ETM
ENGINEERING & TECHNOLOGY MANAGEMENT

Title:
Portland Aerial Project Cost Estimation and comparison

Course Title: ***Advanced Engineering Economics***
Course Number: ***ETM 535/635***
Instructor: ***Dr Robert Dryden***
Term: ***Winter***
Year: ***2013***
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Introduction

With the expanding of population from the Marquam Hill neighborhood to South Waterfront district where it used to be an industrial area, the city of Portland tried to find a way to transport people from these two areas back and forth by spending less time as possible. Moreover, some area of South Waterfront district is owned by Oregon Health & Science University (OHSU) that they also have a major facility on the Marquam Hill. Thus, the transportation way between these two points will be convenient for the OHSU employees, patients, and students. The objective of the project was "creating a science and technology quarter." [1]

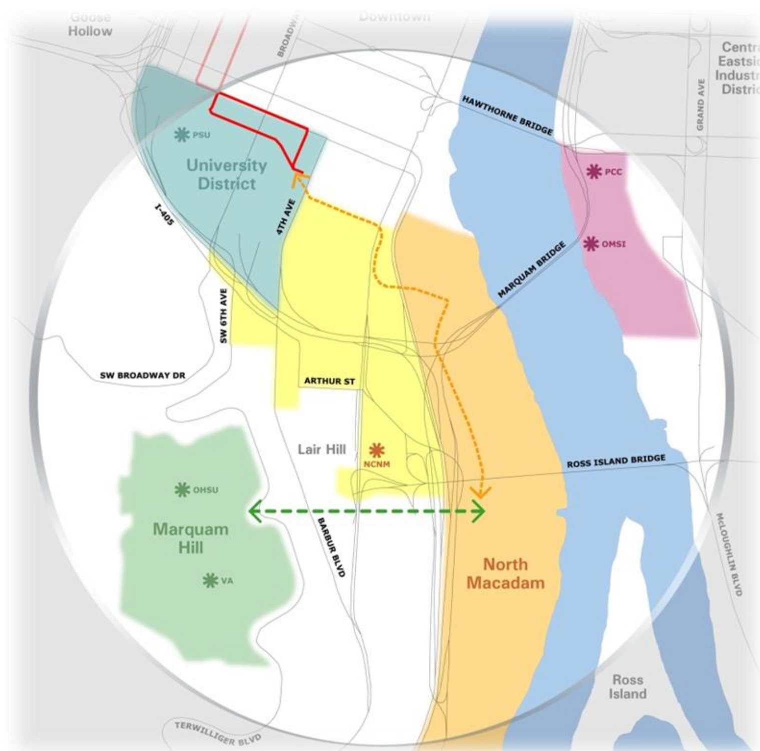

Figure 1: The Science and Technology quarter of the Portland Aerial Tram project

There were many alternatives that the city of Portland and OHSU were considering; funicular rail, streetcar, shuttle bus, mono-rail, and aerial tram. As usual different alternatives will have different disadvantages. However, the city of Portland, OHSU, and South Waterfront property owners had made a decision to construct the aerial tram based on time consuming, initial budgets, and other criteria. The major funding of the project was coming from the OHSU and also from the city of Portland and South Waterfront property owners.

The winner firm of the design competition for the Portland Arial Tram was Angelil/Graham/Pfenninger/Scholl. They had the concept that the tram would consist of four primary elements; the upper station, the intermediate tower, the lower station, and tram cabins which the design team had a concept to make the cabins looked like bubbles floating through the sky [1]. The project was started with $15.5 million cost estimation in 2002. Because the cost estimation in 2002 was more competitive than the other alternatives, the aerial tram was chose to be the best option to transport people back and forth between the Marquam Hill and South Waterfront district. However, the first design of the aerial tram was to have an upper station go directly inside the OHSU hospital, but for the engineering it is not possible. Once the engineering and design team understood this problem, the budgets were raised to be $28.5 in 2004, and then the final budget for the Portland Aerial Tram was at $57 million in 2006 [2].

In this research, the research team would conduct three different methodologies to estimate the project budget based on the information until 2002; two top-down methods (benchmarking and expert judgment) and a bottom-up approach. For the benchmarking approach, the research team was comparing the Portland Aerial Tram project with Roosevelt-Island in New York and Mount Robert in Juneau, Alaska. The researchers also got the financial estimation from the expert who estimated the Portland Aerial Tram project based on his experience. In bottom-up approach, the researchers built the work breakdown structure for each components of the project, and then estimated the budgets for each part. The goal for this research is establishing baseline understanding for all participants as to overall scope, financials and quantifiable cost/benefits. However, in this study, the researchers will not consider the global steel price sky-soaring in 2004.

Financial Analysis

For the objective of this project, we selected two top-down estimation approach and one bottom up estimation approach. Reference class, widely known as benchmarking and expert panel are used to give a first feeling of the project cost. While for the reference class method we needed to look to similar projects to a benchmarking forecast, for the expert panel judgment idea was simply to see how a experienced project manager will roughly estimate the whole project cost. Bottom –up approach is different since a very detailed list of deliverables and WBS has been prepared and each item/activity was monetized and estimation was the total estimation of all items. In the following each method and results are provided.

Reference Class (benchmarking) Method

Kahneman and Tversky [3], [4] found that human judgment is generally optimistic due to overconfidence and insufficient consideration of distributional information about outcomes. Regarding to the statement instead of focusing on similar completed ventures, people tend to overestimate the benefits and underestimate the costs, completion times and risks of the planned action.

Reference class method of forecasting and widely known as benchmarking is a method to overcome to this challenge by looking at the similar projects and their actual costs in the past to build the estimation for the new project.

For our purpose we identified the scope of Portland aerial project first and then search online resources to find the similar projects that have been done in the past for a reference class estimation method. It is important to note that reference class method is a bottom-up estimation which is useful at the early phases studying and planning a project.

Portland aerial project scope is summarized in the following table.

Table 1- Portland Aerial Tram Project Scope of project

Tram Project	Portland Aerial
Location	Portland-OR
Length of Tram (Horizontal Distance-Vertical Distance)	3300’-500’
Line Length	3297‘
Duration one-way trip (min)	3
Number of Cable Cars	2
Passenger Capacity Per Car	78
Number of Stations	2
Number of Intermediate Supporting Towers	1
Structure Type	Steel
Maximum Speed (mph)	22
Art Type	Arial Tram

Identifying a list of similar projects which have been done before 2002 was the next step. To minimize the geographical impacts, North America was the first target as following:

1. Alyeska Resort in Alaska
2. The Cannon Mountain Tram in Franconia, New Hampshire
3. The tram at El Paso, Texas ascends the Franklin Mountains as part of the Texas State Park system.
4. The Hawks Nest State Park aerial tram, in Fayette County, West Virginia, carries park visitors from the rim of the New River Gorge to the bank of the New River, a descent of more than 800 feet (240 m).
5. The aerial tramway at Heavenly Ski Resort, near South Lake Tahoe, California
6. Jackson Hole Tram at Jackson Hole Mountain Resort near Jackson, Wyoming
7. Jay Peak Resort ski resort in Jay, Vermont. Built in 1967 by Von Roll of Switzerland; the cabins (cars) were replaced in 2000.
8. The Lone Peak Tram at Big Sky Ski Resort, in Montana
9. Mount Roberts Tramway, in Juneau, Alaska
10. The tram to Ober Gatlinburg ski resort and amusement park in Gatlinburg, Tennessee
11. The Palm Springs Aerial Tramway in Palm Springs, California, which transports passengers to the top of Mount San Jacinto
12. The aerial tram at Pipestem Resort State Park in Pipestem, West Virginia The Portland Aerial Tram, a commuting tram in urban Portland, Oregon, connecting the South Waterfront district to the Oregon Health & Science University and the Marquam Hill neighborhood. It has a capacity of 30,000 passengers per day.
13. The Roosevelt Island Tramway in New York City is one of two aerial tramways in North America used by commuters as a mode of mass transit (the Portland Aerial Tram being the other). Passengers pay with the same farecard used for the New York City Subway.
14. The Sandia Peak Tramway in Albuquerque, New Mexico.
15. Snowbasin Olympic Tram
16. The tram at Snowbird, Utah, a ski and summer resort near Salt Lake City
17. The Squaw Valley Aerial Tramway at Squaw Valley Ski Resort, California, taking skiers from the base to the High Camp area

18. The aerial tram at Sterling Vineyards in Calistoga, California lifts guest to their wine tasting rooms.
19. The sky lift at Stone Mountain, near Atlanta, Georgia

Among a few projects that were found similar as far as scopes were we could only find the Roosevelt and Mount Robert tramways financial data available. So these projects were selected to the benchmarking analysis. The major scope discrepancy was the number of intermediate supporting towers. Other aspects of the projects are summarized in the following table.

Table 2- A comparison between Portland Aerial tram project and Roosevelt Island and Mount Robert

Tram Project	Portland Aerial	Roosevelt Island	Mount Robert
Location	Portland-OR	New York	Juneau- Alaska
Time of Project (Start-Opening)	2000-Dec.2006	1968-1976	1995-1996
Length of Tram (Horizontal Distance-Vertical Distance)	3300’-500’	250’-3,100’	Vertical 1745’
Line Length	1005 m	940 m	Slope 3100’
Duration one-way trip (min)	3	4	Traveling time 2.2m
Number of Cable Cars	2	2	2
Passenger Capacity Per Car	78	125	60
Number of Stations	2	2	2
Number of Intermediate Supporting Towers	1	3	2
Structure Type	Steel	Steel	?
Engine or Electric Motor specifications	?	?	?
Maximum Speed (km/h)	22mph 35.4	16 mph	23mph
Art Type	Arial Tram	Arial Tram	Aerial Tram
Investment Cost	50 million	6,250,000	17 million

Assumptions

A) Actual dollar vs. Real dollar: First assumption is that cost of the projects is reported as the sum of all accounting expenditures. It only takes real dollar amounts to the calculation and over look the inflation rate. For example in regard to Roosevelt island project, cost of project (real) has been reported as 6.25 million dollars but taking to account all ten years than expenses have been distributed across the project makes the actual cost of project even bigger. Following histogram represent the concept of the real and actual cost of project at the end of the life of project in 1976.

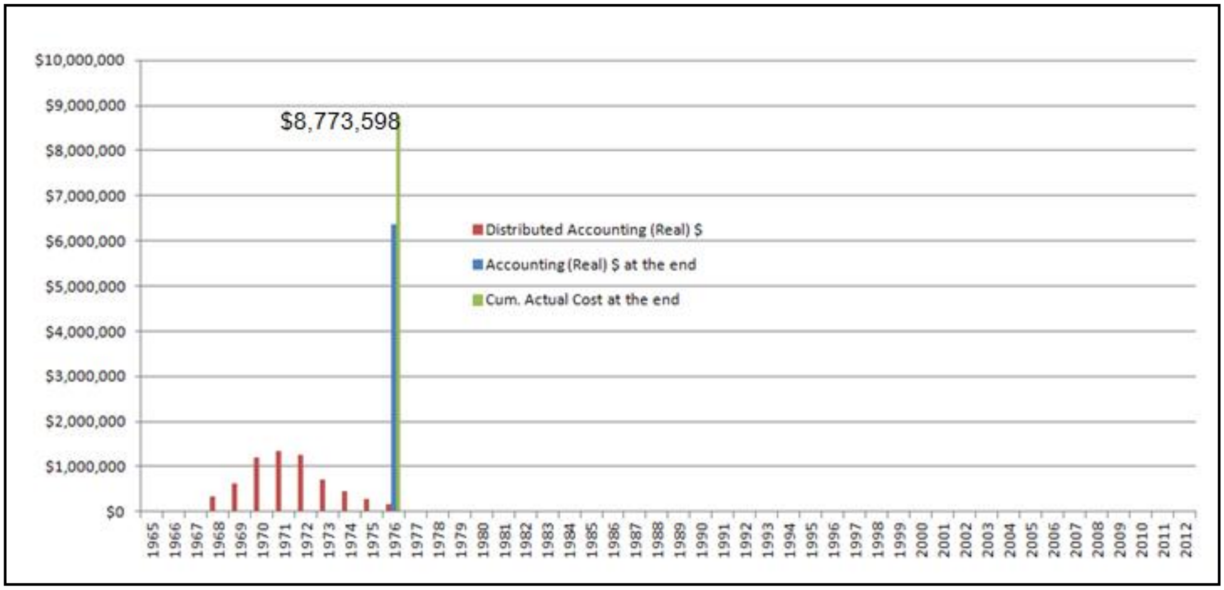

Figure 2 - Real dollar vs. Inflated dollar

B) Bell shape distribution. Next assumption is based on PMBOK project standard, in which any typical project has a bell shape distribution for the cost and staffing across the life cycle of the project. While at the beginning and end phases project expenses are lowest at the execution plan, growing and maturity phases, project deploy the maximum amount of resources.

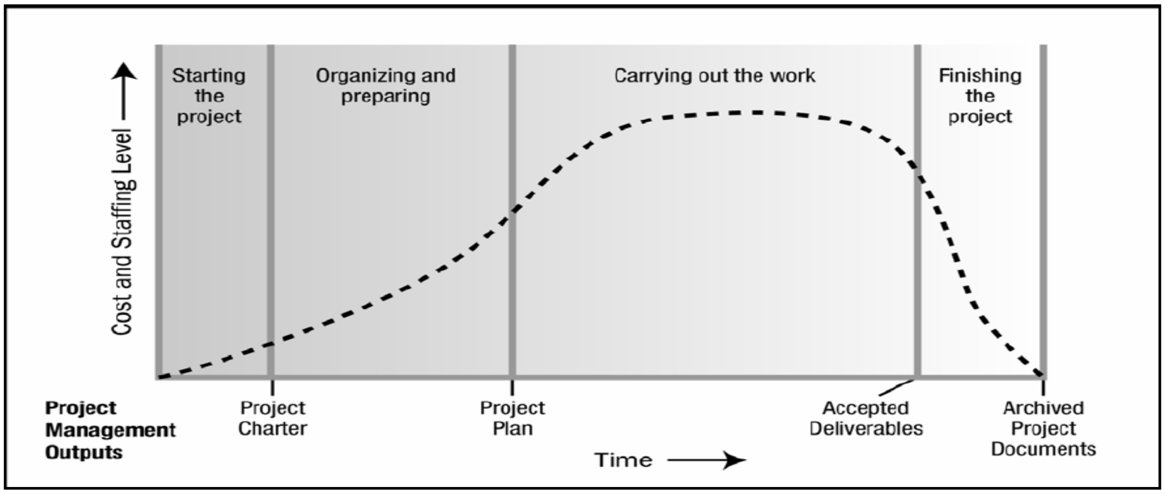

Figure 3- Typical bell shape cost and staffing level across the project life cycle

C) UG general Inflation rate history. To easily convert the value of dollar in different point in time we needed to have the general inflation rate. Next diagram shows the general inflation rate in the US from 1965 to 2012. Although what we used for our forecasting was the data until 2002. [5]

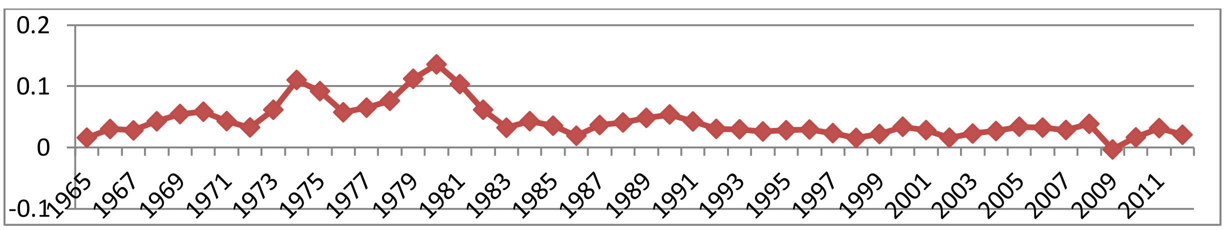

Figure 4- USA general inflation rate from 1965 to 2012

D) Analysis timeline. As it mentioned earlier, since this research intended to give a budgetary plan of the Portland aerial project and compare it with the actual estimation, it seemed fair to only use the data that has been available in the same time period, meaning 2002.

Case 1: Roosevelt Island Tramway

Roosevelt Island tramway project life cycle was 8 years, 1968-1976 and its estimated cost was 6,250,000. But as described above this numbers only reflects the real dollar and not the inflation effect on the const value. By adding the inflation impact based on the US general inflation rate, total inflated cost of the project at the end of the project in 1976 equals $8,773,598. Also by using the general inflation rate we converted the 1976 worth of the project 2002 dollar value. It shows that the equivalent project starting at 2002 will have a cost of $27,754,489. Following histogram shows the estimation cost with this method at 2002.

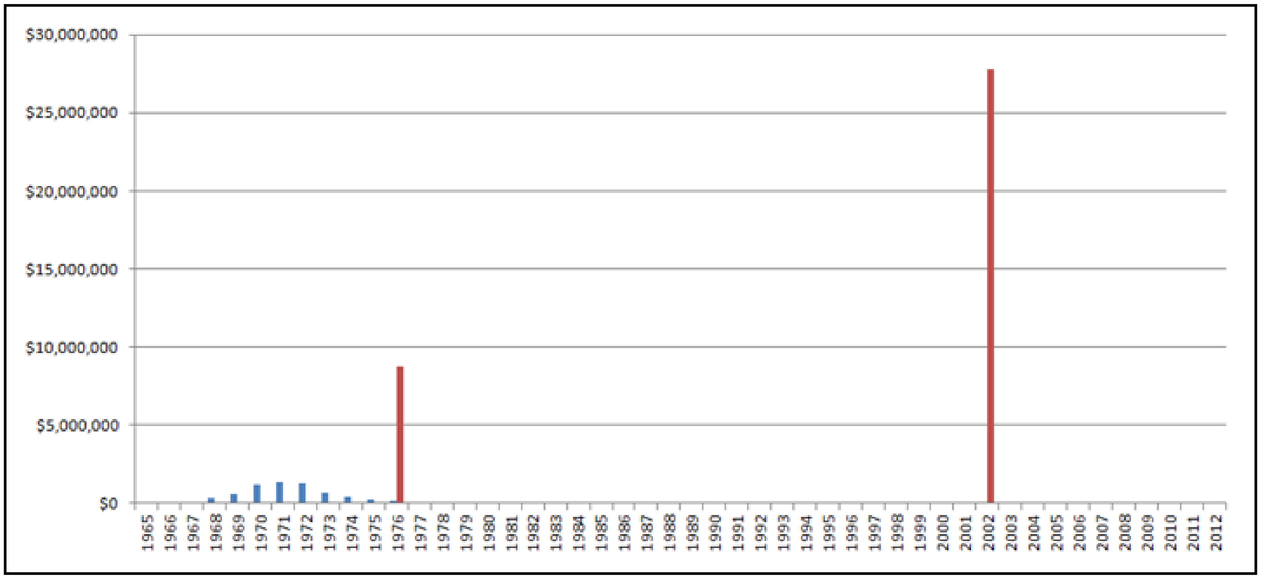

Figure 5- Converted actual cost and estimation for equivalent project in 2002

This is a close estimation of the project cost but still in can be improved by taking assumption-B in to account. We can assume that this project will also be done similarly in 8 years and expenses will be again distributed across life cycle of the project. The only point here is at that time of this study (2002) we do not have the actual inflation rate data for the next 8 years. What we can use though is minimum inflation rate of the past, let's say previous 20 years. This will give a 2.5% minimum inflation rate required spreading the cost of the project in the future. Of course the result would be almost a best case scenario due to using the minimum rate of the past. We will address this issue later. By moving the same distribution form from 1968-1976 to the equivalent period from 2002 to 2010 following histogram will be formed. Now the actual (inflated) dollar of total cost of the project is $30,065,340.

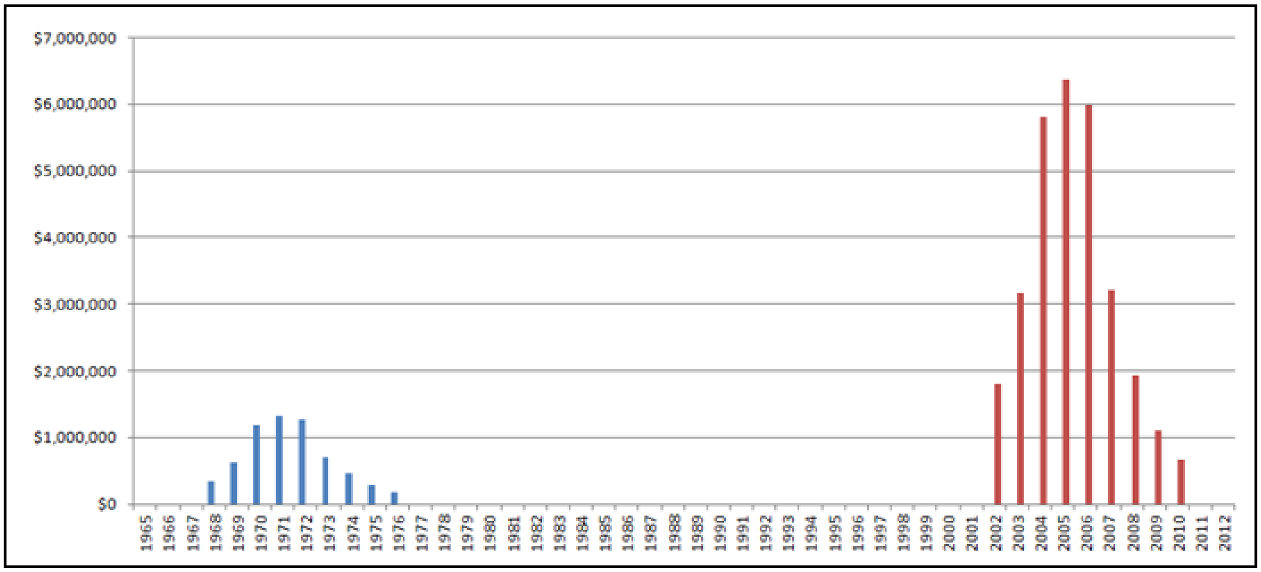

Figure 6- Same distribution shape for project expenses moved to 2002

Due to scope differences between Portland aerial project and Roosevelt island tram though, it is reasonable to use a range of estimation as opposed to an exact number. Considering that Portland aerial project has two less towers in the scope, we estimate that it will maximum save up to 25% of the whole project cost and at the best case scenario total cost of the project will be around $22,549,005. This is quite optimistic estimation though, since we have used the minimum inflation rate and anticipated no risk in the scope change or any fluctuation of the price of any equipments or materials. So it makes sense to have the upper level of the estimation added to the range. We used the same 25% increase in the cost to be consistent with lower level and it gives $37,581,675 as the upper level of project cost.

Case 2: Mount Roberts Tramway

The same process has been used for another case study. Mount Roberts's tramway in Juneau-Alaska was picked since had similar scope and was finished before 2002. Major difference in scope was having one less intermediate tower comparing to Portland aerial tram. Project cost in real dollar in 1996 was 17 million and as it depicted in the histogram below, converted dollar in 2002 was $19,766,839. Since project has been done in two years we did not apply the same rationale of spreading the expenses along a bell shape distribution.

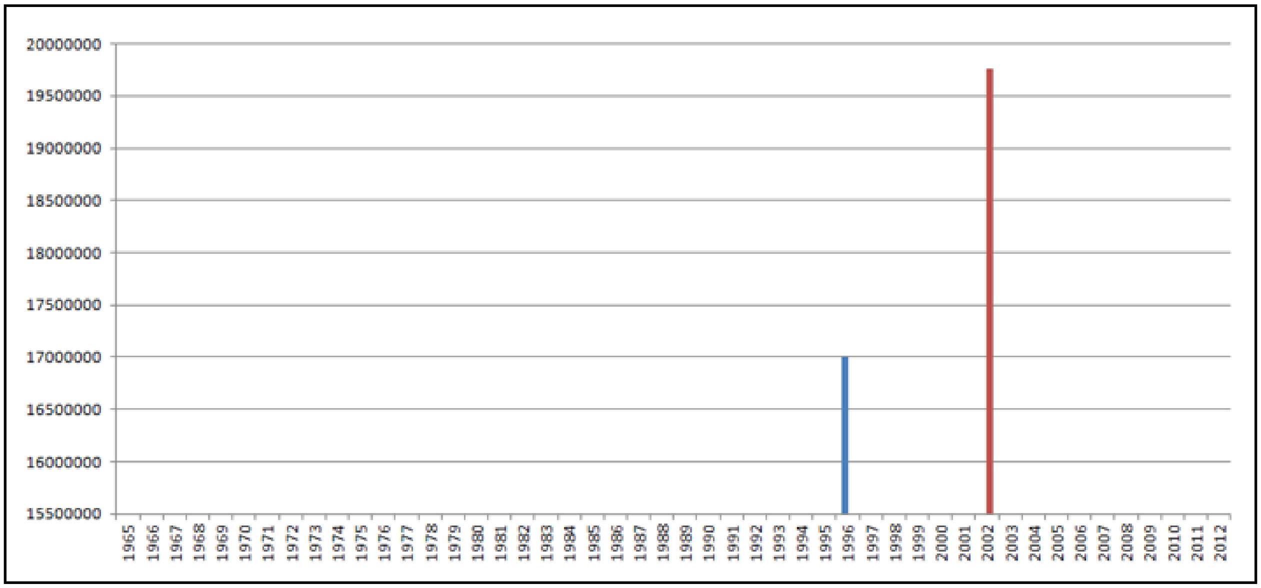

Figure 7- Equivalent cost of project in 2002 (Mount Robert tram project)

Applying the same concept of adding 25% as the upper level cost estimation due to fluctuation in the prices not covered by general inflation rate of 2.5% and also any unpredicted scope changes, gives the ($19,766,839, $25,000,000) as the estimation range.

Expert Judgment rough cost estimation

The approach behind our second top-diagram was to reach out to an expert with years of experience in estimation and has a background in construction management. We hope that this individual is able to provide us with an approximation of how much the tram would cost if it was built today. The expert we connected with was Ron Vergara, a Senior Estimator at Tri-Met. We asked Ron very general questions and didn't expect him to give us very detailed estimates which included labor costs, material costs, and excavation costs. The categories that Ron provided us include: Site Work & Foundation, Engineering & Administration Services, and Material & Components [1]. As you can see in figure below, the top-down approach that we came up with per Ron's suggestion is a very high-level approach that contains just the three categories and doesn't reveal what makes up these categories.

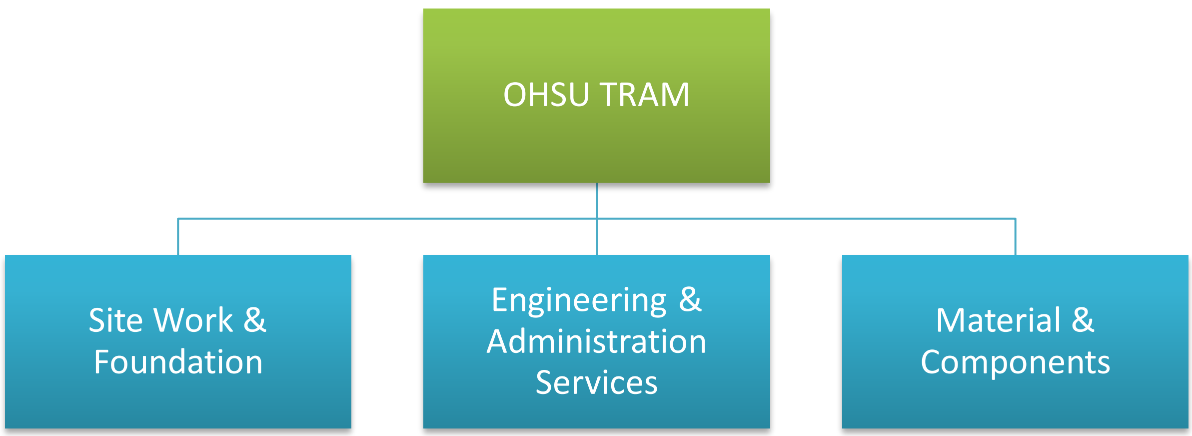

Figure 8- Expert Judgment basis for cost estimation (Top-down Approach)

As seen on the next table, it only mentions what Ron believes each category will cost based on his years of experience with similar projects that he's encountered over the years. As you look at the total number that makes up the three categories, Ron believes if the tram was built today, it would cost roughly $24.8 million [1]. With that note, it shows that if we compare Ron's given estimate, it is much higher than what was originally estimated back in 2002 at $15.5 million.

1 Vergara, Ron. Personal Interview. 20 02 2013.

Table 3 - Expert Judgement cost estimation table

Site Work & Foundation	Engineering & Administration Services	Material & Components	Total
Upper Station: $1 Million	5.8 Million	$15 Million	$24.8 Million
Tower (Mid-level Support): 1 Million			
Lower Station: $2 Million			

Bottom-Up cost estimation method

In Bottom-Up approach, the research team estimated the Portland Aerial Tram project by conducting the Work Breakdown Structure (WBS). The structure consists of five elements; upper station, tower, lower station, tram, and engineering service. Moreover, in each element is also broken down into the details that relate with each parts of the Aerial Tram project. However, for the tram and engineering service section, the research team did not break the structure into details because in the actual project, these sections were outsourced to Doppelmayar, and Kiewit Corporation. The zero level WBS for Bottom-Up approach is shown in figure 9. Figure 10 is shown the WBS for overall Portland Aerial Tram project that the researcher developed based on the information that we got from Tri-Met Project Director, Rob Bernard.

As the research team had the assumption that is time to study will be in 2002, and OHSU hired the team to be the consultants for them. The research team would use the different methodologies to estimate the cost that could be in 2004. The cost estimate that the team gets should not make the team underestimate the budget because in this case, the project will be postponed and the consultant team will lose the money. Moreover, the consultant team cannot estimate the cost to be overestimate the budget because in this case, the overestimate budget can lead the consultant team loses the project due to the OHSU might decide to hire another consultant team.

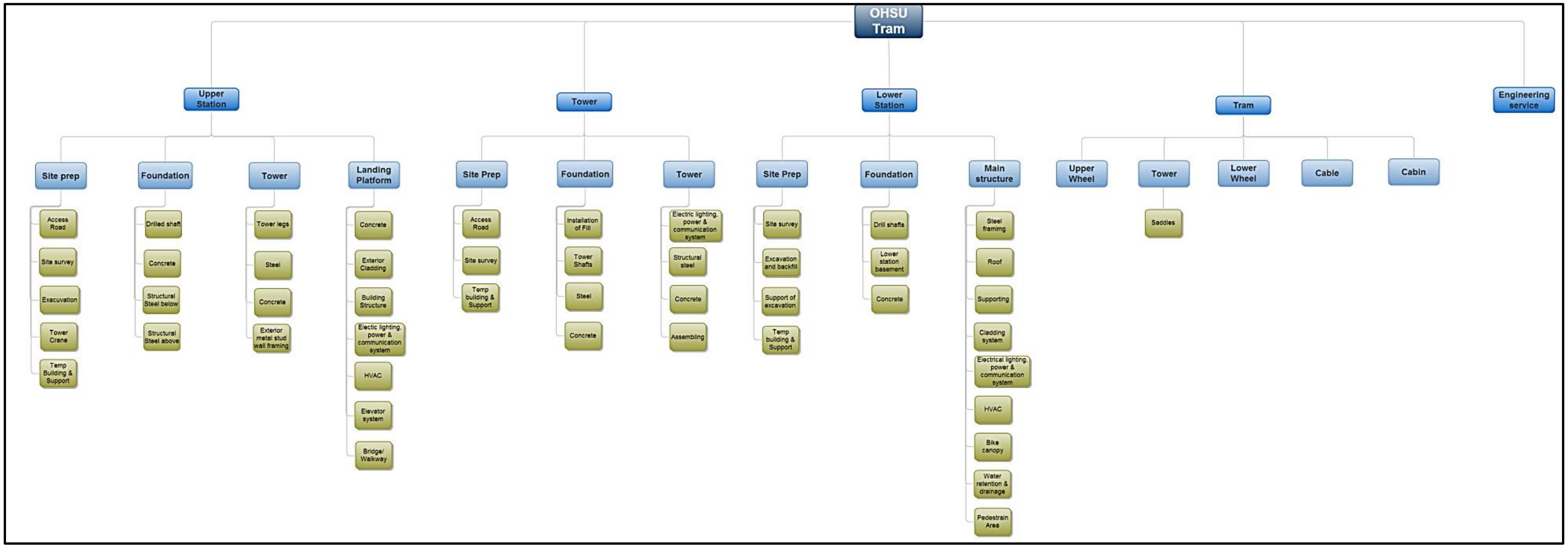

Figure 9: Work Breakdown Structure for Bottom-Up Approach

Upper Station

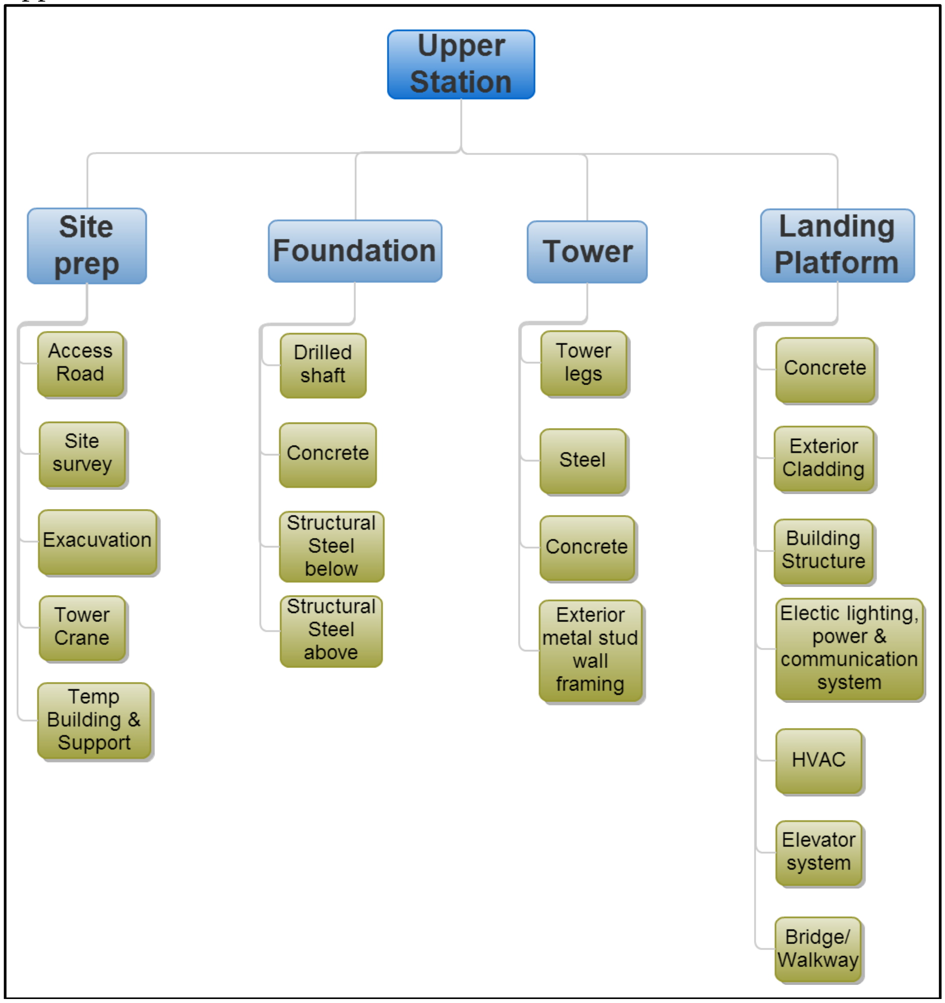

Figure 10: WBS for Upper Station

Once the concept of the tram was approved by OHSU, city officials and near-by residents, the engineering design firm that won right to design the Tram did so with the intent of docking the upper level of the tram in very close proximity to the hospital itself. Essentially tying the landing platform as an extension of the hospital. The initial cost estimate reflected this design concept. However, soon after conducting more rigorous studies, structural engineers, hospital officials and city of Portland officials soon realized that such a structure was not feasible – at all.

In order to accommodate such a massive undertaking, they recognized the need to build a sizable Upper Station, one that could handle the demands and needs of the hospital. An example of such a demand is the Casey Eye Institute is in very close proximity to where the Upper Station would be located. Incredibly delicate surgery is performed at the institute. As such, the tram would need to be built in such a way such that there would be no vibrations from the operation of the tram. To accommodate that need, additional structural design was required, which again was out of the scope of the first and second generation design. Another constraint was the building site itself. All of the construction had to take place in very tight quarters, and had to be done without interrupting hospital activities and without temporarily closing the main road to and from the hospital. The construction team had little room to move materials in and out of the site, and had to be done with extreme precision and synchronicity.

Once the design hurdles were overcome, then came the build phase of the Upper Station. The WBS for Upper Station was developed as shown in table 4 above which consists of 4 important sections; site preparation, foundation, tower, and landing platform. It is here where they incorporated 500 tons of steel below the platform, 120 tons of steel above, and nearly 2000 cubic yards of cement. The landing platform also contained the following: Building Structure, Exterior Cladding and Elevator System. A complete listing is contained in the Upper Station Cost Estimation worksheet as shown in table 4.

Table 4- A summary of Bottom-up cost estimation for Upper station

	$=2002		$=2004			
UPPER STATION			TOTAL			
Site Prep/Foundation/Drill Shaft			$	1,000,000.00		
Excavation/Access Road/Tower Crane			$	947,280.00	(P/F, 3%, 8) 0.7894	$ 1,200,000.00
STEEL**						
Below Platform		Ton				
Rebar	$ 700.00	500	$	371,315.00	(F/P, 3%, 2) 1.0609	$ 350,000.00
Above Platform						
Finished	$ 700.00	120	$	89,115.60	(F/P, 3%, 2) 1.0609	$ 84,000.00
		CY				
CONCRETE^^	$ 1,000.00	2000	$	2,121,800.00	(F/P, 3%, 2) 1.0609	$ 2,000,000.00
LANDING PLATFORM						
Building Structure			$	2,000,000.00		
Exterior Cladding			$	600,000.00		
HVAC			$	25,000.00		
Electrical/Lighting/Power			$	630,000.00		
Plumbing/Fire System/Paving			$	140,000.00		
Misc. Expense			$	500,000.00	`	
Elevator System			$	220,000.00		

Furnish/Install Stair System	$	315,000.00
UPPER STATION TOTAL	$	8,959,510.60

The research team had the information for steel and concrete price in 2002, and then the prices are moved to the future by using the future worth method to 2004 to calculate the possible cost of both steel and concrete for the Upper Station. However, for the excavation/access road/tower crane cost, the research team had only the information for 2012, so the team used that amount of money to be our cost and then move it back into 2004. The inflation rate that the research team used in the calculation was 3 percent in both future worth and present worth calculation. Due to the amount of time that the researchers had, other detail costs will not consider. After finish with the calculation, the research team had the total cost for the Upper Station is around $9 million.

Tower

The tower stands 197 feet tall, nearly as tall as OHSU Building One in the South Waterfront. The WBS of the tower as shown in figure 11 below is consisted of site preparation, foundation, and the tower itself that is comprised of three unique sections and two "Saddles" which help guide the cables linking Upper to the Lower Station.

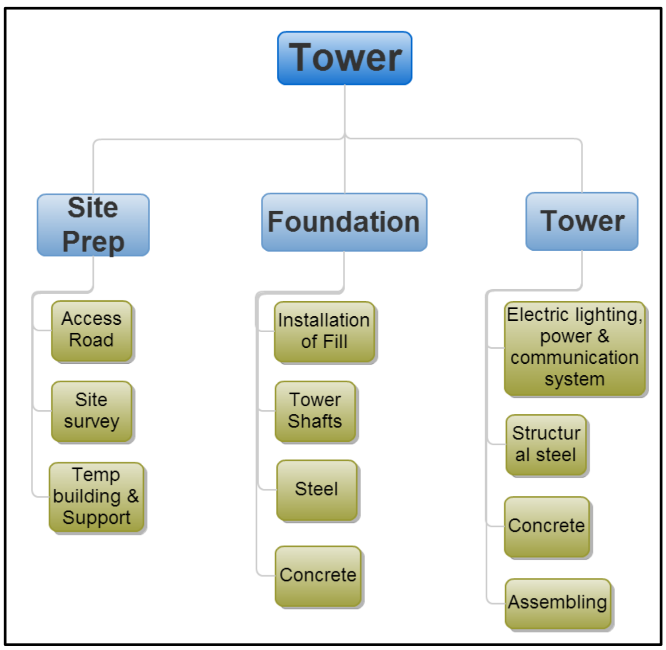

Figure 11: Tower WBS

Materials to complete the tower are 240 tons of steel, over 500 cubic yards of cement and nearly 4500 cubic yards of fill was required. The Tower represents another engineering feat in and of itself, in that the precision in which the three unique tower segments had to be joined and aligned with both upper and lower stations allowed for zero room for error.

	$=2002		$=2004			
TOWER			TOTAL			
Site Prep/Foundation/Drill Shaft			$ 340,000.00			
		Ton				
STEEL**	$ 700.00	240	$ 178,231.20	(F/P, 3%, 2)	1.0609	$ 168,000.00
		CY				
TOWER FOOTING CONCRETE^^	$ 1,000.00	300	$ 318,270.00	(F/P, 3%, 2)	1.0609	$ 300,000.00
TOWER FILL CONCRETE^^^	$ 525.00	250	$ 139,243.13	(F/P, 3%, 2)	1.0609	$ 131,250.00
TOWER IMPORTED & FILL^^^^	$ 65.00	4450	$ 306,865.33	(F/P, 3%, 2)	1.0609	$ 289,250.00
TOWER						
Structure			$ 230,000.00			
Electrical/Lighting/Power			$ 35,000.00			
Misc. Tower Expense			$ 105,000.00			
TOWER STATION TOTAL			$ 1,652,609.65			

Table 5: Bottom-Up Estimation for Tower

Same as the Upper station, the steel and concrete prices are in 2002 and move to 2004 to find the possible total Tower's cost. However, there are three different types of concrete that are used in construction of the Tower; footing concrete, fill concrete, and import and fill concrete as shown in Table 5 above. Then, the total cost of concrete for different types is moved from 2002 to 2004. $1.7 million is the total cost for Tower.

Lower Station

Though the Lower Station did not face a similar set of building constraints as the Upper Station, the Lower had its own unique building restrictions and limitations. Simultaneous to the Lower Station build-out, on one side was South Waterfront streetcar in active construction mode and on the other side of the Lower Station was Zidell Marine, building out expansive steel barges. The Lower Station not only included the tram components, but also included a main building structure, sophisticated draining, a pedestrian area and a bike station to accommodate bike commuters. The WBS for Lower Station is shown in Figure 12.

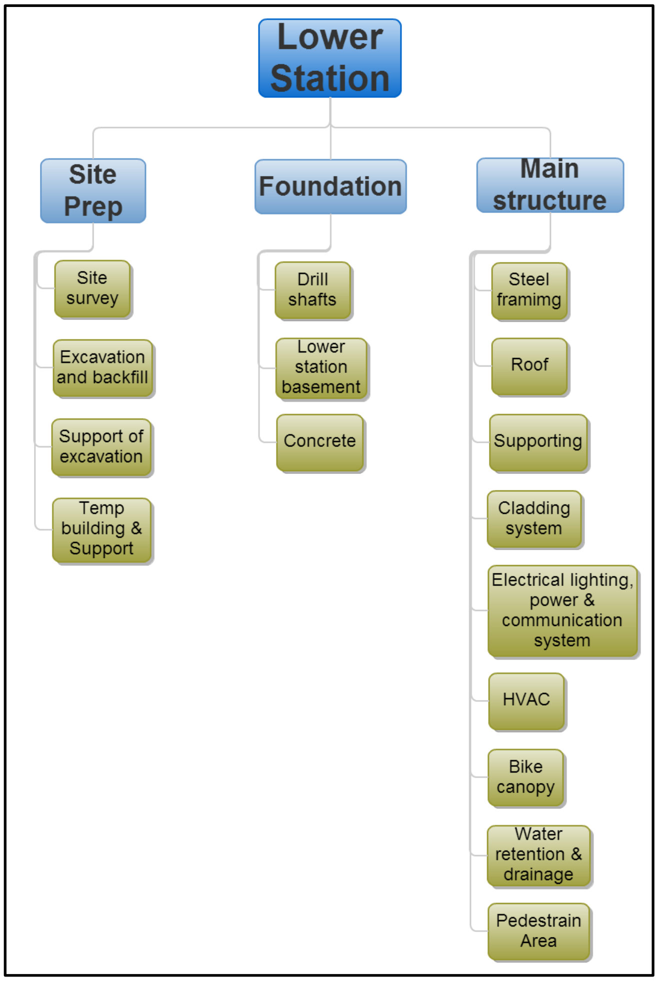

Figure 12:The WBS forLower Station

Base materials include: 125 tons of steel and 785 cubic yards of concrete. The cost estimation for Lower Station is shown in Table 6. All of the calculation was the same as calculation of the Upper Station. Once the research team had all components to construct the Lower Station, the total was calculated to be $3.8 million.

	$=2002		$=2004					
LOWER STATION			TOTAL					
Site Prep/Foundation/Drill Shaft			$	500,000.00				
Excavation			$	592,050.00	(P/F, 3%, 8)	0.7894	$	750,000.00
		Ton						
STEEL**	$ 700.00	125	$	92,828.75	(F/P, 3%, 2)	1.0609	$	87,500.00
		CY						
CONCRETE• • ^^	$ 1,000.00	785	$	832,806.50	(F/P, 3%, 2)	1.0609	$	785,000.00
MAIN STRUCTURE								
Building Structure			$	385,000.00				
Exterior Cladding			$	160,000.00				
HVAC			$	80,000.00				
Electrical/Lighting/Power			$	400,000.00				
Plumbing/Fire System/Paving			$	100,000.00				
Drainage			$	125,000.00				
Pedestrian Area			$	110,000.00				
Misc. Expense			$	390,000.00				
LOWER STATION TOTAL			$ 3,767,685.25					

Table 6: Bottom-Up Estimation for Lower Station

Tram

In 2002, Doppelmayar of Wolfurt, Austria merged with Garaventa AG of Switzerland to form the world's largest ropeway manufacturer. Doppelmayr was the clear leader in Tramway production, as such, was selected to oversee, manufacture, transport and install all elements of the OHSU – S. Waterfront Tram. All deliverables came essentially pre-packed and at a set price. Hence, Tram production, delivery and setup was outsourced to Doppelmayar. The Tram's component is shown in figure 13.

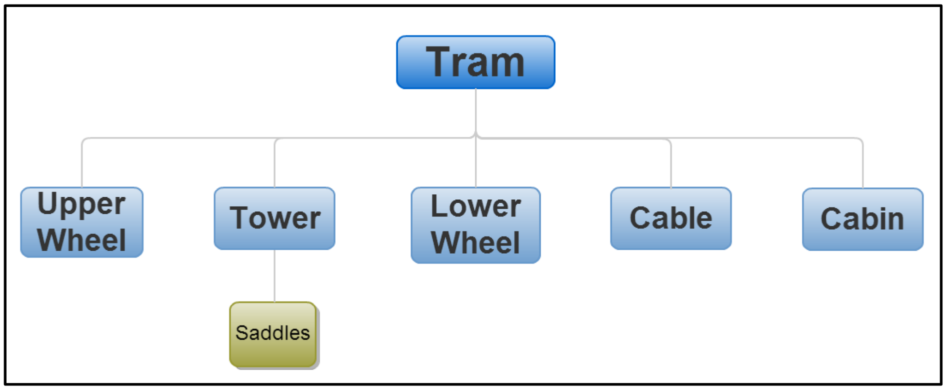

Figure 13: Tram WBS

Engineering Services

Kiewit Corporation is an employee owned Fortune 500 contractor based in Omaha, Nebraska. It is one of the largest contractors in the world. Recent projects have included several bridge retrofitting in the San Francisco Bay area, Interstate H-3 project in Hawaii, and building the world's largest geodesic dome at Henry Doorly Zoo in Omaha. Along with significant mining and off-shore operations, the company also contracts small grading (dirt moving) projects for residential or commercial development .

Similar to the acquisition of Tram services, Kiewit was selected to manage primary construction deliverables and report cost projections, scheduling and work completion back to Tram officials. In 2004 terms, Kiewit represented approximately 10% of the total estimated cost.

Total Cost Estimate

After the research team had the total cost estimation for each component of the Portland Aerial Tram project; Upper Station, Tower, and Lower Station, the total cost for overall project was calculated as shown in Table 7 below. However, the tram and their component cost and engineering service cost were the estimate cost that the team got from Tri-Met project director. As shown in the table that the grand total cost for the Portland Aerial Tram project is around $25.3 million compare with the actual cost estimate which is $28.5 million.

STRUCTURE TOTALS	(UPPER, LOWER & TOWER STRUCTURES)	$ 14,379,805.50
DOPPELMAYR	(Tram, Fabrication, Cables, Wheel Housing, Delivery & Setup)	$ 8,040,000.00
KIEWITS	(Engineering Services / Project Mgmt. & Consulting)	$ 2,845,000.00
GRAND TOTAL		$ 25,264,805.50
References: Materials		
Excavation	http://www.homewyse.com/services/cost_to_excavate_land.html	
STEEL**	http://www.econstats.com/rt_steel.htm	
CONCRETE^^	Due to the complex nature of mix design (tilt up slabs, poured in place walls, slabs on grade, elevated slabs, etc. we used a general pricing index furnished by OHSU Tram authorities.	
CONCRETE^^^	Keiwits Engineering Services	
TOWER IMPORTED & FILL^^^^	Keiwits Engineering Services	
Materials Catalog	http://rsmeans.reedconstructiondata.com/	

Table 7: Total Cost Estimation for the Portland Aerial Tram project based on Bottom-Up Approach

Addendum to Bottom-up WBS:

Project Scope (complexities with all construction facets, Upper, Tower and Lower Station specs)

Production Schedule (borrowing money, financial costs associated with time delays, time value of money)

Project Risks (escalation of prices, 3rd party approval required before proceeding to next building phase – causes time delays, restrictions as to *when* to build, agreement risks between all parties, right away risks for hospital and local residents, procurement risks when accessing necessary resources in a timely manner, spike in exchange rates to obtain materials)

The **Unique Nature** of this particular tram structure, with all of the associated requirements and constraints facing this project and difficulty benchmarking against other tram structures.

By increasing the knowledge base from the above variables will facilitate in more accurate cost projections and a time to completion forecast.

Looking to Alternatives

It was out of the scope of this project to look to the other alternatives besides building a tramway like funicular rail, streetcar, bus stops or a people mover (mono-rail). But in a broader project it was definitely needed to pay lots of attention to studying the pros and cons of each of these other options. In our interviews with TriMet project managers, it seems that some of the alternatives have been easier to reject due to interest of main investor or lack of reliability or even more sociological reasons like prestige and public perceptions.

Conclusion

As we have analyzed three different methodologies to estimate the project budget based on the information until 2002, several overall conclusions can be drawn. As we have seen that all three methodologies that we have research into gave us an estimation range that was between to mid-$20 to $30 million dollars. As the estimation figures have showed us that building a tram for $15.5 million maybe near impossible as new requirements are being surfaced. As Kaheman and Tversky, have pointed out that human judgment is generally optimistic due to overconfidence and insufficient consideration of distributional information about outcomes. Therefore, people tend to underestimate the costs, completion times, and risks of planned actions, whereas they tend to overestimate the benefits of those same actions. And also during our research we learned that the more you know about the project and where it's heading the better planning and estimation could be achieved. Such as knowing what the project scope, production schedule, and project risks. It will help us to have a more accurate forecast when trying to figure out a certain cost on a particular item and how long that particular process should actually take.

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Appendices

A) Potential Similar Gondola projects Ski Resorts Gondolas

California:

1. Heavenly- Heavenly Gondola
2. Mammoth Mountain- Panorama Gondola Lower/Upper- Village Gondola
3. Northstar at Tahoe- Big Springs Express Gondola- Highlands Express Gondola
4. Sugar Bowl- Magic Carpet Gondola
5. Squaw Valley Ski Resort
6. Pulse (Pulse Gondola)

Colorado:

1. Aspen/Snowmass
2. Beaver Creek
3. Breckenridge
4. Keystone
5. Steamboat

6. Telluride
7. Vail
8. Winter Park

Idaho:

1. Silver Mountain
2. Sun Valley

Maine:

1. Sunday River
2. Chondola

Minnesota:

1. Lutsen Mountains

New Hampshire:

1. Loon Mountain
2. Mt. Whittier Ski Area, Ossipee, New Hampshire (closed in 1985)
3. Wildcat Mountain Ski Area

New Jersey:

1. Mountain Creek
2. The Cabriolet (Open-Air Gondola)

New Mexico:

1. Ski Apache

New York:

1. Gore Mountain
2. Northwoods Gondola
3. Whiteface Mountain
4. Cloudsplitter Gondola

Vermont:

1. Sugarbush Resort (removed in 1984)
2. Killington
3. Stowe
4. Stratton Mountain

Utah:

1. Canyons Resort
2. Deer Valley
3. Snowbasin

Washington:

1. Crystal Mountain

Wyoming:

1. Jackson Hole

B) Images of Portland aerial project major deliverables

Upper Station

Tower

Lower Station

Tram