The Marquam Hill – OSU Project
Portland Oregon

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Joe Gmuender, of Gmuender Engineering LLC, grew up in the ski industry following his father's career through Canada and the Eastern US. He graduated from Lehigh University, Bethlehem, PA in 1984 with a Bachelor of Science in civil engineering. He is a licensed Professional Engineer in 9 states. He worked for Lift Engineering part time from 1980 to 1983 and full time from 1984 to 1986 as a project engineer. Joe also worked from 1986 to 1990 as General Manager and Project Engineer for Doppelmayr Ski Lifts based in New Hampshire. Joe worked for Pettit-Morry, now Acordia, Insurance Company, providing inspection services for ski areas throughout the west from 1991 to 1997. Joe started Gmuender Engineering LLC in 1997 and has designed and constructed projects throughout the western US, including three gondolas at Mammoth Mountain. He has served on the ANSI B77 committee for 6 years and is the chairman of the detachable subcommittee.

His company specializes in providing ropeway engineering and inspection services for ski areas requiring new lift design and construction, modification and relocation of existing lifts, and feasibility studies for ropeway installations. Currently, he is serving as a technical advisor for Portland Aerial Transportation, Inc. on the Marquam Hill Aerial Tram project.

Abstract:

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The politically charged Marquam Hill Tramway is designed to connect Portland's Largest employer – the landlocked Oregon Health Sciences University – with 120 acres of underused, industrial land at the edge of the Willamette river. Logistical challenges associated with the alignment and the construction of the tram as it passes over a national historic district and fits into the existing footprints of existing structures are just part of the unique issues of this public transportation link project

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The Marquam Hill Aerial Tramway
A connection to Portland's Future

Joe Gmuender, PE[1]

The city of Portland, Oregon has been an innovator in providing unique public transportation systems that leverage public and private investment and create a catalyst for redevelopment of underutilized areas. The Portland Streetcar project (www.portlandstreetcar.org) was the key component in revitalizing a 34 acre (14 hectare) abandoned railroad yard site into a vibrant neighborhood of new residences and businesses. The lessons learned with the Portland Streetcar are now being applied to a new aerial ropeway project to help assure the future of one of Portland's main economic engines-the Oregon Health and Science University (OHSU).

Oregon Health and Science University

OHSU is the state's only health and research university. It services nearly 200,000 patients a year. With over 11,000 employees, OHSU is the largest employer in the City of Portland and the fourth largest employer in the state. It is recognized as one of the premier trauma centers in the United States.

The 116 acre (47 hectare) main campus for OHSU is located on Marquam Hill, just southwest of downtown Portland, on steep topography with virtually no flat ground. The land for the campus was originally donated to the then University of Oregon Medical School in 1917. The first building, Mackenzie Hall, was erected in 1919. The Marquam Hill campus now consists of 33 major buildings.

A major expansion of OHSU from 1985 to 2003 doubled the building space from 2.4 million square feet (223,000 m^2) to 5.3 million square feet (492,000 m^2). The annual operating budget increased from US$190 million to US$1.05 billion. Most importantly, research award grants grew from US$18 million to US$221 million, placing OHSU in the top 2% of NIH funded facilities in the country[i].

But more expansion is needed for OHSU to meet its goals of being in the top 20 academic health and research centers in the United States. There is little space available on Marquam Hill. Research grants have been passed over for lack of space to conduct the research.

One alternative studied was to expand future research on a separate OHSU campus located in Hillsboro (west of downtown Portland). However, the synergy of having all the players on the same campus-a key element in successful bioscience centers-would be lost. Over time the City of Portland could see their major employer move their focus out of the city limits. There was another alternative-but it would require a unique transportation solution.

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One possibility for expansion was the South Waterfront district, an underutilized area situated just to the east of Marquam Hill. This 130 acre (53 hectare) area is the largest block of vacant land within the city core. Located along the Willamette River, it was historically a heavy industrial area for shipbuilding, lumber mills, and steel fabrication. However, access to the district has traditionally been difficult, as the site is cut off by Interstate 5 to the west.

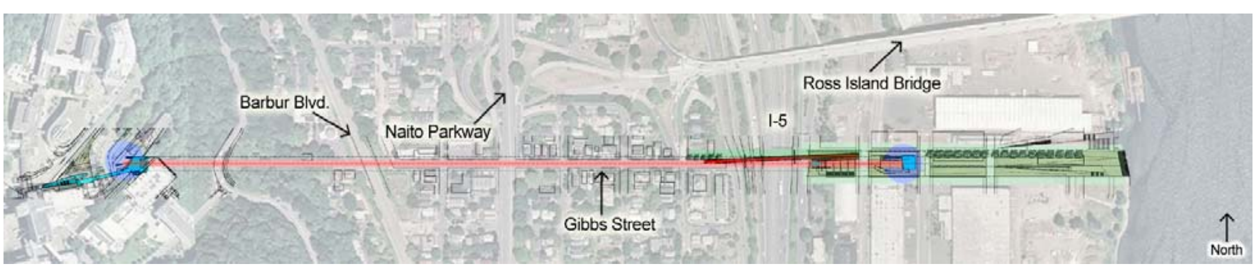
South Waterfront District (North Macadam)

View from South Waterfront to Marquam Hill

Why an aerial tramway?

While the Marquam Hill campus and the South Waterfront district are less than ¾ mile apart, between them are several obstacles:

- Terwilliger Parkway, a scenic forested park that wraps around the base of Marquam Hill.
- Barbur Boulevard and Naito Parkway, two 4 lane highways that connect downtown Portland with areas to the south
- The Lair Hill neighborhood, a historic district of residential homes that has been
- Interstate 5, a major arterial highway connecting cities from Seattle to San Diego along the west coast of the United States



OHSU transportation studies on the needs between Marquam Hill and a potential South Waterfront campus showed that a key element to success was to provide for a 'door to door' travel time of no more than 15 minutes for the researchers and professionals that would travel between the two campuses. Studies of shuttle bus service pointed to travel times of 5 to 37 minutes from shuttle stop to shuttle stop depending on the time of day.[ii] Clearly a different solution was needed.

In 1998, OHSU had commissioned a study that considered aerial ropeways (trams and gondolas), funiculars, cable propelled people movers, and streetcars as a connector between the Marquam Hill campus and a proposed women's health care facility in the North Macadam area.[iii] Further study was performed in 2001, with OHSU again concluding that an aerial tramway was the best solution. The aerial ropeway concept was incorporated into the City of Portland's transportation plan for Marquam Hill.

A peer review of the transportation plan was conducted for the city in January 2002.[iv] The panel agreed that an aerial ropeway system was the most feasible and effective way to connect the Marquam Hill and Waterfront campuses. However, the report stated that the City should consider gondola technology as well as aerial tramway technology, and study alternate routes to the Gibbs Street alignment.

In order to facilitate the public-private partnership needed to complete the project, an Oregon non-profit corporation was formed. Portland Aerial Transportation, Inc. (PATI) is modeled after the successful non-profit used to build the streetcars (Portland Streetcar, Inc.). PATI's purpose is to oversee design and construction of the aerial ropeway, and at completion turn it over to the City of Portland. This mechanism provides solutions to several problems, including access to a public right-of-way for the alignment and involvement of the private stakeholders who finance a large portion of the project.

The City of Portland Office of Transportation (PDOT) developed a "Process for Consideration of a Suspended Cable Transportation System" that provides a framework to evaluate, select, and design the system. It includes opportunities for public input, and public go/no go decisions by City Council at the end of each phase of the process. Working with PDOT's Matt Brown, PATI's first mission was to tackle the analysis of which ropeway system and what alignment should be used. The author of this paper assisted PATI with the technical analysis of the ropeway alternatives.

Five alternatives were studied:

1. Shuttle Bus connection (4 different routes studied)
2. Aerial Tramway-Gibbs Street Alignment
3. Aerial Tramway-Gibbs Street Alignment plus Monocable Tram to Barbur
4. Monocable Gondola-Gibbs Street Alignment with mid station at Barbur
5. Aerial Tramway-Ross Island Bridge Alignment
6. Monocable Gondola-Grover Street Alignment with mid station at Barbur

The studies recommended Alternative 3, based on the following factors:

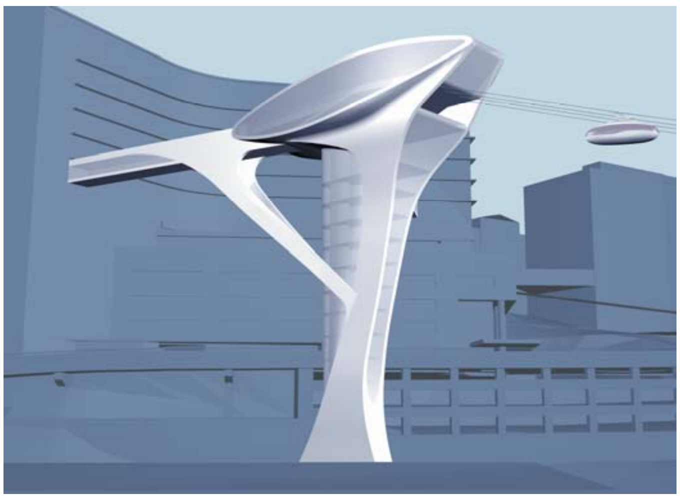
- Travel time for the Aerial Tramway on Gibbs was estimated at 12 ½ minutes door-to-door, which met the criteria of 15 minutes or less.
- The aerial tram had the lowest level of impact on the adjacent neighborhood.
- The aerial tram and monocable tram were the most reliable and mechanically simple systems.
- The monocable tram would provide a direct connection to the Barbur transit stops.
- The short term operating costs and long term maintenance costs were lower for the aerial tram.

Subsequently the monocable tram option was dropped in the design development phase, and the project has proceeded with Alternative 1.

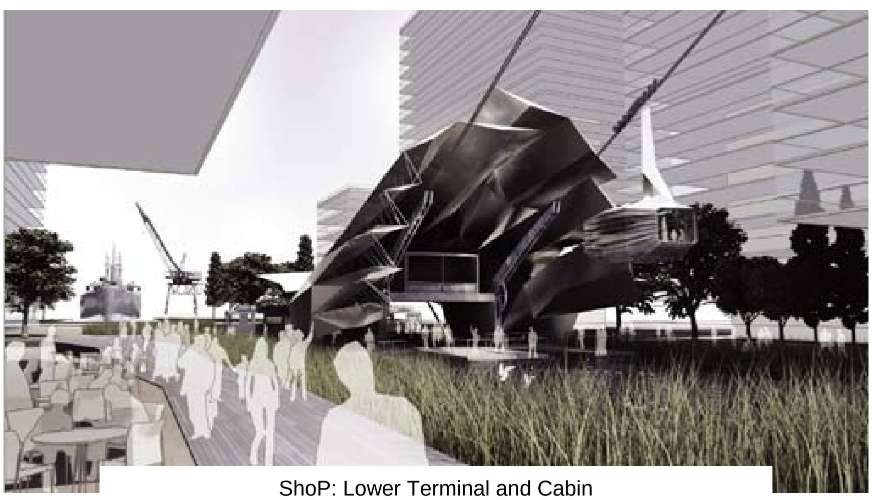
International Design Competition

PATI's next project was the initiation and management of an international design competition. This was undertaken so the project would achieve the highest levels of architectural and urban design quality, while balancing the needs of the affected neighborhoods. Based on the Gibbs Street alignment and a proposed budget of US$15 million, each team was given the task of presenting their vision of the project. Advised by Reed Kroloff, editor-in-chief of 'Architecture' magazine, the PATI board interviewed seven firms and four teams were selected to compete:

- UN Studios, Amsterdam, the Netherlands
- ShoP (Sharples Holden Pasquarelli), New York
- Guy Nordenson and Associates, New York
- Angelil/Graham/Pfenninger/Scholl (AGPS), Los Angeles/Zurich

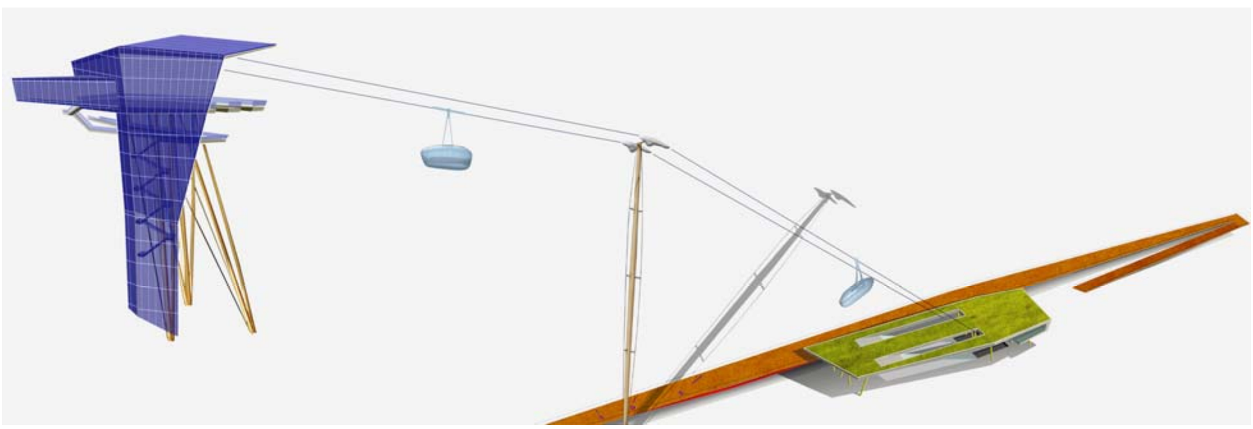


UN Design: Upper Terminal, Mid Terminal with deflection



ShoP: Lower Terminal and Cabin

Guy Nordenson, Intermediate Tower



AGPS: Upper Terminal, Intermediate Tower,

A six member jury heard public presentations on March 24, 2003. The UN Studios presented a unique solution that involved a tall intermediate station, which was offset from the chosen alignment. Their proposal used two reversible trams running parallel to each other, which would load/unload at the intermediate station, as well as negotiate a curve. Ultimately the jury selected AGPS as the winner, in large part to the 'minimalist' design of the cabin and intermediate tower intended to blend into the surroundings.

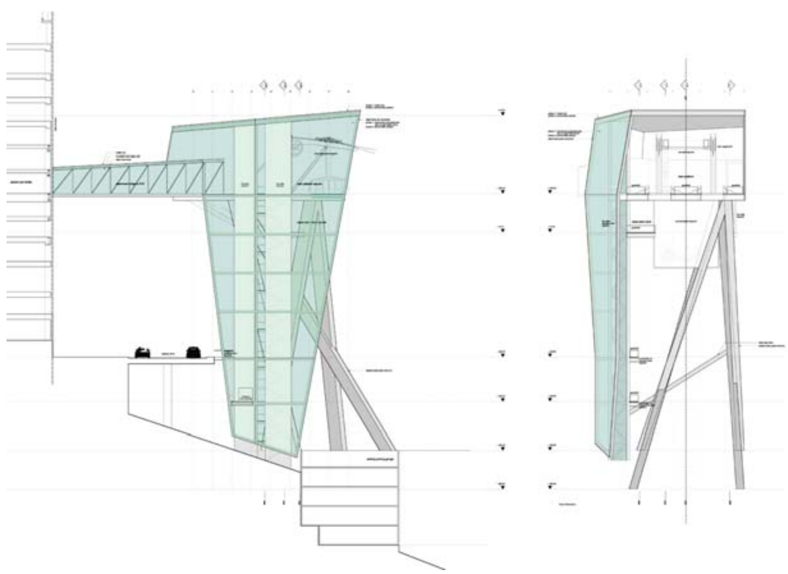
Selection of Tramway Equipment Supplier (TES)

PATI then issued a Request for Proposals from ropeway manufacturers to enter into a pre-construction and engineering services contract. The selected manufacturer would work with the design team to refine the design to meet the technical needs of the tramway, and then negotiate with the City on a guaranteed maximum price on the final design. Doppelmayr CTEC/Garaventa and Leitner-Poma both submitted proposals. After an interview process, the PATI board selected Doppelmayr-CTEC/Garaventa in November 2003.

Engineering Challenges

Working with Doppelmayr-CTEC/Garaventa and with Arup, the structural/mechanical/electrical engineer, AGPS has refined the design over the last 14 months. While the original concepts for the upper terminal and intermediate tower used wooden-steel cable composite members, it became clear that different materials would have to be employed.

The toughest challenge is top terminal. The tram arrives at the 9th floor level of the complex, which is a common circulation level. The site for the terminal is extremely constrained between an existing parking garage structure and a new patient care facility. Due to microsurgery, the tram terminal is separate from the hospital structure. This results in a cantilevered structure with the track ropes and haul ropes reacting up to 180 ft above grade with a force of 1000 k (4450 kN). The structural engineers, Arup, and the geotechnical engineers, GeoDesign, Inc. have designed a structure utilizing steel-concrete composite legs that are triangular in section along with drilled pier foundations.

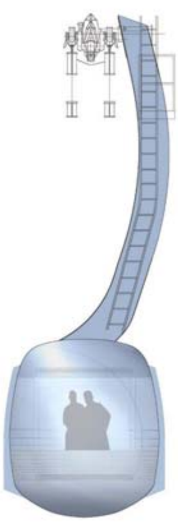


Upper Terminal

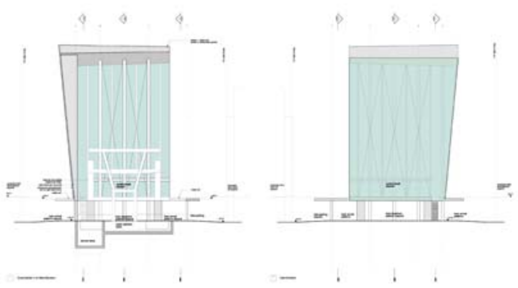
The intermediate tower as proposed in the design competition was not feasible, as it did not have any torsional stiffness. The most economical design, in terms of material cost, is a lattice type structure. However, AGPS and the public did not want a 'transmission line' tower design. The present design is a cantilevered structure with a triangular view in its cross sections and plan view.

Intermediate Tower-design evolution

The cabin design concept was an asymmetric oval shape based on a soap bubble. Several iterations between AGPS and Doppelmayr-CTEC led to the present shape that allows for guides on the side of the cabin for entry into the terminal. The cabins are a unique one-off design that has a significant effect on the project budget. However, it was important to AGPS and the client that the cabins are not a 'box' in the sky.



The lower terminal was originally envisioned to be 'of the ground' with the carriers disappearing into slots in the ground. However, Doppelmayr-CTEC pointed out the increase in trip time during the slow movement by the slots, and the design was changed to a more conventional terminal.



Lower Terminal

The installation of the four track ropes and the haul rope is a tremendous challenge. The alignment crosses Interstate 5, a major north-south route along the west coast from Seattle to San Diego. Traffic cannot be stopped during the rope installation. The alignment crosses 7 other city streets along with a wooded park and numerous overhead utility lines.

Alignment looking from Marquam Hill

Based on the changes required to the design, the budget for the project is now at US$28.5 million.

Selection of Construction Manager/General Contractor (CM/GC)

Through a similar selection process as used for the Tramway Equipment Supplier, several construction firms were prequalified to present bids for the Construction Manager/General Contractor. Kiewit Pacific Structures of Vancouver, Washington was selected in August 2004 based on their expertise in excavation, foundation systems, and complex steel structures. Doppelmayr-CTEC/Garaventa will be responsible for installation of the tramway equipment and ropes.

Some noteworthy projects completed or underway by Kiewit include the new Tacoma Narrows suspension bridge in Tacoma, WA, the Crooked River Bridge in Terrebonne, OR and the Turtle Bay Sundial Bridge in Redding, CA.

Turtle Bay Sundial pedestrian bridge

The Marquam Hill aerial tram is scheduled to start construction in early 2005. It is the linchpin for the birth of the South Waterfront district-without it the development does not proceed. The public investment of US$75 million over the next several years will leverage up to US$1.5 billion of private investment, creating 10,000 new jobs and 3,500 new residential units.

References:

[i] OHSU website, www.ohsu.edu/about/facts/, Sept 2003

[ii] Carl Buttke, PE, Draft Report on OHSU Inter-Campus Transportation Connector, 27 Feb 2001

[iii] Jewett Engineering Limited, North Macadam to OHSU Tram Study, 22 Aug 1998

[iv] Kittelson & Associates, Inc; Peer Review Panel Report, 2 Jan 2002

Portland Department of Transportation, Portland Aerial Tram-Final Reccomendations and Report, 6 June 2004