are a number of benefits and drawbacks to each alignment that are outlined below.

*Bi-Directional (Yellow)*

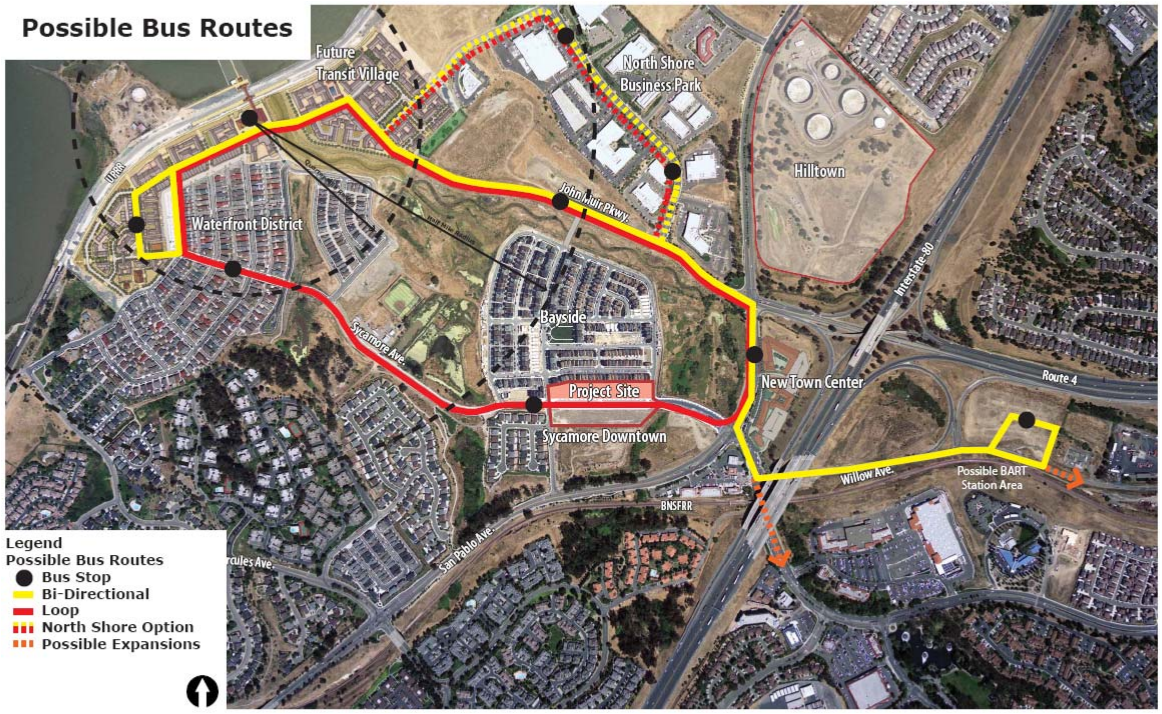
This bi-directional route moves people from the east side of I-80 and by the New Town Center site using Willow Street, Sycamore Street, and San Pablo Avenue. It would then drive to the commuter and ferry commuter terminals using the extension of John Muir Parkway. A loop would turn the bus around in the Waterfront District neighborhood and on the east side of I-80. The benefits of this route are that it is the most direct and is able

[67] Thompson, Rob. Email Correspondence: re: Hercules Circulator. 27 March 2007.
[68] 2004 National Transit Database. Bus Passenger Trips and Bus Operating Costs

to get there and back quickly without many stops.  It also would be able to pick people up from any new development east of I-80.

The drawback of this alignment is not being able to get closer to the Sycamore Downtown area and other residential areas south of Sycamore Avenue.  It also requires the bus to have a turning loop in order to return using the same streets.  It also has to navigate three major intersections.  This route misses the North Shore Business Park.

**Map 2.**




*Loop (Red)*

This loop route moves people from the New Town Center site to the commuter and ferry commuter terminals using right-of-way on John Muir Parkway and Sycamore Avenue.  There would be no need for a turning loop at either end, and residents in Bayside could pick up the loop on either the north or the south side.

The drawbacks of a loop are that the buses would be slowed subject to cycles at two lights instead of one.  There would also need to be a bus loading area at the New Town Center which allows the bus to get out of traffic when loading and unloading on San Pablo Avenue.  It also does not extend to the eastside of I-80, however it could with expansion or by following a similar route to the bi-directional yellow line.

*North Shore Option (Dashed Red and Yellow)*

The north shore options would allow the loop and bi-directional routes to drop off and pick up passengers in the North Shore Business Park. Commuters would be able to reverse commute from other cities along the commuter ferry or rail lines and use the circulator to get to work. This route bypasses most of the John Muir parkway and incorporates the first two routes for the rest of the route. For the bi-directional route, there would be a benefit in passing through the Business Park on trips both ways, therefore allowing people to come in by transit or live along the route.

The drawbacks of this option would be that reverse commuting workers at North Shore would have to go all the way around the loop before reaching their destination. The option on both routes would also increase travel time between the New Town Center and the commuter transit terminals.

*Expansions (Dashed Orange)*

Expansions to this initial circulator system would extend to new development to the north of the current City Hall and Sycamore Avenue east of I-80. It should be noticed that typically buses respond to development, while fixed guideway investments such as trams and streetcars are able to catalyze development. So while the bus will be able to respond to new development much easier than either of the other services, it will not focus development given developers wariness of flexible stop locations and service.

**Light Rail/Streetcar**

Streetcars, like buses, are a proven technology. As a subset of light rail, they can be designed to have their own right-of-ways or run in the street. Local examples of streetcars include the Muni Metro lines that run in streets and the F-Line historic streetcars in San Francisco. Streetcars are a transportation choice that attracts passengers, attracts development, rides smoother than buses, and runs on electric power. The downsides include initial capital investment, construction time, inflexible routing after construction, and being subject to traffic if in street.

*Benefits of Streetcars*

<u>Passenger Attraction</u> – Streetcars do not have the stigma of buses and attract more passengers. A study done in 1989 by Ed Tennyson for the Transportation Research Board found that rail vehicles have a ridership bonus over equivalent bus service of 34% to 43%.[69]

<u>Development Attraction</u> – Developers are more apt to build along streetcar routes. After investing in streetcars, cities have had development returns on their investments of over 1000%.[70]

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[69] Tennyson, Ed. TRR 1221: Impact on Transit Patronage of Cessation or Inauguration of Rail Service. Transportation Research Board. 1989.
[70] Ohland, Gloria and Poticha, Shelley. Street Smart: Streetcars and Cities in the 21st Century. Reconnecting America. 2006.

Electric Power – Electricity allows streetcars to have greater acceleration and power than buses. Moving parts are limited and electric motors are easier to maintain than internal combustion engines. Electricity can also be generated from a number of alternative sources, including solar, wind, and hydro electric.

*Downside of Streetcars*

Initial Capital Investment – When compared to normal bus operations, capital costs for streetcars are higher.

Construction Time – It takes longer to build the infrastructure for the streetcar than for bus, since buses use existing streets. Construction for Portland's streetcar built in three block segments took three weeks per segment.

Flexibility - Once constructed, streetcar systems are not as flexible as buses. New routes must be constructed for new demand. This is also a benefit, as the permanence of the line attracts developers and riders that buses do not.

Overhead Wires – Used to power streetcars, electric conductors must be erected above the right-of-way.

*Streetcar Costs*

The capital costs of building a new streetcar route are moderate or low when compared to other rail-based solutions such as metro light rail or heavy rail. Capital costs, which include track and vehicles, have ranged from $6 million for the two-mile heritage system in Kenosha ($3M/mile) to $55.2 million for Portland's initial 4.8 mile modern system ($23M/mile). Costs can be contained by not being too elaborate in the design, using simple construction methods, and experienced consultants. Streetcars, whether heritage or modern, can be equipped with internal ramps or lifts for ADA compliance and only need a concrete slab or platform to load and unload persons with special needs. The streetcar also requires storage and maintenance space.

Acquiring a heritage streetcar is much cheaper than purchasing a modern vehicle, though costs depend on rehabilitation and new construction costs. Gomaco makes completely new heritage streetcars and has sold them recently for $868,000 per car to Little Rock, Arkansas[71]. Operators of heritage streetcars would, however, need to either obtain a waiver from the Public Utilities Commission(PUC) or increase the streetcars' body strength. Modern streetcars cost just under $3 million per vehicle according to discussions with staff at LTK engineering.[72] The PUC also exerts extra regulatory

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[71] Smatlak, John. Replica Vintage Trolley Cars Page. RailwayPreservation.com. Accessed 27 March 2007. <http://www.railwaypreservation.com/vintagetrolley/replicacars.htm>
[72] Furmaniak, Tom. Email Correspondence: re: Streetcar Costs. 9 January 2007.

barriers to rail projects as has happened in other cities in California such as Pasadena along the Gold Line.[73]

Another option might be rehabilitating vehicles that are owned by Muni, Gomaco, or a trolley museum. There are a number of streetcars sitting in the Geneva Yards in San Francisco that need repairs but don't have the funding available to be rehabilitated. Similarly, Gomaco has a yard full of Peter Witt vehicles from Milan, Italy, waiting to be restored. Kenosha bought old Toronto PCC cars (Presidential Conference Committee, a 1930s streetcar design) and rehabilitated them through the Brookville Equipment Company.

Operating costs are dependent on maintenance and operations of the vehicles, often a factor of the labor and maintenance cost for each streetcar running on a given route, overhead costs for operations managers, and continued maintenance. For streetcars, this cost is similar to buses. Data from the 2004 National Transit Database on five streetcar systems (Little Rock, Tampa, Kenosha, Memphis, and Seattle) states that operating costs for these systems average $4.06 per trip and $164,593 per vehicle. It should be noted that this comparison is between streetcar lines and not complete streetcar or bus systems with the exception of Memphis which operates more lines. Costs are not directly comparable to the WestCAT system but a baseline comparison allows rough comparisons between the operations of various modes.

**Figure 3. 2004 Operating Costs**[74]

| Place | Length (Miles) | Annual Cost | Annual Trips | Cost Per Trip | Vehicles | Cost Per Vehicle |
|---|---|---|---|---|---|---|
| Little Rock* | 2.5 | $224,300 | 44,500 | $5.04 | 3 | $74,766 |
| Kenosha | 2 | $301,600 | 58,900 | $5.12 | 5 | $60,320 |
| Seattle** | 2 | $1,426,800 | 398,600 | $3.48 | 5 | $285,860 |
| Tampa | 2.4 | $1,626,200 | 519,600 | $3.03 | 8 | $203,275 |
| Memphis | 7 | $3,577,400 | 982,500 | $3.64 | 18 | $198,744 |
| Average | | $1,431,260 | | $4.06 | | $164,593 |
| | | | | | | |
| WestCAT | | $4,733,100 | 1,100,400 | $4.30 | 30 | $157,703 |

* Partial year of operation

** Seattle has stopped running its system until a new car barn can be constructed.

*Possible Routes*

Map 3, Streetcar Routes, represents different options for a possible circulator connecting main destinations in the City of Hercules. It should be noted that these routes are being suggested as single-track streetcar routes to keep possible costs reasonable. Given the distance traveled, it is not unreasonable to assume that future expansions of a streetcar

[73] Rabin, Jeffrey. Safety Issues Could Delay Expo Line. Los Angeles Times. 17 April 2007. < http://www.latimes.com/news/printedition/california/la-me-expo17apr17,1,3742790.story?coll=la-headlines-pe-california>

[74] 2004 National Transit Database. Transit Agency Passenger Trips and Operating Costs

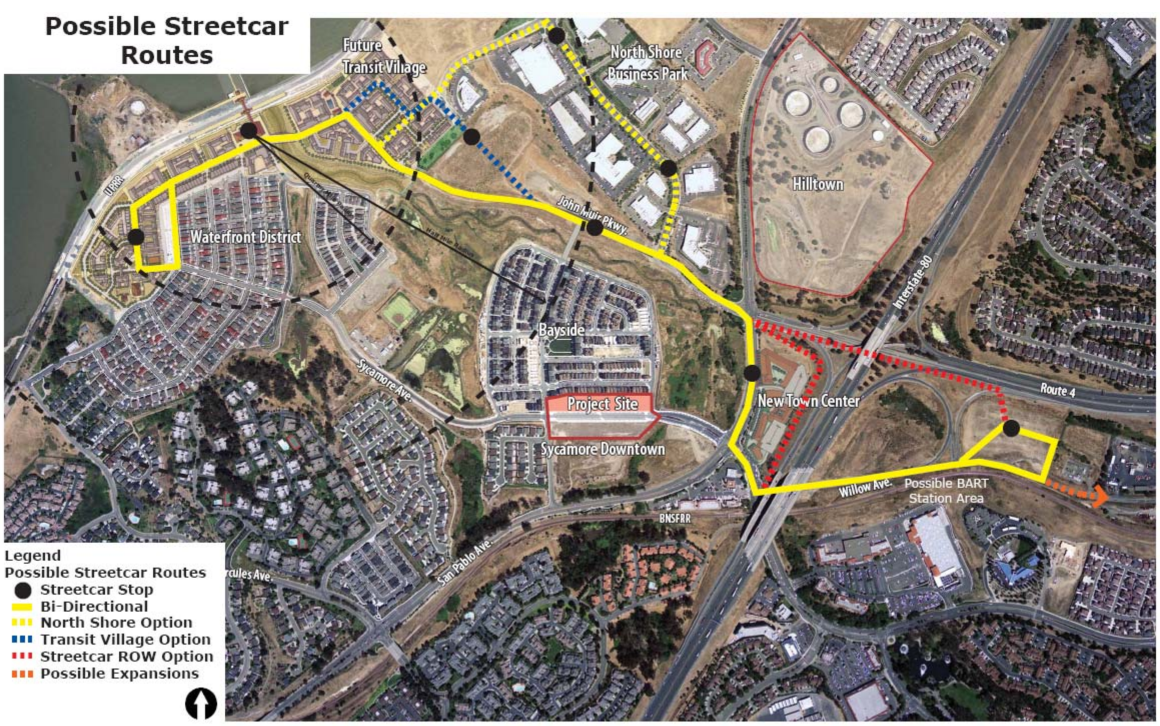
system might require passing track at certain points along the line to expand capacity. Planning for this future possibility must be taken into consideration by engineering staff. There are a number of benefits and drawbacks to each alignment that are outlined below.

Bi-Directional (Yellow)

The bi-directional streetcar route follows a similar route to the bi-directional bus route. However, the streetcar needs a larger turning radius and unless the vehicles are double ended, they need space to turn. Benefits include the possibility of running primarily in its own right of way for most of the route. There would need to be a signal specifically for the streetcar at the intersection of Sycamore and Willow to avoid traffic. This could be designed into the buildings, like those that Portland State University has built, to allow the streetcar to cross a block diagonally without disrupting development potential.

The bi-directional route could also incorporate the North Shore option, but would cause costs to increase due to more street excavation and route length. The drawbacks of the bi-directional route include limits on turning and limited access by residents that live along Sycamore Avenue. A route such as the red bus loop is not feasible due to street width restrictions on Sycamore Avenue. It also puts the streetcar in traffic with cars and must pass through three signals between the east side of I-80 and John Muir Parkway. San Pablo Avenue and Sycamore must also have double tracking or a center lane dedicated to the streetcar.

## Map 3.




Transit Village Option (Dashed Blue)

The transit village option allows the line to follow and create new street grids in order to guide development on the vacant parcel east of the new Transit Village area. The streetcar could be a catalyst for higher densities that could in turn pay for the streetcar's capital costs. Streetcars have been used as development tools for over 100 years, and this would be an opportunity for the community to get a return on the transportation investment.

The drawbacks of the Transit Village option might be that the Future Transit Village streets might be too narrow for roads to accommodate a bi-directional streetcar if already designed. Another drawback could be slower speeds when operating through neighborhood, versus the right-of-way on John Muir Boulevard.

Streetcar Right of Way (Dashed Red)

Two possible options exist for streetcar-only right-of-way (ROW) between John Muir Parkway and property north of Hercules City Hall. There is ample room for a bi-directional streetcar-only ROW from the New Town Center without entering traffic or worrying about the intersections of Sycamore and San Pablo Avenue or Sycamore and Willow Avenues. This traffic bypass would improve travel times between destinations and allow for the free flow of auto-traffic. A streetcar sequence in the light series for John Muir Parkway and San Pablo would have a minimal impact on traffic. Future reconfiguration of the Highway 4 and I-80 interchange could also allow for a streetcar dedicated right-of-way.

Two possible options for this streetcar-only ROW are behind the New Town Center and under the Highway 4 and I-80 interchange. The section behind the New Town Center would only require 12 feet of ROW while the freeway interchange option would require reconfiguration of the interchange where cars and streetcars would not cross paths.

Expansions (Dashed Orange)

The expansion lines are meant to connect the possible BART station area and possible future increased development in the district north east of the current City Hall with The New Town Center and commuter rail and ferry terminals. These are lines that have the most potential for future development-oriented transit and for paying the capital costs of the entire streetcar circulator system. Development-Oriented Transit such as a streetcar, has the ability to focus more intense development along routes. The routing of the two northern most expansion lines are through the center in order to focus development blocks on each side on the streetcar line. The expansion of this line along Willow Avenue to where Sycamore Avenue meets Highway 4 allows expansion of the walk shed and continues to build at transit-oriented densities. Focused development schemes could also include property north of Highway 4.

## *IX. Possible Funding Sources:*

Federal, state, and local sources of funding and tools for acquiring capital and operational funding.

**Possible Planning Sources**

*State 5305 Funds – Transit Technical Planning Assistance*

Cities can apply through the Metropolitan Planning Organization[75] for 2008/2009 federal funds that help with the technical planning for transit improvements. There is a requirement of an 11% match by local funds. The maximum grant from the FTA is $100,000 and must be used to plan transit service for communities of under 50,000 people. Grant applications for the 2007/2008 fiscal year have already closed.[76]

*MTC Transportation for Livable Communities Funds*

"TLC provides funding for projects that provide for a range of transportation choices, support connectivity between transportation investments and land uses, and are developed through an inclusive community planning effort."[77] Grant applications will be taken in the spring of 2008 by the Metropolitan Transportation Commission. The TLC funds can be used for planning and capital costs. Funding comes from Urbanized Area Formula Grants and Congestion Management and Air Quality funds.

**Possible Capital and Operations Funding Sources**

*1. FTA New Starts/Small Starts*

Given the size and scope of this project, the Very Small Starts, Small Starts, and New Starts programs are more than likely not options. The requirements for Very Small Starts include fixed guideway projects which are at $3 million a mile or under and have ridership of 3,000 per day on the route. Applying for Small Starts is possible, however the rules are not yet final. The New Starts program is for larger projects and takes about 10 years to go through the process.[78]

*2. FTA Bus and Bus Facilities*

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[75] In the Bay Area, the MPO is the Metropolitan Transportation Commission (MTC)
[76] Caltrans. Caltrans Planning and Research WebPage. Accessed 22 March 2007 <http://www.dot.ca.gov/hq/tpp/grants.htm>
[77] Metropolitan Transportation Comission. TLC Grants WebPage. Accessed 22 March 2007. <http://www.mtc.ca.gov/planning/smart_growth/tlc_grants.htm>
[78] Federal Transit Administration. New Starts Planning Webpage. Accessed 28 March 2007 < http://www.fta.dot.gov/planning/planning_environment_5221.html>

The Bus and Bus-Related Facilities program provides capital assistance for new and replacement buses and related equipment and facilities. The Secretary has the discretion to allocate funds, although Congress fully earmarks all available funding.[79]

*3. Federal Highway Administration Transportation, Community, and System Preservation (TCSP)*

The Transportation, Community, and System Preservation (TCSP) Program is a comprehensive initiative of research and grants to investigate the relationships between transportation, community, and system preservation plans and practices and identify provide transportation sector-based initiatives to improve such relationships. Authorized funding for the TCSP Program is $61.25 million per year for FY 2006 through 2009. These funds are subject to the obligation limitation. The Federal share payable on account of any TCSP project or activity shall be 80% [80]

*4. The State Transportation Improvement Program (STIP)*

The STIP is a multi-year capital improvement program of transportation projects on and off the State Highway System, funded with revenues from the State Highway Account and other funding sources.[81]

*5. Proposition 1B MTC Funding*

Small Operators will be able to apply for operations and capital funding under new programs by the MTC. $41 million in operations funding would be programmed for small operators as the result of unprogrammed surpluses. $25 million will be programmed for capital costs of small operators that receive current funding from the State Transit Assistance (STA) base program. [82]

*6. Farebox Revenue*

Farebox revenue is the fee charged for the service. WestCAT charges $1.50 per trip. Farebox recovery ratios can be low or high depending on the amount of patrons. In 2003 WestCAT had a farebox recovery ratio of 19.2%.[83]

**Additional Tools**

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[79] Federal Transit Administration. Bus and Bus Facilities Webpage. Accessed 28 March 2007. <http://www.fta.dot.gov/funding/grants/grants_financing_3557.html>
[80] Federal Highway Administration. TCSP Webpage. Accessed 23 March 2007. <http://www.fhwa.dot.gov/tcsp/index.html>
[81] California Department of Transportation. Caltrans STIP Web Page. Accessed 23 March 2007. <http://www.dot.ca.gov/hq/transprog/stip.htm>
[82] Metropolitan Transportation Commission. Regional Transit Funding Proposal. 7 March 2007 <http://www.mtc.ca.gov/funding/infrastructure/transit/Regional_Transit_Funding_Proposal.pdf>
[83] 2003 National Transit Database. Fare Per Passenger and Recovery Ratio. 2003. <http://www.ntdprogram.com/ntdprogram/pubs/dt/2003/PDF_files/2003_Table_01.pdf >

*1. Assessment Districts*

The Tampa City Council created a special assessment district to cover the streetcar route. Properties are assessed 33 cents per $1,000 of assessed value. Owner-occupied residential properties are not assessed. There has been tremendous development and economic growth in the district, which has increased the assessments and generated $500,000 over the first two years to cover 25 percent of the operating costs. The district was established using natural boundaries such as the freeways, Hillsborough River, and the Garrison and Ybor Channels. Areas within the district that are not yet served by the streetcar receive trolley bus service; the buses are painted with the same color scheme as the streetcars. Hearings and meetings are held annually in sub-areas of the district. The county collects the assessments and passes them to the streetcar.[84] In Seattle an assessment district was created by property owners who will generate $25 million dollars for construction of the streetcar project.

*2. Tax Increment Financing*

The California Transit Village Development Planning Act allows for the creation of tax increment financing (TIF) districts within a ¼ mile of a transit station, and they may be eligible for 25% development density bonuses. TIF's allow local jurisdictions to capture a portion of increased property tax revenues and direct them back into the district for redevelopment and transit-oriented development purposes.[85]

*3. Local Improvement District*

The local improvement district (LID), as specified in Oregon state law, provided for a one-time-only assessment to fund part of Portland's streetcar capital costs. There were several assessment rates based on how close the property was located to the streetcar line and the principle use of the property. The assessment rates in Zone A, for property located within 200 feet of the streetcar, were double that in Zone B, which included all the other property in the LID. The highest rates were for regional institutions including Portland State University and Good Samaritan Hospital; rates for commercial uses were about half the highest rates; rental residential property was assessed at about two-thirds of the commercial rate.[86]

*4. Endowments*

Tampa Historic Streetcar Inc., the nonprofit organization that manages the streetcar system, had led the effort to reintroduce streetcars to Tampa. In order to advance their plan they bought an existing People Mover system that transported people from Harbour

[84] CTOD. South Lake Union Financing Strategies and Case Studies. 4 December 2004.
[85] National Governors Association. Growth Toolkit webpage. Accessed 28 March 2007. <http://www.nga.org/portal/site/nga/menuitem.9123e83a1f6786440ddcbeeb501010a0/?vgnextoid=4adc5aa265b32010VgnVCM1000001a01010aRCRD>
[86] Ibid

Island to downtown and back. The system had been operating at a loss of well over half a million dollars a year, and the owners were willing to buy their way out of their 17-year contract for $5 million. Tampa Historic Streetcar bought the People Mover, and demolished it for $1 million. The business plan called for the establishment of an assessment district to pay for a third of the operating budget and for the creation of an $8 million endowment fund – into which was deposited the remaining $4 million from the People Mover – to pay for the rest. Corporate sponsorships are helping to build the endowment fund, which is slated to cover the system's operating costs from year 4 on, and which now totals almost $6.5 million.[87]

*5. Transit in Lieu of Parking*

Stanford University, a private university, was operating a free shuttle around campus, the Marguerite Shuttle, on a budget of $2 million per year. The shuttle began as a small scale employer shuttle at peak hours that went to the train stations and then during the day looped around the campus. But the shuttle eventually became too expensive and was overextended. After calculating the cost to the University of each parking structure space per month, $155/ space for the life of the structure, Patrick Siegman of Nelson Nygaard, showed it was actually cheaper for the University to pay people not to drive. In addition to the cost of the parking spaces, the University may also incur additional expenses as a condition of the University's General Use Permit from Santa Clara County, which stipulates that the University is not to generate any new traffic. If the University fails to meet the condition, it must fund intersection improvements or other traffic improvement projects. The resulting University plan included: an expansion of the Marguerite Shuttle; an increase to the campus bike project to $4 million ($800,000/year for 5 years), which funds lockers, locks, and staff; and direct cash payments to faculty, staff, and off-campus students ($180/year) who are at least part time, and leave their cars at home.

*6. Development Agreements*

Development Agreements were used in Portland to trade public improvements for community benefits, including affordable housing, reduced parking requirements, parks, and transit improvements. For example, Portland's development commission was able to sign an agreement with developers to give park space, affordable housing units, and other amenities in exchange for public service, increased density, and infrastructure such as the streetcar.

## *X. Recommended Next Steps:*

- Decide if a local circulator is desired.
- Visit Portland, Oregon or Kenosha, Wisconsin to learn more about their experiences.

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87 Ibid

- Narrow the range of alternatives.

- Hire a planning/engineering firm to fine tune the selected alternatives and provide additional feasibility analysis.

- Study the development potential along the alternative routes and estimate potential TOD and ridership.

- Return to City Council.

## *XI. Historical Appendix*

**Ropeways History**

As one of the first technical means of transport conceived, different forms of aerial ropeways have been operating since the formation of ancient civilizations in India and Japan. Ropeways were initially made of hemp or rawhide to transport people and materials over generally impassable terrain. Getting from point A to point B in a straight line over craggy mountains or rivers was only possible using aerial ropeways.[88]

An immediate need for point-to-point transportation was in military operations. The transportation of ammunition, cannons, and fortification building materials necessitated that ropeways be designed that were stronger and able to carry heavy objects. Initial reference to the use of ropeways for this function can be found in a weapons catalog from the year 1405 called *Bellifortis*. Between 1411 and 1440 more references are made to monocable (one rope loop) and bicable (track rope and pull rope) operations in Europe.[89]

In South America, aerial ropeways to transport gold have been reported as far back as 1536.[90] In 1644 Adam Wybe, a Dutchman, engineered a continuously circulating ropeway to carry the earthworks material in baskets for the Danzig fortifications. While this was a modern marvel, aerial ropeway technology stalled and its possible use for mass transport stalled as well.[91]

Aerial ropeway technology would not be seen again for the movement of heavy duty materials or people until the mid 19th century. The main reason for the pause was that the rope itself had not progressed and metal wire was not manufactured en masse until the 19th century. Mass production of wire rope began in 1837 and set off a new course for aerial ropeways.[92] The first known passenger ropeway from this period was in the Hartz

[88] Bittner, Karl. *Milestones in Ropeway History*. International Aerial Ropeway Review. March 1984.
[89] Ibid
[90] Dwyer, Charles. Aerial Tramways in the United States – An Historical Overview. OITAF 1988
[91] Bittner, Karl. *Milestones in Ropeway History*. International Aerial Ropeway Review. March 1984.
[92] Ibid

Mountains of Germany around 1860. The first bicable system followed in 1869 and soon manpower was replaced by engines.[93]

Expositions in Italy were the first to show off the technology to a wide audience. Eight-passenger gondolas were shown at numerous events from 1894-1912.[94] Again the military application was the main reason for their rise in use even when passenger travel interest was growing. The Italian military was using ropeways at the turn of the century, and in 1908 aerial ropeways were being used in the Turkish-Italian war. They could be quickly assembled, disassembled, and moved using pack animals.[95]

During World War I heavy-duty ropeways were used in the Alps to reinforce difficult terrain with troops and supplies. This practice continued into the Second World War where more sophistication went into using the ropeways as a short term solution for destroyed bridges and other water crossings. Components left over from army ropeways were used to build the first chairlifts. The development of aerial ropeways continued after the war to include a number of different types of ropeways including all of the ones we see today. Chairlifts, gondolas, and aerial trams would become the most recognizable and owe a lot to their early materials and personnel predecessors.[96]

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[93] American Steel & Wire Company. Aerial Wire Rope Tramways. Cuneo Press. 1935.
[94] Bittner, Karl. *Milestones in Ropeway History*. International Aerial Ropeway Review. March 1984.
[95] Ibid
[96] Ibid