



## Eagle P3 Project

# Design-Build Final Lessons Learned Report

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## Executive Summary

The EAGLE P3 Project consists of the East Corridor (University of Colorado A Line) connecting downtown Denver to Denver International Airport, the Gold Line connecting Denver to Arvada and Wheat Ridge, the Northwest Rail Electrified Segment (B Line) to Westminster, the Commuter Rail Maintenance Facility (CRMF), procurement of the rolling stock, and a 28-year operations and maintenance period.

In August 2011, RTD published a comprehensive Lessons Learned report that covered all aspects of the procurement of this project, which was undertaken through the Federal Transit Administration’s Public Private Partnership Pilot Program (Penta-P). This report focuses on the Design-Build phase of the project. RTD also anticipates continuing to collect and share Lessons Learned during the Operations and Maintenance phase. In the meantime, RTD hopes that the lessons included in this report will be beneficial to other transit agencies and interested stakeholders who are developing or pursuing similar projects.



  
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## Lessons Learned Basics

Lessons Learned (LL) are general statements that describe good practices or innovative approaches that are captured and shared to promote repeat application. They may also be descriptions of adverse practices or experiences that are captured and shared to avoid recurrence. Typical sources of Lessons Learned include:

- Improvement Actions
- Contract Changes
- Value Engineering Studies
- Partnering Reports
- Meeting Minutes
- Interviews
- Opinion Surveys
- RTD Board Actions
- Dispute Resolution Findings
- Claims/Lawsuits/Bid Protests
- FTA Lessons Learned Program
- Other Transit Agency Programs

Each lesson will include the same base information: Title, Overview, Background, and Lesson. This will be supplemented by additional information to provide context, querying, and reporting, such as: Project, Phase, Additional Project Information, and Major Asset Type.

To facilitate the continuous collection, analysis, and sharing of Lessons Learned, the RTD FasTracks project team has deployed a web-enabled database application (the “Lessons Learned Module”), which is used to capture, review and approve Lessons Learned at the time and point where those lessons are realized.

## Acronyms

ALJ – Administrative Law Judge

CA – Concession Agreement

CDPHE – Colorado Department of Public Health and Environment

DTP – Denver Transit Partners

FRA – Federal Railroad Administration

FTA – Federal Transit Administration

IFC – Issued for Construction

NEPA – National Environmental Policy Act

SPD – System Performance Demonstration

PDR – Periodic Design Review

PUC – Colorado Public Utilities Commission

QMO – Quality Management Oversight

RTD – Denver Regional Transportation District

UPRR – Union Pacific Railroad

USACE – United States Army Corps of Engineers

## Environmental Regulatory Agency Coordination Meetings

**Phase:** Design-Build

**Lesson Type:** Exceeded Expectations

### Overview

The EAGLE Project has held quarterly meetings with relevant regulatory agencies during construction to provide a forum for the agencies to understand the project progress and to voice any concerns early in the process. This meeting forum has resulted in more efficient regulatory reviews when necessary for the project, which in turn has helped the project avoid costly delays.

### Background

There are a number of environmental regulatory agencies at the federal, state, and local levels that remain active during the construction process and have the responsibility for approvals throughout the process. Examples of these agencies, and their responsibilities, are as follows:

- Federal Transit Administration (FTA) monitors mitigations up to the operations phase. They also have the responsibility to approve any project scope changes from the EIS design.
- US Army Corp of Engineers (USACE) provides the project clearance through their 404 permit (allows impacts to wetlands and waters of the US if unavoidable with mitigation). The project must provide annual updates to the USACE, obtain their permission to construct, notify them of any project changes that impact the permit, and obtain their approval.
- Colorado Department of Public Health and the Environment (CDPHE) provides construction permits for the project, such as discharge and dewatering permits and hazardous materials-related permits.
- Local governments inspect stormwater management plans and erosion control.

These agencies can act to facilitate approvals if they are kept fully informed of the project's progress, and have the forum to voice any concerns, enabling the project team to take action right away.

### Lesson

Regular coordination meetings with environmental regulatory agencies can facilitate the review and permitting process and help the project avoid costly delays.

## Design Criteria Conformance Checklists

**Phase:** Design-Build

**Lesson Type:** Needs Improvement

### Overview

Although the EAGLE Project had a Design Criteria Conformance process, in some instances construction of work was begun prior to completion of this process.

### Background

Design Criteria Conformance Checklists are used to verify that the EAGLE Project Design Basis Manual criteria (developed by Concessionaire Denver Transit Partners) have been incorporated into the final design specifications and drawings for construction. Review and approval of documentation contained in the conformance checklists by the Safety and Security Working Group results in the issuance of a Design Criteria Certificate of Conformance for each project segment. Then, construction may proceed according to the Issued for Construction (IFC) process.

### Lesson

The Design Criteria Conformance process was not always scheduled in a timely manner during the Design-Build phase. This resulted in delays in gathering required documentation from the design teams. In some cases, construction was completed prior to the certification of the design. This could result in significant cost and schedule impacts if the design is not ultimately certified, although this is a risk borne by the Design-Build Contractor.

### Steps to Implement

RTD should review project schedules and milestones to verify activities and durations have been included for the Design Criteria Conformance Checklists to be completed for each certifiable item, prior to the 90% submittal. If the Contractor has included in their schedule, this will enable the Safety and Security Working Group to review the checklists, certify the items, and issue the Design Criteria Certificates of Conformance. In addition, the need for timely submittal of the Design Criteria Conformance Checklists should be communicated clearly and early to all design teams, with regular status updates. The ability to complete the Design Criteria Conformance Process in a timely manner is the responsibility of the Design-Build Contractor.

## Periodic Design Review Meetings

**Phase:** Design-Build

**Lesson Type:** Unexpected Results

### Overview

Periodic Design Review Meetings will bring value to projects when they are held both early and later in the design process, and when third parties participate.

### Background

The EAGLE Project Concession Agreement required the Concessionaire, Denver Transit Partners (DTP), to plan and conduct Periodic Design Review (PDR) meetings, which are formal documented reviews of the design and related issues. RTD and DTP discussed the timing of the PDR meetings, and agreed that they were not necessary prior to every submittal milestone (30%, 60%, IFC). Generally, DTP had one PDR meeting before the 60% submittal, with the intent that further coordination would occur during the Technical Working Group meetings. The result was that the PDR meetings held prior to the 60% submittal were not as productive, due to lack of design detail. Additionally, DTP was responsible to ensure that groups such as construction, operations and maintenance, and project third parties were invited to attend, but in reality such participation was infrequent. This created the potential for construction documents that were not well coordinated. For example, the Stations design team had to undertake an extensive value engineering effort at the 100% milestone to address constructability comments, that could have been caught during the PDR meetings.

### Lesson

The benefits of Periodic Design Review meetings include documents that are better coordinated among design disciplines, operations and maintenance staff, constructors, and third parties. RTD design managers should clearly communicate these benefits to Concessionaire and Design-Build team design managers, stress the importance of conducting such meetings on each project, and resist requests to eliminate the meetings. It is also advisable that additional PDR meetings be held later in the design process, when a greater level of project details are available, to generate comments that will have more value. Also, RTD should encourage the participation of all affected internal groups and project third parties.

### Steps to Implement

The EAGLE Project CA requirements for Periodic Design Review Meetings should be incorporated into each RTD contract. RTD design managers should emphasize that the Contractor conduct such meetings and also prepare and submit meeting minutes.



## Three-Way Approval of Nonconforming Construction Work

**Phase:** Design-Build

**Lesson Type:** Unexpected Results

### Overview

The review and approval by the EAGLE Project Concessionaire, Denver Transit Partners (DTP), of nonconforming construction work with proposed dispositions of use-as-is or repair was not being documented.

### Background

The EAGLE Project Concession Agreement (CA) required a three-way approval (by DTP, RTD, and the designer of record) for the use or repair of nonconforming work. The Aconex workflow process established by DTP Construction Quality Assurance included steps for the designer of record and RTD to document their review and approval, but did not include a similar step for DTP to do so, making it difficult for RTD to verify that this had occurred. RTD included this requirement in the CA to ensure that DTP's senior leadership, O&M Contractor, and Systems Integration staff would be notified and have the opportunity to review and approve such dispositions, prior to any approval by RTD.

(Proposed dispositions of remove-and-replace, and rework, did not require DTP or RTD approval.)

### Lesson

RTD and DTP reached an agreement, whereby DTP would issue a monthly official letter, identifying the nonconformances they were approving. This practice enabled DTP to comply with the contractual requirement, although the monthly letters did not provide RTD with detail regarding issues that DTP or their O&M and Systems Integration staff had considered before providing their approval. RTD agreed to this practice, principally as a safeguard against potential claims, should unscheduled maintenance or repairs be necessary which could interrupt the commuter rail service.

This practice was documented in DTP's Construction Quality Assurance Plan.

### Steps to Implement

Consider developing and incorporating stronger contract requirements into future procurements, to ensure the participation of Concessionaire senior leadership, O&M Contractors, and Systems Integration staff in the design review and construction quality processes, and the appropriate documentation of the same.

## At-Grade Crossing and Grade Separation Considerations

**Phase:** EIS/BE/PE

**Lesson Type:** Unexpected Results

### Overview

RTD's rail transit projects, including the EAGLE Project, typically create new at-grade crossings and expand or abolish existing crossings. At other locations, the transit projects construct grade separations – a bridge that carries the rail line over a local street or highway, or vice versa. All of these features – at-grade crossings and grade separations – are defined during the NEPA process, with stakeholder input, prior to the design phase. A reality of large, complex projects, however, is that there will be political, financial, and developmental changes among the various stakeholders during the Design-Build phase.

### Background

The ability to abolish existing crossings has particular benefits, since the outcome is the removal of either the rail or vehicular/pedestrian traffic at the crossing, which decreases the public's exposure to possible car-train or pedestrian-train collisions. There are also cost benefits that result from the elimination of the crossing infrastructure, signaling and warning systems. On the EAGLE project, there were seven existing freight crossings which were abolished. Five of these served industry lead tracks on which the freight railroad had terminated operations. The other two were low-volume local streets where it was determined that nearby crossings (within two or three city blocks), which would be reconstructed by the project, would have capacity to handle the small amount of additional traffic from the streets where the crossings were closed.

Where abolishment is not a viable option, RTD has an established analytical methodology for evaluating existing and potential at-grade crossings to determine if a grade separation is appropriate, and this analysis was conducted for the entire EAGLE Project. The results of this analysis were included in RTD's NEPA studies. However, subsequent to those studies, there were two significant changes on the project, for which RTD had to negotiate contract changes with the Concessionaire, Denver Transit Partners:

- 1) A municipality requested that two at-grade crossings be converted to grade separations (rail line over local streets), for potential safety benefits in light of expected future development in the area, and higher traffic volumes
- 2) Two municipalities collaborated to construct a grade separation (local street over the rail corridor) at a location where an at-grade crossing was identified. This location had been evaluated by the RTD EIS team as a potential candidate for a grade separation, but with local agency input, it was determined that an at-grade crossing was appropriate.

### Lesson

During the NEPA process, key project features (such as at-grade crossings and grade separations) are defined. As time passes from the end of the NEPA process and into project implementation, political,

financial, and developmental changes should be expected. These changes have the potential to affect how the eventual project is delivered.

In the first example described above, RTD agreed to construct the two additional grade separations as part of a larger negotiated change package requested by the municipality. RTD subsequently had to negotiate a contract change with DTP to remove some elements of the infrastructure (such as the grade crossing warning system) and construct others (such as bridges, retaining walls, and additional earthwork).

In the second example, the independent grade separation project resulted in RTD negotiating a contract change with DTP to remove the at-grade crossing and warning system from their scope of work, and to coordinate their construction activities with those of the municipalities' contractor. RTD also had to prepare and submit a revised PUC application for a temporary at-grade crossing, to facilitate DTP's construction sequencing.

In each example, although the municipalities contributed financially, RTD also incurred additional costs for contract changes, oversight, and some capital items. The changes also presented unnecessary risks to the project schedule.

## **Steps to Implement**

Locations where abolishment of existing crossings may be possible should be identified and evaluated as early as possible during the NEPA process.

Although some changes between the NEPA phase of a project and final design and construction are inevitable, RTD should consider the following during the NEPA process to minimize the impact of such changes:

- Although the NEPA process dictates how land use forecasts are incorporated into the project, RTD should also understand municipal land use aspirations outside of the defined process. These desires should be explicitly documented during the NEPA process to provide a basis for future project development.
- If stakeholders wish to have supplemental grade separations included in the project, RTD should spend additional focused efforts to determine if the grade separations should be included in the RTD project or deferred to the municipality. The resulting NEPA documentation should explicitly document this process and the results.
- If a supplemental grade separation is included in the project, RTD should obtain a written commitment for the associated funding. This can be accomplished through an intergovernmental agreement, a letter of commitment, or a memorandum of understanding.

## PUC Coordination

**Phase:** Design-Build

**Lesson Type:** Needs Improvement

### Overview

Whenever RTD’s commuter rail infrastructure intersects a roadway, the Colorado Public Utilities Commission (PUC) has regulatory authority. As new RTD projects either modify or abolish existing crossings or create new ones, RTD is responsible for submitting an application to define the proposed crossing, although in some situations, a third party such as a municipality or freight railroad may submit the application. The EAGLE Project has worked through multiple applications with the PUC, and heard repeatedly that coordination early and often is prudent.

### Background

Whenever RTD’s commuter rail infrastructure intersects a roadway, the PUC has regulatory authority since commuter rail falls under the same Federal Railroad Administration (FRA) rules as Colorado’s existing freight railroads.

The PUC’s application process consists of both a technical review and a public comment period, which allows input and possible intervention from affected stakeholders such as municipalities and freight railroads. Additionally, applicants are not permitted to communicate with the PUC regarding a given application for a 30-day period prior to its submittal (an *ex parte* period). Following the PUC’s review, they may request additional information or clarification from the applicant, and if they continue to have concerns, they may forward the application to an Administrative Law Judge (ALJ) for resolution, which has the potential of adding up to 90 days to the review and approval process. RTD has received clarification requests on several EAGLE Project applications, and at least one application went to an ALJ hearing for technical reasons.

There were several locations on the EAGLE Project where existing freight railroad service had been terminated, and existing at-grade crossings could be removed (a process known as abolishment). The same PUC application and review process was necessary for these locations.

### Lesson

The PUC process is designed to protect the citizens of Colorado. Therefore, the application process provides mechanisms for both technical review and public comment. As an additional public protection, the PUC statutes require that applicants do not communicate with the PUC regarding a given application for a 30-day period prior to its submittal. This period, known as the *ex parte* communication period, often deters projects on a tight schedule from speaking with the PUC prior to submitting an application since that has the potential to add 30 days to the process.

Applicants such as RTD are very sensitive to project schedules, and therefore have an incentive to proactively engage regulators such as the PUC, and all affected stakeholders, well before the formal

submittal of any applications, to reduce the impacts of providing additional information, the likelihood of a stakeholder intervention, and especially, the need for an application to be referred to an ALJ.

### **Steps to Implement**

RTD should work with the PUC and stakeholders such as municipalities and freight railroads prior to submitting applications. Project schedules should allow for the 30-day *ex parte* communication period, using this time to address final comments, obtain signatures, and perform final reviews.

## Rolling Stock Oversight

**Phase:** Design-Build

**Lesson Type:** Exceeded Expectations

### Overview

The rolling stock supplier (a subcontractor to the EAGLE Project Concessionaire, Denver Transit Partners) had the primary responsibility for quality assurance and quality control of the rolling stock assembly and testing. RTD's role is to independently oversee the quality process, production, inspection and testing to assure that the end product is satisfactory. RTD should seek to not interfere with or disrupt the supplier's ongoing processes while still adding value through the oversight effort.

### Background

RTD developed a procedure for the RTD resident inspector to provide guidance on how to perform the oversight. Key elements were providing an independent review of activities and reports, i.e. not just following the supplier's staff around; discussing in-process issues with the supplier and DTP quality representatives onsite and recording these issues in a weekly report; using these reports and other records gathered during the production process as a checklist during final inspection to verify close-out of items while also inspecting all other items; and recording final inspection observations in RTD's Quality Management Oversight (QMO) database.

As a result, RTD's independent oversight activities were well documented and complemented other RTD quality oversight activities such as management system audits and monthly and quarterly quality review meetings. It also resulted in a healthy relationship with DTP and the rolling stock supplier.

### Lesson

Provide a procedure to staff doing potentially repetitive oversight tasks, so that the staff have an element of independence and discretion, which in turn adds value to the performance of the tasks.

### Steps to Implement

The procedure was developed between the inspector/engineer, the engineering team, the quality team and the project management team resulting in a procedure that met multiple goals and was accepted by all.

Although the procedure was internal to RTD, it was shared with DTP to promote understanding.

## RTD Oversight of Structures Design Review

**Phase:** Design-Build

**Lesson Type:** Needs Improvement

### Overview

The Concessionaire for the EAGLE Project, Denver Transit Partners (DTP), undertook extensive independent design review of the project's commuter rail bridge structures, and implemented several categories of structural retrofits (such as girder replacements, column retrofits, and fiber-reinforced-polymer retrofits) and in an extreme instance, removal and replacement of an entire bridge. While DTP was required by contract to design and construct these structures in accordance with specified requirements, including responsibility for all design and construction quality management, RTD's oversight presence was an opportunity to provide value to DTP and the project through design reviews during the design-build process. RTD's oversight presence on future projects should consist of a stronger systematic, targeted review approach, identifying challenging design elements for special focus during design review, reviewing structural technical issues, and reviewing design plans and details.

### Background

During 2013, RTD's design and construction review of the EAGLE Project's bridge structures identified numerous deficiencies against the AREMA Manual for Railway Engineering, which is the designated design standard for RTD commuter rail bridges. The deficiencies included improperly designed box girders and caisson-to-column reinforcing steel splices, many of which had already been constructed. The results of these discoveries in turn prompted extensive investigation by DTP, who tasked their designers with a complete review of all structures for AREMA compliance. Ultimately, this review resulted in recommendations for the complete demolition and redesign of one bridge, two bridge deck retrofits, girder Fiber Reinforced Polymer (FRP) retrofits for shear, steel jackets for selected concrete pier columns, and pier cap retrofits.

### Lesson

The RTD EAGLE Project oversight team's role was to focus principally on contract compliance, rather than conduct formal, detailed design reviews. This makes conducting an in-depth review of bridge design calculations an unreasonable expectation. However, while DTP was still responsible for all design and construction quality management on the project, the bridge design deficiencies could have been identified by the RTD oversight team earlier in the design-build process, during design review, had a systematic, targeted review approach been implemented. Components of such a review approach should include the identification of challenging design elements, the review of structural technical issues, and the review of design plans and details.

### Steps to Implement

**Identify Challenging Design Elements:** During the design review, the oversight team should identify particular elements of the design that are unique, challenging, or that approach the recommended limits

of design codes, and question the design engineers to ensure their understanding of the design codes. Examples of such design elements on the EAGLE Project included skewed box girders (does computer software account for amplified local effects?) and box girder local reinforcing (bending and shear for ballasted bridges without a composite slab).

Review of Technical Issues: Examples of technical issues encountered on the EAGLE Project included:

1. Box girders (shear amplification and torsion at obtuse corners of skewed box girder ends, uneven bearing pressure as a result of skewed ends, and local web and flange shear and bending forces)
2. Column-to-drilled shaft splice design (bundled bar stagger of individual bar splices, clearance between bars, use of Class C splice designs, and use of adequate splice lengths)
3. Cast-in-place, post-tensioned concrete box girder bridges (deck, interior and exterior webs, hammerhead pier caps and straddle bent pier caps, column hinge design, curb effect on section properties, column reinforcing splices, freight railroad clearance envelope)
4. Bridge deck negative moment reinforcing (adequate bar length before cutoff, to ensure negative moment continuity)
5. Bearing pad design (use of AREMA or AASHTO criteria)
6. Pier straddle bent design (torsion design, and design of hanger reinforcing for inverted-T bent caps)

Review of Design Plans and Details: The oversight team should consider identifying a sample of specific structural elements and comparing details from different bridges for consistency, reviewing whether the details properly reflect the results of the design calculations. Inconsistencies can be discussed with the design team. Potential causes of detailing errors include inexperienced staff, improperly duplicated details, and plan production occurring at multiple offices. Examples of detailing issues encountered on the EAGLE Project included:

1. Joints between drilled shaft foundations and bridge columns (correctly designed as a splice of reinforcing, or just to provide development length of the column reinforcing bars into an enlarged drilled shaft)
2. Box girder webs (properly designed for both flexure and shear, but reinforcing detailed for shear, which did not control the design)



## RTD Oversight of Railroads - Cost Review

**Phase:** Design-Build

**Lesson Type:** Needs Improvement

### Overview

The EAGLE Project required work to be performed by the Union Pacific Railroad (UPRR) for the relocation of the UPRR tracks to enable the construction of the commuter rail infrastructure. The work performed by UPRR was from design plans which were prepared by a consultant under contract to RTD, then reviewed and approved by UPRR. (This work was initially planned to be part of an early work package, but the package was delayed.)

The original cost estimate for the UPRR relocation was based on the 30% design plans submitted at the beginning of the project. The agreement with UPRR included the original cost estimate, but required RTD to pay the actual cost incurred by UPRR. The RTD oversight presence on future projects should include the oversight of construction phasing and sequencing coordination between freight railroads and RTD contractors, and verification of work performed for invoice review and approval.

### Background

The project Concessionaire, Denver Transit Partners (DTP), held weekly construction coordination meetings with UPRR, which RTD also attended, to discuss upcoming construction activities, railroad flagging and track outage requirements. The RTD oversight team focused primarily on monitoring the progress of UPRR's work, to assure that DTP's schedule would not be negatively impacted. RTD also reviewed UPRR's invoices, and during 2014, noticed increasing overages on their invoices, in comparison to the original cost estimate for track construction activities.

The UPRR invoices were often general in nature and not highly detailed regarding the work which was being billed. RTD's analysis of the invoicing determined that while the material costs were within the estimate, the labor and equipment costs were significantly over the estimate. Further investigation by RTD determined that the absence of a formal, mutually-agreed schedule between DTP and UPRR for subgrade preparation (performed by DTP) resulted in delays that were not tracked for timing or severity. This affected UPRR's work gang scheduling and while RTD did make periodic observations of this activity, it was not frequent enough to facilitate detailed tracking and accurate review of their invoices.

### Lesson

The RTD EAGLE Project oversight team should have spent more effort to verify that the progress of UPRR's work, allocation of resources, and invoicing of the work, were in line with expectations. Having an approved schedule, estimates of task durations and unit costs, supporting documentation to validate the invoices, and on-going weekly meetings to discuss schedule, work performed, and upcoming work, will help the oversight process function well and avoid surprises.

## Steps to Implement

The role of the project oversight team was twofold: 1) to review progress and resolve issues, and 2) to review and approve the invoices from the freight railroad relocation and construction work. To maximize the effectiveness of the invoice reviews, the following steps should be implemented:

- **Updated Cost Estimates:** The original estimate, with back-up documentation, showed gang consists, time spent, materials, and other items in detail. The estimate should be updated after the final set of plans is accepted by the railroad, and again annually to take into account progress and inflation.
- **Construction Work Oversight:** Priority planning should be implemented, based on the railroad and DTP schedules, so inspectors will know what work activities and elements to inspect. Inspection reports should record date, location, the work being performed, crew size and equipment being used, then filed according to the applicable document control and/or quality management oversight procedures.
- **Weekly Construction Coordination Meetings:** Weekly meetings including the contractor, railroad and RTD should include discussions of the schedule, current work being performed by both the contractor and the railroad, and a three-week look-ahead for any additional work, changes, or redesign which needs to be performed. Costs and invoices should also be discussed, including any variations to the estimates.
- **Joint Coordination for Public Improvements:** The project oversight team should include the railroad in discussions with regulatory authorities such as the PUC, who have jurisdiction at public highway-rail grade crossings, regarding the nature of the improvements and coordination of the work.

A documented procedure for performing oversight specific to this type of contractual arrangement, describing responsibilities and process steps, should be developed and included in the Project Management Plan.

## Design and Construction Coordination for Proper Bus Operations

**Phase:** Design-Build

**Lesson Type:** Unexpected Results

### Overview

Most of the commuter rail stations on the EAGLE Project will also serve as bus transit facilities for RTD's Bus Operations and their passengers. As such, Denver Transit Partners' (DTP) stations design submittals required RTD's approval as a step towards ensuring safe and efficient bus operations when the stations opened for service. However, bus facility designs can be difficult to review, even by Bus Operations staff, on paper alone, and RTD's design review process was not able to detect certain aspects of the bus facilities (namely the sawtooth bus bays) that would have proved challenging to bus operators. Fortunately, cooperation among the RTD EAGLE Project staff, RTD Bus Operations, and DTP was able to identify and correct these issues prior to opening day.

### Background

The EAGLE Project Concession Agreement required DTP to design and construct bus transit facilities in accordance with RTD's Bus Transit Facility Design Guidelines and Criteria, and to design bus bays with sawtooth geometry to accommodate both 45- and 60-foot buses. DTP's designers employed bus turning templates to develop their designs, but while the designs were reviewed by both the RTD project design staff and RTD Bus Operations, the adequacy of the designs could not be fully assessed until Bus Operations brought a bus out to selected stations while they were still under construction.

With the bus at the stations, several issues were identified and determined to be unacceptable:

- An instance of a bay that was designed correctly but constructed incorrectly;
- An instance of a design with too tight of a radius, where the typical bay design had been modified because of site restrictions;
- An instance of a bay where the bus could not pull in parallel to the curb, such that only the front door of the bus could be aligned with the curb.

Because these conditions were identified early enough, DTP was able to address them without an impact to the project schedule.

### Lesson

RTD bus facility designs can be difficult to review, even by Bus Operations staff, on paper alone. Site conditions sometimes dictate that designs be modified from RTD's criteria. RTD design reviews can be more effective when the designer's turning template details are available. Bringing a bus to the station sites, while still under construction, proved to be very helpful for the identification of conditions that would have been challenging for RTD once the facilities were in service.

## **Steps to Implement**

Consider requiring designers to show turning template details on their design submittals. At a minimum, schedule review sessions for each major design submittal (30%, 60%, 90%) to include the designer, the RTD project staff, and RTD Bus Operations staff. If uncertainty still exists after this review, consider bringing a bus to the site, while still under construction, as another means of verification.

## Monthly Quality Updates for Senior Project Managers

**Phase:** Design-Build

**Lesson Type:** Unexpected Results

### Overview

The RTD and DTP Quality Managers on the EAGLE Project have conducted a monthly, hour-long update meeting for the respective Project Directors and other senior managers, to focus on the activities and results from the two quality programs. The meetings have served to elevate awareness of quality management activities and procedures, and have served as a platform to escalate and resolve issues for which there was disagreement. The meetings have been most effective when issues of concern are exchanged in advance, to provide time for research and investigation prior to the meeting, and when both Project Directors have been able to attend.

### Background

In late 2013 the RTD Quality Oversight Manager and RTD Project Director proposed to their DTP counterparts to hold a monthly quality update to review results of the two quality programs, such as levels of conformance of the work, trends, audit results, upcoming audits, status of Corrective Action Requests (CARs), and other current issues. The participation would include the Project Directors and Quality Managers from the two entities, as well as other senior managers with the authority to take follow-up actions and make decisions. While these senior managers already participated in numerous meetings together, it was felt and agreed that quality-related issues were not discussed often enough during those meetings, and that a separate meeting would provide a forum to focus on those issues and direct attention and resources to areas of concern.

Particularly on the EAGLE Project, where DTP is responsible for delivering a large and complicated design-build project while simultaneously preparing to operate and maintain a commuter railroad, communication challenges can arise among the multiple consultants and contractors performing separate scopes or portions of the work. The DTP-entity quality managers sometimes found themselves challenged to obtain resources to fulfill their obligations, such as having enough staff and having access to project sites to perform inspections, and RTD was able to spotlight these needs to DTP's senior management.

### Lesson

The benefits of having the monthly quality update for senior project managers, in terms of spotlighting areas in need of attention, have always been recognized. In practice, some meetings have been more productive than others. Several meetings were rescheduled, and it was difficult to find workable alternative times for enough key participants. Discussions have also proven to be more productive when issues of concern have been exchanged with DTP in advance of the meeting. It is therefore important that senior managers, with the authority to make decisions and assign resources, attend the meeting in addition to the quality managers.

## **Steps to Implement**

Consider conducting a monthly meeting which will include the RTD Project Director or Manager, the Quality Oversight Manager, Design, Construction, Systems Testing, and other senior project managers, and their counterparts from the Contractor or Concessionaire. The Quality Oversight Managers can solicit topics of interest or concern from their respective organizations in advance of the meeting, and exchange with each other with adequate time for review. It is also important to adhere to a consistent meeting schedule, to achieve the greatest participation. The participants' time demands mean that rescheduled meetings invariably will have less participation, and less opportunity for productive outcomes.

## Coordination with Utilities

**Phase:** Start-Up/Testing

**Lesson Type:** Needs Improvement

### Overview

Because RTD and not Denver Transit Partners (DTP) is the party of record in agreements with major utility companies, it is vital to establish and maintain open lines of communication with these organizations.

### Background

During a high voltage, short circuit test at a traction power substation, there were some minor low voltage issues that tripped an Xcel Energy breaker during the middle of the night. Fortunately, it was never a life safety issue, and there were no significant impacts to the Xcel Energy system. The issue was resolved, retested, and passed. While conversations were held amongst the DTP, RTD, and Xcel Energy workers on site, reports of the breaker tripping were not immediately relayed to Xcel Energy's management. This lack of notice strained the relationship between RTD, DTP, and Xcel Energy for several months.

### Lesson

RTD should not rely on contractors to provide utility companies' management with full reports of test activities, including reports of anomalies such as the breaker tripping incident. Since RTD is the party of record from the utility companies' perspective, RTD should always notify these companies and other stakeholders of any significant events.

### Steps to Implement

Consider clarifying what contractors' roles and responsibilities are for reporting test failures and similar events to utility companies and other stakeholders. Request to be copied on all correspondence between contractors and utility companies and stakeholders. Identify any notification responsibilities that will remain with RTD, and assign an individual responsible for providing those notifications.

## Design Criteria for Crossing Gate Arms and CCTV

**Phase:** Design-Build

**Lesson Type:** Needs Improvement

### Overview

RTD did not provide specific design criteria for crossing gate arms, for the street and highway grade crossings on the EAGLE Project. During the summer of 2015, there were two locations on the project where the gate arms and other equipment sustained damage during severe weather events, when high winds blew the arms into the overhead catenary system. Similarly, RTD did not provide specific design criteria for closed circuit television (CCTV) at street and highway grade crossings. No jurisdictions besides RTD required design documentation for CCTV, therefore no formal design submittals were furnished to RTD prior to installation and testing.

### Background

Neither the EAGLE Project Concession Agreement (CA) nor the RTD Commuter Rail Design Criteria called for a specific type of gate arm; rather they just state that an arm is required at grade crossings. Denver Transit Partners (DTP) chose to use a standard-type gate arm, as typically used at grade crossings on RTD Light Rail corridors. Unfortunately, such gate arms are intended to be used at relatively-narrow crossings, and were not structurally adequate for the wider grade crossings (hence, much longer arms) on the EAGLE Project. During a summer wind- and rainstorm, the gate arms deflected while in the upright position, and due to their length, blew into the overhead catenary lines, causing a ground fault. Besides being a safety hazard, the gate arm housing and nearby relay house were also damaged. Fortunately, no one was in the area of the ground fault at the time, and it occurred during the early phases of testing. This was determined to be a life safety issue.

In the case of CCTV at street and highway grade crossings, there was no authority other than RTD [e.g. a municipality, the Public Utilities Commission (PUC), or the Federal Railroad Administration (FRA)] which had jurisdiction over these elements. Therefore, it was not necessary for DTP to submit CCTV designs to entities other than RTD. RTD received an informal design, marked up with the presumed areas of camera coverage. Fortunately, the actual coverage once the cameras were installed and tested turned out to be adequate, even though this was not demonstrated by the informal design. As such, DTP did not have to provide additional cameras, poles, or handholes.

### Lesson

Even secondary elements of a system, such as crossing gate arms and CCTV at street and highway grade crossings, should be designed by a Registered Professional Engineer. Additionally, if gate arms in the upright position are as tall as an energized element such as the overhead catenary system, they should be designed to prevent contact with those elements. If such an incident occurred during revenue service, RTD and DTP would experience significant delays and impacts to operations.



## **Steps to Implement**

Consider requiring more formal design documentation for crossing gate arms and CCTV at street and highway grade crossings, and clarifying the requirements for these elements to be designed by a Registered Professional Engineer. The layout of grade crossings should be reviewed carefully during the design phase, to compare the height of the gate arms when raised, to the height of the overhead catenary system. For CCTV, consider providing criteria for image quality, to establish criteria for testing acceptability.

## System Performance Demonstration Oversight

**Phase:** Start-Up/Testing

**Lesson Type:** Unexpected Results

### Overview

The EAGLE Project Concession Agreement required Denver Transit Partners (DTP) to perform a comprehensive demonstration of each commuter rail corridor as the culmination of the integrated testing program. These demonstrations were called System Performance Demonstrations (SPD), and their objectives were to test the complete integrated commuter rail network, including subsystems, operating personnel and operating procedures, in order to confirm readiness for entry into revenue service. While the primary responsibility for developing and implementing the SPD belonged to DTP, the RTD project team developed several oversight strategies to verify DTP's reporting and identify incomplete work elements.

### Background

DTP was responsible for preparing a management plan and test procedures for the SPD, which required RTD's approval. The SPD allows DTP to have the opportunity to demonstrate that they have provided a system capable of satisfying the performance requirements of the Concession Agreement reliably. The SPD included conducting failure scenarios (simulations of the failure of various system components in order to test the organization's response) and, generally, performing all inspection, maintenance, and administrative functions that would be required during normal revenue service operations.

The RTD project staff, under the direction of the Systems Integration Manager, organized a committee to oversee the SPD, which engaged in the following activities:

- Test train witnessing – staff performed the role of passengers on the test trains and recorded observations such as departure and arrival times at stations, and onboard conditions such as the functioning of audio and visual announcements
- Station inspections – staff documented the conditions at stations, such as completion status of signage and railings, and the functioning of grade crossing warnings, lighting, and audio and visual announcements
- Grade crossing observations – staff documented train movements and the functioning of the grade crossing warning systems, including traffic signals and gate-down times
- Coordination meetings – staff met weekly with the Systems Integration Manager to review observations and identify trends and issues in need of escalation
- Management Plan Reviews and Management System Audits

## **Lesson**

While the primary responsibility for developing and implementing the SPD belonged to DTP, the RTD project staff was able to develop a systematic approach for monitoring and documenting key aspects of the demonstration, such as on-time performance of the trains, status of audio and visual announcements, and the functioning of grade crossing warning systems.

The RTD staff attempted to witness the demonstration from a passenger’s point-of-view, providing a complementary perspective to the reports being prepared and submitted by DTP. To obtain an even broader perspective, representatives of RTD’s Bus Operations and Marketing teams participated in the oversight effort.

The RTD staff was able to communicate to DTP and realize some improvements from the SPD for the University of Colorado A Line, to the SPD for the B Line. For example, during the SPD for the A Line, train operators were not opening the train doors while stopped at stations (as they would do as part of normal revenue service), but operators did open the doors at Westminster Station during the SPD for the B Line. Also, DTP was able to make pronunciation corrections to the onboard, automatic PA announcements based on RTD’s feedback.

Even with these lines operating in revenue service, RTD staff still make periodic trips and site visits to document train departure and arrival times, station dwell times, and conditions at the commuter rail stations, to compare against DTP’s own reporting.

## **Steps to Implement**

Consider implementing a similar oversight program for future System Performance Demonstrations, prior to future commuter rail project openings. Develop a project-specific oversight procedure for inclusion in the Project Management Plan or Quality Management Oversight Plan to describe the process or strategy for overseeing System Performance Demonstrations or similar important processes.