Light Rail Project Management in Portland

Focusing on Interstate MAX:

Project scope, Risk Management, Knowledge Transfer

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Executive Summary

This paper is a research report of Project Management activities related to the construction of the Interstate MAX light rail system in Portland, Oregon from 2000 to 2005. This is a $350M project by multiple public agencies and private companies. This report focuses on four aspects of the project related to PM: Project Selection, Project Management Tools, Risk Management, and Lessons Learned & Knowledge Transfer. In order to frame our findings in a proper manner, the paper begins with a project description, then goes through a review of literature relevant to the topics, and finally discuses the PM relevant aspects of the Interstate MAX project in detail. Our research combines written and published reports with interviews of individuals with Project Management knowledge of this particular project to create a summary of PM relevant activates that helped make this construction project a success.

I. Introduction of Interstate MAX Light Rail Project

1. Light Rail - Background

The MAX is the name for Portland's light rail system. It is part of the TriMet public transportation system. TriMet is a public organization that controls bus, light rail, commuter train, and streetcar transportation options. The organization started in 1969 in bus transportation. The TriMet mission is: "striving to build a safe, comfortable, reliable and innovative transit system that delivers transportation options to our growing region." [1] The first light rail branch, Westside, opened in 1998. Today, the MAX is a light rail system that covers a vast area of Portland:

Figure 1. The map of TriMet light rail system [2]

Each branch of the MAX rail system is shown in a different color above. This paper focuses on a particular project of the MAX system, the Interstate Line, shown in yellow on the map above (Figure 1).

The Interstate Line was done as a project to connect North and Northeast Portland with Portland City Center and the rest of the MAX light rail system. The line opened May 1, 2004. It was the third project of the MAX system, years after the Westside (Blue, 1998), Airport (Red, 2001) braches opened. [2]

It was a national model for environmentally friendly construction practices and community involvement while at the same time enhancing the neighborhood. The project received high accolades for enhancing an old Portland Neighborhood that had fallen on hard times. The project improved the neighborhood with construction of improved road, pedestrian and bike trails, bike lockers, planting trees and even placing art objects. The project also included helping existing local businesses and even helping create fifty new businesses. Even during construction the project helped local businesses by hiring local construction work force through its Disadvantaged Business Enterprise plan. Most notably, the project came in under budget and on time. The project won many awards including American Council of Engineering Companies Project of the Year Award, 2005. [3]

The construction of this large public project started in November 2000. It included 5.8 miles of light rail track with 10 stations (Figure 2). The total cost of the project was $350 million. But long before the first shovel hit the ground much work and in particular Project Management related work was done.

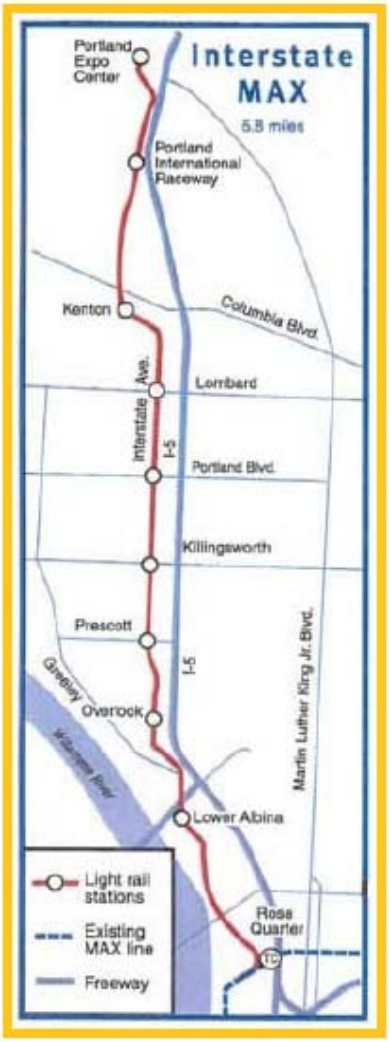


Figure 2. Interstate MAX alignment [4]

2. Organizational structure

During all light rail construction projects in Portland metropolitan area, there always existed the complex relationships between stakeholders. In the article of L. S. Flak, S. Nordheim, and B. E. Munkvold, stakeholders can be classified in three ways: normative assumptions, descriptive aspects, and instrumental aspects. [5] Therefore, in this chapter, we will conduct the diverse stakeholders and their roles. Figure 3 is the sources of funding by the Federal Transit Administration (74%, $257.5M), regional transportation funds (11%, $37.5M), TriMet capital

funds (7%, $25M) and urban renewal funds (8%, $30M): No additional property taxes needed and completed ahead of schedule and millions under budget for Interstate MAX light rail project [6].

In this figure 3, several stakeholders are shown: TriMet, The City of Portland, Metro, and the Federal Transportation Administration.

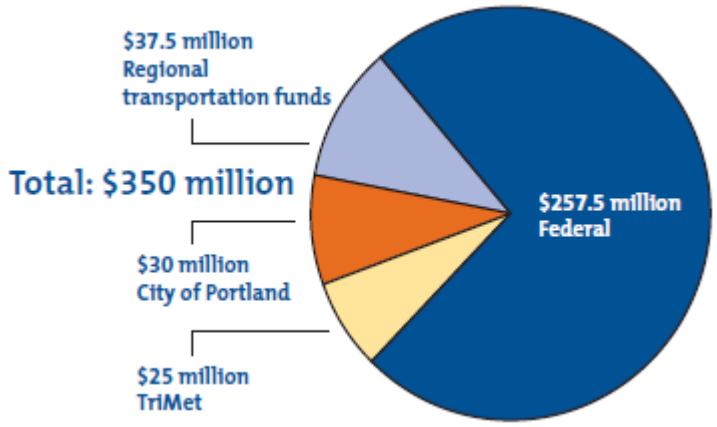


Figure 3. The source of funding for Interstate MAX light rail project [14]

2.1 TriMet

The Tri-County Metropolitan Transportation District of Oregon (TriMet) established in 1969 is the largest public transit agency of the Oregon state to cover the Portland metro area in the three counties, Washington, Multnomah, and Clackamas County. Through the diverse mass transportation system including Bus, Metropolitan Area Express (MAX) light rail, WES Commuter rail, and Portland Streetcar, TriMet provides a high quality of public service for commuters and users [7], [8], [9], [10]. Recently, the TriMet opened the green line from the downtown Portland transit mall to Clackamas City center. Now the MAX light rail system covers over 52 miles. [10] The role of the TriMet in the Interstate light rail construction was the owner and transit operator [19].

2.2 The City of Portland

Portland is the biggest and most populous city in the state of Oregon, located on the confluence of the Willamette and Columbia Rivers. It is well-known as a “green city” in the US due to the efforts of eco-environmental activities. The City of Portland is bound up with TriMet because of the governing relationship. They have worked closely with several development plans to improve the quality of life throughout the Portland neighborhoods. [11] Through the construction of Trimet project, the City of Portland must involve directly and indirectly.

1) Portland Development Commission

The Portland Development Commission (PDC) is an agency of the City of Portland for the urban renewal established by Portland voters in 1958. The PDC is managed by five commissioners who are approved by the City Council and chose by the Mayor of Portland. The main jobs of PDC are evaluation and judgment of the development plans for residents of Portland improving the sustained livability. [12]

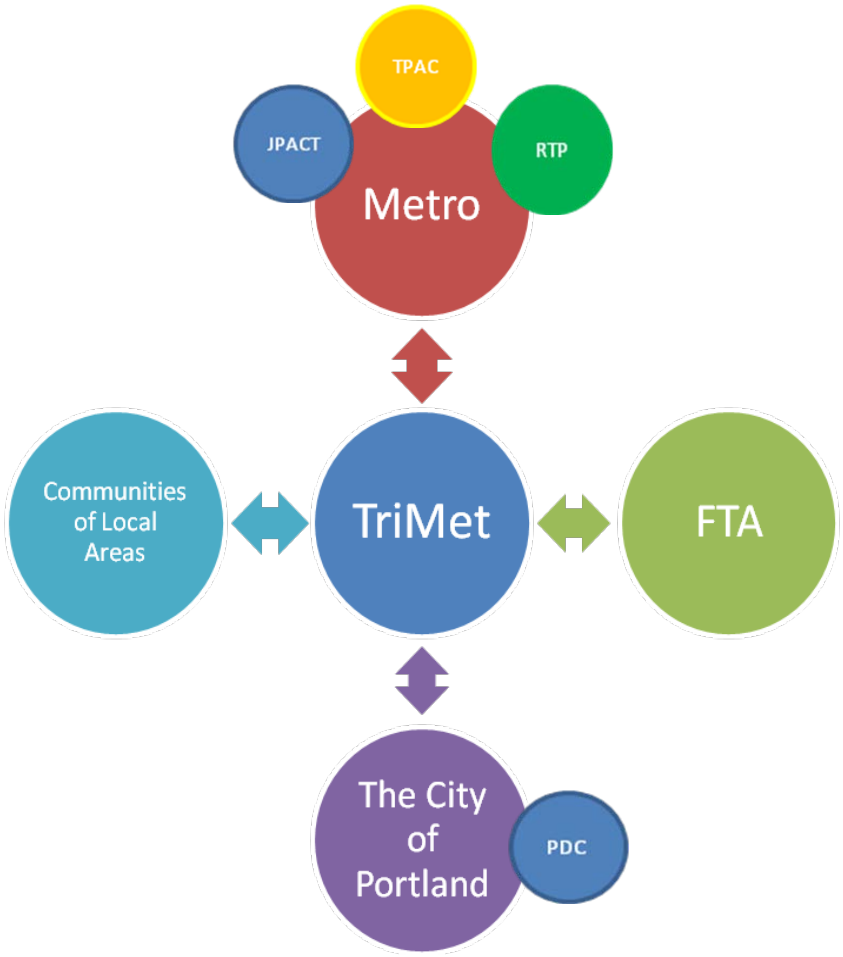


Figure 4. The relationship between the TriMet and Stateholders

2.3 Metro

Metro, a regional government agency is managed by the Metro Council that is a governing body to elect by the local voters through the 25 cities in Portland, Oregon including three counties, Clackamas, Multnomah and Washington. In the Metro Council, there are one president and six councilors. The president must be elected by local neighborhood and each councilor is elected by a regional district every four years. According to agenda of the Metro

Council, it set up the long-range plans, establishes policies, and decides the annual budget and fees. [13], [14] In Metro, there are several sub committees which are relative to advice and decide the transportation policy and plan.

1) Joint Policy Advisory Committee on Transportation (JPACT)

JPACT is comprised of 17 members who are representatives of local communities and government agencies involving in mass transportation for a regional area. The main purpose of this committee is to make recommendations connected with transportation policy to the Metro Council [15].

2) Transportation Policy Alternatives Committee (TPAC)

TPAC is also one of the committees to advise Metro Council to support financing alternatives and transportation planning priorities in technical way. And six citizen members organize the TPAC [15].

3) Regional Transportation Plan

The Regional Transportation Planning (RTP) or Metropolitan Transportation Planning (MTP) is performed by the Metropolitan Planning Organization (MPO) for urbanized areas in which the minimum required population is over 50,000. In partnership with the regional governments and public transportation corporation, the MPO must set up a long-term transportation plan over 20 years and a transportation improvement program (TIP) in a four year.[16] Metro Council set up the regional transportation plan for the Portland metropolitan area. It provides a blueprint of development project that leads investments in the local transportation system to decrease crowding, build new bicycle facilities and sidewalks, access to transit and maintain freight access, and finally improve transit service. The typical examples of the RTP are to plan the direction planning for future investments in the regional transportation system, set up policies and priorities for all types of moving transfer, examine federal, state and local funding and calculate costs of projects. [17] Table 1 introduces the major elements of transportation planning in metropolitan areas for the TIP. [16]

2.4 Federal Transit Administration

One of the big stakeholders for TriMet projects is the Federal Transit Administration (FTA). FTA is an operating administration of the U.S. Department of Transportation. The FTA's headquarters are located in the Washington, DC and others spread out throughout the U.S. nation. The FTA provides the federal funds to support various public transportation systems in regional areas across the nation for planning, constructing, and operating as authorized by the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users of 2005

(SAFETEA-LU). The categories of the transportation systems contain buses, subways, light rail, commuter rail, passenger ferry boats at etc. [16]. According to the FTA brochure, the main purpose of capital investments and support is that increase mobility and enhance the quality of life for millions of Americans [18]. Figure 5 shows the FTA new starts planning and project development process [15].

1) Federal Transportation Development Process

The Federal transportation development process is lengthy and extensive, requiring layered cooperation among overlapping jurisdictions. Regional Organizations and jurisdictions identify corridors where significant transportation challenges need to be addressed. Then localities complete investment studies identifying locally preferred alternatives and design schemes to address the identified issues. The Federal Transit Administration (FTA) collaborates with localities and regional governments to then select a suitable transportation alternative. Once this and all processes consistent with the National Environmental Policy Act are satisfied, the project can receive funding and begin the process that involves the following essential steps [25]:

a. Systems Planning

Localities identify problematic areas or corridors and petitions FTA for beginning the Federal Project Planning Process.

b. Scoping

Essential Stakeholders such as jurisdictions, agencies, and the general public potentially impacted by the project meet to discuss the scope of the project and of its environmental impacts. Environmental impacts, in this case, do not exclusively mean the natural environment, but the entire effected external environment (including traffic, business, employment, traffic, land use, etc…)

c. Major Investment Study

FTA and localities assess the alternatives identified throughout scoping, and following the study, select the locally preferred alternative and local, regional, and state transportation plans are amended to reflect the new project's needs.

d. Environmental Impact Study

Local and federal development agencies performed detailed assessments of the environmental impact of a range of preferred alternatives, and per FTA's requirements, submit Draft then Final Environmental Impact Studies (DEIS/ FEIS). The FEIS details the impact of the selected locally preferred alternative. By FEIS, the project has proceeded to 30% design.

e. Preliminary Engineering

Following the FEIS, FTA must authorize the project to move forward with preliminary engineering, in which the project teams proceed with a more detailed level of design that helps estimate project costs and incorporate risk-mitigating strategies.

f. Final Design and Construction

Once the previous steps have been completed, FTA issues a Record of Decision and then executes a full funding grant agreement, after which further design, right-of-way purchases can be made, and construction can begin. [25]

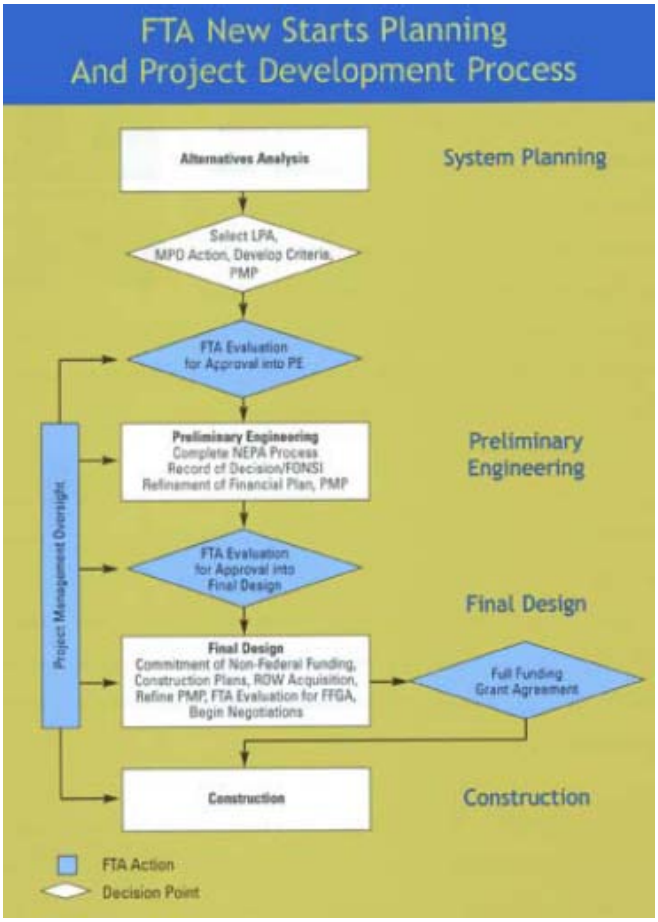


Figure 5. The FTA New Starts Planning and Project Development Process [15]

II. Relevant Literature Review

1. Organizational Structure models for Major Rail Projects

For large transit infrastructure projects there are always many procurement strategic options. In Simon Zweighaft's paper "Dividing *the Pie: Organizational Models for Major Rail*", he grouped the strategies into two broad categories: design-bid-build and design-build [19]. For an agency to develop a major project as light rail project, it always involve not only its own staff but also a large number of outside contractors, such as designers, design support consultants, construction companies and manufactures. Consequently, the agency must plan for an organization that has the ability to manage and integrate different departments from different companies. Major rail projects usually involve outside parties including local public works and traffic departments, utility owners, and adjoining property owners. To consider both the skills and needs of all these parties, the organizational structure for major rail projects must be carefully designed.

The author discussed two broad categories of basic organization structures for large rail projects.

1.1 Design-Bid-Build

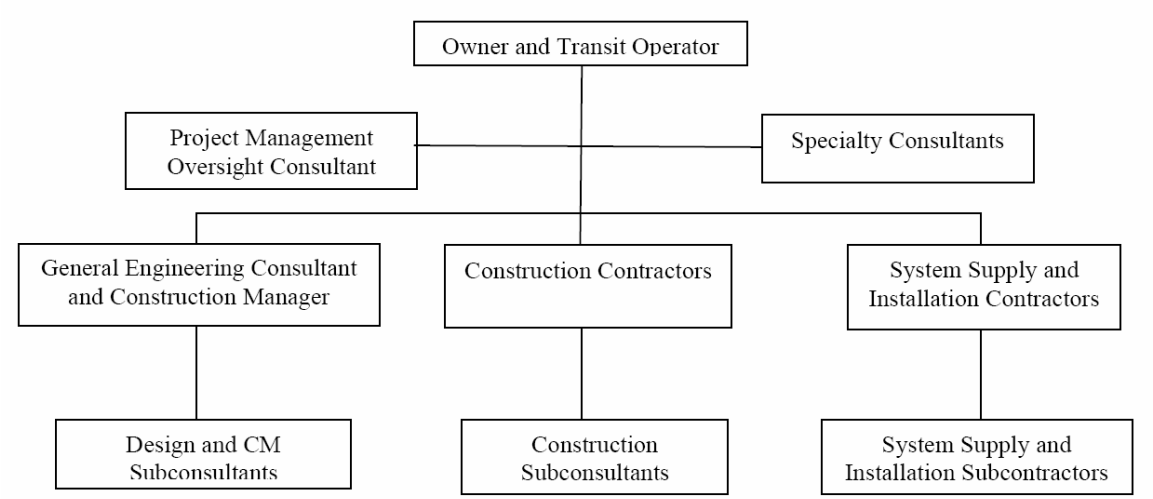


Figure 6. Typical Design-Bid-Build Organization Chart [19]

In this organization structure, owners and transit operators have the authority to hire services of an engineering and construction management team. The engineering team prepares detailed designs. Owners and transit operator solicits construction and system hardware bids and awards contracts. Regular permits and approvals are obtained from owner and transit operators. Construction management team monitors construction and manages the change process. Owners and operators operate the new systems.

1.2 Design-Build

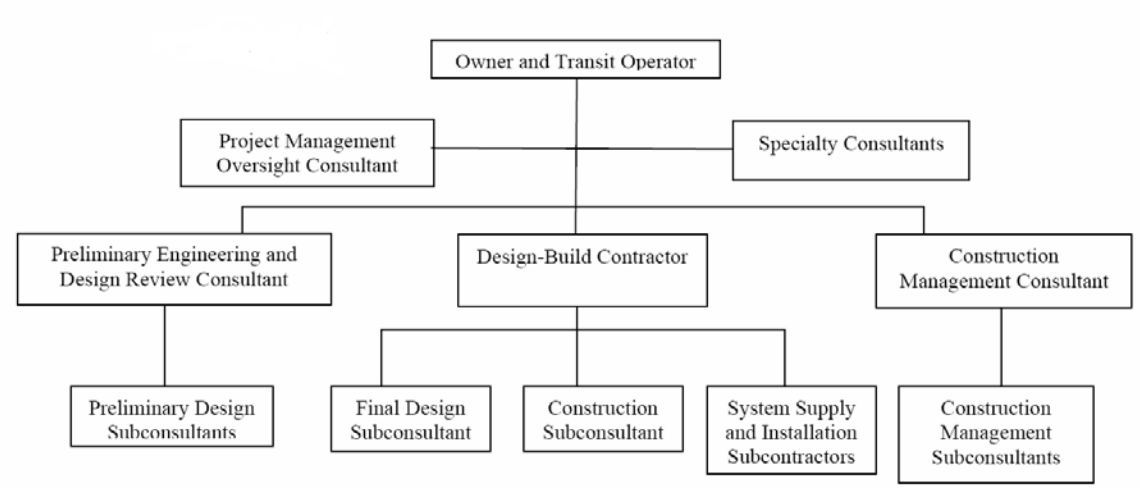


Figure 7. Typical Design- Build Organization Chart [19]

In Design-Build organizations, owners and transit operators hire services of an engineering and program management team. The engineering team prepares preliminary designs, design requirements and performance specifications. Owners and transit operators solicit bids at typically 30% level of design. Bidders must be pre-qualified by owners and transit operators. Final bids are contracts are done by owners and transit operators. Contractor's engineers prepare detailed designs for which contractor is responsible. The engineering team hired by owners performs construction oversight. The new system is operated by owners or contractor under design-build-operate-maintain contract.

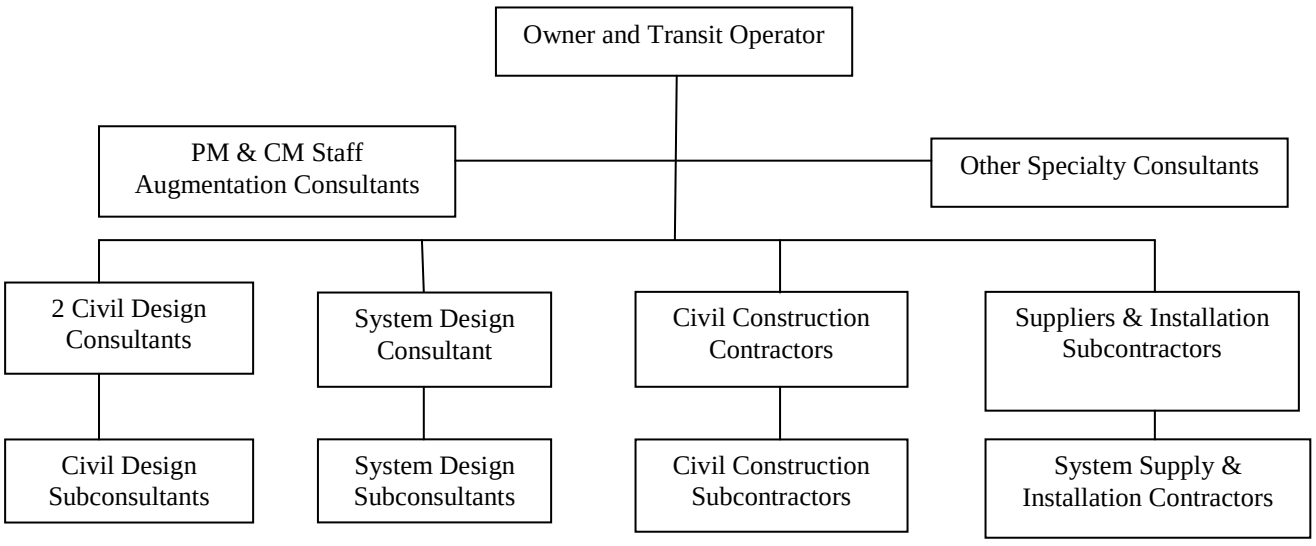


Figure 8 Portland Westside Transit Project Organization Chart [19]

Compare to design-bid-build structure, design-build has better control in time and construction cost under right circumstances. However, if many changes occur on these projects, the design-bid-build environment can resolve those less expensively.

The paper gives an example of Portland's Tri-Met Light Rail Project organization structure. Tri-Met adopted design-bid-build organization structure. There are two separate Civil Design Consultants for the separate sessions of the project, because of a 2 years separation in the procurement processes. Agency staff together with substantial Staff Augmentation Consultants provided project management services and CM services. The staffs from consultants are under Agency's direction. The consultant's liabilities are limited due to Agency's day-to-day supervision.

2. Proposal Selection and Evaluation

In order to solve our question about how the light rail project was selected to conduct, we did a literature review on proposal evaluation for build, operate and transfer (BOT) project. Robert LK Tiong and Jahidul Alum's paper " *Evaluation of proposals for BOT project*" provided insight discussion on this topic.[20] Normally, evaluating BOT project is a decision making process made by different government officials from different departments together with their consultants. There are three elements in a "best" proposal selected by them. First is the quality of the definition of specific criteria. Second is the quality of evaluation of the available alternatives. Third, the quality of the understanding of what these alternatives can produce.

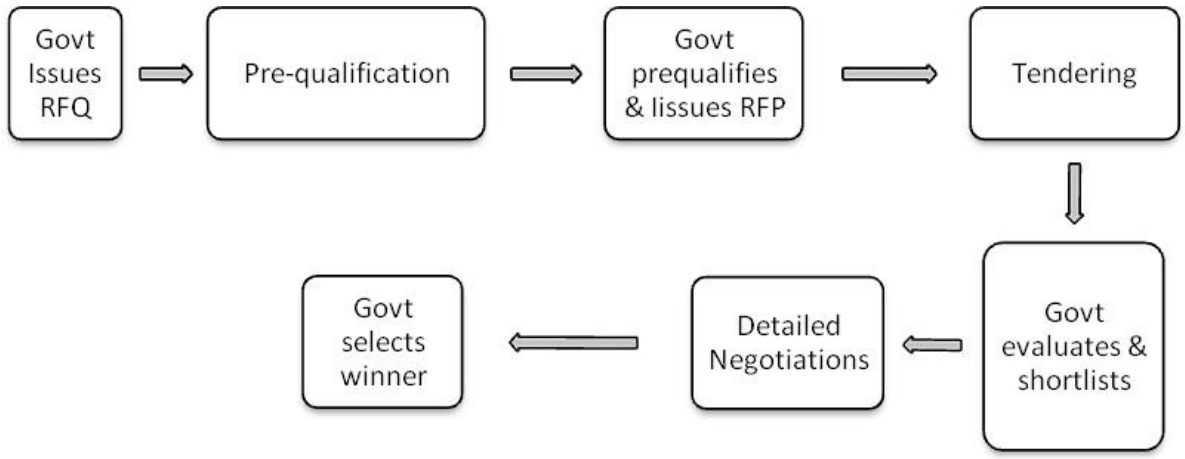


Figure 9 Selection Process in Competitive Tender of BOT Project [20]

Moreover, the macro requirements for BOT projects were described in this paper as: the project must be economically feasible and can bring benefits to the community; the project should have sound environmental impact; it considers public safety; from the social and political aspects, the project is acceptable; the proposed development must achieve the project demands; it should be the best solution to that demand and be consistent with a co-ordinate

development strategy of government. The micro requirements the author proposed are strength in technical and sound in financial, which means the technical proposal must provide the solution to meet the macro objectives and the demand for the services adequately and the financial proposal must be attractive and competitive to support the level of tolls or tariff specified or proposed.

In order to select BOT projects more efficiently, a pre-qualification process is adopted in countries including Australia, Canada, the Philippines, the UK and the US. A short list from a number of competitive proposals will be selected by some reputable and experienced contractors, operators and bankers. The ones with technical, financial or political constraints will be excluded.

The current techniques for evaluating BOT projects are based on net present value (NPV) method, the scoring system and the Kepnoe-Tregoe decision-making technique. The NPV and the score system are the two most common methods used by governments.

2.1 The NPV method

The NPV method is performed after government evaluating the commercial and financial package. The lower the NPV, the cheaper the offer is. For Light Rail project, it is more complicated as traffic is always uncertain. The government will compare the NPV of the cash flows based on the light rail revenues, operation and maintenance costs, financing charges and loan repayments.

Although NPV method provides a way to compare proposals base on calculated numbers, it ignores the relative advantages and disadvantages of the technical solution in different proposals.

2.2 Score system

In this system, several selection criteria are identified and points are given to the selection criteria. The proposal with the highest score is considered to be the best overall proposal. The NPV method could also be used first to evaluate the cash flows. However, the score system doesn't differentiate the importance of selection criteria.

3. Risk and uncertainty assessment in public transportation project

In "*How Transportation Planners and Decision Makers Address Risk and Uncertainty"*[21], which was written by Shomik Raj Mehndiratta, Daniel Brand, and Thomas E. Parody, the author mentioned that without sophisticated risk management strategies consistent with insights of the real-options approach, the transportation projects could not be implemented successfully.

In Daniel Brand, Shomik Raj Mehndiratta, and Thomas E. Parody's work "*Options Approach to Risk Analysis in Transportation Planning*", they viewed risk analysis as a three-step process.[22] First is to identify risk by identifying the sources of uncertainty that can lead to risk. Second is to assess risk by quantifying the effects of these risks on the project costs and benefits. Third step is to mitigate by developing an implementation plan, which the aim of systematically reducing downside exposure to risk and increasing the possibility of benefits. For transportation planning, incorporating risk analysis including a two-phase process; determine the degree of risk associated with a (preferred) transportation investment; if the project is risky (as opposed to being a clear winner or loser), develop and implement a risk management plan to mitigate the risk. The table below shows the different source of risk and how to manage these risks.

Table 1 risk source and management option in public transportation project [22]

Risk Category	Source of Risk	Risk Management Option
Before project is implemented		
Political (short term)	• Party in power changes reducing support for project • Impacted Neighborhood Oppose project as public hearings and elsewhere forcing design changes which cost market impact • Nature or economic events occur changing spending priorities	Incremental planning, building coalitions, staged implementation Same Same
Political: Long Term	• Public opinion and values change (e.g., on environmental or community disruption), changing valuation of project impacts • Laws governing project design change (e.g. taking of parks, compensation for takings), changing designs, costs and other outcomes • Promises made to project opposers have unintended consequences (e.g., cost and market risks)	Incremental planning, building coalitions, staged implementation same same
Forecasting (Market)	• Validity of input assumptions regarding the future (growth rates, land use patterns, energy costs, value of time, economic (including inflation) and wage projections, etc. • Validity of assumed relationships	Incremental planning, sensitivity analysis, staged implementation same plus additional data collection and model

	• Validity of modeling techniques (ecological fallacies, aggregate versus disaggregate modeling needs and techniques)	development Methodological research
Funding (Financial)	• Expected stream and form of funding does not appear • Reductions in funding levels • Constrained funding, e.g., earmarked funding may come with riders that impose unexpected costs or unintended consequences that eliminate alternatives or force concentration on a few aspects of the original proposal	Building coalitions, develop plans with smaller discrete phases Same Same
Litigation	• Possible litigation risks at the planning stage include: Environmental and air-quality interests under 1990 Clean Air Act regulations; Mobility impaired interests under ADA regulations; Racial/social class action suits brought under civil rights or constitutional grounds • Lowered ridershsip and revenue forecasts and higher cost estimates to lessen risk of future liability on privately financed projects	
Cost (including Time) Technology	• Delays, cost overruns in construction/ installation • Litigation by losing bidders for construction contracts • Innovation in technology that make project prematurely obsolete	Additional engineering and cost estimation writing appropriate contract language, turnkey contracts Transparency in bidding process Staged implementation
After a project is implemented		
Market Operational	• Low ridership/travel volumes, how levels of use • System doesn't perform as planned or	staged implementation marketing and advertising, pricing flexibility Additional prototype

Performance	performs in an unsafe manner(particularly relevant with "new"/untested technologies such as computer software, software bugs, compatibility issues) • Travel volumes lead to unanticipated congestion	testing, additional engineering development practices that allow for staged development, contractual language based on performance. Incremental planning, staged implementation
Operating and Maintenance cost	• Operating and maintenance costs higher than expected	same as above
Institutional /Organizational	• Possibilities of labor-management disputes etc. • Inability to manage-operate project effectively	long term contracts, BOT contracts Same
Political: Long Term	• Special interest legislation such as ADA, the Clean Air Act etc. • Change in the regulatory structure (deregulation) of upstream supplier, or downstream consumers	staged implementation same
Financial	• lower levels of subsidy forthcoming	staged implementation long-term contracts
Political: Short Term	• Change in public attitudes on issues such as toll roads, congestion pricing, etc.	staged implementation, building coalitions
Liability	• Litigation over project outcomes not being as planned	Legislation to limit or clarify liability, incremental planning, staged implementation

In "*Evaluating the risks of public private partnerships for infrastructure projects*" Darrin Grimsey, Mervyn K. Lewis proposed nine risks face in infrastructure project. [23]

1) Technical risk caused by engineering and design failures
2) Construction risk, which comes from incorrect construction techniques and cost escalation and delays in construction

3) Operating risk. Higher operating cost and maintenance costs are the reason;
4) Revenue risk. Revenue deficiency can be caused by traffic shortfall or failure to extract resources, incorrect forecast of prices and demand for products and services sold.
5) Financial risks due to inadequate hedging of revenue streams and financing costs
6) Force majeure risk, involving war and other unexpected calamities
7) Regulatory/ political risks, due to legal changes and unsupportive government policies,
8) Environmental risks, because of adverse environmental impacts and hazards
9) Project default, due to failure of project from a combination of any of the above

III. Project Selection

1. Project History: The South/North Corridor Project

The Interstate Max extension project is perceived today as a glowing success for having been built under budget, having been completed four months ahead of schedule with many economically stimulating advantages for local disadvantaged businesses. However, the project's trajectory tells a very different story.

The South/North Corridor project was originally conceived with the intent to both address future growth in the Portland Metro area as well as direct development toward transit-oriented development in the region's long-term goals. The project was selected following nearly two decades worth of extensive research on transit, employment, congestion, geography, topography etc.

However, as this section details, the scale, scope, and intent of the project were forced to shift dramatically following challenges with project funding, resource allocation, and agreement in various communities about the need and benefit of the project's implementation. From these numerous and significant challenges emerged a more modest and targeted project on a very limited budget.

2. South/North Corridor Project Objectives

The goal of the original South/North Corridor project was "to implement a major transit expansion program in the South/North Corridor that supports bi-state land-use goals, optimizes the transportation system, is environmentally sensitive, reflects community values, and is fiscally responsive." [24]

Spanning across two states, three counties, and three cities, the project was an ambitious attempt at accommodating a rapidly growing Portland/ Vancouver Metropolitan Region. Over twenty years, the population had grown by nearly 45% and by 1999, the employment growth rate exceeded the national employment growth rate by 40%. [24].

The South/ North Corridor Project became the region's way of addressing rapid growth throughout the Metro area and to satisfy numerous plans outlined throughout the metro area including Metro's own *Region 2040 Growth Concept* and *Regional Framework Plan.* This plan outlined the larger Portland Metro area's growth, density patterns, and development over 50 years. Light rail expansion was also essential to the air quality plan approved by the EPA in 1997. The Region 2040 plan also identified Portland's city center as the region's central hub with the Clackamas Town Center, Oregon City, and Milwaukie as regional centers and suggested linking them with light rail. Likewise, Clark County prioritized growing urban centers and transit-oriented development in its own Community Framework Plan [24].

In an effort to curb increasingly congested roadways, address increasing operating demand, service hours, and costs for Tri-met bus routes, the South/North project was conceived [24].

Additionally, the project's objectives were to:

1) provide high-quality transit service
2) ensure effective transit system operations
3) maximize the ability of the transit system to accommodate future growth in travel
4) minimize traffic congestion and traffic infiltration though neighborhoods
5) promote desired land-use patterns and development
6) provide fiscally stable and financially efficient transit system
7) maximize the efficiency and environmental sensitivity of the engineering design of the proposed project. [24].

3. Project History and Funding Challenges

Project Timeline [25]:

Below is a timeline that introduces the project history detailed further below.

1983 - First Regional Transportation Plan was adopted
- Eastside Light Rail Transit Opens

1994 - Local funding approval: $475 Million in Tri-Met General Obligation Bonds for South/ North project (passed with 66% of vote and Increased Property Taxes)
- Funding Distribution:
  - FTA Starts at 50%
  - WA contributes 16.7%
  - OR contributes 16.7%
  - Localities collectively contribute 16.7%

1995 - South/ North Project Scoping
- WA Clark County votes for $475 million in funding and fails with 65% against, WA portion cut out of scope.
- OR Legislature votes for $475 million. State approves $375 million in funding, $100 million less than budgeted.

1996 - South/North Major Investment Study Completed
- Statewide vote later eliminates all Oregon State Funding, as voters across the state were voting on a local issue.

1997 - 1998 – Project is segmented, South/North Cost Cutting Process Initiated

1998 - Regional vote reauthorizing bonds fail outside of Portland, especially in Clackamas County

1999 - Published South/North DEIS
Adopted South/North Locally Preferred Strategy
Westside Light Rail Transit Line Opens

In addition to the region's growing transportation needs, it had already experienced significant success with previous light rail transit projects. In 1987, the East Side light rail transit line opened. In 1991, a TriMet General Obligation Bond was approved for the Westside light rail line extension. It passed by a 74% vote with the expectation of increasing property taxes. The MAX Airport line and streetcar were also under consideration and, all together, created a "portfolio" of highly desirable and successful projects that appealed to the Federal Transit Administration. Likewise, Portland benefitted from an impressive reputation with FTA that enabled the region to petition for larger regional project funding and approval. [25]

Following the Systems Planning process, the South/North Corridor project was conceived with the line extending from the South end of Clackamas Town Center, through Milwaukie, downtown Portland, through North Portland crossing Interstate, and finally crossing the Columbia River into Vancouver, WA and ending at Clark College. [25]

Assuming an expansive scope of work, the project was estimated to cost $2.85 billion collected from numerous funding sources. The original funding plan assumed a 50% contribution by FTA, with the remaining half split evenly among Oregon, Washington, and aggregate contributions from localities. [25]

In 1994, voters approved $475 Million in Tri-Met General Obligation Bonds for South/ North project with 66% of the vote and requiring an increase in property taxes. [25]

In 1995, the "Project Scoping" phase began while the funding approval process continued. The project first encountered funding challenges in Clark County, where $475 million in funding was voted down with 65% against the project. There were numerous arguments against the extension of the MAX to Vancouver. First, with so few active rail lines at the time, MAX had not established the near glowing reputation it has today and residents may have been understandably apprehensive of the financial commitment. Moreover, though the barrier is miniscule and Portland/Vancouver residents often work in one city and live in another, Clark County residents may have still felt an emotional barrier to giving Oregonians access to their community. The project also likely fueled concerns about increases in congestion. Many sources also speculate that Clark County residents showed concern about crime and gang presence in North Portland having easy access to their communities with the introduction of light rail. Therefore, without appropriate funding from the Clark County, the Washington extension of the project was cost-prohibitive and eliminated. [25]

That same year, the OR Legislature voted to fund the $475 million. After many deliberations, the state approved $375 million of the $475 million budgeted and dropping yet another $100 million from the budget. Though the budget was tighter, the project team considered this a victory until the following year when the state funding was placed on the statewide ballot. To the project's detriment, Oregonians throughout the state were voting on an issue that effected only the Portland Metro Area and the issue wasn't connecting appropriately for them to approve. For example, it may have been challenging for Burns

residents to see the value of funding several hundred million dollars for light rail that they would never use, so the statewide funding was rejected [25].

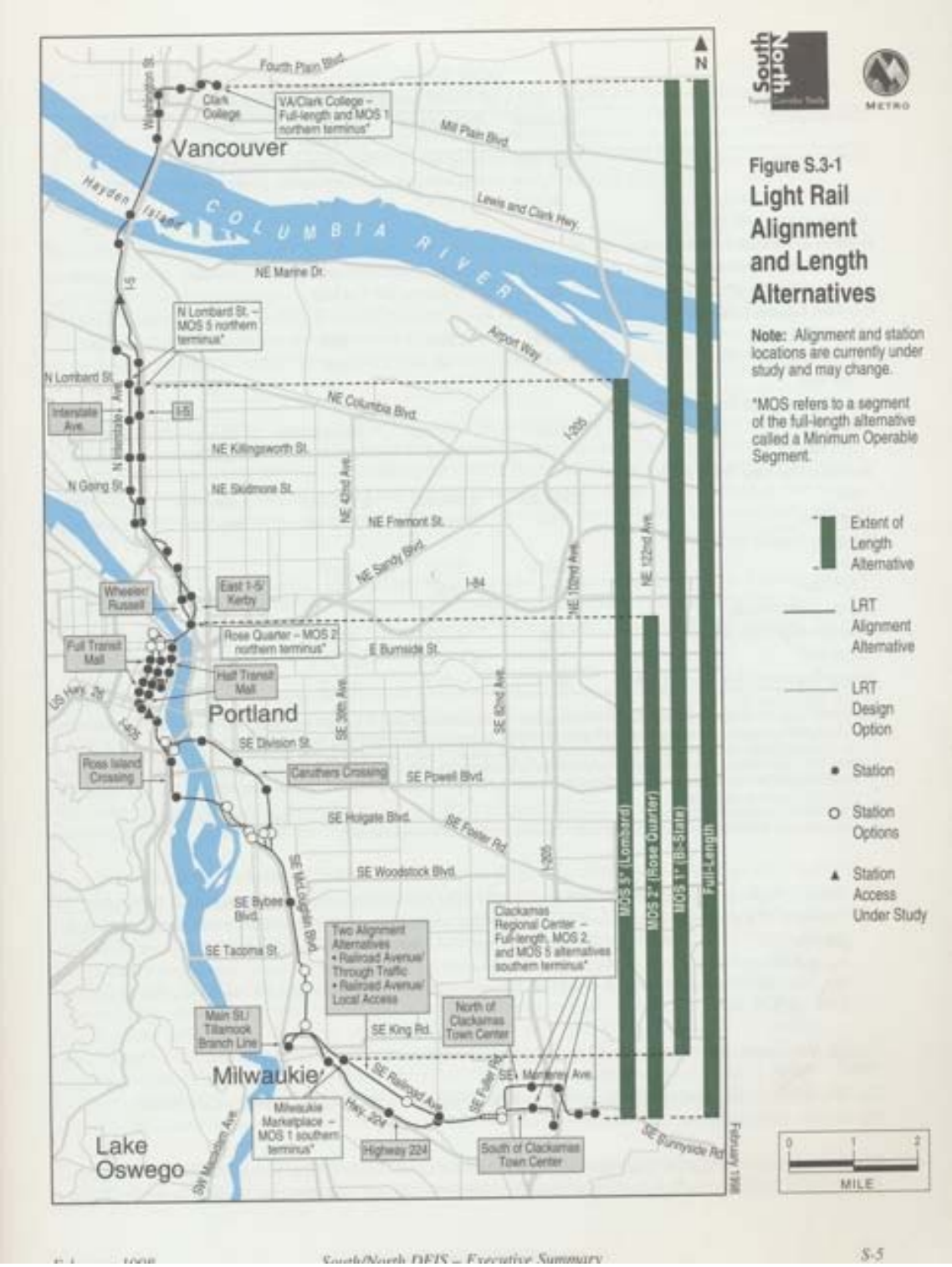


Figure 10. Proposed South/North Corridor Light Rail Alternatives [24]

With the project having already lost more than $1 billion from Oregon and Washington Funding, as well as proportional drops in its 50% FTA match, the project had deviated dramatically from its original $3 billion budget. The project began a rigorous cost-cutting phase between 1997 and 1998. Though the Northern-most portion of the project had been eliminated, the southern portion could remain possible provided that the region (communities in Clackamas County, Milwaukie, etc) would reapprove funding for $475 Million in Tri-Met General Obligation Bonds. [25] [38]

In 1998, much like in Clark County, residents of the city of Milwaukie felt strong resistance to the prospect of connecting such a vast light rail line to their community. Residents responded with furious protests against the project, arguing concerns about congestion and increases in density that are spurred by transit-oriented-development. Likewise, MAX enjoyed only a small selection of actively running lines and its reputation had not been ingrained into the Milwaukie community yet. Equally important, there were many measures on the ballot for parks, schools, and the convention center, all of which failed because of a resistance to property tax increases and the volume of ballot measures. [25] [38]

Protests became so heated that community groups were formed to fight the issue, and several city councilors as well as the mayor were recalled in response. Therefore, the regional vote to reauthorize the bonds failed dramatically outside of Portland. Observing the distribution of votes, however, the Metro team noticed surprisingly overwhelming support for the bond in Portland, particularly the North Portland community. [25] [38]

From the wreckage of this funding catastrophe, local agencies and jurisdictions reassembled to understand the needs of the community and how to integrate those needs into their regional development plans while still addressing Portland's rapid growth and congestion. [25] [38]

Metro formed "Listening Posts" to inquire about what the community wanted them to prioritize. Through this process, the business community and a very enthusiastic North Portland Business community responded and petitioned for an "All Interstate Alignment." [25] [38]

4. Interstate/ North Corridor MAX Alignment Emerges

From the ashes of the South/North Corridor project emerged a much simpler, scaled down project proposal that would address the most interested community's most urgent needs while building with a much more limited funding plan. This new Interstate/ North Corridor project would eliminate the "new" downtown alignment proposed in the South/North Project. The extension would only be 5.5 miles long from the rose quarter to the expo center. [38]

The advantage of pursuing this small segment of the former South/North Corridor project is that it strategically avoided all of the challenges posed by the much larger project. This new alignment would not require another local funding vote. Since it did not cross county or states

line, it would not need multi-jurisdictional approval. Furthermore, because of Trimet's glowing reputation with FTA and its imminent successes with the Airport alignment and Portland Streetcar, FTA looked very favorably on this new, slimmer project and agreed to fund an unheard of 74% of the project [25].

The final distribution of funding was as listed below:

- Federal Transit Administration (74%, $257.5M)
- Regional transportation funds (11%, $37.5M)
- TriMet capital funds (7%, $25M)
- Urban renewal funds (8%, $30M)
- No additional property taxes needed and the project ended up being completed ahead of schedule and millions under budget for Interstate MAX light rail project

5. Lessons Learned from South/North Corridor project

Interestingly, the successful construction of the Interstate, Westside, and Airport MAX lines have since compelled residents of Clark County and Milwaukie to accept the prospect of light rail in their communities. Though Clark County has not yet reached its final approvals, the project is considered much more valid and necessary than it had been in the 1990s. [38]

On the other hand, Milwaukie residents have now fully embraced the prospect of light rail, and this project is in the EIS phase now and is slated to open in 2015.

Ultimately, the most critical lessons learned from the South/North Corridor project were:

- To incorporate more community involvement throughout project selection process. If the community is not in agreement with one large project that is outlined in a 50 year development plan then either the project is not worth pursuing or should be phased to give the community time to gain support. Public projects differ from private sector projects in that they can be conceived in a more long-term capacity than private sector projects. It is not advantageous to pursue too large a project too quickly or its approval will implode.
- To understand the conditions and political climate that surrounds the project since that climate will largely dictate the project's access to fund.
- To avoid projects that require a statewide vote on a local issue. At that juncture, it is wise to restructure and avoid the problem then make the attempt and lose all funding options at the state level. [38]

6. Interstate MAX Project Description

In March of 1999, following inquiries with local businesses, community leaders and stakeholders, a supplementary DEIS was initiated and filed enabling the project to be pursued at a more macro level.

The project team also amended the locally preferred strategy that was selected from the South/North alignment following recommendations from Trimet, the City of Portland, Joint Policy Advisory Committee on Transportation (JPACT), and the Metro Council. This LPS would focus construction of the project from the rose quarter and would align fully on Interstate Avenue rather than a windy trajectory throughout North Portland [26].

With a much more narrow scope than the South/North Corridor project, the Interstate MAX extension would span 5.8 miles, connecting downtown Portland to the Expo Center on a linear path. The project's attention would focus on stimulating disadvantaged businesses through extensive community involvement, creative contracting, and technical and financial assistance. [26].

Also unlike South/North Corridor, Interstate assembled an Advisory Committee of neighborhood businesses, representatives, and community groups to assist in implementing outreach. They also held three lengthy open houses throughout the SDEIS process, distributed the SDEIS to local libraries, agencies, and organizations, and organized consistent community meetings [26].

Much like its predecessor, the Interstate/ North Corridor MAX alignment's objective was to: "to implement a major transit program in the North Corridor that maintains livability in the metropolitan region, supports bi-state land-use goals, optimizes the transportation system, is environmentally sensitive, reflects community values, and is fiscally responsive." [26]

Echoing the South/North corridor objectives, the Interstate MAX alignment's specific objectives were to:

1) provide high-quality transit service in the North Corridor
2) ensure effective transit system operations in the North Corridor
3) maximize the ability of the transit system to accommodate future growth in travel demand in the North Corridor
4) minimize traffic congestion and traffic infiltration though neighborhoods in the North Corridor
5) promote desired land-use patterns and development in the North Corridor
6) provide fiscally stable and financially efficient transit system
7) maximize the efficiency and environmental sensitivity of the engineering design of the proposed project [26].

Table 2 details the project's objectives and the measures it would evaluate to determine the project's success.

Table 2. Interstate MAX Objectives and Measures [26]

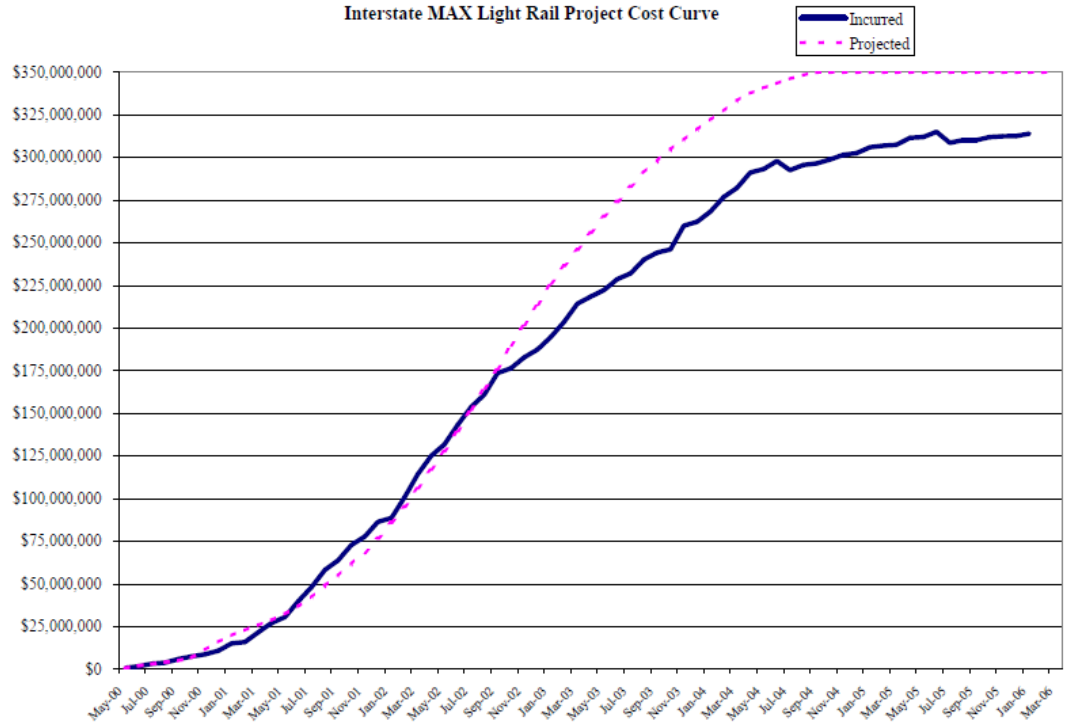
Objective/ Criteria	Measure
Provide High-Quality Transit Service	
Light Rail Coverage	• Increase in population within ¼ mile of LRT stations • Increase in employment within ¼ mile of LRT stations
Reliability	• Miles of exclusive transit right-of-way • % of protected trunkline intersections • % of passenger miles on exclusive transit right-of-way
Travel Times	• P.M. peak hour-in vehicle and weighted transit travel time for selected trips
Transit Ridership	• Total Transit Trips • Light rail ridership • Radial trip mode split
Ensure Effective Transit Operations	
Operating Effectiveness	• Downtown Portland operations (qualitative) • Safety considerations (qualitative) • Maintenance facility requirements (qualitative)
Maximize the Ability of Transit to Accommodate Growth in Travel Demand	• Transit network expansion capability (qualitative) • Place miles of transit
Year 2020 Growth Accommodations by Transit	• Percent of new radial corridor trips using transi
Minimize Traffic Congestion and Traffic Infiltration Through Neighborhoods	
Highway System Use	• Reduction in regional vehicle miles of travel • Reduction in regional vehicle hours of travel • Reduction in capacity-deficient lane-miles • Reduction in p.m. peak hour vehicles trips
Neighborhood Infiltration	• P.M. peak-hour vehicles at key cutlines • P.M. peak-hour LRT rodership at peak load-point
Facilitate Efficient Land-Use Patterns	
Support Development Objectives Support Local Policies and Activity Centers	• Vacant and redevelopable acres served by LRT • Number of residents within a 30 minutes of major activity centers by transit
Neighborhood Infiltration	• Manage urban growth boundary (qualitative)
Balance the Efficiency and Environmental Sensitivity of the Engineering Design	
Displacement	• Number of residential units displaced • Number of businesses displaced • Number of institutions displaced
Noise and Vibration	• Number of structures impacted (with/without mitigation)
Wetlans	• Acres of filled wetlands
Parklands	• Acres of Parklands Displaced • Numbers of parks impacted by noise (construction use)
Floodplains	• Cubic yards of fill in floodplain
Historic and Archaeological	• Number of adversely impacted or used sites

In the end, the project's scope and goals were dramatically reduced through cost cutting measures from the South/North Corridor project as well as the Value Engineering process that occurred throughout the design process. When the project ultimately came in 20 + million dollars under budget, it was perceived as an enormous success that neglected the failures that led to the loss of nearly $2.5 million in funding and drastic reduction in scope. Metro sources suggest that route and design features were modified substantially and subsequent cost savings were achieved largely because of fear of losing additional funding [38].

IV. PM Tools

There are many PM tools used on a project this size. This section will showcase the major software tools used. Like most projects these days, lots of Microsoft tools were used: Word, Excel, Access, Power Point, and Project Manger. Word was used for writing reports. Excel and Access were used for managing numerical data and creating charts of numerical data, for example the running costs [27]:

Figure 11. Interstate MAX Light Rail Project Cost Curve [27]



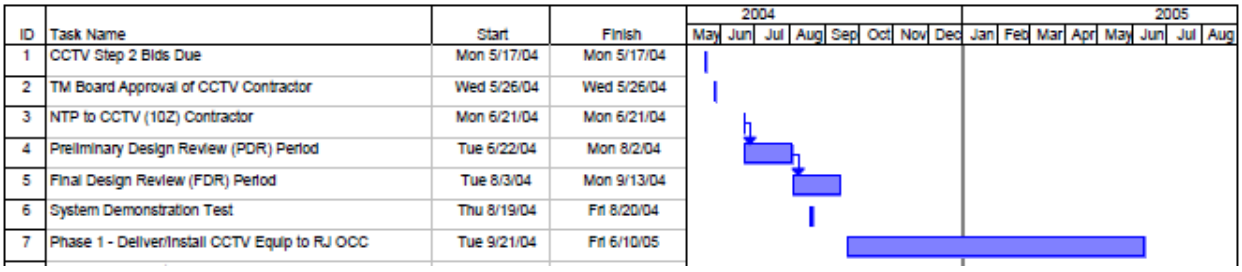
The two lines above reflect, by month, the incurred to-date compared with the projected to-date for the Interstate MAX Project. The projected cost line is derived from the cost-loaded Master Program Schedule.

The incurred to-date of $314,015,009 reflects actual disbursements to the end of January 2006.

Microsoft Power Point was used for presentations.

Microsoft Project Manger was used for schedule tracking through the use of Gantt Charts [27] :

Figure 12. The example of Gantt Charts [27]

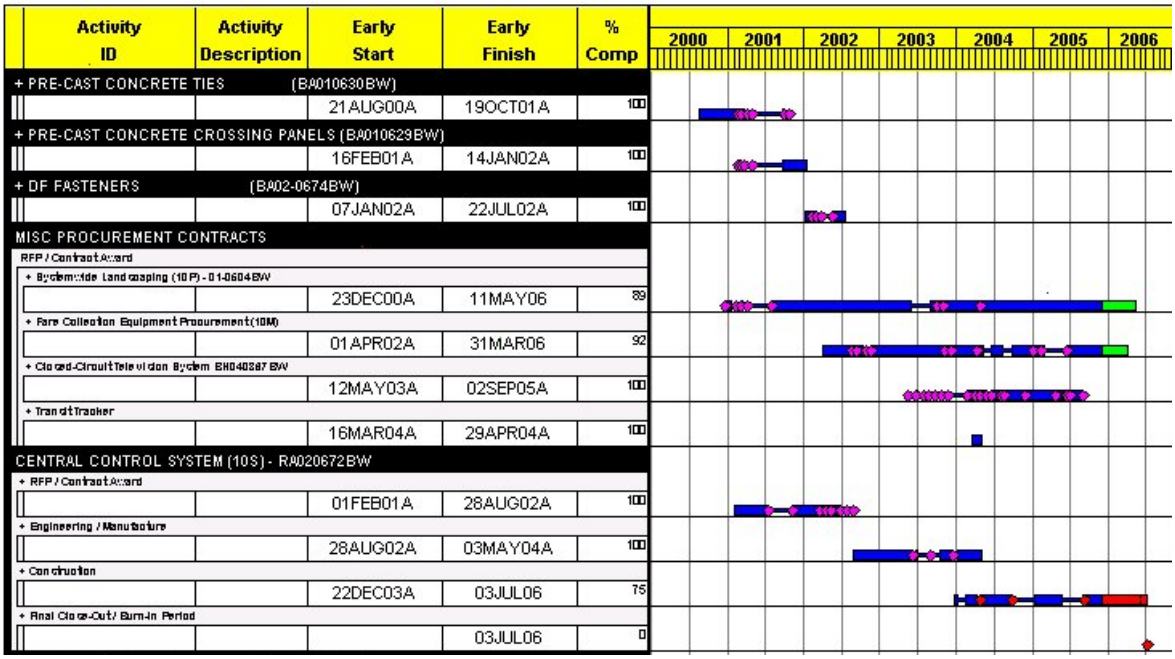


Besides the “standard software” discussed above, there was also special software used specifically for project management.

Primavera is a Project Management specific software used. Oracle, the owned of Primavera brand, describes the tool as:” project financials, human resources, supply chain management, product lifecycle management, business intelligence, and infrastructure software are expected to provide the first, comprehensive Enterprise Project Portfolio Management solution. This solution is expected to help companies optimize resources and the supply chain, reduce costs, manage changes, meet delivery dates, and ultimately make better decisions, all by using real-time data.”

Gant Charts are one of the Primavera features used on the project [27]

Figure 13. The example of Primavera program



PM specific software used on the project was Prolog form D5 Solutions. The software is described as “providing total construction project management control for large to mid-sized organizations including general contractors, architects, engineering firms and public and private owners and operators.”

Specifically for this project Prolog was used for Prolog Manager for grant accounting/Grant Management Information System (GMIS), Work Breakdown Structure (WBS) code budgeting, engineering, superintending, expenditure authorization, field orders, clarifications, minor revisions, RFI’s and submittals. [28]

V. Risk Management

Risk management is a high priority on any multi-million dollar project. In these high cost projects, problems can cause costs to sky rocket many millions of dollars if they are not identified and mitigated early in the project. In Trimet's case, if the project was expected to cost 600 million dollars, and they used it up ¾ the way through the project, Trimet would have to stop the project until they could find more funding. In order to avoid this type of costly problem, Trimet has many processes and systems to manage risk. There are two methods that Trimet uses to prevent risk from affecting them. The first is to use resources to identify and plan contingencies and the second method is to pass the risk on to a third party contractor.

1. Method 1 – Using Resources to manage risk

In our interview with Professor Jeff Busch of Portland State University [29], we discussed what types of risk management that Trimet would use and Professor Busch thought that they would do very little in the line of formal risk management. He suggested that one form of informal risk management would be to hire a project manager with 20 years of experience. When we went to Trimet to Interview David Unsworth, a senior project manager currently working on the Milwaukie light rail project [30], he told quite the opposite story. He started with the importance of risk management and spoke about the cost implications of unforeseen problems. As an example, he mentioned that they need to cross the Union Pacific Railroad at certain locations. If the plan includes that crossing, but during negotiations on the line, Union Pacific decides not to let them cross, the project will come to a halt and could cost millions of dollars to renegotiate or find an alternate solution.

David Unsworth mentioned a few practices that they use to help them manage risk. One is that they hire a project management oversight consultant. This group is not hired to make decisions for Trimet, but they are there to question decisions and help resolve problems that arise. Another practice is that they hire an internal Risk Manager, who helps Trimet organize their risks using risk register software to find probabilities that the problem will occur and what the costs would be. Then the risk manager analyzes the contingency plan and fallback contingency plan to determine costs and probabilities that they will be successful. David also mentioned that the hire a contingency manager or team to determine what happens when a problem has occurred. "Contingency" was used by David as the pool of money that was gathered in excess of the cost estimates. In the example of the railroad problem, the contingency manager would step in to help resolve the problem and try to keep additional costs down.

Trimet does most of their risk identification and planning in the engineering phase. It is imperative that they plan for high risk or high cost problems early in the project. Usually, the longer they wait, the more the problem will cost. For example: if they have already been laying track and find out that an abandoned gas station that is near the rail has contaminated the

ground and it is unsafe to place tracks in that location, they have no choice besides to clean up the hazardous waste from the path of their tracks. If they conduct a few soil samples from the location during the planning phase, they might choose to move the tracks away from the gas station to avoid the $500k mess.

The purpose of the risk management is to avoid the last minute costs that will drive up the end cost of the project. As mentioned before, when the budget is gone, they can either try to obtain more money, which is nearly impossible, or reduce their scope.

Another type of risk that Trimet manages is business owners and residents who would be affected by construction. Trimet needs to protect their reputation to be able to continually add infrastructure to the light rail system. If there are several businesses that go out of business, because Trimet has a six month construction project on their street, they will lose the opinion of the public that they are being a beneficial program to the community. Trimet has several methods for managing the risk of upset business owners. One is that they will schedule construction to take as short of time as possible even if it will cost more money. By shortening the time of loss for these businesses they will have a longer time to make it. Another risk mitigation plan is to take work busses from the Trimet office and eat and shop at the impacted businesses. They also will pass out coupons to the construction workers to help the business. Trimet, with the assistance of PSU, has been helping some of these smaller businesses with accounting and securing loans to help them through any slow periods during construction. Trimet also will give the customer a pager number that will forward to someone dedicated to resolving their problem, for instance, if there is a construction truck parked in their driveway, or their utilities are not working.

2.Method 2 – Passing the risk on to a contractor

As mentioned before, the Yellow MAX line was greatly successful by being under budget and finishing ahead of schedule. Fred Hansen, Trimet's general manager said, "The agency broke the mold on Interstate MAX by improving on contracting and incorporating construction efficiencies and better materials." [31]. One way that they did this was by moving all of the construction management to a third party instead of managing it themselves as in previous lines. The CM/GC (Construction Manager / General Contractor) is an approached used across the country on multi-million dollar construction projects.

One benefit to a CM/GC management system is the experience that you bring to a project. Construction Managers rely on their ability to successfully complete a project on time and on budget to keep their reputation high. The experience of managing large construction projects helps control the amount of mistakes that could be made by an employee managing dozens of contractors.

The CM/GC process adds additional teamwork between Trimet and the construction companies. The CM/GC is brought in during the design phase to review plans and look for

errors. Their experience can catch these problems in design before there is a lot of re-work that needs to take place.

This level of teamwork has to do with the responsibilities of the CM/GC. When the contract is negotiated, there is a guaranteed maximum price (GMC) that is set. This will alleviate the risk taken by Trimet to keep this project under budget and pass that risk on to the CM/GC. Now Trimet does not have to worry as much about running out of money and the project coming to a halt.

In previous light rail projects, contractors had more of an opportunity to expand their profits by using the change order process to add additional work. The change order process was an unproductive method of catching mistakes. For example: if there was a problem with the electrical system and the tracks were becoming misaligned with the overhead power, the electrical contractor would go through the change order process and be approved to extend their work, at a higher rate (because of the overtime needed to stay on schedule). The CM/GC process does not eliminate these types of problems entirely, but the construction management company will have the engineers and level of management to be able to catch the problems before they are costly.

The CM/GC process adds additional cost to a project and is not necessarily the best process for all projects, but with the additional cost, there is the ability for Trimet to pass their risk on to another party. This approach was a major factor in the success of the Yellow line and Trimet has continued to use it as they expand and build new lines [29],[30][31].

VI. Lessons learned and Knowledge Transfer

This section of the paper deals with the lessons learned of the Interstate light rail project. The key learning's are extracted and explained. In addition to that TriMet's approach to transfer the gained knowledge to future projects is examined. Challenges of knowledge transfer in the construction industry are addressed, too.

1. Lessons learned

A review of the official lessons learned documents of TriMet and an interview with TriMet's Senior Project Manager David Unsworth [32] build the base for the following section. Lessons were learned in a variety of fields. Key fields like scope definition, contracting, public involvement and introducing new project management software are presented in the next paragraphs.

1.1 Scope

A comprehensive analysis of the project selection and scope definition process is already given in the part *III project selection* of this report. From David Unsworth's point of view the knowledge how to negotiate with the federal government is the most important learning from the interstate project.

An interesting finding is that there is no official lessons learned document, which deals with the process of defining the scope and federal bureaucracy. The final report includes a description of the scope, but does not mention the process, which led to this result. Probably this is due to the fact that negotiation strategies lose their effectiveness if everybody knows them. In addition to that, a report that deals with the bureaucracy of federal agencies might offend the institutions that are needed for funding future projects. This interdependencies lead to a situation at which the process knowledge is only accumulated by the team members. To transfer this knowledge is probably one of the hardest parts, for details see Knowledge transfer part of this report.

1.2 Contracting

TriMet focuses on the management of the construction projects and does not do the construction work itself. Subcontracting is a common approach to share the risk of construction projects, as mentioned by construction consultant Dr. Gerald H. Williams. This risk sharing approach also led to a breakdown of the construction project into three contract packages:

- Line Section 10 AB, which began at the Rose Quarter and ended at Argyle
- Line Section 10 C beginning at Argyle and ending at the Expo Center

- Civil construction package 10R, which deals with changes at the existing operation facility at the Ruby Junction.

According to the Oregon statutes public agencies are allowed to use selection methods beside from the low bid process. TriMet decided to establish a two step process. First of all, TriMet requested proposals from potential general contractors. These proposals are scored by an evaluation committee, based on criteria which were set up in advance. The Second step was intensive negotiation with the company that was ranked highest in order to come up with an acceptable price for both sides. This method was used for Line Section 10 AB and Civil construction package 10R. This process is a slight variation of the design bid build method, which is presented in the literature review section. As many changes are expected to happen, it makes sense to use this approach, which goes along with more flexibility.

Line Section 10 C contained a large bridge and was located in an area were only little effects to the public were expected. The focus at this section was the budget and the schedule. That is why this part was contracted out by using a design-build arrangement. In contrast to the design-bid-build approach the design work and the building itself are contracted with one entity.

The yellow line interstate project was TriMet's first project, which used a general contractor. According to the lessons learned document the main goal of using this approach was to establish a partnership with the general contractor based on trust rather than an adversarial relationship [32]. This atmosphere should lead to an owner/contractor/designer "team approach", which would be helpful to tackle complexities and resolve issues. TriMet's goal was to improve all three fields of the project management triangular by using Construction Management General Contracting (CMGC):

Time:

- Increase the ability to meet critical schedule milestones and minimize the amount of construction disruption.

Costs:

- Control the costs through Value Engineering (VE) and constructability reviews during design. This leads to an increased probability to meet the budget restrictions.
- TriMet also wants to minimize the third party costs. This means costs for lawyers that are needed because of construction claims. The team approach was used to solve problems cooperatively and avoid construction litigation.

Performance:

- CMGC was expected to guarantee sufficient quality control and also to assure that the expectations of the different stakeholders like the Federal Transit Administration (FTA), the community and the city were met.

- An additional goal was to minimize the negative impacts of construction activities on property and business owners. Methods to avoid these effects are discussed in detail in the section Public involvement.

The project manager David Unsworth and the review documents published by TriMet both emphasize the huge advantage of CMGC.

1.3 Public involvement

In order to increase the public acceptance of a light rail project an integrated approach for the public involvement is needed. Even though TriMet has the possibility to take needed property a way from the owners, its goal is to avoid any litigation. Cases that go to court usually cause budget and schedule overruns. Therefore TriMet developed several actions that are designed to assure the involvement of the community. The following paragraphs deal with the different techniques, which were used to generate a cooperative atmosphere.

TriMet has a proactive communications approach (see appendix B). Several meetings were held to inform the people and business owners, who were likely to be affected by the construction activities. From TriMet's point of view it was important to communicate what they planned to do but what was more what they will not do, to take away unnecessary fears. The interstate project took place mainly in an industrial area. Therefore the focus was on helping local business, which were affected. Negative effects were for instance: dirt and noise pollution, limited access to the stores and blocked parking lots. TriMet put up "Open for Business" signs to attract customers. To give business owners the opportunity to complain about inappropriate limitations of their businesses TriMet assign one responsible person to each of the businesses and set up a 24- hour hotline. In addition to that TriMet tried to convince the shop owners that they will benefit from the completed Max project, since it will bring new customers to their shops. The business owners argued that they will not benefit from the new Max line if they went to bankruptcy before the project completion. To avoid these insolvencies, due to the construction project, low-interest loans were offered to help businesses to get through the period of low revenues. These funds were provided by the Portland Development Commission, US Small Business Administration, Enterprise Foundation, Cascadia Revolving Fund and the Albina Community Bank. Many businesses used the opportunity for. TriMet also issued food coupons to the construction works to support the local food stores.

In order to get the community involved in the project TriMet started an art program (see appendix B). The selected art was designed to represent the diversity of north Portland and make the project a project of the north Portland community rather than a project of TriMet or the City of Portland. A neighbourhood committee selected local artists. The general construction contractor installed most of the art work and provided lighting.

The interstate project had also the goal to contract 16% of the construction work to smaller local businesses, so called disadvantaged Business Enterprises (DBE) (see appendix B). The goal was to support the local construction industry and link the project with the Portland community. TriMet communicated this goal to the prime contractor at an early stage of the project. Meetings were held to make the prim contractor familiar with the DBEs. TriMet took several actions to help the DBEs. For example the workload was split up in small pieces to enable small companies to bid for this work. But initiatives came also from the small businesses. A number of truckers founded the NE Urban Trucker Consortium to bid on a contract that was way too large for the individuals. TriMet also offered assistance with barriers like bonding. All in All these measures lead to the fact that about 19% of the construction work was performed by DBEs.

Project manager David Unsworth is convinced that the way how TriMet dealt with the public had a positive impact on the project schedule, which justifies the additional effort.

1.4 Project management tool implementation

During the Interstate MAX light rail project a variety of project management tools were used, for details see *IV project management tools*. An important lesson learned from this project was the implementation of the new Prolog Manager [37]. The first step was a market evaluation. As TriMet has no personnel that has detailed knowledge of the project management tool market, TriMet sought for assistance of a consultant. Based on the organizational needs Prolog Manager was selected. The success of any software introduction depends on the user acceptance. The training courses for the staff used examples from real TriMet projects and were focused on the benefits for the employee's and the company. The personnel experienced first-hand that the new tool is valuable and made their work easier. According to the project manager Linda Tribbett brainstorming sessions hold with administrative staff and key engineers helped to address their concerns and led to a smooth implementation.

2. Knowledge transfer

Knowledge transfer and knowledge management are difficult in a project orientated environment, since teams change after every project. The need for a systematically approach of Knowledge management to remain competitive is widely accepted [33]. This Section deals with the concepts published in books and journals in general and TriMet's approach in particular.

2.1 Knowledge transfer in the construction industry

Knowledge transfer and organisational learning in a project orientated environment like the construction industry is a special challenge, due to discontinuities in the flow resources as personnel and information [33]. Necessary construction knowledge is often only available in

the minds of the employees. The intention behind certain decisions is frequently not recorded. People who are in charge for the documentation do not see the need for it. Documentation is usually not an ongoing process, but takes place at the end of a project. Therefore key players might have left already. Lessons learned usually refer to special project and are hardly ever generalized. Even if the organisations have an organized database of reports, it is hard to contact the authors, since people change the organisation frequently in the construction industry [35]. The literature provides different approaches to tackle these Problems. For Kululanga is the first step to improve knowledge transfer and knowledge management a reliable framework to measure knowledge management [35]. Vakola and Rezgui state the need for business process re-engineering (BPR) and evaluation [34]. The paper of Brenser reveals the importance f social patterns and consequences for knowledge transfer in the construction industry [33].

2.4 TriMet's approach

TriMet uses two main strategies to transfer the knowledge from their light rail projects.

Documentation is a manifestly way to pass knowledge from project to project. TriMet archives their project reports and also special lessons learned documents. Project managers have access to this database and can learn from mistakes, which were made in previous projects. The difficulty is to motivate the team members to document their work and to contribute to the final report after the project completion. Often team members do not see any benefit for themselves in project documentation, since they leave anyway. All the more management awareness is a prerequisite. It is likely that managers want to terminate the project as soon as possible and abandon the opportunity to transfer the knowledge [36].

Besides the project documentation TriMet relies on a core team of high skilled people. This team consist of experts that have accumulated TriMet specific knowledge. These core team members cover competencies like finance, scheduling, contracting. The usage of consultants can be reduced if the core competencies are available within the organization. The knowledge of core group members is not limited to the formal structures, but covers informal processes. Having someone who already knows the key players in other organisations can become an important advantage. This is also the way knowledge about the federal bureaucracy is kept. TriMet keeps these key individuals even if for a certain amount of time TriMet does not run a big construction project. This is a consequence of the effect that a future project without these key players will cost more than keeping the core team members in times of low workload. This leads to an additional positive effect of having a core team. Because of their knowledge members of the core team have a high job security, which is rarely found in the unsteady construction industry. As only the most valuable people become part of the core team members are motivate to do their best [30].

VII. Conclusion

The interstate MAX line extension was an elaborate project that, in the end, was perceived as successful because the project came in under budget and four months ahead of schedule. It is also heavily lauded in the community for having benefitted local businesses and listening to the North Portland community's needs.

As an individual project, the Interstate MAX extension can be perceived as a success because of its timely completion, adherence to budget, attention to cost-saving management techniques, strategies for curbing risk, and extensive community involvement. When considered within the larger context of its original project team could make dramatic improvements.

While the federal government has specific and systematic development process guidelines, localities and the regional governments should have developed a project scope that was more consistent with community priorities, while recognizing and anticipating future growth. Project teams would benefit from assessing the community with the greatest need, addressing those needs first within the larger context of future projects and design plans, and then proceed with obtaining funding from resources that will be directly effected by the benefits of the project.

For future MAX line development projects, we would recommend that:

- Projects are considered within the political context of the development plan
- Long-range projects are reviewed to determine appropriate phasing for high-budget, large geographic projects.
- The project teams continue to very actively engage local businesses and community members who are both active stakeholders and salespeople for the project's public relations effort.
- Project teams continue to employ risk-management efforts that not only assess the risk of a project meeting its financial projections but equally the project meeting its funding projections.
- The project team creates and consolidates one comprehensive document listing the lessons learned and process improvements across organizations and throughout the entire development process. That way, if project leaders leave, or if people are interested in assessing the project dynamics across organizations they can do so without having to probe each individual participating stakeholder. This could greatly improve implementation efficiency, and cross-organizational communication in future MAX extension development projects.

References

[1] Unknown, “Strategic Direction,” Available [http://trimet.org/about/organization/strategicdirection.htm], Accessed [12/5/2009 3:25:11 PM].

[2] Unknown, “The TriMet Story,” Available [http://trimet.org/about/history/trimet_story.htm], Accessed [12/5/2009 4:05:10 PM].

[3] Unknown, “Engineering Excellence Awards,” Available [http://www.acecoregon.org/assets/excelence/EE_2005_nwsltr_story.pdf], Accessed [12/3/2009 5:35:17 PM].

[4] J. Ryan, K. K. Rabiner, and J. Trumbull, “Resolving Union Pacific Railroad Intermodal Concerns from TriMet’s Interstate MAX LRT Line,” Available [http://onlinepubs.trb.org/onlinepubs/circulars/ec058/08_03_Ryan.pdf], Accessed [12/4/2009 2:44:20 PM].

[5] L. S. Flak, S. Nordheim, and B. E. Munkvold, “Analyzing Stakeholder Diversity in G2G Efforts: Combining Descriptive Stakeholder Theory and Dialectic Process Theory,” e-Service Journal, 2009, Vol. 6, Issue 2, p.3-23.

[6] Unknown, “Interstate MAX Yellow Line,” Available [http://trimet.org/pdfs/history/railfactsheet-interstate.pdf], Accessed [12/3/2009 2:40:25 PM].

[7] Unknown, “Organizational Governance,” Available [http://trimet.org/about/organization/orggov.htm], Accessed [12/4/2009 1:34:31 PM].

[8] Angela Wilson, “Interstate MAX DBE & Workforce Story – overcoming Barriers to inclusion,” Available [http://trimet.org/pdfs/business/DBE_Workforce_Story.pdf], Accessed [12/1/2009 1:30:31 PM].

[9] Unknown, “Transportation District Uses Prolog® Software to Achieve Immediate Cost Control, Time-Saving Document Management and Visibility into Potential Problems,” Available [http://www.byrnesoftware.com/Downloads/Case%20Studies/TriMet.pdf], Accessed [12/4/2009 1:30:21 PM].

[10] Unknown, “TriMet Investment Plan – FYI 2010,” Available [http://trimet.org/pdfs/tip/tip.pdf], Accessed [12/4/2009 12:30:31 PM].

[11] Unknown, “Lesson 45: Tri-Met's Successful Disadvantaged Business Enterprise Program on the Interstate MAX Light Rail Project,” Available [http://www.fta.dot.gov/printer_friendly/publications_1362.html], Accessed [12/2/2009 2:30:21 PM].

[12] S. Andrews, B. Ferran, J. Mohlis, S. Straus, C. Wihoite and B. Warner, “Annual Urban Renewal Report, Covering Fiscal Years 2008-09 and 2009-10,” Available [http://www.pdc.us/pdf/ura/urban-renewal-report-09-10.pdf], Accessed [12/3/2009 2:25:21 PM].

[13] Unknown, “Metro Council,” Available [http://www.oregonmetro.gov/index.cfm/go/by.web/id=28], Accessed [12/3/2009 2:20:22 PM].
[14] Unknown, “Mission, charter and code,” Available [http://www.oregonmetro.gov/index.cfm/go/by.web/id=24270], Accessed [12/4/2009 1:20:25 PM].
[15] Unknown, “Committees, partners and public participation,” Available [http://www.oregonmetro.gov/index.cfm/go/by.web/id=24273], Accessed [12/4/2009 1:10:15 PM].
[16] Unknown, “Planning and Project Development Process,” Available [http://www.fta.dot.gov/publications/reports/other_reports/publications_135.html], Accessed [12/4/2009 2:09:25 PM].
[17] Unknown, “Regional Transportation Plan,” Available [http://www.oregonmetro.gov/index.cfm/go/by.web/id=137], Accessed [12/2/2009 3:10:15 PM].
[18] Unknown, “Highlights of the FTA impact on Public transportation in the US,” Available [http://www.fta.dot.gov/documents/FtaImpactBookZ.pdf], Accessed [12/4/2009 11:10:44 AM].
[19] Zweighaft, S. “Dividing the Pie: Organization Models for Major Rail Projects.” Paper presented at APTA Rail Conference, Seattle, WA, 2001.
[20] Tiong R. and Alum, J. “Evaluations of proposals for BOT projects”, International Journal of Project Management, (1997), Vol. 15 No. 2, pp. 67-72.
[21] Mehndiratta, S. R., et al., 2000. “How Transportation Planners and Decision Makers Address Risk and Uncertainty”, Transportation Research Record 1706, TRB, National Research Council, Washington, D.C., pp. 46-53
[22] Brand, Daniel, S. R. Mehndiratta, and T. E. Parody. “Options Approach to Risk Analysis in Transportation Planning” In Transportation Research Record 1706, TRB, National Research Council, Washington, D.C., 2000, pp.54-63
[23] Grimsey, D. and Lewis, M.K., “Evaluating the risks of public private partnerships for infrastructure projects,” 2002, International Journal of Project Mgmt, Vol. 20, pp. 107–118
[24] Metro, U.S. Department of Transportation Federal Transit Administration, The Southwest Washington Regional Council: “South/North Corridor Project: Draft Environmental Impact Statement.“, February 1998. Pp. P-1 – S34
[25] Roberts, R. “The fall and Rise of the South/North Corridor in Portland, OR: Lessons Learned in Project Development” FTA New Starts Roundtable, June 7, 2001.
[26] Metro, U.S. Department of Transportation Federal Transit Administration, The Southwest Washington Regional Council : “North Corridor Interstate MAX Light Rail Project: Final Environmental Impact Statement.”, October 1999.
[27] A. S. Bayram, J. Garlitz, D. Soose, W. Sumitsawan, C. Yang, “Project Delivery Sytems: Analysis of the IMAX Light Rail Project, ETM Student project 2002-S-545-26.

[28] Unknown, “TRI-MET EMBRACES TECHNOLOGY,” Available [http://www.d5solutions.com/product/prolog/downloads/portland_tri-met.pdf], Accessed [12/4/2009 1:20:25 PM].
[29] Interview: Professor Jeff Busch (PSU), November 15, 2009.
[30] Interview: David Unsworth (Trimet), November 18, 2009
[31] Frank Malone, “ Portland’s common sense approach: building trust with local citizens and funding providers, TriMet’s practical approach to operations and extensions has ensured further growth for the 17-year-old MAX system – Metropolitan Area eXpress,” Available [http://findarticles.com/p/articles/mi_m1215/is_11_204/ai_111269158/], Accessed [12/2/2009 1:40:25 PM].
[32] TriMet, “Lessons Learned: Disadvantaged Business Enterprise (DBE) Outreach”, 2007 Available [http://www.fta.dot.gov/printer_friendly/about_FTA_9642.html], Accessed [12/1/2009 4:31 PM].
[33] Bresnen M., Edelman L., Newell S., Scarbrough H., Swan J., “Social practices and the management of knowledge in project environments”, International Jurnal of Project Management, Issue 21, PP. 157-166, 2003
[34] Rezgui Y., Vakola M. , ”Organisational learning and innovation in the construction industry”, The learning Organisation, 2000, Vol. 7, PP. 174-184,
[35] McCaffer R., Kululanga G. K. , “Measuring knowledge management for construction organizations”, Engineering and Architectural Management, 2001, Vol. 5, Number 6, PP. 346-354.
[36] Anumba C. J., Egbu C. O., Carrello P. M., ”Knowledge management in construction”, Wiley-Blackwell, 2005
[37] Unknown, “TRI-MET Embraces technology”, Available [http://www.d5solutions.com/product/prolog/downloads/portland_tri-met.pdf], Accessed [12/7/2009 7:31 PM].
[38] Interview: Ross Roberts (Metro), November 30, 2009

Appendix A

Elements	Features
A proactive and inclusive public involvement process	
Consideration of eight broad areas	• support for the economic vitality of the metropolitan area • increase safety of the transportation system • increase security of the transportation system • increase the accessibility and mobility for people and freight • protect and enhance the environment, promote energy conservation, improve the quality of life and promote consistency between transportation improvements and state and local planned growth and economic development patterns • enhance the integration and connectivity of the transportation system • promote efficient system management and operation • emphasize the preservation of the existing transportation system
Area studies	• conducted to address significant transportation problems in a corridor or subarea that might involve the use of federal funds
Development of financial plans	• for implementing the transportation plan and TIP; and Assurance that the transportation plan and TIP in air quality nonattainment areas conform to the State Implementation Plan as required by the *Clean Air Act* as amended in 1990.

Table 1. The major elements of transportation planning in metropolitan areas [12]

Appendix B

Trimet's internal lessons learned documents

"Lessons Learned: Disadvantaged Business Enterprise (DBE) Outreach

Summary of lessons learned:

- Establish goals with prime contractors early
- Introduce DBEs, primes, and subcontractors to each other
- Assist DBEs with traditional hurdles (e.g., bonding)
- Develop a directory to assist DBEs in promoting themselves
- Embrace innovative ideas, such as trucking consortium

To promote its 16% participation goal, TriMet held "lessons learned" sessions to understand the challenges minority firms faced on past large public works projects and incorporated solutions into the Interstate MAX program. TriMet and other agencies provided technical and business assistance to DBEs and other small firms to help them build their capacity to deliver on the work, including bonding, insurance and timely invoicing to help meet cash flow needs.

TriMet also held networking sessions, giving interested DBE firms direct access to prime contractors and large subcontractors. Large contracts were divided into smaller scopes of work so historically underutilized DBE firms and small contracts could compete for work. Subcontracting areas with the best potential for DBE participation such as concrete, masonry, landscaping, paving, electrical, trucking, excavating, traffic controls and painting were identified. TriMet developed a directory to support DBE efforts in marketing themselves to prime contractors.

Small trucking firms partnered to create the NE Urban Truckers Consortium, allowing the consortium to bid on contracts too large for any individual company. Dozens of small truckers in North and Northeast Portland became involved with this innovative consortium.

The DBE firms succeeded in performing approximately 19% of the construction work. "

"**Lessons Learned: Contracting Plan**

Oregon statutes allow public agencies to use selection methods other than a low-bid process; some criteria require that the involved contracting review board adopt findings in support of the contracting method. TriMet developed criteria for the selection of construction contracting method (attached).

Based on the selection criteria, TriMet determined that to a two-step, Request for Proposals, negotiated CM/GC contract best served the project for the Line Section 10AB civil construction work and the Ruby Junction expansion. Because of the long bridge, TriMet selected a design-build arrangement for the Argyle to Expo segment.

As noted in the objectives below, TriMet attempted to create a "team" approach to resolving issues, rather than an adversarial relationship.

The lessons learned can be summarized as follows:

- Identify risks at the beginning
- Selects contracting plan based on criteria
- Shares risks with selected contractor
- Foster "team" approach to problem solving
- Reward value engineering ideas and safety culture

Summary of Interstate MAX construction contract plan

Objectives

- Meet critical schedule milestones; minimize construction disruption to public
- Meet budget; control costs through VE and constructability reviews during design
- Assure public safety and safe traffic management throughout construction
- Assure adequate quality control and meet FTA/community/city expectations
- Assure maximum responsiveness to community needs
- Provide best opportunity for local and DBE contractors/workforce diversity

- Procure services from experienced, expert contractors that match needs of project
- Minimize third party costs and construction claims; avoid construction litigation
- Create owner/contractor/designer "team approach" to resolve issues/complexities

Procurement/contract options

- Quality Based Selection (QBS) Design (quality based selection for design services; price negotiated after selection)
- Low bid construction (traditional approach or 2 step w/RFTP; lowest bidder gets contract)
- Request For Proposal construction (selection based on evaluation criteria and price)
- CMGC construction (selection based on evaluation criteria, but not final construction price; includes pre-construction services; final construction price is bid/negotiated as a guaranteed maximum)
- Design/Build (selection based on evaluation criteria including price)
- Sole source (emergency or only one source satisfies requirements)

Procurement and construction schedule/status

Contract	Contract method	Contract amount	Construction schedule	Comments
Civil design	QBS, negotiated	$8m		
Systems design	QBS, negotiated	$7m		
Light Rail Vehicles	2-step RFP/BAFO; (17 + 7 option)	$80m	Aug '00-May '04	All vehicles in service
Civil/utilities, paved track, RQ to Kenton	2-step RFP, CMGC negotiated	$103m	Advance Utilities Nov '00; roadway/trackway Jun'01- July '03	Completed 5 months early; 3% change orders
City Albina Overcrossing*	Low bid within CMGC	$6m	May '01-Jun '02	City funded project; 6.1% COs
Civil/utilities, bridge, track, Kenton to Expo	2 step RFP/BAFO Design-Build	$34m	June '01- July '03	Completed 3 months ahead of schedule; 9% change orders
Ruby Junction expansion	2-step RFP, CMGC negotiated	$15m	June '01-Dec '02	1.8% COs
Traction Power	2 step low bid	$10m	Sept '02 –Mar '04	
Signal/Comm	2 step low bid	$17m	Sept '02 – Apr '05	
Central Control	2 step RFP/BAFO	$3.5m	Aug '02 – Mar 07	
Fare Collection	Sole Source	$1m	May '03 - May '04	
CCTV	2 step low bid	$1.9m	June '04 – Feb '05	Scope restoration
Signage/graphics	Design/build	$2m	Sept '00 – May '04	
Landscaping	2 step low bid	$1.5m	Apr '01– May '04	Established 5/06
Rail	Low bid/RFP	$4.5m	Apr '01– Oct '02	Installed
Simulated Rev Svc/Testing	TriMet self-perform	---	Nov '03 – May '04	Opened early May 1, '04 v Sept '04

* companion project, funded separately from Interstate MAX Full Funding Grant Agreement project "

" Lessons Learned: Art Program Administration – Community Based Art

Summary

- Begin early in the design process
- Develop and communicate a vision
- Select local artists who can interact directly with the community
- Collaborate with project architects and designers
- Select art with maintenance, conservation, accessibility, safety and security in mind

The Interstate MAX Public Art Program recognized that its challenge was to recognize the region's cultural richness and to promote community pride. The program was guided by a vision of multiculturalism and community involvement.

The Interstate MAX Advisory Committee began its work in November 1999 and developed an Art Plan. The plan's central concept viewed Interstate MAX as an urban spine that would function both as "a protected passageway for the flow of people, energy and ideas" and a stimulant for the whole of the community.

The Art Plan also echoed the commitment of the advisory committee to involve a broad range of artists representative of the communities along the line. Artists were selected either by the committee or by a special neighborhood selection committee. The neighborhood committees also served as special resources for the artists as they commenced their research and design work. The artists' primary goal was to establish a unique identity for each station based on history and culture of the immediate neighborhood.

During the four-and-a-half years of the Interstate MAX art program, TriMet staff kept the communities informed about its progress. Illustrated boards were set up at several sites; presentations were made at neighborhood association meetings and cultural events; developments were outlined on a web page, in fact sheets and in TriMet publications. A major exhibition of artists' drawings, models and sample materials was on view at the Interstate Firehouse Cultural Center for two months in the summer of 2003.

All of the fabrication of Interstate MAX art was either done or directed by the artists. Often they worked as their own contractors, hiring numerous sub-contractors with special expertise.

The general construction contractors provided lighting and foundations where needed and installed most of the artwork at the stations.

TriMet recognized that the Interstate MAX project could either add to the divisive inequities of earlier urban renewal efforts or create a new paradigm of community building. The art program gave voice to people that had not been heard, and identity to places that had been stripped of character. It delivered artwork capable of transforming one group's history into a shared experience.

Interstate MAX Public Art Program Elements

Publications

Interstate MAX Public Art Guide

Intersections: TriMet Interstate MAX Light Rail Community History Project

Interstate/Rose Quarter

- Illuminated metal trees generate their own electricity from solar panels
- A virtual campfire flickers with light at night, surrounded by stainless steel stump seats
- Concrete tree rings in the platform symbolize the forest once abundant on the site
- Custom guardrail feature branching tree limbs and roots

Albina/ Mississippi

- A bronze, tree-like vine flowers with forms representing the arts of the area
- Bronze benches incorporate images from neighborhood industries
- Community map features lyrics of songs from cultures of historic importance to Albina

North Prescott

- A stainless steel ship's "prow" gathers rainwater and funnels it to a greenspace
- Blue glass brinks in the platform hint at imaginary waterways beneath the station
- An etched granite map features Portland's "disappearing streams"
- A rusted steel propeller sculpture rests amidst a swirling pattern of grasses
- Three basalt basins collect water for birds

North Killingsworth

- Glass mosaic on columns recalls the colorful patterns of African Kente cloth
- Metal flags hand from the station canopy like the torans of India
- Guardrail panels were inspired by South American textiles
- Cast-concrete benches evoke the carved wooden stools of Africa
- Community maps feature Adinkra symbols and proverbs relating to education and community

Overlook Park

- Light towers modeled after roadside shrines in Poland feature portraits of community members overlaid with images of nature
- Art glass in the windscreen suggests the transforming power of nature
- Community map artist Margaret Eccles created a symbol for the relationship between good health and the community

North Portland Boulevard

- Steel column wraps were inspired by Columbia River Gorge petroglyphs
- Platform pavers outline a traditional Klickitat basket weaver pattern
- Guardrail panels feature symbols of salmon and Thunderbird

- Bronze sculptures are mounted at the ends of shelter canopies.
- Ainsworth greenspace: three tree totems with poetry written by students at Ockley Green Middle School surround a small plaza

North Lombard
- Mosaic guardrail panels feature tools
- Community map uses symbols of farm labor as metaphors for social progress
- Shelter columns and trash containers are wrapped in colorful glass tile

Kenton / North Denver
- Stainless steel cutouts feature cowboys and cattle
- Steel column bands are etched with historic architectural motif
- Terrazzo seats on custom benches highlight scenes from Kenton's past
- Community map displays artifacts of daily lie in Kenton in epoxy tiles
- N. Denver Plaza: seating sculpture inspired by Babe the Blue Ox
- Fenwick Pocket Park: terracotta fragments came from Portland Union Stockyards building; mosaic medallion from the building's entryway was restored and embellished

Vanport Bridge
- Ninety flaming comets inspired by the car culture of the 1950's blaze northward from Kenton
- Blue metal panel on the north end of the bridge allude to the Columbia River

Delta Park / Vanport
- Corten steel sculptures recall rooftops adrift in 1948 floodwaters
- Remnants from a Vanport foundation are set into the sidewalk
- Bronze railing features cast artifacts from the Chinookan culture, Vanport and the Portland International Raceway

Expo Center
- Traditional Japanese timber gates strung with metal "internee ID tags" mark station entrances. Vintage news articles are etched in steel and wrapped around the gate legs.
- Bronze trunks provide seating on the platforms
- Community maps feature the floor plan of the converted livestock exhibition hall and a copy of the exclusion order"

"

Interstate MAX Light Rail Project Final Report

This final TEAM report summarizes the scope, schedule and cost of the Interstate MAX light rail project in Portland, Oregon, which opened for revenue service in May 2004.

Scope

The Interstate Light Rail Project was an extension of the region's Metropolitan Area Express (MAX) system. Interstate MAX light rail line travels 5.8 miles north from the Rose Quarter along Interstate Avenue to the Kenton business district, then north along Denver Avenue to the Expo Center. The alignment is generally at-grade, in a separate median from the Rose Quarter to Kenton (Argyle Street). From Argyle north to the Expo terminus, the alignment follows Denver Avenue on structure over Columbia Boulevard. A new light rail bridge crosses the Columbia Slough, with the alignment grade separated from Highway 99W. North of Victory Boulevard, the trackway parallels the existing Expo Road to the Expo Center parking lot.

The project constructed ten stations: Rose Quarter Transit Center, Russell, Overlook, Prescott, Killingsworth, Portland, Kenton, Portland International Raceway (PIR) and the Expo Center (Expo). Two stations (PIR and Expo) provide a total of approximately 600 park-and-ride spaces.

In addition, the project purchased 24 low floor light rail vehicles, and modified the operations and maintenance facility at Ruby Junction.

The project installed systems elements: direct current traction power distribution, substations, and alternating current power connections, as well as an automatic block signal system, train-to-wayside communications system, and insulated joints. The project upgraded the communications system with improvements to fiber optics, backbone, supervisory control and data acquisition. The project also installed closed circuit television and fare collection equipment.

Project activities included the permanent or temporary acquisition of real property, design, engineering, management, public art program and start-up.

As a companion, but separately funded project, the City of Portland constructed an overpass and concurrent road improvements in the Lower Albina area, intercepting Interstate Avenue at Tillamook Street.

Milestones (see also Timeline at end of report)

Record of Decision	January 5, 2000
Full Funding Grant Agreement	September 22, 2000
Notice to Proceed for civil construction for 10AB	May 21, 2001
Rose Quarter/Rose Garden track tie-in complete	May 25, 2001
Notice to proceed for 10C design/build contract	June 11, 2001
Private utility relocation substantially complete	May 10, 2002
Lower Albina overcrossing bridge open to public	May 30, 2002
Trackwork in 10AB substantially complete	March 3, 2003
First light rail vehicle delivered (ready for testing)	April 16, 2003
Vanport bridge substantially complete	July 15, 2003
10C Argyle-Expo final contract completion	December 31, 2003
Traffic/train signals test (start of integrated testing)	January 16, 2004
Finalize run times for operating schedule	February 5, 2004
17 vehicles delivered	March 3, 2004
Begin revenue service	May 3, 2004

Civil construction packages

TriMet divided the civil construction into contract packages:

- **Line Section 10AB was approximately 4 miles long, beginning at the Rose Quarter and terminating at Argyle.**
- **Line Section 10C, was approximately 1.8 miles long, beginning at Argyle and ending at the terminus at the Expo Center. It included a 3,850-foot bridge.**
- **A third civil construction package (10R) made modifications to Ruby Junction, the existing operations facility.**

Contracting Methods

In the fall of 1999, TriMet prepared a contracting plan that described the type of construction and the particular challenges to be expected in each segment. Based on the criteria for selecting type of contract, TriMet elected to issue separate Requests for Proposals for the Line Section 10AB, Line Section 10C (design-build) and Ruby Junction (10R) contracts.

TriMet selected the construction manager/general contractors through a two-step qualifications-based process. In the first step, the source evaluation committee scored proposals. In the second step, TriMet negotiated with the highest rank proposer to reach an acceptable contract price.

Civil Construction

Track Materials

TriMet competitively bid all trackwork. To reduce costs, the construction manager/general contractor for Line Section 10AB suggested using steel ties rather than concrete, to reduce the width and depth of the track slab, and to hold the centerline of rail relative to trackway curb. As described in the Environmental section, the contractor also developed an alternative tie, made of recycled plastic, and engineered it to provide the support, gage and elevation control required.

Ruby Junction Modifications

The project expanded the Ruby Junction Operations and Maintenance Facility to accommodate the storage and servicing of, initially, 17 light rail vehicles for 2004 start-up with 10-minute peak headways. With passenger demand requiring 7.5-minute headways with two-car trains before 2020, Ruby Junction would also serve the additional 7 vehicles required for Interstate MAX.

The expansion included:

1. Increasing the storage yard capacity from 48 light rail vehicles to approximately 70. Seven of those spaces are located on the combination storage-and-test track.
2. Adding a yard substation to handle the increased electrical load of the expanded fleet and modifying existing substations in the yard vicinity to accommodate the increased number of vehicles leaving and entering the yard.
3. Remodeling the paint and body bays into full service bys with body pits with both pits and overhead platforms.

4. Constructing a satellite building with a 21,000 square foot footprint, known as Ruby South. Ruby South contains relocated paint and body bays, one new flat truck bay for interior car work, a relocated metal fabrication area, parts storage, maintenance-of-way shop and offices, restrooms, lockers, and a lunch room to accommodate 60 workers over three shifts.
5. Adding staff parking.
6. Remodeling Ruby Junction to expand the rail control room and the operators' ready and locker rooms
7. Grading to the south to balance cuts and fills within the 100-year flood plain.

The expansion was on vacant land TriMet-owned land to the south of the main Ruby Junction building. Ruby South is a low cost, functional, pre-engineered steel frame building.

Concurrent with the Interstate MAX expansion, TriMet relocated the bus dispatch function from Center Street to the third floor of the main Ruby Junction building, adjacent to rail dispatch activities.

Environmentally-sensitive Construction Practices

The Interstate MAX project captured approximately $3 million in savings through environmentally sensitive construction practices.

1. Replacing steel bollards with recycled plastic bollards. Because plastic bollards do not require grounding, the project saved approximately $100,000 in material costs and an additional $150,000 in grounding expenses.

2. Installing recycled plastic railroad ties in embedded trackway. Instead of using steel, the MAX line used 6,000 plastic ties made of recycled plastic automobile gas tanks. Unlike steel ties, plastic ties do not affect the MAX signaling system.

3. Replacing storm water collection system with vegetated buffers and infiltration trenches. This saved approximately $186,500 by eliminating catch basins, piping, manholes and pump station.

4. Recycling approximately 80,000 cubic yards of existing roadway and concrete. This saved approximately $186,667 in costs for trucking, disposal fees and material purchases.

5. Overlaying existing roadway substrate in lieu of rebuilding the full road depth. This saved approximately $2,383,332 in an overlay area of 47,600 square yards, by avoiding demolition, removal, disposal and hauling in new material.

6. After demonstrating to environmental regulators that excavated soil was not polluted, TriMet reused the soil as fill material along the line.

7. Devising environmentally sensitive solutions where construction was near waterways, and incorporating art into its storm water management projects.

8. Tripling the number of trees located along Interstate Avenue and relocating numerous large trees in the area. Neighbors helped select the size and types of tree species, and chose plantings that could survive in an urban environment requiring minimal water, fertilizers and pesticides.

9. Expanding and recreating the wetland next to the Forebay Slough on Portland International Raceway property. Approximately 18,000 cubic yards of soil was excavated to allow the newly restored wetland and the Forebay Slough to become one continuous body of water. TriMet enhanced the wetland by planting more than 200 trees, 12,000 deciduous shrubs and 12,000 plants. The wetland provides wildlife habitat and the ability to bio-cleanse the water.

10. Reducing the impervious surface area along Interstate Avenue. More than two acres were converted to pervious surfaces. Concrete unit pavers were used at all ten station platforms, allowing rainwater to filter into the ground. The pavers also provide easy access for maintenance.

Light Rail Vehicles

TriMet issued a Request for Proposals (RFP) for low floor light rail vehicles. Through a two-step process, TriMet contracted with Siemens Transportation, Inc to design, manufacture and deliver 17 low-floor light rail vehicles at a per vehicle cost of $3 million. In June 2002, FTA issued a Letter of No Prejudice for up to ten additional vehicles and TriMet exercised a contract option for ten vehicles.

The vehicles were manufactured in Carson, California, assembled in Sacramento, and shipped via rail or truck to Portland. All seventeen of the base order vehicles were on-site by March 3, 2004.

These vehicles are nearly identical those purchased for the Westside project, which opened in 1998. The middle section of the vehicle (approximately two-thirds of the total length) is four inches above the station platform. A short ramp, or bridge plate, extends from the door to the platform, assisting passengers using wheelchairs, walking aids, strollers and bicycles. Interior steps lead to seats over powered wheel assemblies at each end of the car. Features include air conditioning, seating for 72, maximum capacity of 166 riders (including standees) and space to accommodate four wheel chairs and four bicycles per vehicle.

Each vehicle weighs 109,000 pounds (empty), is 92 feet long, uses 19 microprocessors, contains 30 miles of wire, and can achieve a maximum speed of 55 miles per hour. Cabs at both ends allow for reverse running. The vehicles employ regeneration whereby the braking system returns energy to the line.

In December 2003 seven of the option vehicles were included as part of the FTA-approved scope restorations to the project. The option vehicles were commissioned and accepted by TriMet by September 30, 2005.

TriMet issued a change order requiring the provision of automatic passenger counters (APC) on the Type 3 vehicles. TriMet performed annual manual counts at a cost of approximately $100,000 each year. The APCs collect all of the data collected in the manual counts in a digital form, ready for evaluation and summarizing. The APCs also collect the data on a daily, continuous basis, giving greater accuracy and reflecting seasonal characteristics.

Signals, Traction Electrification, Communications

TriMet originally intended to procure all these elements as a single package with a combined budget of $35.1 million. Initial bid results for the combined package were beyond budgeted amounts.

Subsequently, TriMet re-bid the components. The resulting contract packages combined signals and communications into one contract (10G); traction electrification was a separate contract (10F). In addition, TriMet recognized that with the addition of Interstate MAX and changes in communications technology since the Westside extension, new central control design was needed. A separate contract for central control, not envisioned originally, was issued.

TriMet originally assumed that the control center system software (provided with the Westside-Hillsboro project) could be modified to add the Interstate line at a modest cost. This assumption proved to be incorrect. The software was expandable, however, the hardware (computer servers) was not capable of handling the increased workload and required replacement. However, hardware capable of running the expanded software was no longer available.

TriMet solicited competitive bids, asking bidders to either modify or replace the existing system. TriMet received one proposal to modify the existing system, at a higher price than the successful bidder's proposal to replace all hardware and software with a new system.

The successful company was experienced and interested in expanding its market share. It was subsequently able to leverage the hands-on field experiences from this contract to other clients.

TriMet assumed that the existing control center console arrangement could be reused with no or few changes. A subsequent more detailed analysis by TriMet's Operations department showed that a reconfigured floor plan could optimize the console arrangement and would permit operation of the system with a modest headcount increase.

TriMet planned to reuse the overview projection system procured as a part of the Westside-Hillsboro project. However, the control center remodeling described above resulted in changes in the lighting conditions. As part of the scope restoration program, the project replaced the existing projectors with brighter and sharper projectors to improve the viewability of the displays.

Insurance and Safety

TriMet implemented an incurred-loss, Owner Controlled Insurance Program (OCIP), and promoted an active safety-awareness culture. On the job site, contractors prepared pre-task analysis (PTA) and job hazard analysis (JHA) cards prior to beginning new tasks. Civil contractors employed full-time safety managers on-site. Pre-employment physicals, morning stretching exercises prior to beginning work and regular crew safety meetings minimized the severity of workers' compensation claims.

Regular meetings were held with contract managers on the status of workers' compensation claims, return to work schedules, and light duty opportunities.

The contractors put a portion of their fee at risk, paid on the basis of their safety performance. TriMet matched all or a portion of the fee at risk, depending upon the safety results. TriMet performed quarterly safety audits and discussed the results with the contractor principals.

TriMet management emphasized safety, hosted safety summits, and issued safety awards for exemplary performance. TriMet also conducted mandatory track access training for any personnel working, inspecting or regularly visiting the track.

September 11, 2001 reverberations: On September 11, the project experienced a fatality; and the following day, a very serious accident that resulted in long-term rehabilitation. As a result, TriMet instituted a "safety stand down."

Expected workers' compensation and general liability losses were estimated at $1,664,078 based on Oregon averages. TriMet's broker's feasibility estimate predicted $1,404,582; incurred losses were $1,368,518.

Contractors worked approximately 950,000 hours on the project.

Other Contracted Services and Intergovernmental Agreements

TriMet executed intergovernmental agreements with or needed permits from the City of Portland, Metro, the Oregon Department of Transportation (ODOT), the State of Oregon, the City of Gresham, the Portland Development Commission, and the Metropolitan-Exposition and Recreation Commission (MERC).

The City of Portland provided staff services throughout the project. The Portland Department of Transportation (PDOT) assigned two full-time engineers to the project, as well as other personnel as needed from traffic engineering. In addition, the Bureaus of Water Works and Environmental Services assisted with water and sewer relocation efforts. The Parks Bureau collaborated with the project on general landscaping and restoration of the Forebay Slough.

ODOT personnel reviewed and commented on the design and construction of the long bridge over Highway 99W, including the preservation of an historic building situated close to one of the bridge piers.

Through the Department of Environmental Quality, the State of Oregon provided hazardous materials review and analysis as needed.

The Ruby Junction maintenance facility is located within the City of Gresham.

The Portland Development Commission and TriMet partnered in the selection and development of the projects described under the Station Area Development section.

MERC owns and operates the Expo Center. The project concluded a long-term lease arrangement for the parking spaces associated with the terminal station.

Capital Cost of Contracting (Interim Financing)

TriMet assumed that all local funds would be available initially and that construction would continue with interim borrowing rather than be delayed or interrupted if federal funds were not available. The calculation of interim financing costs was determined by the amount and timing of the receipt of federal funds.

TriMet developed three scenarios to estimate the interim finance costs: annual federal appropriations of $70 million, $60 million or $50 million. All scenarios assumed that the annual appropriations were received in April of each year and that borrowing costs were 6%. TriMet selected the mid-range appropriation of $60 million, and the resulting $6,781,275 cost in 2000$.

Actual federal appropriations are reflected below. The final interim finance cost was $5,340,350.

Real Estate Activities

The real property activities included 247 files for street dedications, fee acquisition, staging sites and a variety of easements. There were no permanent relocations or displacements. The only relocation involved temporarily moving the office of an independently owned waste disposal and recycling facility and later returning it to its original site. Real property costs also include the capitalized lease cost of a 15-year lease for parking spaces at the Expo Center.

Start Up

TriMet prepared and executed a start-up plan consistent with the FTA guidelines, including hiring and training of all personnel needed to operate and maintain the new line. Rail operations start-up activities specifically focused on qualifications training, vehicle commissioning, systems installation and testing, system safety and security drills and pre-revenue simulated service.

Public Art

The Interstate MAX Public Art Program's mission was to recognize the region's cultural richness and to promote community pride. Interstate MAX runs down the center of Interstate Avenue, or 99W, a portion of the historic Pacific Highway that linked west coast cities from northern Washington to southern California. The community is the most culturally diverse in Portland.

In November 1999 an independent Interstate MAX Art Advisory Committee was formed. The Committee selected a team of artists that collaborated with the architects and engineers on final design of the stations and developed an Art Plan for Interstate MAX. The central concept of the plan was viewing Interstate MAX as an urban spine that would function both as "a protected passageway for the flow of people, energy and ideas," and as a stimulant to the whole of the community. The art sought to establish a unique identity for each station by restoring to public view "layers of the urban landscape often overlooked, forgotten or buried."

The project published two books: *Interstate MAX Public Art Guide* and *Intersections: TriMet Interstate MAX Light Rail Community History Project.* The *Guide* describes the development of the art program and the results. *Intersections* is a compilation of stories told by residents about their neighborhoods.

Station Area Development

The Interstate MAX Station Area Development work program had three primary elements: redevelopment planning, joint development and community education about development.

Redevelopment Planning

The Interstate MAX Station Area Revitalization Strategy, funded jointly by TriMet, the Portland Development Commission (PDC) and the Oregon Department of Transportation, engaged more than 500 community members in walks and workshops held between November 2000 and May 2001. The Revitalization Strategy identified station area redevelopment opportunities and a series of public and private investments that would capitalize on light rail. The PDC and Portland City Council adopted the Revitalization Strategy in 2002.

TriMet also provided assistance to PDC for site-specific redevelopment planning for a key parcel located at North Interstate and Killingsworth Avenues. A mixed-use project with a condominium component is expected to break ground next year.

Joint Development

Joint development is intended to increase the effectiveness of the transit system by promoting transit-oriented development on key station area parcels. TriMet used the analysis provided in the Revitalization Strategy to identify a number of catalytic sites and collaborated with Metro and PDC in further site selection. Two sites were acquired for joint development:

Crown Motel, 5226 N. Interstate - In January 2005, TriMet received concurrence from the FTA to proceed with the acquisition of this 26,000 square foot site. The acquisition was completed in September 2005. TriMet issued a development solicitation in March 2006 and selected a team led by REACH Community Development from among 10 proposers. REACH will plan and execute joint development on this site. REACH held two community meetings to discuss the project design and is in regular contact with the neighborhood association. The proposed 5-story building with 53 units of affordable housing and 7,000 square feet of ground floor commercial space would be the first new mixed-use building along the Interstate alignment. The project was submitted for design review in September 2007 and is expected to break ground in spring 2008 with occupancy in 2009.

2133 N. Argyle St - In April 2006, TriMet received FTA's concurrence for the purchase of this 2.2-acre site. A stakeholder outreach process during the spring and summer of 2007 gauged developer interest in and community expectation for redevelopment of the property. At the writing of this report, the site is one of four that Multnomah County is considering for a North Portland library branch. The library would be part of mixed-use project. Demolition of the building on the site is slated for October 2007.

Community Education

In addition to the extensive public involvement incorporated into the redevelopment planning and joint development elements of the program, two specific community education events were held:

At the request of the Interstate Avenue Business Association and the Cascadia Revolving Fund, TriMet sponsored an Interstate Avenue Development Workshop on June 17, 2003. The workshop explained what a "developer" does, provided an overview of City programs available to assist development and an introduction to the City's permit process.

Development along Interstate (partial list)

Gotham Building, 2240 N. Interstate - This former mattress factory received $15,000 storefront improvement loan, which was leveraged by more than $400,000 of the owner's equity. The building is completely remodeled for a variety of tenants including a commercial kitchen that can be rented by caterers.

Ainsworth Drug, 4027 N. Interstate - This locally owned drug store relocated from another area of NE Portland to capitalize on MAX access and invested more than $600,000 to improve an existing building that now houses the store

DeWolf Building (Interstate and Skidmore) - New offices for Richard DeWolf's architectural practice opened April 19, 2002.

Interstate Housing and Head Start, 6800 N. Interstate - Interstate Crossing opened September 19, 2002. This is a 12-unit Housing Authority of Portland (HAP) project for mothers with children and a 36-student Head Start program. $1.95 million project on donated land. Central City Concern operates it.

North Star Coffee Shop, 7540 N. Interstate **-** Reuse of existing house.

Fred Meyer, 7404 N. Interstate - New 150,000 sq. ft. store (home, garden, variety, grocery) completely remodeled facility reopened for the holiday season 2005.

Fenwick and Argyle Housing - The Housing Authority of Portland (HAP) constructed a 27-unit project on 25,000 square foot site. The 19 units are available to households at or below 60% of median income; 8 units are reserved for people with special needs.

New Seasons Market, 6400 N. Interstate. \ - The former site of Oregon Armored was redeveloped as a 32,479 square foot grocery store.

The Palms Motel, 3801 N. Interstate - The motel reopened its historic, but long vacant, café following a $40,000 storefront facelift.

An Nguyen, 4057 N. Interstate - A single-family residence was converted to teriyaki take-out/cafe.

Marino Furniture 3950 N. Interstate -This would be the initial project of the "Overlook Village" station area proposal. The property is under contract to two novice developers who would like to link the commercial aspects of the project to the adjacent Polish church.

Interstate Home Ownership Campaign - Portland Development Commission secured private activity bonds to offer $10 million in below market rate mortgages to 200-300 first time buyers in N/NE Portland.

Community Outreach and Business Support

TriMet identified approximately 107 businesses affected by the Interstate MAX project. Four full-time community relations outreach staff maintained one-on-one contact with business owners. Operators answered a 24-hour construction hotline. Pagers to resolve after-hours issues alerted community relations staffers.

Construction was conducted in "reaches", each approximately 4 blocks long. Each phase of construction was completed in each reach before starting the next reach. Rebuilding the outside lanes and sidewalks required approximately 8 weeks per reach. The street or sidewalk was restored if there was a time lag between phases of construction.

The project maintained access to businesses at all times, with vehicle route into parking areas and a pedestrian route into the business entrance. At least one sidewalk was open in each reach at all times, as well as at least one lane of traffic in each direction. TriMet provided "Open for Business" signs and directional signs for customers when the route into parking was blocked along Interstate Avenue. TriMet created a "Doing Business on Interstate Avenue" directory to make it easy for people to continue to patronize businesses.

A partnership of Portland Development Commission, US Small Business Administration, Enterprise Foundation, Cascadia Revolving Fund and Albina Community Bank, offered low-interest loan and technical assistance program for small businesses on Interstate Avenue.

Disadvantaged Business Enterprises and Workforce

TriMet committed to contracting with people from the Interstate community to build the project. Besides providing opportunities to work on the project, TriMet also committed to assisting minority and women-owned firms to build their long-term capacity.

Disadvantaged Business Enterprises

TriMet set an ambitious goal: 16% of construction contract dollars would go to Disadvantaged Business Enterprises (DBE) firms, with a focus on North and Northeast Portland businesses. In all, DBE firms performed 19% of the construction contract work.

Approximately16% of the DBE subcontractors came from the Portland area, with 8% from North and Northeast Portland. The Interstate MAX project delivered a total of $13 million to Portland DBE firms with $8.1 million going to North and Northeast Portland DBE firms.

Workforce

TriMet's goal was for 17% of workforce hours to be performed by apprentices. The agency exceeded this goad, with apprentices performing 25% of the hours. In addition, minorities and women completed 35% of the workforce hours.

Scope Restorations

In the fall of 2003, cost forecasts indicated that the project would be completed under the $350 million budget. In consultation with FTA Region 10 staff, TriMet developed a package of "scope restoration" items for funding within the overall project budget. On January 14, 2004 FTA approved 10 items for a total of $8,187,000, pending the outcome of a Safety and Security Threat & Vulnerability Study. The items were selected based on the following criteria:

- Items that were originally included in the scope of the project, but were modified, deleted or deferred during the final budget negotiations
- Items that directly relate to the reliability of the light rail system once Interstate MAX is added.
- Safety and security items in the wake of September 11, 2001

Power switches at Ruby Yard – purchase and installation of 9 powered switches, signal bungalow, cable and testing

Central control overview display balancing – replace seven overview display projectors to match brightness and sharpness levels of new Interstate project.

Bureau of Water Works cost reconciliation – reconcile outstanding cost issues regarding relocation of water facilities along Interstate Avenue per prior agreement

Northbound platform shelters – install eight shelters: one each at the northbound platforms at Overlook, Killingsworth, Portland, Lombard and Kenton stations; two each at the northbound platform at Delta Park/Vanport; one at the southbound platform at Expo

Closed circuit television – outfit stations from Expo to SW 11th with closed circuit televisions (scope correct?)

Sidewalk between Larrabee and Tillamook – construct approximately 1,700 linear feet of sidewalk to allow for continuous pedestrian walkway along Interstate Avenue between Larrabee (north of Rose Quarter station) and Tillamook (south of Albina station)

Marine Drive pedestrian crossing – install lighting, pedestrian call buttons, and striping at to allow pedestrians to safely cross Marine Drive to reach Expo Station.

Traffic calming – install appropriate devices (speed bumps, curb extensions, crosswalk islands) to maintain safe auto speeds on neighborhood streets receiving traffic displaced from Interstate Avenue

Before and After study – develop and analyze comparisons for capital costs, ridership and operating costs

Rose Quarter paved track – install paved track in lieu of tie and ballast for 889 route feet between the north end of the Interstate Rose Quarter station and Larrabee Avenue

Interstate MAX Light Rail Project Timeline

2000 and Prior

Final Environmental Impact Statement	**October 18, 1999**
Record of Decision	January 5, 2000
Approval to Initiate Final Design	February 17, 2000
Full Funding Grant Agreement	September 22, 2000

2001

Notice to proceed for special trackwork	February 22
Notice to proceed for tee rail	February 23
Notice to proceed for grade crossing panels, concrete ties	April 26
Notice to Proceed for civil construction for 10AB	May 21
Rose Quarter/Rose Garden track tie-in complete	May 25
Notice to proceed for 10C design/build contract	June 11
Modifications to Ruby Junction operations building complete	October 31
Received pre-engineered building for Ruby Junction South	November 26
Notice to proceed for traction electrification contract	December 13
Notice to proceed for signals/communications contract	December 28

2002

Signage and graphics manufacture complete and in storage	February 4
Paul Bunyan statue moved	February 21
Private utility relocation substantially complete	May 10
Lower Albina overcrossing bridge open to public	May 30
Ruby Junction trackwork and overhead catenary complete	June 21
Ruby South maintenance building substantially complete	July 3
Waterline relocations and tie-ins in 10AB complete	July 31
Sewer relocations in 10AB complete	August 2
Ruby Junction existing body shop conversion complete	November 11

2003

Trackwork in 10AB substantially complete	March 3
First light rail vehicle delivered (ready for testing)	April 16
Vanport bridge substantially complete	July 15th?
10C Argyle-Expo final contract completion	December 31

2004

Traffic/train signals test (start of integrated testing)	January 16
Finalize run times for operating schedule	February 5
17 vehicles delivered	March 3
Public grand opening	May 1 – 2
Begin revenue service	May 3
Systemwide landscape final completion – start 2-year warranty	May 11

2005 - 2007

Last (24th) Interstate light rail vehicle commissioned	February 6, 2005

Installation of motorized switches completed at Ruby Junction	**April 7, 2005**

Marine Drive crosswalk and lighting completed	**May 24, 2005**
Completion of closed circuit television installations	June 29, 2005
Signals/communication contract substantially complete	July 21, 2005

Skidmore lighting safety improvements completed	**September 29, 2005**
Landscaping two year warranty complete	May 11, 2006
Central control contract complete	February 28, 2007
Traffic calming construction completed	April 5, 2007
Final Section 5309 funding appropriation received	July 3, 2007
Before and After study prepared	Summer/fall 2007

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