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**Acronyms**

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<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>AGC</td>
<td>Association of General Contractors</td>
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<tr>
<td>APTA</td>
<td>American Public Transportation Association</td>
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<td>BAS</td>
<td>Before and After Study</td>
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<td>BRT</td>
<td>Bus Rapid Transit</td>
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<td>CCB</td>
<td>Change Control Board</td>
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<td>CDOT</td>
<td>Colorado Department of Transportation</td>
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<td>CDPHE</td>
<td>Colorado Department of Public Health and Environment</td>
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<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
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<td>CM/GC</td>
<td>Construction Manager/General Contractor</td>
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<td>CRS</td>
<td>Colorado Revised Statutes</td>
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<td>CO</td>
<td>Change Order</td>
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<tr>
<td>D-B</td>
<td>Design-Build</td>
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<td>D-B-B</td>
<td>Design-Bid-Build</td>
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<tr>
<td>DBE</td>
<td>Disadvantaged Business Enterprise</td>
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<td>DUS</td>
<td>Denver Union Station</td>
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<td>DTCG</td>
<td>Denver Transit Construction Group</td>
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<tr>
<td>Eagle</td>
<td>East and Gold Line (Extension)</td>
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<td>EIS</td>
<td>Environmental Impact Statement</td>
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<td>ESA</td>
<td>Environmental Site Assessment</td>
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<td>ETC</td>
<td>Estimate to Complete</td>
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<td>FFGA</td>
<td>Full Funding Grant Agreement</td>
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<td>FTA</td>
<td>Federal Transit Administration</td>
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<td>GMP</td>
<td>Guaranteed Maximum Price</td>
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<td>IGA</td>
<td>Intergovernmental Agreement</td>
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<td>LRT</td>
<td>Light Rail Transit</td>
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<td>LRV</td>
<td>Light Rail Vehicle</td>
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<td>OCS</td>
<td>Overhead Catenary System</td>
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<td>OCIP</td>
<td>Owner-Controlled Insurance Program</td>
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<td>P3</td>
<td>Public-Private Partnership</td>
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<tr>
<td>PI</td>
<td>Public Information/Public Involvement</td>
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<td>PMOC</td>
<td>Project Management Oversight Consultant</td>
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<td>PUC</td>
<td>Public Utilities Commission</td>
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<td>REC</td>
<td>Recognized Environmental Condition</td>
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<td>ROCIP</td>
<td>Rolling Owner-Controlled Insurance Program</td>
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<td>ROW</td>
<td>Right-of-Way</td>
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<td>RTD</td>
<td>Regional Transportation District</td>
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<td>SBE</td>
<td>Small Business Enterprise</td>
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<td>SCADA</td>
<td>Supervisory Control and Data Acquisition</td>
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<td>SOP</td>
<td>Standard Operating Procedure</td>
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<td>SPSP</td>
<td>Subcontractor Performance Self-insured Program</td>
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<td>SSO</td>
<td>State Safety Oversight Program</td>
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<tr>
<td>SSWG</td>
<td>System Safety Working Group</td>
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TOD  Transit-Oriented Development
T-REX  Transportation Expansion Project
VCUP  Voluntary Clean-Up Plan
VE  Value Engineering
VECP  Value Engineering Cost Proposal
WBS  Work Breakdown Structure

Glossary
FasTracks:  A 122-mile project consisting of commuter rail, light rail transit (LRT), and bus rapid transit (BRT) in the Denver metropolitan area.
Public Utilities Commission:
  The State Safety Oversight organization and railroad crossing authority in Colorado.
Quieter Crossing:
  An at-grade crossing with directional units that adjust sound levels based upon ambient noise levels instead of standard bells that radiate sound in all directions at a much louder level.
Executive Summary

This report provides key, overall lessons learned related to program management on the West Rail Line (WRL) Project, a 12.1 mile, new Light Rail Transit (LRT) extension that opened within budget and ahead of schedule on April 26, 2013. A map of the line, with other lines in the FasTracks program, is shown in Figure 1.

Building major infrastructure, such as the West Rail Line, through built-up urban areas is a complex and challenging endeavor. By documenting lessons learned, this report offers insight to RTD and its program management teams. It also complements the lessons learned modules which RTD’s Quality Management Group manages annually.

The report provides historical perspective of the West Rail Line project, but more importantly offers valuable information for ongoing and future rail corridor project management approaches.

Although the WRL had many unique features and was delivered as a Construction Manager/General Contractor (CMGC) project, it provides many lessons for all major, rail corridor projects and delivery methods, both at RTD and other transit agencies.

The West Rail Line Project was the first corridor started and built through the FasTracks program. As such, valuable insight was gained, which has been applied to subsequent projects.

There were four major construction contracts issued for the West Rail Line. Civil and Systems used the Construction Manager/General Contractor (CM/GC) procurement method while the parking garages at Sheridan and Wadsworth were stand-alone Design/Build (DB) contracts.

Upon completion of planning, the Capital Programs Department at the Regional Transportation District (RTD) is responsible for all aspects of program management for new capital programs including the WRL project. This includes design, construction and integrated testing. The Capital Programs Department emphasizes the documentation of lessons learned to continually improve project performance. Previous lessons learned efforts have included:

- Transportation Expansion (T-REX) Project (2007)
- FasTracks program (2009)
- East and Gold Line Extension (Eagle) Project, a public-private partnership (P3) procurement (2011)
Background and Overview

Project Background
The Regional Transportation District (RTD) is in the process of developing its FasTracks transit system. The FasTracks Program of projects is bringing 122 miles of commuter rail, light rail transit (LRT), and bus rapid transit (BRT) to the Denver metropolitan area.

FasTracks at a glance:
- 122 miles of new rail service
- 18 miles of bus rapid transit
- 57 new stations
- 31 new Park-n-Rides
- 21,000 new parking spaces
- Redevelopment of Denver Union Station (DUS)

The entire FasTracks Program of projects is shown in Figure 1.
Figure 1: FasTracks Map
West Rail Line Project Overview

The West Rail Line is the first of the FasTracks Program of projects to be completed. The line, referred to as the “W” Line, opened on April 26, 2013. The project was completed eight months ahead of schedule and within budget.

Project Description

The West Rail Line Project spanned 12.1 miles between DUS in downtown Denver and the Jefferson County Government Center Golden Station. It runs through two counties (Denver and Jefferson) and three cities (Denver, Lakewood and Golden). There are 11 new LRT stations, a relocated station on the Auraria Higher Education Campus, and six Park-n-Rides. Three parking garages (Jefferson County Government Center, Sheridan, and Wadsworth) were built as part of the project. The existing Cold Springs Park-n-Ride was relocated and expanded as the Federal Center Station.

Figure 2 shows the West Rail Line Project alignment, LRT stations, and Park-n-Rides. The alignment is double-tracked from DUS to the Denver Federal Center LRT station (nine miles), and single-tracked (three miles), with a passing track, from the Denver Federal Center to the Jefferson County Government Center station.

Trains run every 7.5 to 30 minutes, depending on day of the week and time of day. Headways on the single-tracked section range from 15 to 30 minutes. An estimated 18,300 people will use the rail line each business day.

West Rail Line Statistics

The West Rail Line Project cost $707 million. Approximately $309 million was provided under a Full Funding Grant Agreement (FFGA) with the Federal Transit Administration (FTA). Some relevant facts about the features, costs and benefits of the West Rail Line Project:

- Direct wages paid – $71,020,000
- Equipment, materials and supplies – $98,131,000
- Subcontractors (more than 60 percent hired locally) – $250,000,000
- Construction provided employment to 755 people

**Construction Facts**

- 10 light rail bridges
- Three roadway bridges (Decatur, Federal and Sheridan)
- Two light rail tunnels (Simms/Union and I-70)
- Four pedestrian structures (three bridges, one tunnel)
- 115 retaining walls with more than 10,000 feet of noise wall
- 22 at-grade crossings
- Nine miles of double-tracked and three miles of single-tracked light rail
- 11 at-grade “quieter crossings”

**Project Challenges**

- Narrow right-of-way (ROW)
- Work on federal property
- Coordination with local governments and stakeholders
- Managing citizen expectations including: betterments, designs, stations
- Managing two corridor construction contracts: civil and systems

**Awards and Recognitions**

**Merit Winner of the 2013 Alliant Build America Award:** The West Rail Line Project was named a Merit Winner of the 2013 Alliant Build America Award in the highway and transportation category. Presented by the Association of General Contractors (AGC), the award recognizes the nation’s most significant construction projects. A panel of judges representing all areas of construction evaluated the project’s complexity, innovative technique, and client satisfaction, among other criteria. The AGC noted the West Rail Line Project was completed eight months ahead of schedule and on budget. This award is considered by many to be the most prestigious recognition of construction accomplishments in the U. S.

**Alliant Build America Merit Award:** Lakewood-based Denver Transit Construction Group (DTCG) was one of six firms to receive this award.

**WTS Colorado Large Innovative Transportation Solution of the Year:** The West Rail Line Project received this award for 2013.
Lesson #1: Construction Manager/General Contractor (CM/GC)
Contracting Approach

Lesson Overview and Background
The original intent was to complete 100 percent design through a civil design firm selected specifically for the project, while RTD’s systems engineering consultant would design the traction electrification, signals, communications, and system-wide electrical components. Once final plans were complete, the intent was to bid the work out to one or more contractors through a traditional design-bid-build (D-B-B) contracting approach. However, in the interest of seeking contractor input to the design, the WRL Project management team changed the contracting approach to Construction Manager/General Contractor (CM/GC) prior to the 65 percent design level, enabling the CM/GC to submit comments and recommendations at this stage of design. In retrospect, the CM/GC should have come on board at the earliest possible opportunity—ideally at the 30 percent design level.

Using the CM/GC project delivery approach, RTD expected the CM/GC to provide value engineering/cost containment and constructability suggestions to reduce the price of the project. The CM/GC provided a number of comments throughout the design process starting at the 65 percent design level. However, the civil designer did not accept many of the recommendations submitted by the CM/GC. As designer of record, it was unwilling to assume the risk associated with many of the suggested changes. This significantly reduced the benefits of bringing the CM/GC on board during the design phase. Some of these design recommendations were later incorporated by the CM/GC as VECPs after final design was complete. But at that point in the project, RTD was not able to realize the full cost savings had these changes been incorporated earlier during the design phase.

During construction, the project team including the right of way group met frequently with the CM/GC to develop workarounds and mitigations to changes in the right of way delivery schedule. The CM/GC was very flexible and innovative in developing the workarounds. There were no delay claims due to ROW issues.

Negotiations to reach a final Guaranteed Maximum Price (GMP) were difficult. RTD ended up negotiating each element of the project. The two parties almost did not reach an agreement on the final GMP. Had agreement not been reached, the project might have been delayed by up to a year, and could have seriously impacted the overall FasTracks Program. RTD viewed the risk of failing to reach a GMP as unacceptable.

CM/GC negotiation is done on the basis of open books, with the Owner having full access to CM/GC costs. However, RTD has concluded the CM/GC contracting approach provides for less certainty of competitive pricing when compared to a competitive bid. The final GMP was negotiated with a single prime contractor, originally selected through a pre-construction services contract, rather than competitively bid at the end of design. RTD ultimately converted the contract to a lump sum contract.
Another challenge to the project was that the CM/GC and RTD staffs were not co-located with the designer. Co-location during design would have improved coordination and cooperation. During construction, the CM/GC and RTD did co-locate to a shared project office and communications and coordination were significantly improved.

Overall, RTD considers the final negotiated GMP to have been a good value. As noted earlier, the project was completed within budget and eight months ahead of schedule. Also, there were no claims. RTD attributes these successes to the cooperation and partnering between RTD and the CM/GC.

**The Lessons**

Ways to maximize the benefits of the CM/GC contract delivery approach:

- In the selection criteria for the design contract include provisions for interfacing with a CM/GC
- Procure the CM/GC under a pre-construction services contract early in the design phase—preferably at the 30 percent design level, but no later than the 65 percent level
- Co-locate the designer, CM/GC and Owner’s representatives during design to maximize communication during the construction stage
- Institute formal partnering to resolve conflicts and promote teamwork
Lesson #2: Separation of Civil and Systems Contracts

Lesson Overview and Background
During the process of negotiating a GMP, RTD decided to split the civil and systems work into separate contracts. There were two reasons for this approach:

- To avoid the added 12.7 percent mark-up the CM/GC would include on the systems portion of the WRL Project
- To maintain a competitive cost effectiveness rating under the FTA New Starts criteria so the project could obtain a FFGA.

By separating the two aspects of the contract, RTD saved approximately $10 million. This separation required additional staffing and effort on RTD’s part, and had some cost impacts, but the net effect was significant overall cost savings on the WRL Project.

By creating two separate contracts, it resulted in the need to develop a Systems Interface Responsibility Matrix. This matrix was included in the Construction Services Agreements for each contract. The responsibilities for delivering these interfaces were clearly delineated between RTD, the civil contractor (CM/GC), and the systems contractor. However, a robust systems interface program would have been beneficial.

Using the matrix approach, the CM/GC would install work elements such as duct banks for the main line and laterals, but it was the systems contractor’s responsibility to install the final duct bank run to the signal or communication house and install the necessary wire and cabling within the duct banks. There was little opportunity for the systems contractor to inspect civil work during civil construction, so if a conflict or area of noncompliance was found during the systems work, there could have been cost and schedule impacts. RTD mitigated these potential problems by requiring the CM/GC to implement a detailed quality management plan with RTD oversight. Nonetheless, some conflicts did arise.

Once the systems contractor assumed beneficial occupancy of the jobsite, the track access became the responsibility of the systems contractor. There was great cooperation between the CM/GC and systems contractor for scheduling completion of punch list items and access for key corrective actions discovered during testing and/or systems safety certification. Systems COs and interface issues are to be expected on such a large, complex project. Overall, the COs for a project of this magnitude were not excessive. RTD and the systems contractor had an excellent working relationship. This enabled RTD to avoid many COs that might otherwise have resulted.

The Lessons
Splitting the contract resulted in additional coordination and interface requirements. Although there were COs related to systems/civil interfaces, the project still achieved its goal of saving money.

If civil and systems construction are to be handled by separate contractors, regardless of the method of contract delivery, special consideration must be given to managing such interfaces as:
• Ensure clear delineation of responsibilities between the civil and systems contractors
• Specify robust quality inspection requirements for work that will be buried
• Consider a formal design interface program
• Provide for input from the systems contractor, through the owner’s representative, while the civil contractor is still constructing the work
• Provide for correction of non-compliances and punch list items after the systems contractor has taken beneficial occupancy
• Provide for input by the designers (civil and systems) when unexpected conditions are encountered
• Maintain good working relationships with both systems and civil contractors to resolve interface issues while minimizing COs
Lesson #3: Project Management Implementation and Procedures

Lesson Overview and Background
Project management is critical to the success of any project. To ensure success, RTD selects a dedicated team led by a strong manager who is vested with the authority to manage a “mega-project.” The team is staffed with experienced discipline leads and other staff who have extensive backgrounds in project implementation. The West Rail Line Project organization is shown in Figure 4-1.

To ensure effective management of the WRL Project, RTD focused on:

- Contingency adequacy and management
- Change order management

The WRL was the first corridor to be built in the FasTracks “Program of Projects.” As such, the team had to address many issues requiring development of procedures during the course of the project, including revisions, and many of the processes developed during the project have been carried over to other FasTracks projects.

Contingency Adequacy and Management

RTD started with $32 million of contingency for the WRL Project and allocated 4.0 percent of project costs (or 7 percent of construction costs) rather than the traditional 10 percent contingency. This helped hold costs to a level that met the FTA Cost Effectiveness rating for the FFFA. RTD managed this contingency closely and performed ongoing VE and cost containment to ensure the allocation would be adequate. Managing a project with such a low contingency and numerous outstanding risks was a major accomplishment on the part of the project team.

The FTA and the Project Management Oversight Consultant (PMOC) had concerns over the limited amount of contingency in the project budget and RTD’s ability to successfully manage the project with so little contingency. Several risk assessment workshops were conducted to demonstrate to the FTA/PMOC how the project would manage the contingency through the life of the project. A risk register was created and updated monthly to monitor projected contingency drawdown. Contingency drawdown charts were developed to project and track contingency over time. Value engineering and cost containment were used extensively to reduce costs during construction, and project staff actively searched for monetary credits from the contractor where appropriate.

Regular “budget scrub” meetings were held with the assistant general manager, project manager, and project controls manager to review the contingency. These meetings focused on the contingency status with an emphasis on remaining outstanding risks. These budget scrub meetings provided an excellent means to review the project, budget and remaining project risks with senior management.
With a limited contingency budget, the project staff had to manage deliverables in detail, while ensuring the work was completed on budget, and that cost cutting opportunities were constantly identified to stay within budget. To assure the Estimate to Complete (ETC) dollars were correct and to eliminate unforeseen budget costs, project reporting included details of each potential change and potential risk, backed up with estimates. To keep the project on budget, mitigation measures were initiated to minimize budget overruns, and to give project controls time to identify cost savings in other areas of the budget.

RTD began planning two years in advance to mitigate risks. Some items were added to the risk register late in the project. An example would be additional work required for at-grade crossings. During construction it was identified that changes at the crossings would be necessary. This item was added to the risk register and a conservative preliminary cost estimate prepared. As the scope was fully understood, detailed cost estimates were prepared and funding was identified.

In the end, the total contingency was adequate since the project was completed on budget. No money remained at opening day. RTD attributes this to the risk management program, the working relationships within the agency and with the project contractors. Extensive use-of-cost containment, along with VE and CO management, were instrumental in beginning revenue operations with a zero balance in the contingency and no cost overruns on the project.

**Change Order Process**

RTD developed a formal change control process. This included a change control board (CCB) that included representatives from all project disciplines and a contract requirement for formal written authorization to proceed with out-of-scope work. The project manager was given authority to ensure quick decision-making while maintaining proper oversight. A major benefit on the project was full budget authority delegated by the RTD Board of Directors to the RTD general manager. The general manager delegated this authority to the assistant general manager. Similar authority was provided for ROW acquisitions. This meant RTD Board approval was not needed for any COs unless the cumulative amount exceeded the approved project budget. This facilitated decision-making needed for such a large, complex, and fast-moving project.

All potential contract changes were reviewed by the CCB. This ensured the proposed change was processed in accordance with the contract, the change was necessary, impacts of the change were properly analyzed, and the cost of the change was fair and reasonable.

Each CO was assigned to a discipline manager who worked with a contract administrator. The discipline manager “owned” the CO and signed off on the resolution.

RTD provided the CM/GC with $3 million to bear all risks associated with COs. This made the approval process simple and quick in most cases. The systems contractor was not included under an “all-risk” agreement, so RTD had to negotiate risk and contingency for each CO. However, the amount provided for risk in each systems CO was specifically tailored to the characteristics of the required change.
RTD fine-tuned the multiple tier mark-up applied by the CM/GC or systems contractor and each subcontractor level. The mark-up was reduced for the prime contractor and the subcontractors split the full mark-up. This proved to be an effective cost reduction tool.

There were more than 300 CO packages for the CM/GC and more than 50 for the systems contractor. This large volume of changes sometimes caused delays in processing the COs.

**The Lessons**

- Manage to the smallest details and use management tools such as risk registers and contingency drawdown charts. This enables a project to be completed with smaller contingencies than usually required on FTA-funded projects.
- Perform detailed budget reviews, at least quarterly, focusing on contingency and remaining risks.
- Perform ongoing cost reviews to reduce costs while delivering the necessary value.
- Provide escalation ladders in the partnering framework to enable senior management to focus on larger, more critical issues while resolving project issues at the lowest level possible.
- Make approval and authority levels for the project manager high enough to limit opportunities for micro-management by the program office, but sufficiently low so the senior manager of program management and assistant general manager of Capital Programs are involved in all major changes.
- Develop and use a formal, structured CO process including a CCB.
- Ensure that both the schedule and the budget are delineated to the proper work breakdown structure (WBS) level, including COs, so staff can compare actual dollars spent to projected completion dollars, evaluate if dollars are being expended at an appropriate rate, and mitigate potential overruns.
Lesson #4: Project Organization and Staffing

Lesson Overview and Background
FasTracks decentralized decision-making as much as possible to the project level and provided oversight at the program level.

Figure 4-1 shows the specific project organization for the project.

It is sometimes difficult to decide how much autonomy to allow at the project level. Those overseeing the project at the program level are concerned about cost and schedule overruns, construction flaws, safety issues, environmental impacts, and a host of other things. However, FasTracks managers decided to take a more decentralized management approach based on the following assumptions:

- Those closest to the problem are better able to understand the issues and so should be able to make quicker, more informed decisions than those at the program level.
- Adequate and competent resources are provided at the project level.
- Project level personnel are encouraged to seek advice when their decisions impact other projects or when they are not able to reach a satisfactory solution at the project level.
- Program level oversight is maintained through systematic approaches including regular senior management reviews of project budget, schedule, quality, and so forth and by performing regular internal audits. Program office management participate in regular executive partnering sessions with project contractors and interact with stakeholder elected officials and are included in the project partnering escalation ladders.
- Approval and authority levels for the project manager are high enough to limit opportunities for micro-management by the program office, but sufficiently low that the senior manager of program management and assistant general manager of Capital Programs are involved in all major changes.

The Lesson
The FasTracks approach to decentralized management has resulted in staffing the project offices with the right resources to effectively do the work and make expeditious decisions. Those at the program level are available to provide assistance as necessary. This approach, along with the escalation ladders in the partnering framework for each project, has allowed senior management to focus on the larger, critical issues. This has proven to be an effective and efficient management structure for FasTracks projects, as demonstrated by the completion of the West Rail Line Project within budget and ahead of schedule.
Lesson #5: Public Information Process

Lesson Overview and Background
The West Rail Line Project public information/public involvement (PI) program was a comprehensive communications program and included an array of strategies and activities related to public outreach, safety, rail crossings, public involvement, media relations, government relations, internal communications, issues management and crisis communications.

The PI Program operated at two levels: a program team that established and implemented the PI and outreach activities at the FasTracks program level; and a project team to facilitate day-to-day corridor level PI efforts with project stakeholders and residents.

The Environmental Impact Statement (EIS) was critical to the success of the project. Public outreach was an inherent part of the EIS. The communities along the corridor were active and vocal about the way they wanted the project to look and how they wanted it integrated with their neighborhoods. The project completed the EIS process in 2004. Then an almost two-year period ensued from the end of the EIS to the beginning of the final design phase, which presented a communications challenge – conveying to project stakeholders and residents how their participation evolves from the extensive public involvement during the EIS process to a narrower approach in design and construction.

Safety was a particular concern due to the heavily residential nature of the corridor, the large number of schools, and the desire of the residents to have “quieter crossings.”

The WRL Project passes through a mix of low- and medium-density neighborhoods with nearby schools and light industrial areas. Meeting the needs and desires of the residents, businesses and stakeholders was challenging. The two main focus areas for PI were:

- Outreach
- Safety

Outreach
The RTD FasTracks PI program was developed to establish and maintain a high level of communication with and outreach to project stakeholders throughout the implementation of the FasTracks program of projects. Effective communication was an essential part of keeping communities connected and engaged throughout the West Rail Line Project EIS, design, and construction, thereby ensuring public confidence and identifying and resolving issues and concerns.

RTD held meetings with residents and stakeholders along the proposed West Rail Line as part of the EIS and design processes. During the design meetings RTD sought design inputs for stations, walls, crossings, and other portions of the line. The local residents were active, vocal and eager to participate on an RTD-proposed urban design committee. In fact, the level of interest was so
high RTD went to large group meetings, eventually holding 16 meetings along four sections of the project.

During these meetings, residents provided significant input to the station designs. They chose between interurban and neighborhood design features and unique features for each station, such as glass block for entry areas and wall designs. Unfortunately, when the GMP was received from the CM/GC, and price negotiations completed, the project was over budget, so VE/cost containment processes needed to be implemented. These processes entailed deleting many features the design committee members had approved.

Reducing input from the urban design committee caused RTD major credibility issues with the neighborhoods and residents. The location of the rail line in an urban/residential corridor and the need to close streets caused many headaches for residents. Placing equipment in, or close to, streets, had a big impact on residents since their homes are close to the street. Keeping residents informed via flyers, door hangers, newsletters, and electronic communications was helpful, but the key was getting streets re-opened as quickly as possible.

RTD started monthly stakeholder meetings to keep the local jurisdictions involved and informed about the progress of design and construction, and later added public and elected officials. This helped rebuild public trust after the design impacts of the GMP negotiations and worked well.

Based on experience from the Transportation Expansion (T-REX) Project, RTD offered property owners the opportunity to opt out of having sound walls in lieu of a cash payment, or being reimbursed for their own improvements. About half of the property owners opted out of sound walls. This benefited the residents and RTD. The residents’ desire to not have a large concrete wall in front of their house was met and by not constructing the wall (even with the cash payments) saved RTD money. An unintended benefit from this effort was that sound walls were eliminated at grade crossings which increased the visibility and ultimately the safety of these crossings.

Public perception of the proposed parking garages at two of the LRT stations diverged significantly from the actual designs, most likely due to stakeholder design presentations and public input at those presentations. However, through ongoing interaction with stakeholders and cities, the Wadsworth and Sheridan garages were completed within budget, and with aesthetic standards supported by the community.

RTD started with several different LRT station designs to blend with the surrounding neighborhood, but ended up using the same design for all stations. While the final stations are aesthetically pleasing, the local residents were not completely happy with the results.

**Safety**

**School Outreach**

School outreach began early in the project and continued through opening day in April 2013. RTD PI staff worked closely with school district staff and with staff at individual schools.
During construction, RTD distributed safety posters in the schools, offered field trips to see construction, provided information tables at back-to-school nights, and sent flyers to parents. Starting a year before opening day, RTD PI staff conducted Safety Road Shows with Operation Lifesaver and the local police and fire departments. RTD’s portion included a portable “mock crossing” which simulated the bells and gates of a rail crossing to teach hundreds of school children (K-8) living within six blocks of the alignment how to safely cross the tracks and look for trains. Children received safety coloring books, informational packets, and temporary tattoos of the safety mascot, FasTracks Freddy.

During pre-revenue operations, local schools were offered field trips to show children the stations, how to board and exit a train, and how to safely cross the tracks at actual crossings. The trips also allowed children to ride on a light rail train. Involving the children, and by extension their parents, in learning safe crossing procedures is critical to avoiding accidents. School-based programs provided RTD the opportunity to talk directly to children and explain how the crossing gates work, what the bell sounded like, and how to be safe around light rail.

The Lessons

- Managing the expectations of the residents, businesses, and stakeholders along a corridor is critical to ensuring and maintaining public support for and acceptance of a project.
- If a design committee is used, closely manage the expectations of the members. RTD has not used citizen design committees on other projects. If the public is given the opportunity to provide input on design elements, make sure they are items that the agency will be able to change based upon their input.
- Early interaction and agreement with key stakeholders and third parties regarding project scope, alignments, and stations is critical. This helped avoid project delays as the project progressed.
- When dealing with the public, it is always better to under-promise and over-deliver. Nowhere was this more evident than in the public outreach/input process. In a number of instances RTD made promises that proved to be financially unsupportable.
- Letting the public know their support and tolerance are appreciated goes a long way toward gaining cooperation. RTD communicated extensively and often, using door hangers, emails, newsletters, and construction notices, as well as special events like barbecues, to thank residents for their patience.
- Develop a school-based program to educate K-8 students in safe behavior near rail lines.
- Convey to stakeholders—early on—that they may need to come up with money if they want design changes or enhancements.
- Offer residents limited choices in station designs and make those options standard across all stations along a line.
- Offer cash or other options in lieu of sound walls. At the same time, ensure these opt outs make it into the design.
- Maintain planning and environmental staff participation throughout the project.
Lesson #6: Working with Public Stakeholders

Lesson Overview and Background
RTD’s FasTracks Plan approved in 2004 assumed impacted jurisdictions would contribute an amount equal to 2.5 percent of eligible corridor costs. The details of such contributions, as well as other coordination requirements, are documented in formal contracts known as Intergovernmental Agreements (IGA). On the West Rail Line Project, RTD entered into IGAs with the City and County of Denver, the City of Lakewood, the City of Golden, Jefferson County, and CDOT. One provision in the CDOT IGA that was very successful was establishment of a full-time Project Liaison, paid for by RTD.

Stakeholder Coordination
Stakeholder coordination on the project was challenging. Stakeholders had differing expectations, particularly in areas such as drainage, roadway and sidewalk construction. Interface with stakeholders required a major effort on the part of RTD management. There were several tools the team used to address issues. This included IGAs that define the legal obligations of each party, regular small stakeholder meetings to work through issues with staff, and quarterly briefings for elected officials. A partnering process with stakeholders was conducted in a limited fashion. RTD believes that on any large transit project built in an urban area working with stakeholders will be a major challenge that requires much attention.

Coordination with the Colorado Department of Transportation (CDOT)
RTD has had a long and positive working relationship with CDOT. The two agencies have coordinated many projects, the most notable being the T-REX Project. On the West Rail Line Project, close coordination with CDOT enabled rebuilding of certain bridges and other infrastructure in concert with light rail construction. This minimized inconvenience to the traveling public and local neighborhoods, and provided maximum value to the taxpayer.

The use of a dedicated CDOT project liaison co-located with RTD’s project team improved coordination of needed design reviews, permits, joint usage of ROW, construction oversight, and management of CDOT-funded improvements. This position was empowered to decide lane closures and accept work and use of CDOT ROW. This person was able to quickly process requests within the same day if the request was above his authority. CDOT treated the project as an “internal” project, speeding approvals and eliminating many routine requests. In addition to the project liaison, RTD paid for additional CDOT staff when needed, co-locating key CDOT staff in the project office.

Another activity that facilitated communications between RTD and CDOT was a monthly meeting between RTD senior management and CDOT regional managers. This meeting alternated between RTD and CDOT locations, sharing required travel between agencies.

Since the West Rail Line Project was part of the larger FasTracks program, CDOT also assigned a FasTracks program liaison, housed at the RTD FasTracks office. This role helped coordinate
IGAs for all FasTracks projects, establish the agenda for the monthly coordination meetings, keep RTD abreast of upcoming CDOT projects, and keep CDOT apprised of the current status of FasTracks projects.

**The Lessons**

- Have full-time liaisons from key stakeholders such as CDOT, and co-locate them with the project team. These liaisons need to be empowered to make routine decisions and have access to home office staff that need to be involved in more complicated decisions.
- Define roles and responsibilities for the liaison within the IGA.
- Invest in additional stakeholder staff during peak work periods.
- Establish a regular schedule of executive partnering/coordination meetings to ensure mutual support at all levels.
- Enhance the use of formal partnering with stakeholders when issues are challenging.
Lesson #7: Right-of-Way

Lesson Overview and Background
RTD’s Real Property group manages real estate holdings and oversees all transactions related to buying, selling or leasing of property. When acquiring property, RTD follows federal guidance using the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 as amended (the Uniform Act); 49 Code of Federal Regulations (CFR) Part 24, dated January 4, 2005; and Colorado Revised Statutes (CRS). Both the Uniform Act and the CRS require a detailed process be followed. This process is intended to protect both the private property owner and the taxpayer. RTD only acquires land that supports construction and operation of a mass transportation system.

For the West Rail Line Project, RTD was fully responsible for all right-of-way acquisition and an informal ROW acquisition schedule was incorporated into the contractors overall schedule during the preconstruction phase. More than 200 separate acquisitions were required. Many of the acquisitions were large, complex and unique. The understanding by RTD’s Real Property group was that the schedule was to be used for informal planning, so it was not vetted in detail. Actual requirements associated with various dates included in the schedule were not fully understood by all project participants. For some parcels, "best case" dates were assumed by the CM/GC to be firm dates. The CM/GC schedule was incorporated into the contract during the GMP negotiations and created contractual requirements for RTD. When ROW was not available in accordance with the schedule, there was a potential for claims. The contractor and RTD staff worked well together to resequence the work and find workarounds for parcels that weren’t available and no claims were submitted as a result of late availability of ROW.

Relocation Complexity and Timeline
The project acquired significant parcels in both residential and light industrial areas. In some cases the property owners spent many months and years contesting the acquisition of their property. Several multi-family buildings were acquired and the relocation of all tenants was a lengthy process. As a result:

- The ROW process took 12 to 36 months for each piece of property RTD acquired
- Significant numbers of staff, including additional hires, were required to support the process
- The notification process took more time than expected and was handled with limited staff

Communication with Property Owners
Since the project line went through a mixed use (residential/light industrial) corridor, and many people had owned their properties for decades, conveying the project needs and timelines for property acquisition was a challenge. Public information (PI) staff were extremely helpful in
meeting with property owners to discuss the ROW acquisition process and the project needs. Project engineering staff was brought in to discuss design details with property owners. However, it is important to note that the eminent domain process is a legal proceeding and caution needed to be taken in discussing any of the details of an acquisition.

To mitigate this difficulty on other FasTracks corridors, RTD has:

- Developed communication guidelines to ensure compliance with the specifications of the Uniform Act and early, proactive communication with stakeholders and potentially impacted property owners.
- Started using meetings with stakeholders and property owners/residents to discuss design issues and answer questions about the property acquisition process.
- Created processes to handle contentious or disputed acquisitions.

The Lessons

- Communicate early and often with stakeholders, property owners and residents.
- Establish processes to deal with contentious or disputed acquisitions.
- Hire additional staff earlier in the acquisition process.
- Ensure a formal, approved schedule for acquisitions is included in the contract with the contractor. Establish firm dates that will be met to avoid potential claims. Litigation is always the last resort and is expensive but the decision of whether to file for immediate possession needs to consider the effects on the project schedule. Ultimately, the decision must be made by the project manager who is responsible for the budget and schedule in conjunction with the ROW manager.
Lesson #8: Rail Crossings

Lesson Overview and Background
The West Rail Line Project rail crossings presented some significant safety and coordination considerations since the line passes through low-density residential areas for much of its 12.1-mile length with a considerable number of at-grade crossings.

In order to meet the needs of residents and stakeholders, minimize construction delays, and ensure acceptance of crossing designs, RTD coordinated closely and regularly with the Colorado Public Utilities Commission (PUC). The PUC has jurisdiction for Rail Safety and is the State Safety Oversight (SSO) agency in Colorado. The PUCs approval is needed before any crossing-related construction activities begin.

RTD and its contractors maintained an exemplary safety record for the duration of the project. The WRL project is the only line that remains accident-free more than one year after starting revenue service. Following an accident which occurred during pre-revenue testing in Salt Lake City, RTD formed a safety task force to ensure compliance with new FTA requirements and directives.

The West Rail Project Approach
There were three safety considerations for the project:

- Comply with EIS commitments to not use train horns and audible bells
- Coordinate with the PUC for approval of crossing designs
- Overall safety procedures

“Quieter Crossings” and At-Grade Crossings
The WRL Project originally had 11 crossings designated as “quieter crossings.” During the course of construction and testing, two more crossings were added to the list of quieter crossings. Although the crossings are not subject to the FRA Horn Rule, the crossings were designed to meet the requirements to establish a Quiet Zone. This provided excellent safety for vehicles. In many areas, particularly Lakewood, the WRL passes through built-up, residential neighborhoods. Using a full volume horn and bells, as is standard at other crossings, would have been disruptive to the neighborhood. Therefore, the use of quieter crossings was an environmental mitigation RTD agreed to in the EIS. This mitigation had to be weighed against the potential safety implications of having no audible warning at a crossing.

RTD coordinated early with the PUC to evaluate crossing designs that did not use any audible signals, but the PUC did not accept that approach. The PUC held public hearings to get input from the community about the type of audible indicators residents and the disabled community would find acceptable. RTD established an ad-hoc committee of city staff, neighborhood organizations, representatives from the blind community and RTD staff. This committee explored options that would meet the expectations of all groups. A unique solution was found: directional bells that would adjust based upon ambient noise levels. This solution met the needs
of the residents by directing the sound at the crossing and provided an audible warning to pedestrians with limited or no sight. A traditional bell radiates sound in all directions at a constant high sound level.

The PI approach used by RTD and the hearings held by the PUC were very effective since there was no public opposition to the “simulated bell sounds” solution.

**Public Utility Commission Approvals and Coordination**

The PUC meets frequently but has many agenda items to consider. RTD maintained a policy of talking to the PUC staff as early as possible to get general agreement on crossing treatments and to avoid potential project slowdowns. By the time the actual design was completed and the application for approval submitted, most issues related to crossings had been identified and resolved.

In a few instances, construction was started without obtaining PUC approval of the crossing design. PUC rules prohibit the start of construction at a crossing prior to receiving PUC approval, unless a specific order allows that construction. The designs were eventually approved, but had changes been required, there could have been schedule and/or cost impacts. RTD modified its construction procedures to assure work would not begin prior to PUC approval.

**Project Safety Processes and Procedures**

**System Safety Processes, Requirements, and Certifications**

RTD used a System Safety Working Group (SSWG) for the project. This SSWG included representatives of the project team: design, operations, contractors, safety and project staff. This approach has proven to be effective on past transit projects. The SSWG met monthly in the early stages of the project, then weekly, and finally daily as the WRL neared testing and start-up. Using the SSWG ensured compliance with system safety processes, requirements, and certifications for design criteria, hazard analysis, and threat and vulnerability assessments.

RTDs Safety, Security and Facilities Department assigned a full time manager to lead this safety oversight process, which was critical to the success of the safety program.

**Working with Jurisdictions**

Since “quieter crossings” were a key component of the project, RTD worked closely with the City of Lakewood to determine which crossings would qualify while still ensuring safe operations. In addition, RTD staff provided special education and field trips for children at nearby schools to make sure they knew how to cross the tracks safely.

**Overall Safety Record**

The West Rail Line Project posted an exemplary safety record during all phases of project design, development, construction, testing, activation and start of operations. This outstanding safety record has continued through the first year of revenue operations.
The Lessons

- Get the design of each crossing completed as soon as possible since PUC approval can take months. In the case of the West Rail Line Project, RTD committed in the EIS to use “quieter crossings” in residential areas. Early design submission enabled the PUC to hold public meetings and solicit valuable input from the blind and other disabled communities and to consider these needs when approving crossing designs.

- Always coordinate with the PUC, or similar railroad safety oversight organization, before beginning construction. Don’t start construction of any crossings without PUC approval. Approval is not guaranteed, and following the PUC’s rules makes for smoother relationships and coordination. If approval is not given, there could be significant project delays. Approval of crossing designs is needed to enable timely access to the rails for moving equipment and material that is too heavy or bulky to move via area roads. Being able to use the rails to move from staging area to other staging areas or construction sites minimizes or eliminates the need for road closures to move equipment and materials.

- A study on crossings was conducted with the City of Lakewood to identify potential quieter crossings and get resident feedback. This was highly productive, although residents who may not have participated went to the PUC later to request additional quieter crossings. The study showed quieter crossings met PUC and other safety requirements.

- Have systems safety participate in the project from early design through start-up, testing, and revenue operations.
Lesson #9: Environmental Conditions and Contamination

Lesson Overview and Background

Much of the WR alignment lies in ROW used by the former Denver Tramway Company and its predecessors for interurban service from 1893 through 1950. After passenger service ended, the Associated Railroad continued to use it as a freight corridor for a few more years before the line eventually became dormant. The corridor’s past history as a rail line meant there would be significant potential for encountering recognized environmental conditions (REC), hazardous waste and other adverse situations.

The WRL project passes through a mixture of low-density residential and light industrial buildings with many residents and businesses accessing the ROW and potentially performing dumping or other unacceptable environmental activities. Significant clean-up was required for the relocated Burnham Yard Lead and at the Denver Federal Center [which is under a consent order by the Colorado Department of Public Health and Environment (CDPHE) and had to be cleaned to residential/federal standards]. A Phase I Environmental Site Assessment (ESA) was completed along with the EIS and the Phase II ESA was completed during design. These reports were available during the EIS and design phase and prior to construction.

The environmental testing and remediation process was not started until the construction phase. Once the process began, RTD held regular coordination and problem resolution meetings. Day-to-day presence of an environmental specialist is essential, as is problem resolution at the lowest possible level.

RTD developed a Voluntary Clean-Up Plan (VCUP) prior to beginning construction. Note that VCUPs typically apply to contiguously-owned property and not to properties owned by third parties unless they give written consent and obtain CDPHE approval. The benefit of having a VCUP in place and approved by CDPHE prior to starting construction is that when materials are encountered, the process for remediating them has been approved. In the absence of an approved VCUP, CDPHE approval would be needed each time a contaminated material is found. The WRL project VCUP applied to most of the corridor, but not to the Denver Federal Center. Since the Federal Center is under a consent order by CDPHE, it had specific remediation protocols that were stricter than RTD’s industrial standards. This information was made available during the design phase. The Federal Center property had to be brought into compliance with residential environmental quality standards—much more extensive and expensive than envisioned under the VCUP. In addition, requirements at the Federal Center precluded reusing some of the excess material, which created an additional expense for unnecessary disposal.

The age of the buildings along the corridor that were to be demolished meant significant amounts of asbestos inspections and abatement. All buildings scheduled for demolition in Colorado must be inspected for asbestos prior to demolition, and if necessary abated prior to demolition. While these costs were within budget, the removal had adverse schedule impacts due to the number of building demolitions required for the project. Colorado has very strict asbestos testing and
abatement requirements, so there were on-site inspectors during the entire process. In addition, RTD became responsible for securing and maintaining these derelict buildings while mitigation was ongoing. On other projects, this had typically been the contractor’s responsibility.

RTD decided to remove the environmental scope of the WRL project from the CM/GC contract. This approach enabled RTD to use one of the two environmental firms maintained under contract. There were pros and cons to this approach, however. Using the RTD environmental consultant removed the CM/GC’s mark-up. However, removing control of the process from the CM/GC resulted in schedule issues since the CM/GC could not immediately and seamlessly stage the environmental evaluation, testing, mitigation, and clean-up in the most advantageous way. There were several schedule challenges to provide workarounds for the CM/GC when the environmental mitigation was being performed by RTD.

Using the contracted environmental consultant had an unintended consequence — one RTD did not anticipate. Every time the CM/GC encountered (potentially) hazardous waste or other RECs, the CM/GC had to stop work until assessment and clean-up were completed. These work stoppages could have potentially impacted the schedule and caused significant claims to be made by the CM/GC. In RTD’s experience on other corridors, a contractor could have better integrated this work into its schedule and proceeded more expeditiously. On subsequent FasTracks corridors, RTD assigned this responsibility to the contractor and did not experience schedule impacts.

In addition, RTD was often risk averse, which added to the potential for delays and more costs. The original budget for hazardous materials was significantly exceeded.

It is important to be innovative in addressing environmental conditions. When an unexpectedly high amount of hazardous materials was discovered adjacent to Paco Sanchez Park, the project team developed an alternative alignment profile. This significantly reduced the need to excavate hazardous materials and saved the project several million dollars.

The Lessons

- On all corridors RTD developed the VCUP, performed the Phase I and II ESAs, and monitored contractor compliance with the VCUP. Contractors may perform additional environmental testing, obtain permits, perform and/or monitor the clean-up activities, and ensure compliance with the VCUP. Regardless of whether the contractor performs the work, RTD is ultimately responsible for regulatory compliance.
- Avoid “historic landfills.” There is no way to know what may be found in a 125-year-old corridor heavily used for freight rail, industrial, transit, and other purposes.
- Avoid sites under a “compliance and consent order” since they have much stricter clean-up requirements and are not covered by the VCUP. This includes sites owned by third parties such as the Denver Federal Center. It is acknowledged there may be limited opportunities to change the alignment or station locations.
• Assure there is contractual capability for the contractor to perform the environmental remediation and share in the schedule risk for this work. Contractors have a better ability to start the work sooner and to integrate work into their schedule.
• Provide more training to subcontractors about proper site access.
• Develop and get CDPHE approval of a standard VCUP and other standard operating procedures (SOP). RTD has done this. All VCUPs for the remaining FasTracks corridors were developed by RTD with standard requirements. RTD's asbestos contaminated soil SOP has been approved by the CDPHE for all RTD properties.
• Have an environmental compliance officer on site during construction. If possible, also have this person participate in the design and design review process. Have this person involved in day-to-day activities beginning during the design phase.
Lesson #10: Value Engineering and Cost Containment

Lesson Overview and Background
The West Rail Line Project was cost-constrained to meet the requirements of and remain competitive for a FFGA. As a result, cost containment was a major focus of the project. Given the FTA’s New Starts rules at that time (2008-2009), RTD most likely would not have received an FFGA if costs for the project were not reduced.

This requirement, along with rapidly escalating material costs, resulted in several major VE changes and scope reductions. The most significant change was single-tracking the section from the LRT station at the Denver Federal Center to the Jefferson County Government Center end-of-line LRT station. RTD determined that projected ridership on this segment could support a longer headway and be served by a single track. Nonetheless, it is recognized that single-tracking is a less-than-ideal operational provision. RTD acknowledged this difficult decision had to be made in order to afford the line. After difficult negotiations with stakeholders, an IGA was signed which defined ridership levels requiring RTD to build a second track.

Other reductions included LRT station esthetics and amenities. This resulted in additional challenges with local communities that had higher expectations for the stations.

One item eliminated and eventually reinstated was the communications or Supervisory Control and Data Acquisition (SCADA) system. RTD saved $10 million by eliminating the SCADA system. However, RTD realized this would be burdensome on train operations. Therefore, the SCADA system became the highest priority for reinstatement. RTD eventually identified funding to reinstate SCADA. It was challenging because not all the funding was in place when the West Rail Line Project schedule required commitments for the work to start and continue. RTD authorized the project to proceed even though some risk was associated with this decision. However, had authorization to proceed not been given at that time, future implementation would have been prohibitively expensive and the SCADA system would not have been completed by opening day. This approach required close cooperation by the systems contractor and resulted in the successful implementation of SCADA.

The cost containment effort continued through construction of the project. Due to the extremely low contingency, RTD staff diligently sought other ways to save money. Walls in the final design received a great deal of focus given the costs within this area. Ideas were presented by the contractor but were not incorporated into the final design. RTD would have received the full amount of the savings if the changes were made in final design and included in the GMP negotiations. However, significant cost savings during construction were shared with the CM/GC.

The Lessons
- Identify VE/cost containment changes early in the design process to ensure the savings accrue to the Owner.
A mandatory reduction in a project budget is a very challenging process.
Explain the budget to all parties to facilitate acceptance of necessary changes.
The Final Design Consultant must be open to suggestions made by the contractor. It is preferable to procure the design contract knowing the project will be a CM/GC.
Lesson #11: Rolling Owner Controlled Insurance Program

Lesson Overview and Background

The Owner Controlled Insurance Program

The FasTracks Program of projects utilizes a Rolling Owner Controlled Insurance Program (ROCIP). The benefit of an OCIP is that the cost of the insurance is paid once for the entire scope of work instead of each subcontractor firm obtaining its own insurance. Also, the project crossed BNSF ROW and Railroad Protective Insurance in the amount of $20 million was required. It is more cost effective to purchase one umbrella policy for all the work that would occur in the railroad ROW. A safety expert was hired through the OCIP to work on the entire FasTracks program. This person worked closely with the contractor’s safety manager and ensured compliance with insurance requirements. Overall, the OCIP saved RTD money, but it placed liability on RTD since deductibles were not paid by the contractors.

RTD anticipates the eight-year completed operations on its insurance policy will pay $1.9 million back early, with approximately $2 million held for the duration. Claims on the project were few and minimal in cost. Both civil and systems, and the strong emphasis on construction safety by RTD and the project team, are largely responsible for the excellent safety record of our contractors.

RTD hired a third party engineering firm to inspect damages and to determine cause(s). These claims and recommended settlements were reviewed by RTD Risk Management and the insurance carrier. Initially, the work of the third party engineering firm was performed without consulting with the project staff. These reports could have benefited from reviewing the issues with personnel who had knowledge of all activities. This coordination improved as the project progressed.

Also, a structural engineer was hired to perform pre-construction surveys of the structural condition of buildings along the alignment. The scope of work entailed reviewing the entire alignment, construction methods that would be used in each segment, identifying typical structures that would represent a group of structures (a subdivision where houses were all constructed around the same time with similar construction methods) and unique structures that would require inspections.

The RTD PI staff assisted in contacting property owners to obtain permission to perform the inspection. Not all structures along the alignment were inspected and this caused some confusion. Some property owners requested a house inspection but they were not on the list selected by the structural engineer. Properties were inspected prior to the start of construction and provided a baseline if damage claims were made. The structural engineer prepared notes from these inspections but did not produce reports.

The Subcontractor Performance Self-Insured Program
Traditionally, Disadvantaged Business Enterprises and Small Business Enterprises (DBE/SBE) have a difficult time obtaining appropriate insurance and bonding. In addition to the OCIP, RTD developed a bonding program—the Subcontractor Performance Self-insured Program (SPSP). The program was designed to save RTD money while helping small companies who couldn’t get bonding or who were maxed out on their bonding limits.

Eventually it was changed to apply to any contract of $500,000 or less. Even in cases where a company could get bonding on its own, RTD required that it participate in the SPSP. Each subcontractor had to submit paperwork typical for obtaining bonding. RTD hired a consultant to evaluate the paperwork. Subcontractors who did not meet the minimal requirements for the program could still work on the project, but were required to get their own bonding at no additional cost to RTD.

RTD checked with the subcontractors on a weekly basis to ensure they were paying their bills, taxes, insurance, employees, and so forth. Being proactive with the subcontractors ensured there would not be claims. This program was self-insured by RTD and a loss fund for the SPSP and ended up with no claims.

### Dealing with Theft

Theft of copper was a major security concern. It is difficult to effectively monitor 12.1 miles of rail and associated overhead lines. In one case, two people cut out several sections of copper OCS wire, costing the project over $1 million in deductibles. Theft of copper turned out to be one of the largest claim areas on the West Rail Line Project. In addition to the security provided by the contractor, RTD added security patrols at night and worked closely with local law enforcement agencies which resulted in the arrest and conviction of two individuals who stole the catenary wire.

The ground wire for each catenary pole was also a target for theft. The recycle value of copper for each of the ground wires was about $1, but the cost to replace was over $200. The typical detail on previous projects was to have the bare copper wire on the outside of the catenary pole foundation. After the theft, the design for remaining foundations and for the repairs was changed. RTD is taking these additional steps to mitigate and reduce theft on other FasTracks Program projects.

### The Lessons

- Always stay focused on construction safety. Hire contractors with good safety programs and records.
- An OCIP or CCIP should be used on large projects to reduce redundant insurance costs.
- Develop policies and procedures for claims handling under an OCIP program to ensure project team input to reviewer’s findings. It is critical to have the project review of all reports before they are released outside the organization.
• Establish a fund to pay deductible amounts so that claims can be resolved quickly and ensure that all departments (Capital Programs, Risk Management, Accounts Payable, Legal and Procurement) understand the procedure for payment of deductibles.

• A bonding program can be effective in helping small and disadvantaged subcontractors to work on a large government project. Be proactive with subcontractors to ensure they are meeting their financial obligations.

• Energize the overhead catenary system (OCS) at the earliest time possible to lessen the chances of OCS copper theft. Also, consider other measures such as design changes to the OCS grounding wire, better securement of manholes, and in protecting materials on other projects.

• Coordinate security on the line with the agency’s Transit Police and local police jurisdictions.
Lesson #12: Activation and Testing

Lesson Overview and Background
Activation and testing are critical start-up activities that cross all departments at RTD. Key areas of impact and cooperation included:

- Safety certification program
- Completing all integrated testing
- Completing all construction activities
- Coordinating operations staffing and budget
- Performing an operations and safety readiness review

Based on RTD’s experience with T-REX and the decision to split the civil and systems contracts, RTD decided to perform integrated testing using agency staff. This involved 22 at-grade crossings, with just two months to perform this testing (in a Colorado winter). RTD performed integrated testing on the crossings, OCS, signals, and communications systems. A detailed Integrated Test Plan was developed which specified test descriptions, resources needed and criteria for success. The contractors provided a supporting role and were required to address any issues identified during integrated testing.

Once integrated testing with trains started, it was imperative to control contractor access to ROW. The project team used a permit system similar to that used by the Rail Operations Department. A weekly meeting was held on Thursdays to schedule track access for the following week. If requests were not made at Thursday meetings, they were only granted in emergencies. The weekly meetings are still used by RTD Rail Operations for the entire system.

Overall, the integrated testing program went well. Identified issues were readily addressed by RTDs contractors. The contractors were responsive, but it would have been desirable to require them to have a qualified staff member attend each integrated test. Since the CM/GC contractor’s work was substantially complete, the need for on-call support from the CM/GC became apparent, particularly when a late addition or change was needed for Safety Certification of the rail line.

The integrated testing was completed largely within the two months allotted in the schedule. The WRL project was turned over to Rail Operations, allowing them almost two months for pre-revenue testing, which included training, certification of train operators, emergency drills and simulated service. Revenue service started on-schedule.

Rail Operations provided excellent support to Capital Programs throughout the project, and particularly during the integrated testing period when resources such as trains, train operators/supervisors, and wayside maintenance personnel were needed on site to complete the integrated testing procedures.
Also, the assistant general manager rail operations and assistant general manager Capital Programs noted it would have been beneficial to have a senior rail operations manager work on the project in a major role from the beginning. There are so many decisions that affect rail operations on any rail corridor. This has been addressed on subsequent corridors by hiring a senior manager within the rail operations department, but funded through the FasTracks program.

Following an incident in Salt Lake City, RTD management directed a thorough review of WRL project safety and operating procedures for pre-revenue and revenue operations. RTD contacted APTA for this peer review. A panel of safety and operations experts from other transit agencies across the country was led by an APTA facilitator. This review focused on procedures, testing plans and results, and public outreach. The peer review team validated that RTDs approach to safety and operations for the WRL was sound and provided ideas for improvements.

RTD used a new approach to integrated testing, start-up, and revenue service. RTD performed “pre-integrated testing” and then issued a certificate before going into integrated testing to prove the readiness of the WRL project. This was favorably received by FTA as it documented how RTD had a formal process in place before the first train operated on the line, had the right people involved, and open items were identified.

FTA was involved with activating and testing of the WRL. From the Region 8 office, the PMOC conducted Oversight Procedure 54 (OP54) – Readiness to Enter Revenue Operation and FTA headquarters Office of Safety and Security conducted a Safety and Security Readiness Review (SSRR). FTA was revising OP54 during the construction of the West Rail Line. FTA and RTD staff worked together on a draft of OP54 that was based upon experience with the project. This review focused on traditional requirements for projects with a FFGA and lasted over a year. The SSRR was focused on safety and security issues related to beginning revenue service. A site visit was conducted by the SSRR review team and a report published with items that required a response from RTD. The SSRR review lasted several months. Both of these processes were new to FTA under MAP 21.

The West Rail Line Executive Safety Committee was created as a subcommittee to the RTD Safety Committee to monitor all tasks and schedules essential to the successful opening of the WRL project. The committee included representatives from each department within RTD and was led by the assistant general manager for safety, security and facilities. Meetings were held monthly until six months before the scheduled opening day at which time they were held bi-weekly and more often, as needed. The meetings served as a forum for each department to understand the schedule and determine what they needed to accomplish prior to opening day. FTAs oversight, which required extensive coordination and documentation, was also monitored through the activation process. The West Rail Line Activation Committee was successful as evidenced by the on-time start-up of the project. The successful opening of the project has become a model for other agencies to consider as they prepare their rail start-up projects.
The Lessons

- Perform a thorough review of safety and operating procedures for integrated testing and pre-revenue and revenue operations.
- Start activation and testing planning and processes at least two years in advance of the projected opening day. Set up a formal rail activation team with high level agency support and representation from each department and division affected by the new line.
- Develop a detailed Integrated Test Plan which should include each test description, resources needed, and criteria for success. The certification process for entry into integrated testing and pre-revenue testing and ROW access control procedures (if applicable) should be included in the Integrated Test Plan.
- No matter which entity [Agency or contractor(s)] performs testing, make sure the contractor has appropriate personnel on-site to make needed repairs and fixes. Make sure this is a contractual requirement for this support. Have an on-call contractor available to make small changes.
- Projects with a FFGA should expect OP54 and SSRR review from FTA. Significant agency staff time is required to work with FTA for these reviews. The amount of documents to be reviewed under OP54 is substantial (RTD used a 2 TB hard drive to transfer documents to FTA) so a sophisticated document control system is necessary.
- Be prepared for unexpected costs and requirements. This means having even more detailed testing and activation plans (both operations and safety), allowing a two-year planning timeframe, keeping at least two years of detailed documentation, and performing more testing and certification at a deeper level of detail.
- Make sure there is adequate staff to control access to ROW during testing. This is essential for safety plans and goals compliance.
- Have an Operations liaison involved with the project from the outset. This is being done on current RTD projects.
- Consider using relevant professional associations to perform peer reviews (operations, safety, and so forth) early enough to make adjustments.
Lesson #13: Transit-Oriented Development

Lesson Overview and Background
The WRL project runs through a predominately residential area interspersed with light industrial facilities and the Denver Federal Center, and is bracketed by the Jefferson County Government Center on the western end and lower downtown Denver on the eastern end. Much of the residential portion is low to moderate income housing with access to basic shopping and markets.

Based on RTDs enabling legislation established by the state legislature, RTD can only acquire property for mass transit. This includes the rail guideway, stations, systems elements, bus facilities and parking. RTD cannot take private property for the purpose of development.

During the ROW acquisition process for the West Rail Line some conflicts arose because documents from local jurisdictions showed private development on RTD-owned land. As a result, RTD had to assure property owners whose land RTD was acquiring that RTD land would not be used exclusively for private development.

To avoid this contention on future rail projects, RTD prefers to work with local jurisdictions prior to initiating property acquisition to address how private development could be integrated with RTD facilities. If private development is desired by local jurisdictions, RTD would consider allowing someone other than RTD to purchase property, thereby providing greater flexibility in the future use of that property.

On a related note, the WRL project was constructed during the last U.S. economic recession (2007-2009). This encouraged several affordable housing entities, both public and non-profit, to purchase area property at lower rates than would have been possible during a healthier real estate market. As a result, several affordable housing projects have moved forward in the corridor.

The Lessons
- Partner with local jurisdictions well in advance of RTD ROW acquisition to clearly identify how RTD facilities could be integrated with development.
- Because of RTDs limited ability to acquire property, allow for someone else to purchase property to be used exclusively for private development or between RTD and private development.
- Design LRT stations through thoughtful design of parking and bus transfer facilities so as not to preclude the potential integration of private development in the future.
- Work with local jurisdictions to encourage greater flexibility in integrating private development. This can be accomplished by identifying stations with a high potential for development and by removing the parking and bus transfer facility elements of those stations out of the transit project

1 Source: Denver Urbanism blog (http://denverurbanism.com/tag/west-rail-line)
Lesson #14: Quality Management

Lesson Overview and Background
RTD has managed several large projects in the past and has developed a quality program based upon knowledge gained. Beginning with the T-REX project, RTD placed the responsibility for quality assurance in addition to quality control with the contractor on alternative delivery mega projects. This is a model has been very successful for RTD. The agency is ultimately responsible for the quality of the projects, but RTD’s role changes from full time inspection to assessing the quality of the constructed work and to verifying the contractor is following its quality management plan. Two new tools of priority planning and process audits were put in place on the WRL project.

Priority Planning
RTD has a small field staff for the project. There were only three true inspectors for the entire 12 mile corridor. As a result, it was important they remained focused on most critical activities. On past projects, the planning for inspections happened informally. For this project, a formal process was implemented. The contractor’s three week look-ahead schedule listed all of the anticipated activities.

Each activity was given a risk factor (1, 2, or 3 from highest to lowest), and sampling frequency to produce a priority list. The inspectors planned their assessments based upon the priority list. A weekly meeting was held by the construction manager with all construction staff to develop the priority plan, make assignments and review past assignments. This process ensured that the highest priority/risk construction activities were being assessed. If installation of a storm drain had proceeded without any issues, it would be given a lower priority. If there had been issues with the storm drain installation or if the pipe was being installed in a critical location, it would be given a higher priority. This process provided confidence in the quality of the finished products.

Process Audits
A process audit module in the quality management system was also added. On previous projects, the focus would be on the constructed work, the product. While it is important to assess the product, it is equally important and perhaps more effective to assess how the contractor is implementing its Quality Management Plan (QMP). The contractor was responsible for the acceptance testing and inspection of the constructed work. It is important to ensure the contractor’s QA staff is performing its work in accordance with the QMP that RTD had approved. Process audits provided a means to assess the contractor’s conformance with its approved QMP.

Acceptance Process
On the T-REX project, an acceptance dashboard was used. It was a web based program loaded with the acceptance criteria from the contract. The contractor would log into the program and provide evidence that the acceptance criteria had been met. RTD staff could use the system to accept or reject the contractor’s entries. Not only did this program provide an organized method for accepting the project, it also provided a way for RTD and contractor management to see the progress being made toward acceptance. This program was successful for the acceptance of the T-REX project.

A similar system was employed for the WRL project. Contractual requirements were loaded into the program and training was held with RTD and the contractor’s staff. Unfortunately, the program was not introduced to the contractor’s production staff at the beginning of the project and some aspects were not in accordance with contractual terms. The program was not used to its fullest extent. Acceptance of the project was done in a more traditional manner using paper and spreadsheet to track contractual requirements. Acceptance of WRL would have been more efficient if the acceptance database program had been set up and implemented in the manner that the contractor’s production staff chose to “sell the finished product.”

The Lessons

- Priority planning is an effective tool to focus the activities of the owner’s field staff.
- Allow for the inspection/assessment of the constructed work, but also assess the process. The contractor is paid to perform quality assurance so make sure it is performing in accordance with contractual obligations and its approved QMP.
- The use of an acceptance database program can make the project more efficient. It can also provide senior management confidence that the project is on schedule and that all contractual requirements have been met. If a system like this is to be used, make sure that it is in the contract so that the contractor understands that it will have to use the program.