

FEDERAL TRANSIT ADMINISTRATION
PROJECT MANAGEMENT OVERSIGHT PROGRAM

Lessons Learned
The T-REX Mega-Project Experience
June 2007

TRANSPORTATION EXPANSION PROJECT
Final Lessons Learned Report
June 2007

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Executive Summary

The Transportation Expansion (T-REX) Project was an exceptionally successful example of a Design-Build (D-B) contract delivery method applied to a multi-modal (highway and light rail transit) infrastructure mega-project. While there are several other examples of highly successful D-B infrastructure projects, none were multi-modal and of the size and scope of the T-REX Project.

From the beginning of the T-REX Project we set four major goals:

1. First and foremost—*Minimize inconvenience to the public.*
2. Complete the Project at or under the \$1.67 billion budget.
3. Deliver a quality Project.
4. Meet or beat the June 30, 2008 completion date.

Meeting these goals was set as the benchmark to measure overall T-REX Project success. To that end we succeeded beyond anyone's expectations.

Many factors contributed to the overall successful completion of T-REX. Some of these factors were beyond our control and could have just as readily had a negative impact on Project delivery:

Actions that helped meet or exceed Project Goals:

- Bringing together the owner and D-B Contractor together as a true Team—co-locating them, allowing decision-making at the lowest possible level, agreeing from the outset that the “*Project Comes First*” and to speak as “*One Team, One Voice.*”
- A strong commitment to partnering from top to bottom.
- Having the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) function as a “*One DOT*” to facilitate their oversight role as one entity.
- Assigning risk to the party best able to manage the risk.
- Using the D-B contract delivery method and inviting comments and alternative configuration concepts from bidders during the Request for Proposal (RFP) phase.

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- Having a proactive public information campaign involving both the owner and design-build contractor staffs and the other T-REX Project stakeholders.

Favorable circumstances that were beyond our control:

- Exceptionally mild, dry winters during the major construction timeframe.
- The enhanced availability of a quality labor force as a result of the economic slowdown that followed the unfortunate events of 9-11.

Factors that could have negatively impacted our schedule and/or costs, but did not:

- Third-party requested betterments, enhancements, and changes.
- Right-of-Way (ROW) acquisition and utility relocation coordination and costs.
- Developing and implementing Intergovernmental Agreements (IGA) with all affected local governments.
- A very lean contingency.
- Insurance claims.

During the nearly 66-month timeframe from beginning the T-REX Project to the first day of revenue operations we learned many valuable lessons, summarized in the report that follows this Executive Summary. The most valuable of these lessons were:

- We would have identified light rail transit station planning as a major area of focus early in the Project.
- We would have placed a greater emphasis on transit oriented development.
- Our IGAs would have addressed more aspects of permitting, design reviews, approvals, and related issues prior to contract award, at least to the extent possible.

Applicability

There are many potential and in-progress major infrastructure projects that are intended to be delivered using the design-build contract approach. Most, if not all, similar projects could benefit from the pre-planning and goal-definition process used for the T-REX Project. Involving all the interested parties and stakeholders, including the project owner, potential design-build contract bidders, the actual contractor, stakeholders, and the general public, is the key to getting a D-B project completed on-time and within budget.

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The commitment on the part of all T-REX Project participants to function as “*One Team/One Voice*” and use of the D-B construction approach proved to be a powerful, workable structure. As municipalities and states move forward with multi-modal (highway and transit) infrastructure or other construction projects, T-REX could and should serve as a model.

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Acknowledgments

The success of the Transportation Expansion (T-REX) Project involved many factors, but people really made it happen. Many people contributed to the success of the T-REX Project, starting with the T-REX owner team, made up of Colorado Department of Transportation (CDOT) Regional Transportation District (RTD), and private sector staffs, our Design-Build Contractor, the Southeast Corridor Constructors, a joint venture of Kiewit and Parsons Transportation Group and their many subcontractors, vendors, suppliers, sub-consultants, and designers. The T-REX Project had great support from the Federal Highway Administration (FHWA), Federal Transit Administration (FTA) and all of the local entity staffs that were impacted by the Project. Outside of the design-build portion of T-REX, Mortenson and Siemens also provided key deliverables with the construction of the RTD Elati Maintenance Facility and the delivery of the light rail vehicles.

We would also like to extend our appreciation to the many stakeholders who were impacted by the construction of T-REX, including adjacent residents and businesses, commuters and anyone who traveled through the T-REX Project during its construction.

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**T-REX Project
Keys to Our Success**

The Keys:

- “*Minimize inconvenience to the public*”
- Remember “*the Project comes first*”
- Partnering—top to bottom
- Develop a well-defined contract
- Develop and focus on project goals from the outset—update at the start of each major phase
- Implement an effective public information program to get public “buy-in”
- Put appropriate Memoranda of Understanding (MOU) and Intergovernmental Agreements (IGA) in place as early as possible
- Plan for and implement utility relocation and Right-of-Way (ROW) activities as early in the Project as feasible

1. *Minimize Inconvenience to the Public*

We established four primary goals for the T-REX Project, as shown in the following box:

T-REX Project Goals:

- ***Minimize inconvenience to the public.***
- **Meet or stay under the total T-REX Project budget of \$1.67 billion.**
- **Provide a quality project.**
- **Meet or beat the scheduled fully operational target date of June 30, 2008.**

Given the long potential duration of the T-REX Project—up to seven years—and the disruption likely to result from the construction of both additional highway lanes and light rail, we needed public support. To gain the greatest level of public support we chose as our number one goal to do everything reasonably possible to *minimize inconvenience to the public*. While this is not feasible on all transportation infrastructure projects, it was for T-REX.

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2. *The Project Comes First*

- Fostering a team environment—“*One Team, One Voice*”
- Having respect for counterparts’ opinions
- Co-locating all the major T-REX Project Team members

From the outset in 2000, the T-REX Project owners CDOT and the RTD, the federal entities the FHWA and FTA, and the designers operated in a team environment. When the D-B contractor was chosen in 2001, they were added to the team. The entire team was co-located to foster interaction and cooperation. Our motto was “*One Team, One Voice.*”

Beginning in 1999, an IGA between CDOT and RTD provided the foundation for implementing the T-REX Project. This IGA proposed using D-B as the implementation method, along with a joint financing approach between the two agencies. The T-REX Owner Project team visited a number of comparable major infrastructure D-B projects to benefit from those experiences, since this approach had not yet been used on a multi-modal project the size and scope of T-REX.

3. *Partnering—Top to Bottom*

We found that having truly committed partners at all levels was essential to T-REX’s success. We were able to resolve all potential conflicts and issues with our D-B contractor without having to resort to our Dispute Resolution Board, and without incurring any claims. In addition, our reportable accident/incident rate was only 16 percent of the OSHA-acceptable level for a project of T-REX’s type and magnitude.

Having the right people with the right attitude—one of commitment to the Project and to cooperation—was absolutely essential. The entire T-REX Project Team always put the Project before their parent agency loyalties—the Project always came first. The Project Team included professionals with technical expertise in project management, ROW, Public Information (PI), utilities, and other areas—to affect the D-B contract.

The most important elements in successful partnering, in our experience, were:

- Teamwork—Our people: We fostered a teamwork environment by co-locating the Project participants:
 - Owners (RTD, CDOT, and private sector support)
 - D-B contractor team
- Involving the potential bidders through the Statement of Qualifications (SOQ)/Request for Qualifications (RFQ) and Alternative Configuration Concept (ACC) processes.

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- Having the FTA and FHWA functioning as a single US Department of Transportation (DOT)—a *One DOT*.
- Always functioning as “*One Team, One Voice*,” especially with the media, stakeholders, and the public.

Partnering on the T-REX Project involved:

- Co-locating all the key Project personnel: CDOT, RTD, D-B contractor, selected consultants, local agency staff, and federal agency representatives.
- Solving problems at the lowest possible decision-making level.
- Bringing in the “right partners” (no claims resulted).
- Having an industry review through soliciting SOQs and comments to the draft Request for Proposals (RFP).

4. *Developing a Well-Defined Design-Build Contract*

We took the time to research similar projects before beginning the D-B process. This gave us valuable insight into ways to reduce risk and manage costs. By taking time to research other projects and incorporate their lessons learned we were able to develop a solid D-B contract.

We actively solicited input from industry to ensure the RFP we developed did not impose undue risk or potential costs that could negatively impact the overall T-REX Project. Assigning risk appropriately to the party or parties best able to manage it made everything else fall into place.

We also developed our acceptance strategies early to ensure the delivered T-REX Project would meet our Project Goals.

Finally, we chose to separate contracts that were best delivered by other methods [such as Design-Bid-Build (D-B-B)] from the T-REX D-B contract.

5. *Developing and Focusing on Project Goals from the Outset*

We developed, followed, and regularly measured ourselves against T-REX Project-wide goals. We made these goals the foundation of the SOQ/RFP process by inviting qualified potential D-B contract bidders to provide input and feedback, and incorporating our stated goals as part of the evaluation criteria. Our approach included a D-B contracting approach that used:

- Best value rather than lowest cost bidder selection.
- Confidential industry review process during RFP preparation.

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- A thorough evaluation and selection process.
- Dedication to partnering at all levels (federal, state, local, and D-B contractor).
- Review of our stated goals as the T-REX Project evolved.

6. *Creating and Implementing an Effective Public Information Program*

Keeping the public informed about the progress of T-REX and upcoming construction activities and delays was a critical element to getting the commuting public, local residents and businesses, and stakeholders at all levels to “buy-in” to the Project.

We took a number of actions to implement our PI program, including:

- Requiring the establishment of a PI program as one of the criteria in the D-B contractor selection process.
- Co-locating the Owner’s and D-B contractor’s PI teams to create a unified approach and voice for the T-REX Project.
- Creating an instantly recognizable brand and logo to ensure disseminated information was associated with T-REX.
- Providing constant information and updates through the T-REX website (www.TREXProject.com) and a 24-hour hotline.

Extensive public/community meetings were held during the planning phase of the T-REX Project to let the public participate in decisions that affected their communities. This included input into elements of Light Rail Transit (LRT) station design, sound wall aesthetics, and similar aesthetics-related Project elements.

The D-B contractor, on its initiative, took actions including notifying local residents of upcoming nighttime construction activities and offering hotel vouchers for those nights. The Project also made extensive use of interactive message boards to inform potentially affected residents, businesses, and commuters about construction activities. Road closures were well-publicized in advance and detours were marked and signed.

7. *Early Execution of Intergovernmental Agreements and Memoranda of Understanding*

The T-REX Project passed through five cities and three counties. Coordinating a \$1.67 billion project required MOUs and IGAs with local governments—the entity third parties. Entity third parties have a justifiable interest in any major new infrastructure that is being constructed in their environment, and interactions with these third parties can represent a major risk for any large transportation project.

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Our IGA development process included, or allowed for, the following:

- A negotiation phase where agreements were reached on how each stakeholder or third party would pay its share of the local matching funds needed for the Full Funded Grant Agreement (FFGA). We included these agreements in the applicable IGA.
- Provisions for local entity/stakeholder input to design plans and construction review.
- An agreement on realistic design review timeframes.
- A defined process for obtaining permits that also identifies who is responsible for the permit fees.

It is also important to clearly define the use and purpose of a project's contingency fund to the participating local entities. The T-REX Project operated with a very lean contingency. Many local entities wanted additional construction elements that were likely to be outside the scope of the Project, so an upfront understanding of funding limitations was essential to our success in remaining within budget and ahead of schedule.

Using local matching funds through the execution of IGAs showed the strong level of local support and commitment to the T-REX Project. These matching funds were instrumental in demonstrating our commitment to the FTA during the FFGA process. In total there were seven IGAs—one for each local governmental entity. The timeframe to execute the IGAs was 1999-2000.

Requests for improvements or betterments from third parties (both entity and private) occurred frequently. Each request was evaluated in terms of cost and schedule impacts to CDOT/RTD and the stakeholders. In the early stages of the T-REX Project, it was difficult to agree to these requests since there were concerns about being able to stay within the T-REX Project budget and on schedule.

In most cases, third parties paid for the improvements and betterments, with some cost-sharing with the T-REX Project. The T-REX project always provided an entity or private third party with the opportunity to fund any requested "betterments." Many communities took advantage of this opportunity and, as a result, third parties funded a significant number of the Project's change orders that related to enhancements.

In the event there were contingency funds remaining at the conclusion of T-REX construction, agreements were in place with the local governments and Project stakeholders about how the funds would be allocated. This enabled the T-REX funds, along with local matching contributions, to be used to fund some critical highway bridges (Hampden Avenue over I-25 and Colorado Boulevard over I-25) and three additional pedestrian bridges to provide better access to several LRT stations.

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8. *Early Planning for Utility Relocation and Acquisition of Right-of-Way*

The T-REX Project involved a unique collaboration between CDOT and RTD. It also involved collaboration between the FTA and the FHWA, which was formalized in a 1999 IGA, to use a federal *One DOT* approach to managing and building T-REX.

Right-of-Way Acquisitions

Having the “right” staff, experts, and consultants available from the beginning of the T-REX Project in 1999 ensured needed resources were both available and familiar with the intricacies and issues of the T-REX Project. The success of this approach was reflected in not having one ROW claim by the D-B contractor for failure to provide a parcel in the timeframe that was stated in the contract.

Co-locating key personnel from different agencies (CDOT, RTD, FTA, FHWA, D-B contractor, and others) facilitated the exchange of critical information on a daily basis and ensured consistent procedures within and between these agencies pertaining to supervising ROW acquisition and relocation activities for the T-REX Project.

A dual-agency project such as T-REX can often result in divided perspectives and priorities. By co-locating all the major T-REX Project managers and other decision-makers in the Project office, the real estate managers from CDOT and RTD were able to execute ROW activities in a coordinated manner. The CDOT and RTD managers were able to streamline processes by using only one agency’s forms and technical experts, and coordinate the actions of their internal staff and external ROW consultants.

Utility Relocation

To attempt to mitigate the concerns of the utility companies the T-REX Project Team chose to make a significant up-front investment in Quality “A” Sub-Surface Utility Engineering (SUE). This approach was intended to avoid T-REX Project delays related to utility relocations and allow greater opportunities for Value Engineering (VE) of potential utility relocations.

In order to streamline utility relocations, the Colorado Legislature passed, and the Governor signed into law, *Colorado Senate Bill 00-203 (Section 43-1-1410 through -1412, Colorado Revised Statutes)* in the spring of 2000. This legislation provided for a master Project Specific Utility Relocation Agreement (PSURA) with each affected utility. In addition, Senate Bill 203 required the new level of utility cooperation and coordination that was essential to expedite T-REX and other state-wide D-B projects.

To further expedite the utility relocation process and mitigate schedule disruptions, we created a Utility Task Force that began monthly meetings two years prior to the start of T-REX Project construction. The Task Force included utility representatives from CDOT, RTD, utility owners, and the municipalities along the T-REX corridor. The Task Force provided a mechanism for the development of relocation processes and procedures.

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The D-B contractor, once selected, had the responsibility for confirming utility relocations were necessary and coordinating the details of the relocations. This included scheduling relocations, and in some cases designing and performing the construction for the relocations. The T-REX utility team, D-B contractor, and utility owners worked to minimize costs and impacts by seeking ways to eliminate or reduce utility relocations.

T-REX personnel stayed involved throughout the relocation and other Project construction activities, rather than turning the entire Project over to the D-B contractor. This approach enabled the D-B contractor to benefit from the established relationships the T-REX utility team had developed with the utility owners.

9. *What We Would Do Differently*

We would have identified LRT station planning as a major area of focus early in the project. Requests for changes from local governments, developers and the public to station layouts, esthetics and access were challenging throughout the project. Specifically, the stakeholder emphasis on Transit Oriented Development (TOD) was not anticipated and resulted in several impacts to the T-REX Project. In addition, it is important to have the ability to control the ROW during the Project and not depend on land donations or other restrictions as occurred at two LRT stations. In a D-B project, it is important to provide for more flexibility in LRT station design in the contract, given the likelihood of changes.

The financial IGAs successfully addressed the local funding commitments from the cities, counties, and private entities. However, these were primarily financial agreements and did not address areas such as permitting, design reviews, approvals, and related issues. These issues were generally managed on an as-needed basis throughout the T-REX Project. A comprehensive agreement addressing all of these areas is desirable (but not always possible) prior to contract award.

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T-REX Project Awards

The Transportation Expansion Project has won over three dozen national and local awards as of May 2007. A selection of these awards follows:

2002	American Assoc. of State Highway & Transportation Officials	Honorable Mention, Print Internal Newsletter or Magazine
2002	U.S. Environmental Protection Agency & U.S. Department of Transportation	Commuter Choice Employer Initiative for Encouraging Transportation Alternatives
2002	International Assoc. of Business Communication, Colorado Chapter	Distinguished Service Award in Public Information
2003	Institute of Transportation Engineers, CO/WY Section	Outstanding Achievement on the T-REX Project
2003	Public Relations Society of America, Colorado Chapter	Silver Pick for Brochures/Special Publications Greater Than \$10,000
2003	Public Relations Society of America, Colorado Chapter	Gold Pick for Website Budget Greater Than \$5,000
2003	Public Relations Society of America, Colorado Chapter	Gold Pick for Best Communications Program, T-REX Community Relations Plan
2004	Colorado Performance Excellence	Timberline Award for Performance Excellence
2004	Colorado Construction Magazine	Silver Hard Hat Award for Outstanding Public Project (Elati Maintenance Facility)
2004	American Road & Transportation Builders Association	PRIDE Award for Outstanding Media Relations and Public Education Program
2005	American Association of State Highway & Transportation Officials	Photography Public Affairs Skills Award
2006	CDOT Environmental Excellence Award	Leadership and Efforts in Environmental Oversight
2006	American Public Works Association, Colorado Chapter	Extraordinary Public Works Project, Elati Maintenance Facility
2006	Denver Regional Council of Governments	Local Government Innovation Award Cooperative Service Category: Arapahoe at Village Center Park-n-Ride
2006	Federal Highway Administration	Innovation & Subsurface Utility Engineering Excellence Award, Projects Greater Than \$100 Million
2006	International Road Federation	Quality Management & Maintenance Award
2006	Colorado Construction Magazine	Gold Hard Hat Project of the Year Award
2006	Colorado Construction Magazine	Gold Hard Hat Award for Design-Build Project
2006	Women in Transportation - Colorado Chapter	Project of the Year
2007	Associated General Contractors	2007 Marvin M. Black Award for Partnering Excellence
2007	Associated General Contractors	AON Build America Design-Build Renovation
2007	Associated General Contractors	AON Build America Grand Award
2007	Colorado Asphalt Paving Association	Best in Project Delivery Category
2007	Colorado Contractors Association	Environmental Excellence Award: Noise Mitigation & Monitoring Program
2007	Rocky Mountain Chapter American Concrete Institute International	Outstanding Project of the Year

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T-REX LESSONS LEARNED—MASTER ACRONYM LIST

ACC	Alternative Configuration Concept
ADA	Americans with Disabilities Act
BART	Bay Area Rapid Transit
CADD	Computer-Assisted Design and Drafting/Drawing
CAR	Corrective Action Report
CAS	Compliance Audit System
CBCP	Category B Change Proposal
CBD	(Denver) Central Business District
CCB	Change Control Board
CCTV	Closed-Circuit Television
C/D	Collector/Distributor
CDOT	Colorado Department of Transportation
CIL	Certifiable Items List
CMG	Contracts Management Group
CO	Change Order
CPEx	Colorado Performance Excellence
D-B	Design-Build
D-B-B	Design-Bid-Build
DMS	Dynamic Message Signs
DOT	Department of Transportation
DRB	Disputes Review Board
DRCOG	Denver Regional Council of Governments
EIS	Environmental Impact Statement
FEIS	Final Environmental Impact Statement
FFGA	Full Funded Grant Agreement
FGL	Functional Group Leaders
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GARVEE	Grant Anticipation Revenue Vehicle
HIRSYS	Hotline Information Reporting System
IAT	Independent Assurance Testing
IGA	Intergovernmental Agreement
IIR	Issue Identification Report
ISO	International Standards Organization
ITS	Intelligent Transportation Systems
LOI	Letter of Interest
LRT	Light Rail Transit
LRV	Light Rail Vehicle
LTK	Louis T Klauder & Associates
MIS	Major Investment Study
MOU	Memorandum (a) of Understanding
NCR	Nonconformance Reports
NEPA	National Environmental Policy Act

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NTP	Notice to Proceed
OCIP	Owner Controlled Insurance Program
OSHA	Occupational Safety and Health Administration
OVT	Owner's Verification Testing
PA	Project Acceptance
PCIP	Partner Controlled Insurance Program
PE	Preliminary Engineering
PI	Public Information
PMOC	Project Management Oversight Consultant
PSURA	Project Specific Utility Relocation Agreement
QA	Quality Assurance
QC	Quality Control
QMC	Quality Management Consultant
QMP	Quality Management Plan
RA	Risk Assessment
RFP	Request for Proposal(s)
RFQ	Request for Qualifications
ROD	Record of Decision
ROW	Right-of-Way
RTD	Regional Transportation District
SBE	Small Business Enterprise
SCADA	Supervisory Control and Data Acquisition
SECC	Southeast Corridor Constructors
SEP	Special Experimental Project
SUE	Sub-Surface Utility Engineering
SOQ	Statement of Qualifications
TA	Technical Approach (es)
TDM	Transportation Demand Management
TMO/A	Transportation Management Organization/Association
TOC	Traffic Operations Center
TOD	Transit Oriented Development
T-REX	Transportation Expansion (Project)
UIS	Utility Information Sheet
VCC	Valley Corridor Constructors
VE	Value Engineering
VECP	Value Engineering Change Proposal
WBS	Work Breakdown Structure

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T-REX LESSONS LEARNED—MASTER CONTACT LIST

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Lesson Learned # 1
Project Goals

1. Executive Summary

The Transportation Expansion (T-REX) Project had one overriding goal: *To minimize inconvenience to the public.* There were three additional goals:

- Meet or stay below budget.
- Finish on or ahead of schedule.
- Deliver a quality project.

These goals were at the forefront of every aspect of the T-REX Project, from developing the Preliminary Design, to creating the Request for Proposals and evaluating the responses, to working with the Design-Build contractor.

By developing these goals at the outset of the Project, adhering to them, and gaining “buy-in” from the various stakeholders and Project participants, the T-REX Project was completed more than 18 months ahead of schedule, under budget, and had received wide-spread public acceptance as a quality Project.

2. Background

On November 9, 1999, Executive Oversight Committee representatives from the Regional Transportation District (RTD), the Colorado Department of Transportation (CDOT), the Federal Highway Administration (FHWA), and the Federal Transit Administration (FTA) held a meeting to establish T-REX Project goals. The goals developed at that meeting are shown in the inset box that follows.

T-REX Project Goals:

- 1. *Minimize inconvenience to the public.***
- 2. Meet or stay under the total T-REX Project budget of \$1.67 billion.**
- 3. Provide a quality project.**
- 4. Meet or beat the scheduled fully operational target date of June 30, 2008.**

The number one goal for the T-REX Project was always to “*minimize inconvenience to the public.*” To ensure this goal would be met, the T-REX Project Team established a comprehensive *Public Information* (PI) program (Lesson Learned #7).

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The T-REX Project Team formulated these goals very early in the design and development stage. This early development contributed significantly to the success of our efforts to focus people and resources on a common aim for the T-REX Project. During the Request for Proposals (RFP) development process, we focused on our goals, enabling the T-REX Project Team to effectively and efficiently define the scope and design for the Design-Build (D-B) contract delivery method. Careful consideration was given to the level of detail, scope, and development of quality requirements, including the needs of the T-REX Project Owner (RTD/CDOT) for a systematic audit/oversight.

The T-REX Project/Southeast Corridor is shown in Appendix A, Attachment 1.

3. The Lesson

Establishing the T-REX Project goals at the outset, and getting “buy-in” from all levels of the Project team enabled us to focus our limited resources on delivering a successful project. We were able to refer back to our Project Goals to ensure the end result met our definition of a quality project.

Project goals agreed upon at the Owner/Project Management level must be clearly communicated to Project Team members, including the D-B contractor, at all levels. Conveying this information needs to be a high priority.

Making the T-REX Project Goals the cornerstone of the D-B contract RFP requirements, development, and subsequent proposal evaluation processes helped ensure the bidders were on-board with the Project Goals. Having the Project Goals reflected in all documents and in the D-B process ensured the D-B contractor fully understood the role and importance of all of our T-REX Project Goals throughout the entire process.

Goals need to be monitored periodically during project implementation to ensure they are being followed and are still valid.

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List of Acronyms—Lesson #1

CDOT	Colorado Department of Transportation
D-B	Design-Build
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
PI	Public Information
RFP	Request for Proposals
RTD	Regional Transportation District
T-REX	Transportation Expansion (Project)

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Lesson Learned # 2
Project Management Approach and Organization

1. Executive Summary

This “lesson learned” describes the Project Management approach and organization that proved so successful on the Transportation Expansion (T-REX) Project. T-REX was a unique project in many ways, involving:

- A partnership between the State Department of Transportation (DOT) and City transit agencies.
- A two-mode transit system—light rail and highway.
- A nearly \$2.0 billion budget.
- A Design-Build (D-B) construction approach to streamline the process.

The T-REX Project emphasized timely availability of both resources [such as utilities and Right-of-Way (ROW)] and experts operating in an integrated framework. One of the overriding achievements of the T-REX Project Management and Operations approach was the use of delegation. In particular, delegating total T-REX Project authority to the Project Director and Deputy Director was a major success story. As long as proposed changes were within the original budgeted amount, these Directors had the authority to approve these changes.

We relied heavily on our Team approach and Team members, creating a “public-private partnership.” Both Owners and Contractors/Consultants were co-located—a must in any D-B project.

To date there have been no comparable projects anywhere across the continent.

2. Background

The Intergovernmental Agreement (IGA) between the Colorado Department of Transportation (CDOT) and the Regional Transportation District (RTD) was executed on September 9th, 1999. This IGA outlined the intent of CDOT and RTD to work together in a cooperative approach to finance and build the Southeast Corridor Multi-Modal Project. Included in the IGA was the agreement to form a Project Team to work together on all aspects of the T-REX Project, including the D-B contract.

The T-REX Project faced some unique requirements and conditions:

- Two Owner Agencies (RTD and CDOT)
- Multi-modal transit elements:

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- Highway
- Light rail
- A budget of almost \$2.0 billion
- Using a D-B rather than Design-Bid-Build (D-B-B) approach

A nationwide search for similar projects found nothing that met all the T-REX conditions. The Salt Lake City, Utah I-15 highway reconstruction project had similarities to T-REX, but was not a multi-modal project.

The Project Team also visited three D-B Light Rail Transit (LRT) projects:

- Hudson-Bergen in New Jersey
- Bay Area Rapid Transit (BART) Airport Extension in San Francisco, California
- Portland, Oregon

None of the four projects reviewed were either multi-modal or of a scale and magnitude approaching that of T-REX.

Both CDOT and RTD were limited in the number of employees that could be used in support of the T-REX Project. The IGA specified that the T-REX Project Director must be a CDOT employee and the Deputy Project Director must be an RTD employee. The two Directors worked with CDOT and RTD management to create an organization that would be accountable and also include most of the specialty disciplines needed to manage the T-REX Project. For the most part, the T-REX Project was led and managed by Owner (CDOT/RTD) staff with contractors and consultants from the private sector.

To create an integrated team a number of facilitated partnering and team building sessions were held. The goal was to develop a “*Project Comes First*” attitude between the Project Team members—to develop and reinforce the spirit that regardless of what entity a person worked for, *we were all one team*.

3. The Lesson

Design-Build was a new project delivery method for both CDOT and RTD. Neither Owner’s staff had significant experience with D-B. Providing oversight on a D-B project versus the traditional D-B-B delivery method proved to be a challenge for some Project Team members. Not everyone can adjust to this streamlined D-B approach.

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To deal with the D-B approach we sought out Owner and private sector Project Team members who were able and willing to “think outside the box.” The primary requirement for these Team members was to be able to be less “prescriptive” and controlling as was typically required in the traditional D-B-B environment.

To enable our Team members to adapt to the D-B delivery method we provided up-front training on the differences between D-B and D-B-B delivery methods. This gave Team members a good idea what to expect as T-REX started. By preparing the Team members in advance of the T-REX Project start we created a dynamic organization whose members embraced D-B. The up-front training ensured:

- A dynamic, committed T-REX Project Team working environment
- Team members with a strong sense of what needed to be accomplished
- Managers who were able to provide appropriate guidance and direction

We worked diligently to ensure that all Project Team members were committed to and supportive of the ultimate success of the T-REX Project.

The T-REX Project Team was composed of full-time CDOT and RTD employees and private sector consultants and contractors.

The CDOT and RTD Team members came from specialty areas integral to T-REX’s success:

- Quality Assurance (QA)
- Public Information (PI)
- Right-of-Way (ROW)
- Utilities
- Safety
- Insurance/Risk Management

Having full-time staff in these critical specialty areas mitigated the potential risk of having to share staff with other activities outside T-REX. The need to prioritize staff resources with non-T-REX project managers was eliminated. The CDOT Project Director and RTD Deputy Director were given full authority and held accountable for managing all aspects of the T-REX Project.

In order to ensure smooth operations of procurements that were outside the D-B contract scope (the Elati Maintenance Facility and the fare collection system) the Project Team managed these projects as well.

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One of the overriding achievements of the T-REX Project Management and Operations approach was the use of delegation. In particular, delegating total T-REX Project authority to the Project Director and Deputy Director was a major success story. As long as proposed changes were within the original budgeted amount, these Directors had the authority to approve these changes. The Project Director and Deputy Director made extensive use of informal communications with the CDOT Executive Director, RTD General Manager, RTD Board of Directors, and the CDOT Transportation Commission to ensure all the Owners were kept in the loop.

There were over 300 change orders during the course of the T-REX Project. In a D-B delivery model it is essential to be able to make appropriate changes, improvements, and corrections in the most expedited way possible. Releasing change order authority to the Project Director level was a major contributing factor to completing the T-REX Project under budget and ahead of schedule.

We kept in close contact with the Operations and Maintenance staffs since those are the organizations ultimately responsible for maintaining the T-REX infrastructure. We realized early on that the input of those organizations into major project level decisions may affect their operations once T-REX became operational.

We relied heavily on our Team approach and Team members, creating a “public-private partnership.” Both Owners and Contractors/Consultants were co-located—something we believe should be a requirement for any D-B project, regardless of size or scope. Collocation was a major advantage because using part-time resources is a major challenge, especially during the design phase, since D-B projects move quickly. We found three other advantages to collocation:

- Communications at all levels were enhanced.
- Non-owners quickly came to feel they were part of the T-REX Project Team.
- Decision-making and problem resolution could take place at the lowest possible level.

Maintaining staffing during project acceptance and close-out (see Lesson Learned #18—*Project Acceptance and Close-out*) will always remain a challenge since staff members begin to feel a need to move on to new assignments. Project Directors and Managers need to stage the exodus of staff prior to the completion of a project. Keeping key staff on board as long as possible is a necessity for orderly project close-out.

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List of Acronyms—Lesson #2

BART	Bay Area Rapid Transit
CDOT	Colorado Department of Transportation
D-B	Design-Build
D-B-B	Design-Bid-Build
DOT	Department of Transportation
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
IGA	Intergovernmental Agreements
LRT	Light Rail Transit
PI	Public Information
QA	Quality Assurance
ROW	Right-of-Way
RTD	Regional Transportation District
T-REX	Transportation Expansion (Project)

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Lesson Learned # 3
Risk Assessment

1. Executive Summary

Well-executed risk assessment and analysis can reduce contingencies and risk costs in contractors' price proposals and minimize the number and impact of change orders. For Transportation Expansion (T-REX) Project, some risks were best managed by the Design-Build (D-B) contractor, some by the Project Owner, and some were taken on as shared risks. The rule-of-thumb for assigning risks was to assign them to those who could impact them the most and manage them best.

Some of the key risk assessment/allocation processes that led to our successful project were:

- Performing a thorough risk identification and allocation early in the Project.
- Including Risk Analysis/Assessment (RA) in the Request for Proposals (RFP) evaluation criteria.
- Mandating compliance with ISO-9000 requirements for the D-B contractor.
- Retaining acceptance of constructed elements by the Project Owner.
- Early coordination with utilities to facilitate relocation.
- Timely execution of Intergovernmental Agreements (IGA) and/or Memoranda of Understanding (MOU) with all stakeholders and affected entities.

2. Background

The traditional design approach for large multi-modal infrastructure projects is Design-Bid-Build (D-B-B) rather than D-B. The T-REX Project owners, the Colorado Department of Transportation (CDOT) and Regional Transportation District (RTD) opted for the flexibility of the D-B approach.

Risk Assessment and Analysis can assure contract terms that reduce the level of contingency included in a contractor's price proposal and help minimize the number of change orders realized during project implementation. Once the decision was made to proceed using a D-B contracting approach for the T-REX Project, the CDOT/RTD team chose to proceed with a risk analysis that included:

- Developing a risk assessment matrix.
- Identifying significant risk elements on T-REX.

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- Identifying shared (Owner/D-B contractor) risk elements.

When determining which entity would assume the risk, the team went with the maxim: “The entity best able to manage a risk should be assigned the risk.”

After developing goals for the project, the T-REX Project Team focused on the keys to maximizing the probability of successful project implementation. The process used to evaluate risk for the T-REX project involved two distinct steps. The first step was an RA analysis. The second step allowed decisions to be made about owner (CDOT/RTD) versus contractor risk allocation. Although the two terms are often used interchangeably, they were two distinct analyses used for different purposes for our D-B project. T-REX performed a risk assessment that involved an analysis of the T-REX Project risks that were most likely to cause the D-B bidders to include cost or schedule contingencies in their proposals. The risk assessment determined how those risks could be avoided or mitigated prior to D-B contractor selection.

The T-REX Project Team then performed a risk allocation analysis to determine how the remaining risks were to be shared between CDOT/RTD and the selected T-REX Project contractor. Risk was allocated to the party best able to manage each risk. T-REX performed both the risk assessment and risk allocation analyses in light of the project goals.

The process used to evaluate risk for the T-REX project involved two distinct steps. The first step was an RA analysis. The second step allowed decisions to be made about owner (CDOT/RTD) versus contractor risk allocation.

We began by identifying and evaluating other large-scale D-B projects. After performing this evaluation we selected the Utah I-15 Department of Transportation (DOT) risk chart as the model for our RA matrix. We then used a five-step process to develop our RA matrix so we could include it in the RFP and use it as an evaluation criterion:

1. Identify as many risk areas as possible.
2. Discuss each area with members of the Project team to identify the correct area to assign the risk.
3. Assign risk area to the T-REX Project owner or the D-B contractor, or indicate it as a shared risk area in the RA matrix.
4. Seek input from potential D-B contract bidders about the RA allocations in the matrix.
5. Modify and continue to update and reassess the RA matrix until release of the RFP for the T-REX project.

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Significant Owner-Retained Risk Elements

It is not feasible or reasonable to assign all risk elements to the D-B contractor. Some of the key risk areas that were retained by the T-REX Project owner were:

- Geotechnical
- Right-of-Way (ROW) [See Lesson Learned #11—*Right-of-Way*]
- Budget management [See Lesson Learned #7—*Project Budget*]
- Light Rail Transit (LRT) Stations
- Transit Oriented Development (TOD) [See Lesson Learned #16—*Transit Oriented Development*]
- Hazardous materials remediation

Owner-retained risk involved activities and areas that could have dramatically slowed T-REX Project implementation and completion, resulting in significant potential cost overruns. To mitigate the owner-retained risks we took the following steps:

- Early identification of both utilities for relocation and ROW acquisitions.
- Identification of potential environmental and related risks including:
 - Pre-bid site assessments (these were provided to the D-B contract bidders)
 - Provision of a hazardous substances contingency budget
 - Development of site-specific Health and Safety Plans

Design-Build Contractor Assigned Risk Elements

Certain risk elements were identified and assigned to the D-B contractor, with input from potential D-B contract bidders. These risk elements were:

- Final Design (FD)
- Constructability of the design
- Quality Control/Quality Assurance (QA/QC) [See Lesson Learned #9—*Quality Management*]
- Obtaining permits

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- Weather
- Schedule
- Inflation

The T-REX Project was built using a very aggressive construction schedule. In order to meet this schedule, we decided that the D-B contractor was the most reasonable entity to manage FD-, construction-, and schedule-related risks. This enabled the D-B contractor to plan the work in such a way that traffic volumes could be maintained, thereby achieving our #1 goal: *To minimize inconvenience to the public.*

Assigning the responsibility for the QA/QC element to the D-B contractor carried with it a large degree of T-REX Project owner risk. To mitigate this risk the QA/QC process was a major evaluation criterion in the RFP/proposal evaluation process. The D-B contractor was required to certify its work to International Standards Organization (ISO)-9000 standards. In addition, we developed and implemented a risk oversight auditing program [See Lesson Learned #9—*Quality Management*]. Finally, we specified that all constructed elements were subject to T-REX Project Owner acceptance.

Shared Risk Elements (Owner/D-B Contractor)

During the RA process we determined certain risk elements were best shared between the D-B contractor and RTD/CDOT (the T-REX Project Owners). These risk elements were:

- Public Involvement/Information (PI) [See Lesson Learned #8—*Public Information*]
- Coordination with utility owners [See Lesson Learned #12—*Utilities*]
- Integration with RTD systems
- Partner-Controlled Insurance Program (PCIP)
- Local agency design approvals
- Fuel cost adjustment
- Light Rail Transit start-up
- Project acceptance [See Lesson Learned #18—*Project Acceptance/Closeout*]

The ROW and utility implications [see Lessons Learned # 11—*Right-of-Way* and 12—*Utilities*] were significant since the T-REX Project was built along 19 miles of urbanized corridor. The design and relocation aspects were specifically precluded from impacting the Project schedule or

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budget. By performing a significant amount of preliminary ROW and utility identification and coordination we were able to greatly reduce the risks to T-REX costs and schedule associated with those acquisition and relocation efforts.

3. The Lesson

A thorough risk analysis needs to be performed in order to achieve the greatest level of project success when using the D-B contract delivery approach. Having a well-organized and thoroughly implemented risk analysis approach avoided many potential cost and schedule contingencies that otherwise might have been included in D-B contract bidders' proposals. Inherent in risk analysis is the need to determine and properly allocate project risks between the owner and the D-B contractor.

Allocating risk to the entity—Project owner or D-B contractor—that is best able to manage that risk produced positive outcomes, resulting in a project that met all stated objectives for costs and completion. The extensive level of thought and pre-planning that went into the two-step risk analysis identified a number of activities that CDOT/RTD was able to complete prior to D-B contractor selection, thereby eliminating or reducing certain areas of T-REX Project risk. These pre-contract risk reduction or mitigation efforts included preparing utility master agreements and utility information sheets and obtaining environmental permits

The risk-related keys to a successful project were:

- Having a clearly identified set of risks.
- Allocating each risk to the appropriate team member.
- Involving potential bidders in the risk identification/allocation process.
- Making risk allocation/reduction part of the RFP and the evaluation criteria.

Some of the key steps we took that we believe contributed directly to meeting all the T-REX Project Goals covered in Lesson Learned #1—*Project Goals* were:

- Performing a thorough two-step risk identification/allocation.
- Using the RFP process to identify and define T-REX Project QA/QC expectations.
- Making RA part of the RFP and an RFP evaluation criterion.
- Requiring the D-B contractor to adhere to ISO-9000 standards.
- Developing and implementing an RA Oversight Program.
- Maintaining owner acceptance of constructed elements.

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- Performing early coordination with utilities to facilitate relocation.
- Preparing master agreements with utilities.
- Defining and executing IGAs and/or MOUs with all corridor cities.
- Preparing extensive pre-bid site assessment information and providing it to the D-B contractor.
- Developing regulatory partnership to assist in assessment of environmental issues and maintaining a knowledgeable staff to assist in these areas.

In retrospect, we believe that an increased effort to provide as many third party agreements as possible (see Lesson Learned #15—*Third Party Enhancements*) in the RFP, including IGAs and/or MOUs with all corridor cities, could have provided significant additional T-REX Project cost and schedule benefits.

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List of Acronyms—Lesson #3

CDOT	Colorado Department of Transportation
D-B	Design-Build
D-B-B	Design-Bid-Build
DOT	Department of Transportation
FD	Final Design
IGA	Intergovernmental Agreement
ISO	International Standards Organization
LRT	Light Rail Transit
MOU	Memoranda of Understanding
PCIP	Partner-Controlled Insurance Program
PI	Public Information
QA/QC	Quality Control/Quality Assurance
RA	Risk Assessment
RFP	Request for Proposals
ROW	Right-of-Way
RTD	Regional Transportation District
TOD	Transit Oriented Development
T-REX	Transportation Expansion (Project)

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Lesson Learned # 4
Procurement Process

1. Executive Summary

Using a Design-Build (D-B) contract and “*best value*” approach to bidding was a new and innovative approach for a “mega-project” such as the Transportation Expansion (T-REX) Project. The D-B approach was chosen for its flexibility, as well as innovations which we used to ensure high technical performance and good cost management.

The procurement process was conducted by:

- Developing detailed and specific project goals
- Soliciting letters of interest
- Using the Request for Qualifications (RFQ) process
- Composing a short list of qualified teams
- Soliciting industry review from the short list of teams
- Allowing the bidders to provide alternative configuration concepts

Use of the D-B contract and the procurement process outlined above was a major factor in completing the T-REX Project ahead of schedule. Construction could begin while many design elements were still evolving, and Value Engineering Change Proposal (VECP) principles could be applied. Some of the VECPs actually reduced T-REX Project costs, contributing to completing the Project within budget and ahead of schedule.

2. Background

The D-B procurement process for project delivery is being used with increasing frequency by public sector transportation owners. At the outset of the T-REX Project the Project Team surveyed a number of highway and Light Rail Transit (LRT) projects across the country that had made use of the D-B process rather than the D-B-B process. It quickly became clear that D-B projects came in many shapes and sizes. However, to date D-B has been used predominately on relatively small infrastructure projects using the lowest bidder selection approach.

Multi-modal transportation projects the size of T-REX (>\$1 billion and multi-modal)—so-called “mega-projects”—simply did not exist anywhere in the country when the T-REX Project began procurement efforts in 1999. In fact, the State of Colorado procurement regulations had to be partially restructured to allow us to meet our aggressive goals. By developing flexible D-B regulations Colorado Department of Transportation (CDOT) was able to use the “*best value*”

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contractor selection criteria and use the Federal Highway Administration's (FHWA) *Special Experimental Project (SEP) 14* process.

3. The Lesson

The magnitude of the T-REX Project, relatively short timeframe for completion, and overall Project goals necessitated using an innovative procurement process.

The T-REX Project had five primary goals:

- *To minimize inconvenience to the public.*
- To complete the Project within its budget of \$1.67 billion.
- To provide for a quality Project.
- To complete the Project by June 30, 2008.

To meet these goals, the CDOT and the Regional Transportation District (RTD)—the T-REX Project “Owners”—had to choose an innovative procurement process. We chose D-B rather than the traditional and typical D-B-B approach. We also chose the “*best-value*” contractor selection approach rather than the more typical lowest bidder approach.

The main reason T-REX chose the D-B procurement process was to achieve the highest possible level of performance, innovation, and cost management by capitalizing on the flexibility provided in the D-B project delivery approach.

Since combining the D-B procurement process with the “*best value*” contractor selection process and applying the combination to a “mega-project” was an untried approach, we quickly learned the importance of innovation and a “*One Team/One Voice*” approach. The key lessons related to the D-B procurement approach we learned, tried, and applied were:

- **Develop Project Goals:** We began the procurement process by developing overall goals for the T-REX Project. Having Project goals enabled the Project Team to paint a picture of what successful Project delivery would look like. We were able to begin the design and procurement process with the end result in mind. Establishing Project goals provided a target for all procurement decisions including the selection process, risk allocations, and trade-offs.
- **Solicit Letters of Interest:** A request for “Letters of Interest” (LOI) was sent to interested potential bidders to provide the Project Team with basic qualifications and contact information.

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- **Conduct a Kick-Off Meeting:** CDOT/RTD then held an internal “Kick-Off” meeting. At this meeting the D-B procurement process was explained, Project goals presented, and the RFQ responses were reviewed.
- **Use the RFQ Process:** In order to expedite the D-B procurement process it made sense to evaluate and short-list potential bidders based on the LOIs we received. State D-B regulations required CDOT/RTD to compile a short list of between two and five teams of qualified bidders. To do this an RFQ was sent to the respondents that provided Letters of Interest. The resulting Potential bidders’ responded to the RFQ with Statements of Qualifications (SOQ). The SOQs were evaluated in terms of:
 - Past performance
 - Team organization and experience
 - Financial capabilities
 - Legal capabilities
- **Determine RFQ Provisions:** We learned how critical it is to include provisions in the RFQ to determine the financial strength—the “staying power”—of the teams. We also found that including provisions allowing the prime contractor to make changes in team members is very important to ensure a quality team and successful T-REX Project.
- **Short-list Qualified Teams:** As a result of the responses to the RFQ three teams were short-listed. There are only a limited number of prime contractors and resulting teams able to handle “mega-projects” like T-REX which highlights the importance of minimizing the number of requirements included in the RFQ.
- **Solicit Industry Review via a Draft Request for Proposals (RFP):** The three short-listed teams were provided with a draft RFP to enable them to provide industry input to the RFP process. One-on-one meetings were held with each team. At these meetings CDOT/RTD explained the provisions in the draft RFP, went over the selection criteria, and answered questions that each bidder had related to the draft RFP. Each team was invited to provide comments about the selection process, risk allocation, D-B and other contract provisions, and technical requirements. As a result of this process the final RFP differed significantly from the original draft version. Industry review greatly improved the final RFP and enhanced the bidders’ understanding of the CDOT/RTD intended procurement process.
- **Allow Bidders to Propose Alternative Configuration Concepts (ACC)/Technical Approaches (TA):** During the RFP response process CDOT/RTD held one-on-one meetings with the three short-listed teams to discuss ACC/TAs that might be as good as or even better than the requirements in the final RFP. Areas where we found it beneficial to encourage innovation and allow alternate approaches to be submitted were:

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- Basic configuration
- All technical requirements
- Contract drawings
- Right-of-Way (ROW) plans
- Insurance provisions

A total of 58 ACCs were submitted by the two teams that ultimately prepared proposals (one team withdrew from the procurement process prior to the ACC process), and 41 were accepted or accepted with conditions by CDOT/RTD.

- **Use a “Best Value” Approach for Proposal Evaluation:** Two proposals were submitted out of the three short-listed teams. Each proposal contained a technical proposal and a price proposal. The technical proposals included:
 - The approach to the T-REX Project schedule/work plan
 - Team management and organization
 - Draft Public Information (PI) Plan
 - Systems Management Plan
 - Draft Quality Management Plan
 - Draft Construction Management Plan
 - Draft Safety Plan
 - Interface Management/Systems Integration approach
 - Station/urban design/aesthetics approach

Each technical proposal was evaluated using the following adjectival ratings, with evaluators allowed to add a + or – to the assigned ratings:

- Excellent
- Good
- Acceptable

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- Unacceptable

The price proposals included a cost-loaded Work Breakdown Structure (WBS) provided by CDOT/RTD. This enabled each team's price proposal to be evaluated against the CDOT/RTD "Upset Amount" of \$1,225,526,507.

To determine the "best value" proposal the ratings from the technical and price proposals were considered to be approximately equal. The proposal evaluation results are shown in the summary table that follows.

	Price	Variance from Estimate	Overall Proposal Rating
SECC Constructors	\$1,186,451,265	3% under	Good
VCC Constructors	\$1,371,611,873	12% over	Good

The "best value" proposal was determined to be the one provided by the Southeast Corridor Constructors (SECC).

We found that the D-B approach was highly effective since construction could progress as the design process evolved and value engineering (VE) principles could be applied as T-REX matured. Using VECP/Category B Change Proposals (CBCP) enabled the T-REX Project Team to make changes and reduce costs, thereby enabling us to maintain our contingency.

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List of Acronyms—Lesson #4

ACC	Alternative Configuration Concept
CBCP	Category B Change Proposal
CDOT	Colorado Department of Transportation
D-B	Design-Build
D-B-B	Design-Build-Build
FHWA	Federal Highway Administration
LOI	Letters of Interest
LRT	Light Rail Transit
OSHA	Occupational Safety and Health Administration
RFP	Request for Proposals
RFQ	Request for Qualifications
RTD	Regional Transportation District
SOQ	Statement of Qualifications
TA	Technical Approach
T-REX	Transportation Expansion (Project)
VE	Value Engineering
VECP	Value Engineering Change Proposal
WBS	Work Breakdown Structure

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**Lessons Learned #5
Design-Build Contract**

1. Executive Summary

The Transportation Expansion (T-REX) Project team opted for a Design-Build (D-B) contract which was structured to include industry comments and suggestions, maximize contract clarity, and identify project elements that were to be excluded from the contract.

When using a D-B contract, it is important to:

- Involve experienced legal and consulting professionals when structuring the contract.
- Invest time and resources to create a comprehensive, validated contract.
- Evaluate each project element for the correct level of design prior to including it in the Request for Proposals (RFP).
- Review the draft RFP with potential bidders to obtain information and opinions from the construction industry.
- Identify project elements that will be kept separate from the D-B contract.
- Create a flexible contract to incorporate innovations that occur during the construction process.

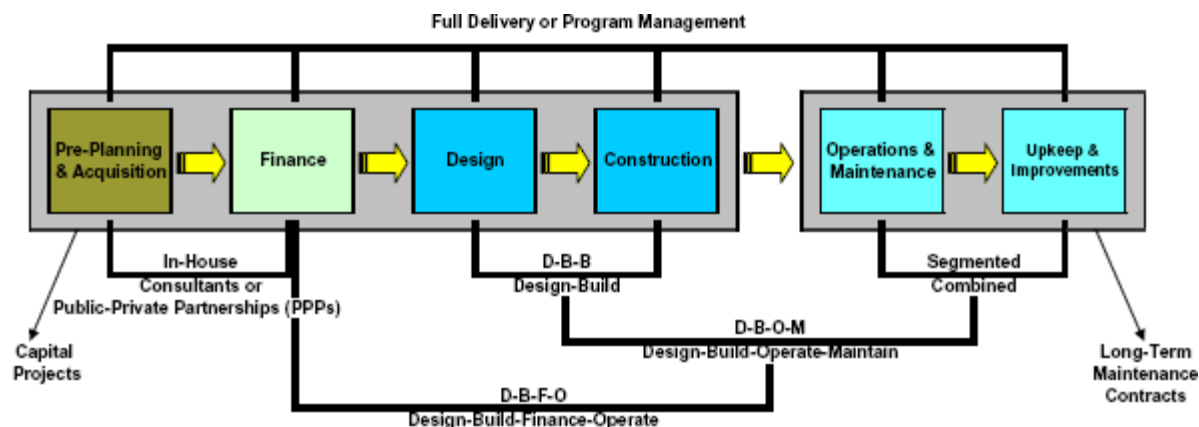
The flexibility of the contract, coupled with our change review process, resulted in nine value engineering changes and 189 small changes to the original design. These changes created a better product without causing cost over-runs.

2. Background

The T-REX Project was successfully completed using a D-B rather than the traditional Design-Bid-Build (D-B-B) contract delivery method. Early on, the T-REX Owners and the Project management team recognized the importance of creating and implementing a comprehensive, effective D-B contract. A D-B contract is significantly different from a D-B-B contract since there is more flexibility in design elements; the bidders are able to reduce costs and streamline delivery as a result.

Neither the Regional Transportation District (RTD) nor the Colorado Department of Transportation (CDOT) had prior experience with a D-B contract; however, early on, the T-REX Owners and the Project management team recognized the importance of creating and implementing a comprehensive, effective D-B contract. The following figure from the Federal Highway Administration (FHWA) shows the most frequently used contracting approaches for major infrastructure projects.

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The D-B contract was structured to:

- Ensure inclusion of contractor requirements that were defined both generally and in terms of highly performance-focused standards while providing the assurance that CDOT and RTD (the T-REX Project Owners) would achieve the stated Project Goals (Lesson Learned #1: *Project Goals*).
- Maximize Project and contract clarity and minimize ambiguities that could lead to later change orders or disputes.
- Clearly identify and allocate the related risks to the T-REX Project Owner and contractor (see Lesson Learned #3: *Risk Assessment*).
- Identify T-REX Project elements such as the Elati Maintenance Facility, Light Rail Vehicle (LRV) procurement, and fare collection equipment that should be excluded from the D-B contract.

The T-REX Project Owners, RTD and CDOT, secured the services of a law firm that had extensive experience in the development of D-B contracts. During the contract development stage, the T-REX Project team worked very closely with this firm to develop the D-B and other contract documents.

The T-REX Project team also hired a consultant who had previously served as Project Director for another D-B “mega-project.” This consultant provided practical contract development experience and helped the T-REX Project management team bridge the many technical and legal aspects of a D-B contract. The T-REX Project management team also conducted peer reviews of completed D-B projects and visited other major, ongoing D-B projects.

In addition, the draft D-B contract was subjected to an ongoing industry review by prospective bidders. This industry review process provided our Project Team the ability to incorporate valuable input from a contractor's perspective.

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RTD and CDOT also reviewed the entire T-REX Project to determine the elements to include and exclude in the D-B contract. Ultimately, we decided to exclude elements that required a high degree of specialization and would not normally be provided by the types of construction companies pursuing the D-B contract. Specifically, the contracts for LRVs, the light maintenance facility, and fare collection systems were excluded from the D-B contract.

The light rail maintenance facility, in particular, was delivered through a separate D-B-B contract. This was a specialized facility and RTD wanted to maintain a higher degree of design control than would be possible using the D-B delivery method. However, the light rail systems elements were included in the D-B procurement package (see Lessons Learned #4 and #15).

Although certain design elements were excluded, the overall D-B contract was still essentially all-encompassing in scope.

The final D-B contract document consisted of the following sections:

- Book 1 - Contract terms and conditions
- Book 2 - Contract technical requirements
- Book 3 - Codes, standards and design criteria
- Book 4 - Contract drawings
- Book 5 - Reference drawings

Book 1 had the highest order of precedence, followed by Book 2, and so forth. The reference drawings in Book 5 provided the bidders with useful information, but could not be used as the basis for change orders should the contractor later discover inaccurate or differing conditions.

The D-B contract allowed for significant design flexibility through means of Value Engineering (VE) Change Proposals (VECP), where savings were split 50-50 between the T-REX Project Owner and contractor, and Category B ("*Equal or Better*") Change Proposals (CBCP) proposed by the contractor. There were nine accepted VECPs and 189 CBCPs during the course of the T-REX Project.

The level of design provided to the contractor varied by T-REX Project component. In general the civil design was to the 30 percent level. Systems and station designs were provided at higher levels.

3. The Lesson

The structure and content of a D-B contract are critical for assuring a successful process between a project owner and a D-B contractor. The contract defines the owner's requirements and the contractor's obligations.

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The development of an effective, clear contract was critical given the importance of the contract documents and lack of prior experience with this delivery method. Experienced legal and professional consulting services were also critical to the D-B project delivery method's outstanding success on the T-REX Project.

The use of a D-B contract was a major factor in keeping the T-REX Project on schedule and within budget. It was also a factor, along with partnering, that resulted in no claims through the conclusion of the T-REX Project.

The significant lessons our team learned about the development and management of the D-B contract include the following:

- Invest the proper time and resources early when defining and developing a “mega-project” to create a comprehensive, validated, workable D-B contract. This is the major document that will govern a project for many years, and the early investment of time, reviews, and potential bidder input proved to be of great value on the T-REX Project.
- Assure that the contract reflects a true D-B environment. Bring resources with experience in the legal and contractual aspects of D-B to assist in the development of the contract.
- Evaluate each project element for the appropriate level of design before the elements are included in the RFP.
- Review the contract with potential bidders during the pre-proposal stage. Input from the construction industry—the future contractor—can identify potential cost drivers or unacceptable risks that can reduce competition and raise prices.
- Identify any specialized elements or other project elements to be kept separate from the D-B contract. On T-REX, these included the LRVs, the fare collection system, and the light rail maintenance facility, which were each procured under separate contracts. Any element excluded from the D-B contract will require significant attention by the project owner to manage the integration and interfaces of these systems with the D-B contract elements.
- Keep the D-B contract flexible to accommodate innovations (VECPs, CBCPs, and Alternate Configuration Concepts (ACC) and new approaches proposed by the D-B contractor.

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List of Acronyms—Lesson #5

ACC	Alternate Configuration Concepts
CBCP	Category B Change Proposals
CDOT	Colorado Department of Transportation
D-B	Design-Build
D-B-B	Design-Bid-Build
LRV	Light Rail Vehicle
RFP	Request for Proposals
RTD	Regional Transportation District
T-REX	Transportation Expansion (Project)
VE	Value Engineering
VECP	Value Engineering Change Proposals

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Lesson Learned # 6
Partnering

1. Executive Summary

By their nature, large multi-modal transportation projects impact many parties and require cooperation across the board. Partnering enabled us to handle the continual flow of issues effectively, and was a key to our exceptional success on the Transportation Expansion (T-REX) Project

Tips for successful partnering relationships include:

- Implementing a formal partnering process with the owner and contractor.
- Communicating the commitment of the Executive level project team members to the partnering process, the need for teamwork, and the project as a whole.
- Managing issues in a formal manner to resolve them at the lowest possible level.
- Co-locating the T-REX Project Owners, the Design-Build (D-B) contractor team, and other key Project participants to facilitate communication, problem resolution, and decision-making.

2. Background

Partnering is a structured process that defines the working relationship among the parties in a project such as the T-REX Project. That working relationship is based on a covenant of good faith and fair dealing with emphasis on a core set of partnering tools that include:

- A commitment to mutual goals.
- An issue resolution process.
- Frequent joint evaluation of team effectiveness.

The T-REX Project made extensive use of partnering. It was probably the largest and most complex multi-modal infrastructure project to do so. Partnering on the T-REX Project was carried out by team members at the Executive level, Project Management level, and the Task Force discipline level. This enabled the T-REX Project Team (the Project Stakeholders) to deal with the continual flow of issues they encountered in a rapid, effective manner.

The following table provides a summary of the key T-REX Project stakeholders.

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Local and State Stakeholders	T-REX—the Owner. A partnership between: <ul style="list-style-type: none"> ▪ The Colorado Department of Transportation (CDOT) ▪ The Regional Transportation District (RTD)
Federal Stakeholders	The “ <i>One DOT</i> ”: <ul style="list-style-type: none"> ▪ The Federal Highway Administration (FHWA) ▪ The Federal Transit Administration (FTA)
The Design-Build (D-B) Contractor	Southeast Corridor Constructors (SECC): <ul style="list-style-type: none"> ▪ Kiewit ▪ Parsons Transportation Group

Our partnering approach was based on three key principles:

- **Accountability**—Essential at both the individual and stakeholder level to facilitate a rapidly evolving, quickly developing D-B project.
- **Collaboration**—Critical in a D-B environment since this type of project moves far more quickly than a more traditional Design-Bid-Build (D-B-B) project and requires many more decisions and issue resolutions.
- **Consistency**—Consistent actions, decisions, and results within an organization that included more than 20 Task Force discipline teams was a result of a dedication to communication.

We chose to co-locate the T-REX Project Owners, the D-B contractor, and consultants to facilitate rapid communication and decision-making.

Types of Partnering

Our partnering took place at two primary levels. The first level was the Executive. The second was the Project level with its four sub-categories:

- Initial/Follow-up
- Third-Party Stakeholder
- Ongoing Project Team Evaluations and Task Force Reporting
- Issue Escalation Meetings

These partnering levels are described in the next sections.

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Executive Level Partnering

The top officials from all stakeholders were strongly committed to the success and support of the T-REX Project. They made this commitment clear from the outset to their staffs, the other Project stakeholders, third-party stakeholders, and the general public.

Executives from the primary stakeholders—CDOT, RTD, FHWA, FTA, and the D-B contractor began regular meetings in July 2001. Throughout the more than five year construction process the Executive level stakeholders emphasized the commitment to the T-REX *Project Goals* covered in Lesson Learned #1. Over the course of the Project there were 24 Executive level meetings.

Project Level Partnering

The entire T-REX Project team set up offices in the same building to foster communications and create an atmosphere conducive to partnering. This ensured frequent, regular contact between and among all the Project stakeholders. In the fast-paced D-B environment, timely decision-making was critical.

The Project used a structured, formal partnering approach that included:

- Approximately 40 meetings that included kick-off and follow-up sessions with the third-party stakeholders and task force team members. This approach helped increase public, business, and local government entity “buy-in” to the T-REX Project.
- An additional 40 or so meetings with the T-REX Project Management Steering Committee (the top executives from the primary stakeholders) to monitor results and iteratively develop partnering strategies.
- Formal, facilitated issue-escalation meetings to present position papers on issues to the next level of Project management and resolve the issues at the lowest possible level.

Included in the Project Level Partnering were four sub-categories of activities.

Initial and follow-up partnering sessions: There were approximately 17 task force teams (including construction, contracts, environmental, public information, and quality management). Each team held its own initial and follow-up partnering sessions to develop goals and an issue escalation/resolution methodology.

Third-party stakeholder partnering sessions: The City and County of Denver (CCD), while not a contractual party in the T-REX Project, controlled key Right-of-Way (ROW) immediately adjacent to the main highway for almost 50 percent of the Project. To facilitate “buy-in,” cooperation, and issue resolution, a series of third-party stakeholder partnering sessions were held. This ensured we were aware of the concerns of local businesses and residents and allowed us to communicate Project activities to these entities. To maintain communications with the CCD

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and the other stakeholders, four CCD representatives were also co-located with the primary T-REX stakeholders and attended issue resolution and other partnering sessions.

Ongoing Project Team Evaluations and Task Force Reporting: The leads of each Task Force prepared and submitted to the T-REX Project Team regular reports with summaries of successes and goals achieved and issues that required escalation. These reports were summarized and submitted as a master report to the Project Management Steering Committee.

Issue Escalation Meetings: Issue escalation meetings were held to deal with problems that could not be resolved at the Task Force or Project Team levels. This approach kept the stakeholders “meeting and talking” while working through difficult issues. During the course of the T-REX Project there were thousands of issues requiring resolution, but only 35 required use of the formal issue escalation process. Of those 35, all were resolved at the Task Force, Project, or Executive level. Although a formal Dispute Resolution Board was available, it was never needed.

3. The Lesson

The T-REX Project can serve as a model for how partnering can work to create and deliver a phenomenally successful major construction project. For a successful partnering process, participants at all levels need to be committed to the project. Key actions we took to implement a successful partnering program included:

- Implementing a formal partnering process with the owner and D-B contractor to positively affect the project goals.
- Communicating the commitment of the Executive level project team members to the partnering process and the success of the D-B contract to all stakeholders.
- Emphasizing the importance of functioning as a team (“*One Team, One Voice*”) to accomplish the project goals.
- Managing issues in a formal manner to resolve them at the lowest possible level. A side benefit of this approach was “zero claims” across the entire T-REX Project.
- Creating trust and cooperation through face-to-face interaction between and among the various stakeholders.
- Co-locating the T-REX Project Owners and D-B contractor team.

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List of Acronyms—Lesson #6

CCD	City and County of Denver
CDOT	Colorado Department of Transportation
D-B	Design-Build
D-B-B	Design-Bid-Build
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
ROW	Right-of-Way
RTD	Regional Transportation District
SECC	Southeast Corridor Constructors
T-REX	Transportation Expansion (Project)
VE	Value Engineering

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Lesson Learned # 7
Public Information

1. Executive Summary

The Public Information (PI) program was one of the keys to the success of the Transportation Expansion (T-REX) Project. An average of 230,000 cars per day traveled through the T-REX construction area, so keeping the public and the stakeholders informed of progress, road closures, and other issues avoided many potential problems.

The major facets of the PI program were:

- Requiring the establishment of a PI program as one of the criteria in the Design-Build contractor selection process.
- Co-locating the Owner's and Design-Build (D-B) contractor's PI teams to create a unified approach and voice for the T-REX Project.
- Creating an instantly recognizable brand and logo to ensure disseminated information was associated with T-REX.
- Providing constant information and updates via the T-REX website and 24-hour hotline.

The T-REX goal of “*minimizing inconvenience to the public*” was effectively met through the combined Owner/contractor Public Information programs. The unified voice and widely-recognized T-REX “brand” ensured the targeted messages were associated with the T-REX Project. Notice of road closures were provided well in advance and announced in a variety of methods including via the website and through a 24-hour telephone hotline. The aggressive Public Information plan was a major reason the T-REX Project was completed ahead of schedule.

2. Background

Historically, PI programs for “mega-projects” have been somewhat of an afterthought. From the beginning of the T-REX Project, the Colorado Department of Transportation (CDOT) and the Regional Transportation District (RTD)—the T-REX Project Owners—and the Federal Highway and Transit Administrations (FHWA/FTA) implemented programs to keep the public informed of progress, road closures, and other issues. The public information program was developed to consider impacts T-REX would have on:

- Existing, ongoing travel requirements
- Road closures
- Nearby residents

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- Local businesses

The first T-REX Project goal was to “*minimize inconvenience to the public.*” During information-gathering in the local community and from past projects we concluded the best way to meet this goal was to have the most effective PI program possible.

During the course of the T-REX Project an average of 230,000 vehicles traveled within the project construction zone each day. The T-REX corridor connected Denver’s Central Business District (CBD) with the Southeast Business District. With the significant potential impact on the public due to the length and duration of the T-REX Project, a timely, accurate, and effective PI communication campaign was essential to address the complicated phasing, duration, and potential business and commuter impacts.

The T-REX Project branding process was essential to effective communications with all stakeholders. The T-REX Project brand and logo were created to provide the public and other stakeholders with instant name recognition. This ensured disseminated information would be readily associated with T-REX. We also wanted to make sure the D-B contractor and T-REX PI team could communicate information in fun and interesting ways. A “*Rocky Mountain News/News 4*” poll taken in July 2001 showed that 94 percent of Denver metro residents had heard of the T-REX Project and that 82 percent of all Colorado citizens knew about T-REX.

Meetings were held with local elected officials, with local neighborhood organizations, and at public open houses. A website (www.TREXProject.com) was developed and maintained to provide T-REX information and updates and contact names. A T-REX Project newsletter provided up-to-date information about the progress of the T-REX Project construction. Baseline research was performed to assist in creating the model PI program and the idea of branding for the project.

Another major T-REX Project PI goal was to ensure that the D-B contractor was keenly aware of our team’s intent to “*minimize inconvenience to the public*” and the high level of communications we expected them to provide to T-REX Project stakeholders. This intent was communicated prior to issuing a Notice to Proceed (NTP)—during the industry review process. Additionally, PI was established as one of the technical criteria that would be evaluated as part of the overall D-B contractor selection process.

Once chosen, the D-B contractor’s PI team and the T-REX PI team began to craft a “*One Team/One Voice*” approach to deliver information and communicate T-REX Project activities to stakeholders. All aspects of PI were managed collectively to ensure shared accountability and proactive commitment to meet the T-REX Project’s number one goal. A PI plan was developed that emphasized and took advantage of the combined resources of both the Owner’s team and the D-B contractor’s team. This helped ensure collaborative decision-making, effective communication networks, and stakeholder understanding by providing timely, accurate, and effective communication of the T-REX Project schedule and activities.

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To further the goal of “*minimizing inconvenience to the public*” a significant amount of demolition and major reconstruction work was done at night. The Dynamic Message Signs (DMS) were used to both publicize the upcoming work and road closures and provide information about detours. An example of a nighttime construction site is shown in the figure that follows:



The final part of the T-REX Project’s PI process was establishing the roles and responsibilities for the “*Vision, Progress, and Coping*” messages seen in print media and on electronic signs above the affected highways. The intent from the beginning of the T-REX Project was to have all the team members present a unified face to the community; this was to be accomplished using our “*One team/One voice*” PI approach.

3. The Lesson

To accomplish the #1 T-REX Project goals, we developed and implemented a highly effective PI program designed to build trust between all T-REX Project stakeholders. The key tactic was ensuring the public was provided with both advance knowledge of upcoming activities and closures and a high level of knowledge about the overall Project. Based on what we learned prior to beginning the T-REX design process, we co-located the D-B contractor’s and Owner’s PI teams. This collocation ensured both cooperation and seamless information collection and dissemination. This provided the cooperation needed to provide optimum value to the public and external stakeholders.

We learned that the definition of requirements for notifying the public must be carefully considered to provide flexibility to tailor the notification effort to the targeted stakeholder group while considering the information that must be disseminated. Doing so ensured the stakeholders were well-prepared for major overnight road closures, construction activities and movement of heavy equipment in their neighborhoods, and other potentially disruptive activities.

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The key PI activities that we believe carry a valuable lesson were:

- Setting the goal of “*minimizing inconvenience to the public*” provided the necessary framework to communicate to the D-B contractor the importance of their PI efforts throughout the project. Adhering to this goal helped us establish a level of stakeholder trust that proved to be invaluable during the T-REX Project.
- Establishing and maintaining a 24-hour T-REX Project hotline. The D-B contractor took the initiative to create this hotline. In addition, the D-B contractor provided at least 30 days notice of road closures and other major activities to local stakeholders and infrastructure users. Regular community and stakeholder meetings were held during all phases of the D-B process to assure public input was heard and considered.
- Branding the project with the “catchy” phrase “T-REX” provided an easily recognizable name to stakeholders, with research results indicating 96 percent name recognition across the metro area.

Co-locating the Owner and D-B contractor PI teams proved to be an extremely effective tool for engaging the entire T-REX Project team in a collaborative partnering mode. The goal of “*minimizing inconvenience to the public*” proved to be both a powerful unifying force for the T-REX Project team and a potent way to achieve public and stakeholder recognition of and “buy-in” to the T-REX Project.

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List of Acronyms—Lesson #7

CBD	Central Business District
CDOT	Colorado Department of Transportation
D-B	Design-Build
DMS	Dynamic Message Sign
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
NTP	Notice to Proceed
PI	Public Information
RTD	Regional Transportation District
T-REX	Transportation Expansion (Project)

Lesson Learned # 8

Project Budget

1. Executive Summary

The \$1.67 billion Transportation Expansion (T-REX) Project was completed within its budget and significantly ahead of schedule. One of the major contributing factors to this level of economic responsibility was the use of a Design-Build (D-B) process, with the contractor assuming a large amount of the financial and design risks. Other processes that contributed to keeping the T-REX Project within its budget included:

- Reconciling multiple *independent* cost estimates prior to opening the Project for bid.
- Maintaining only a lean contingency fund.
- Clearly defining the base project configuration to all stakeholders and communicating that project enhancements outside the basic scope would have to be externally funded.
- Establishing and following cost control procedures regarding changes to the base scope of the T-REX Project.
- Developing cost control tools to forecast the financial impact of potential changes.

It is possible to stay within budget on large construction projects by placing a strong emphasis on iterative, independent cost estimating early in the project. Reconciling multiple, independent estimates should provide a reasonably accurate project cost estimate. Contractor “buy-in” of the budget is achieved through the D-B process. The Project Owner and the D-B contractor, working together to follow cost control procedures, can be fiscally responsible.

2. Background

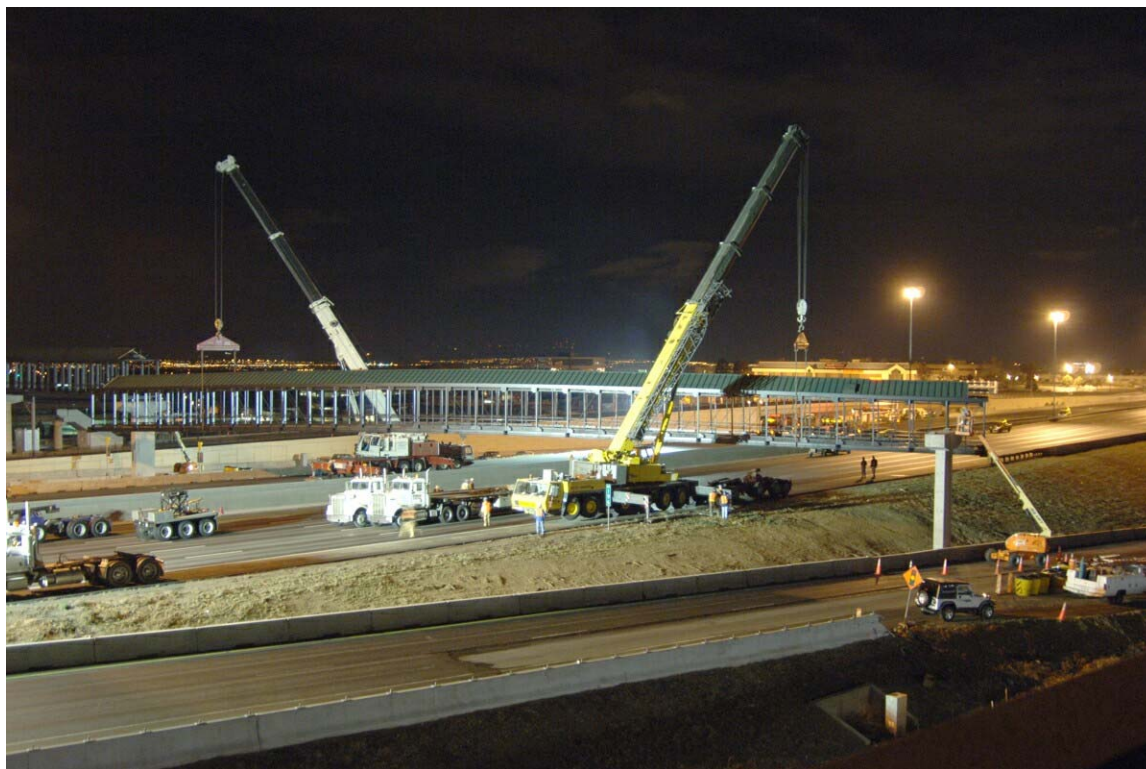
The T-REX Project Budget was developed by performing a series of cost estimates during the environmental impact and preliminary engineering (PE) stage. This iterative cost estimate process was considered to be necessary since the T-REX Project D-B delivery method presented unique challenges for the D-B contractor’s cost estimating process and potentially increased the contractor’s financial risk.

The cost estimate was developed by the Project Management Oversight Consultant (PMOC). The T-REX staff also prepared a cost estimate for the Project. These two estimates were supplemented by a third cost estimate prepared by an independent firm hired by T-REX. The T-REX Project Team reviewed and reconciled the three estimates. The Colorado Department of Transportation (CDOT)/Regional Transportation District (RTD) “Upset Amount” of \$1,225,526,507 was based on the reconciliation of these three estimates.

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The selected bid from the chosen D-B contractor was very close to the CDOT/RTD estimate of T-REX Project costs. Even though the winning bid left very little contingency for the T-REX Project, the accuracy of the multiple pre-award estimates allowed the T-REX team to anticipate and make the necessary adjustments to the project to enable a 2.5 percent (\$30 million) contingency fund to be designated at the start of the D-B contract.

The lean contingency mandated a rigorous emphasis on cost control throughout the T-REX Project. The base scope (configuration) of the Project was clearly defined to all stakeholders. The T-REX Project proceeded with the clear understanding that any enhancements outside the base scope would require additional funding. Many such requests were indeed funded, including three new pedestrian bridges over I-25 that used \$9.3 million in external funding. These items were tracked separately from the base scope and T-REX Project Budget.



Specific tools and approaches were developed to monitor and control the uses of the contingency reserve. These tools and approaches included:

- Procedures to require that any changes to the Project Budget, including change orders, are approved by the Project Director and Project Deputy Director.
- Weekly Change Control Board (CCB) meetings to review Project Budget items.
- Regular project control review meetings review Project Budget items.

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- A contingency trending report developed by the T-REX Project Controls staff, for the Project Director and Deputy Project Director, to identify potential future cost impacts and their probability so that accurate budget projections could be made.

3. The Lesson

Managing a project within a tight budget with a very small contingency reserve and unique D-B construction process is a difficult but doable task. Managing a Project Budget is one of the most important functions for a project management team. Commitments to voters, federal funding officials, and other stakeholders mandated that the T-REX Project stay within its budget. The magnitude of the project meant that any budget overrun could have serious financial impacts to CDOT and RTD. The T-REX Project stayed under its \$1.67 billion budget for the original scope of work, was able to add several key elements, finished on time, and did not use all its contingency funds.

Some of the lessons learned in cost control and budget management during the T-REX Project included:

- Place a strong emphasis on iterative, independent cost estimating early in a project. Continually review cost estimates. Develop an independent estimate and reconcile any differences with the base project estimate.
- Clearly define the base project configuration to all stakeholders and team members. Require that proposed changes to the base project configuration require additional, external funding sources.
- Establish a CCB where key project management staff can review and recommend disposition of all change orders to the Project Director(s).
- Develop cost control tools that can analyze not only historical information, but also trends and the financial impact of potential changes or actions.
- The D-B approach transfers much of the financial risk to the D-B contractor. With this in mind, realize changes will occur and adequate contingency must be available for these changes.

Only a relatively small percentage (about three percent) of T-REX Project change orders costs were due to contractual issues with the D-B contractor. Much of our success is attributed to strong management emphasis and participation and to properly applying resources to writing the D-B contract.

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List of Acronyms—Lesson #8

D-B	Design-Build
CCB	Change Control Board
CDOT	Colorado Department of Transportation
LRT	Light Rail Transit
PE	Preliminary Engineering
PMOC	Project Management Oversight Consultant
RTD	Regional Transportation District
T-REX	Transportation Expansion (Project)

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Lesson Learned # 9
Quality Management

1. Executive Summary

We highly recommend creating an integrated project requirements database. The integrated database enabled us to link the data collected by the Design-Build (D-B) contractor, our Owner's Verification and Testing (OVT) process, and the Independent Assurance Testing (IAT) process into a cohesive whole. In this manner, we could remain informed of any outstanding issues at interim completion points. Color-coding the information in the requirements database gave us a quick, easy method for effectively monitoring the progress of outstanding items.

There were several additional strategies which positively affected the quality of the Transportation Expansion (T-REX) Project.

- Using the broad definition of Quality Assurance (QA), we placed the responsibility for QA on the D-B contractor, since the contractor has the most control over “planned and systematic activities.”
- Our QA expectations were included in the Request for Proposals (RFP), requiring bidders to submit both a draft Quality Management Plan (QMP) and a draft Construction QMP.
- The selected D-B contractor was required to be registered under International Standards Organization (ISO) 9000:2000 within 12 months of contract start.

2. Background

Historically there have been two opposing approaches when assigning responsibility for implementing QA activities on major infrastructure construction projects. The major difference between the two approaches is where responsibility for QA activities rests.

Some project owners do not believe a contractor should be entrusted with monitoring the quality of the work done on a project. Other owners transfer certain QA activities to the contractor, often including inspection and testing, as long as the QA/Quality Control (QC) requirements or tolerances are specified in the contract. Certain federal agencies such as the Army Corps of Engineers have frequently used the latter approach.

Most QA programs fall somewhere in between these two approaches. The T-REX Project Owners—The Colorado Department of Transportation (CDOT) and the Regional Transportation District (RTD)—had to reach an agreement on where to place QA/QC responsibilities and associated risks for the T-REX Project, and how to verify implementation of QA/QC.

The CDOT and RTD organizational cultures and implementation methods for QA were very different. The T-REX Project was a joint project with both agencies as Owners. This necessitated a team approach using a QA program that satisfied both agencies. In addition, the T-REX Project

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was to be delivered using a D-B contract rather than the typical Design-Bid-Build (D-B-B) delivery method. Neither agency had ever used the D-B contract delivery approach. The chosen QA program approach had to be consistent with the requirements of a D-B project delivery.

The QA program and allocation of responsibilities we chose also had to meet the expectations of our other major funding partners—the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA).

Traditionally, when government agencies are implementing capital improvement projects, the agency is responsible for QA and the contractor for QC. However, the accepted definition of QA in most quality circles is “all of the planned and systematic activities implemented within the quality system, and demonstrated as needed, to provide adequate confidence that the product will fulfill quality requirements¹...”

This definition implies QA/QC is much more than simply an inspection program. By including other “planned and systematic activities” the program also includes:

- Hiring skilled workers
- Selecting qualified subcontractors
- Training workers and subcontractors
- Planning project work and activities
- Taking corrective and preventive actions
- Rewarding good work and performance

Using this broader definition of QA, it makes sense to place the responsibility for QA on the organization that has the most control over the “planned and systematic activities”—the project’s contractor. This is what our team chose to do: We placed the bulk of the QA implementation and activities with the D-B contractor.

To help mitigate risk in this approach, the RFP contained carefully defined QA program expectations for the T-REX Project design and construction. As part of their proposals, bidders were required to submit a draft QMP and draft Construction QMP. These plans were considered during the “*best value*” proposal evaluations. Upon receiving a Notice to Proceed (NTP), the winning bidder was required to implement and further define both plans. Once finalized, the two plans were submitted to T-REX Project Management for approval.

To ensure the D-B contractor’s QA program would meet our requirements, the D-B contractor was required to be registered under ISO 9000:2000 within 12 months of contract start. Each of

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the main partners in the D-B contract had already qualified under ISO 9000:2000, but T-REX required the team to qualify as a combined entity. This registration was completed in May 2003.

Once the T-REX D-B contractor was ISO-registered and deemed by the T-REX Project Team to have implemented a comprehensive QMP, it was possible to leave all quality-related activities to the D-B contractor. However, the T-REX Project Team felt that the risks associated with full transfer of responsibility outweighed the convenience. Instead, we chose to implement several monitoring programs and activities to verify the adequacy of the D-B contractor's QMP. Three programs were established to perform these monitoring functions:

- A Compliance Audit System (CAS)
- Owner's Verification Testing
- Project Acceptance (PA)

The CAS Program

The CAS program was a verification methodology that was developed by one of our T-REX Project Team members. Compliance auditing is a proven system that has been used on other D-B projects. The foundation of the CAS was the D-B contract Work Breakdown Structure (WBS); the WBS is a contract management tool that defines the deliverables associated with a project. Using the WBS, the T-REX Project Team created a database of contract requirements containing over 20,000 entries.

Once this CAS database was created and populated, we went through a Risk Assessment (RA) exercise. Each T-REX Project requirement—both product- and process-related—was assigned a risk level of 1, 2, or 3, with “1” being the greatest level of risk. The level of risk assigned to each requirement was based on two factors: the likelihood of failure and the potential severity of the failure. Typically RA focuses on product-related risks; T-REX Management chose to be more proactive by also including process-related risks. This method was chosen to verify the D-B contractor's QA program and provide feedback that was preventive rather than purely corrective.

Using the CAS database we were able to:

- Select contract requirements for audit
- Record audit observations
- Produce audit reports
- Identify and track nonconforming areas to closure
- Identify performance trends

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In addition to using the CAS database as the basis for audits, certain T-REX Project areas were the subject of “Management Systems Audits”—a higher level, less frequent review of D-B contractor management systems. These systems included QA, traffic management, environmental management, and safety.

The OVT Program

The OVT program we used was also developed by one of the T-REX Project Team members, based on the program used on the I-15 D-B contract in Utah. The OVT program provided:

- An electronic storage repository for the materials tests for asphalt, concrete, aggregates, and soils.
- A materials testing program that tested the materials at approximately 10 percent of the testing rate used by the D-B contractor.
- A statistical comparison of our testing results with the D-B contractor’s testing results to validate the data.
- A verification of the D-B contractor’s testing frequencies based on materials quantities.

The results of both the D-B contractor’s tests and the OVT program were consolidated into a materials testing database. These results were summarized each month and statistical comparisons were made on a rolling 12-month basis. This approach allowed us to verify the quality of the materials used for the T-REX Project.

We also used an independent testing agency to oversee testing equipment, processes, and personnel qualifications for both QA and OVT labs. These Independent Assurance Testing (IAT) results were also integrated into the CAS database.

Project Acceptance

Project Acceptance was the third element in the T-REX Project QA monitoring process. The details and lessons are provided in Lesson Learned #18: *Project Acceptance and Closeout*.

3. The Lesson

At the completion of any project, the owner has the ultimate authority and responsibility for accepting the work performed by each contractor. Choosing a QA management approach that allowed the D-B contractor to perform many of the QA-associated functions and verifications combined with a project owner and third party verification program proved to be both efficient and effective.

The CAS program and the OVT program, when combined, led us to the creation of an integrated project requirements database. This enabled us to link the data collected by the D-B contractor,

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our OVT process, and the IAT process into a cohesive whole. This approach proved very valuable during final PA since the database allowed us to synthesize the information collected from the CAS process, nonconformance reports, punch lists, and the certifiable items list to create an overall PA “dashboard.”

The PA “Dashboard,” shown in Appendix A, Attachment 2, is useful since it enables the project owner to track each deliverable in terms of milestone, interim completion, and acceptance. The dashboard also allowed project participants to remain abreast of any outstanding issues related to these deliverables. In addition, the dashboard allowed collaboration between contractor and project owner since the D-B contractor notified the T-REX Project Team when a deliverable was complete by changing the color associated with the item in the database. The T-REX Team then notified the D-B contractor of concurrence/non-concurrence by changing the item’s color to green or red, respectively. This form of communication proved to be highly effective in monitoring the QA and other work activities.

Requiring completion of ISO 9000:2000, registration near the outset of the project is a good way to increase the level of confidence in shifting many QA responsibilities to the D-B contractor.

By accepting the D-B contractor’s work and QA results the T-REX owners concurred that:

- The project met contractual requirements.
- They were taking over the operation and maintenance of the T-REX Project.
- The one-year warranty period could begin.

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List of Acronyms—Lesson #9

CAS	Compliance Audit System
CDOT	Colorado Department of Transportation
D-B	Design-Build
D-B-B	Design-Bid-Build
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
IAT	Independent Assurance Testing
ISO	International Standards Organization
NTP	Notice to Proceed
OVT	Owner's Verification Testing
PA	Project Acceptance
QA	Quality Assurance
QC	Quality Control
QMP	Quality Management Plan/Program
RA	Risk Assessment
RFP	Request for Proposals
RTD	Regional Transportation District
T-REX	Transportation Expansion (Project)
WBS	Work Breakdown Structure

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Lesson Learned # 10
Contract Management

1. Executive Summary

The Change Order (CO) process was handled by the Contracts Management Group (CMG), which was led by the Contracts Manager. The Transportation Expansion (T-REX) Project Team established a Change Control Board (CCB) to review all proposed COs.

During the implementation and continuous fine-tuning of our CO process, the following activities were useful:

- Establishing an active CCB with the participation of the Project's functional group leaders, senior managers, and directors.
- Selecting an experienced Contracts Manager and integrating him or her into the decision-making process.
- Assigning the authority for approving, negotiating, modifying, and/or rejecting most COs to the Project/Deputy Project Director level to facilitate decision-making.
- Understanding the extensive workload involved in managing, negotiating, and processing changes when developing Project staffing plans.

Allowing flexibility in a project, such as that allowed by a Design-Build (D-B) contract, means there will be COs. Having an efficient, effective system in place to handle them is critical for a smoothly run project.

2. Background

As addressed in Lesson Learned #5: *Design-Build Contract*, a significant effort was made to fine-tune the D-B contract approach prior to award. In an effort to provide the “best” possible D-B contract and attract the most qualified potential bidders, the Transportation Expansion (T-REX) Project Owners—the Colorado Department of Transportation (CDOT) and the Regional Transportation District (RTD)—also submitted the proposed contract to extensive industry review. Prior to awarding the contract (on June 1, 2001), CDOT/RTD took several concrete steps to effectively administer the D-B contract, as outlined in the next three paragraphs.

The T-REX Project Team recruited a Contracts Manager with extensive experience in both contract management and system engineering. The Contracts Manager was an integral part of the T-REX Project Management Team throughout the life of the T-REX Project and interacted closely with all functional group leaders. The functional group supervised by the Contract Manager is referred to as the CMG.

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The primary function of the CMG was to manage the CO process. A CCB was established at the start of the T-REX Project to review proposed COs. All functional group leaders were part of the CCB as were the T-REX Project Director and Deputy Project Director. The two Directors had the authority to approve most COs. This CCB provided an excellent means of communication among groups regarding changes and a cross-functional forum for discussing issues associated with any CO.

Representatives of the Federal Highway Administration (FHWA) and the Federal Transit Administration's (FTA) Project Management Oversight Consultant (PMOC) generally attended the CCB meetings. As a federally funded project, T-REX was required to meet the requirements of these agencies regarding contract administration, and FHWA also had to approve any highway-related change orders.

On the T-REX Project there were over 350 COs with a total cost of approximately \$120 million. The major categories/costs of changes were related to the Light Rail Transit (LRT) portion of the D-B contract, and included:

- Changes paid by third parties.
- Changes not in the original Project scope paid by RTD Headquarters. In many cases, RTD secured additional funding and/or found it advantageous to use the D-B contractor for related work.
- Enhancements to the base T-REX Project requested by RTD.
- Transit Oriented Development (TOD) enhancements (see Lesson Learned # 18: *Light Rail Stations and Transit Oriented Development*).
- Environmental related COs. Since CDOT/RTD retained the risk of dealing with contaminated or hazardous materials, any clean-up costs were negotiated as separate COs.
- Contractual disputes or issues were a very small amount of CO costs.

The low cost of COs that arose from contractual issues was due to the excellent partnering program (see Lesson Learned # 6—*Partnering*) and a strong D-B contract. As contract issues arose, an Issue Identification Report (IIR) was developed to define the contractual issues. Ultimately only 41 issues needed to be resolved at the Project Director level through the entire course of the T-REX Project. All these issues were resolved without the need to use issue resolution mechanisms defined in the D-B contract.

Negotiations related to the appropriate cost for each CO consumed significant time and resources for both the T-REX Project owners and the D-B contractor. In several cases, direction to proceed with the work related to a proposed change was provided while negotiations continued to assure that work could be performed in a timely manner.

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3. The Lesson

The D-B contract between a project's owner and contractor provides the basis for management through the long life of a "mega-project." The Contract Management approach incorporates the risk assigned to each party and the process for addressing changes, disputes, acceptance and many other factors. The ability to manage COs and related costs is the key element in maintaining the project's budget (see Lesson Learned # 8—*Project Budget*).

Both CDOT and RTD delegated approval authority for change orders to the Project Director and Deputy Project Director as long as the changes were within the project budget. No approvals were needed from any other level of either agency, although constant communication was maintained with both the RTD General Manager and the CDOT Executive Director when there were large potential COs and issues. This greatly facilitated decision-making and was a key to the T-REX Project's success.

The most salient Contract Management lessons learned during T-REX were:

- Establish an active CCB with the participation of the project's functional group leaders, senior managers, and directors.
- Select an experienced Contracts Manager and integrate him or her into the project organization, CCB, and other decision-making entities.
- Assure that D-B contract-related issues are emphasized during consideration of COs or when issues arise with the D-B contractor.
- Develop IIRs or "white papers" to define contractual issues during mega-projects.
- Assign the authority for approving, negotiating, modifying, and/or rejecting most COs to the Project/Deputy Project Director level to facilitate decision-making.
- Consider the extensive workload involved to manage, negotiate, and process changes when developing project staffing plans.
- Recognize that while the D-B contract delivery approach *does* transfer a large amount of risk to a contractor, it does not eliminate the potential for a number of COs. Although the contingency to address these COs probably does not need to be as high as for conventional Design-Bid-Build (D-B-B) projects, some level of contingency is necessary. For T-REX the contingency amount was approximately 2.5 percent of the budget.

Although a D-B contract delivery approach transfers much of the risk to the D-B contractor, project owners must still expect some number of COs.

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List of Acronyms—Lesson #10

CCB	Change Control Board
CDOT	Colorado Department of Transportation
CMG	Contracts Management Group
CO	Change Order
D-B	Design-Build
D-B-B	Design-Bid-Build
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
IIR	Issue Identification Report
LRT	Light Rail Transit
PMOC	Project Management Oversight Consultant
RTD	Regional Transportation District
T-REX	Transportation Expansion (Project)
TOD	Transit Oriented Development

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Lesson Learned # 11
Right-of-Way Process

1. Executive Summary

The Transportation Expansion (T-REX) Project, while often able to use existing Right-of-Way (ROW) still had a \$100 million ROW acquisition and relocation budget. The Federal Transit Administration (FTA) and Federal Highway Administration (FHWA) signed an Intergovernmental Agreement (IGA), with the FHWA acting as the lead agency. Additionally, they teamed with the Colorado Department of Transportation (CDOT) and the Regional Transportation District (RTD) to use a *One DOT* approach to managing and building T-REX.

The T-REX Project ROW acquisitions and relocations came in 10 percent under budget. Our success is primarily attributed to:

- Creating a team of dedicated experts, composed of both T-REX/CDOT staff and consultants, early in the ROW process.
- Co-locating personnel from the various agencies, jurisdictions, and consultant firms in a single facility to support and encourage information exchange.
- Using existing protocols and forms for the ROW portion of the T-REX Project.

Having an Executive Oversight Committee with senior executives from all major T-REX Project participants helped foster a unified approach to the entire Project, not just the ROW identification, acquisition, and relocation processes.

2. Background

The T-REX Project was a dual agency project that involved:

- Improving/expanding 17 miles of Interstate highways, including bridge removals/replacements, sound walls, and collector/distributor lanes.
- Adding 19 miles of new Light Rail Transit (LRT) service along much of the improved highways.
- Building 13 new LRT stations along the highways—the Southeast Corridor.
- Adding 6,000 Park-n-Ride spaces.

The improved and expanded highways and Southeast Corridor LRT system pass through the cities of Denver, Aurora, Greenwood Village, Centennial, and Lone Tree. Construction required cooperation among these five entities, CDOT, and RTD.

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As the T-REX Project Owners, CDOT and RTD combined the highway and LRT system improvements and additions into a single, \$1.67 billion Design-Build (D-B) contract. Management of the T-REX Project was handled jointly by CDOT and RTD under an IGA that outlined the roles and responsibilities of each agency.

Construction started in the fall of 2001, and major elements and long-term closures were completed in August 2006. The highway segments of the T-REX Project were opened as they were completed; the LRT portion was opened in its entirety on November 17, 2006, over 18 months ahead of schedule.

Much of the T-REX Project construction on and along Interstates 225 and 25 took place within the ROW already owned by CDOT and RTD. However, widening I-25 and constructing both the Southeast Corridor LRT and related facilities required negotiating and purchasing ROW. The required ROW expenditures were significant, consisting of:

- 30 total acquisitions
- 172 partial acquisitions
- 116 residential relocations
- 110 business relocations
- A \$100 million ROW acquisition and relocation budget

Approximately \$65 million of the ROW budget was allocated to acquisition costs and the remainder to business and residential relocation costs, administrative costs, and inflation adjustments. Required ROW acquisitions and relocations were completed on time and approximately 10 percent under budget. Coming in under budget enabled us to return some budgeted ROW funds to the contributing agencies.

The T-REX Project involved a unique collaboration between CDOT and RTD. It also involved collaboration between the FTA and the FHWA, which was formalized in a 1999 IGA.

The FTA and FHWA agreed that the FHWA would be the lead agency and that procedures previously established between CDOT and the FHWA for Federally-aided projects would govern all T-REX Project-related ROW acquisitions and relocations for both LRT and highway construction. They also established common reporting procedures. Finally, the FTA and the FHWA, along with CDOT and RTD, were participants on the Executive Oversight Committee for the T-REX Project. The FTA and FHWA agreed to function as a *One DOT* for the T-REX Project.

RTD was responsible for ROW acquisitions and relocations for the LRT station areas and Park-n-Rides while CDOT was responsible for ROW acquisitions and relocations for the highway widening and the light rail “envelope.” RTD and CDOT were assisted by two qualified ROW

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consulting firms familiar with the requirements of the Uniform Act and FTA procedures. All acquisitions followed the same CDOT procedures and used in-house CDOT staff for review and planning as illustrated in the following:

- The T-REX Project used the CDOT in-house appraisers and ROW Services Department for development of realistic initial acquisition cost estimates.
- The T-REX Project used contract appraisers from the CDOT-approved list.
- CDOT in-house appraisers reviewed the contractors' appraisals and made a fair market value determination for each acquisition or relocation.
- As a result of the CDOT/FHWA ROW procedures agreed to in the 1999 IGA there were no appraisal-review thresholds or concurrence requirements for condemnation filing for the T-REX Project as there normally are in FTA projects.
- RTD and CDOT each hired a qualified ROW consulting firm familiar with the requirements of the Uniform Act and FTA procedures, to assist with ROW acquisitions and valuations. These firms included professionals qualified in acquisition and relocation activities.
- The T-REX Project used CDOT ROW forms.
- The T-REX Project reviewed and approved relocation claims using the CDOT ROW Services Department staff.
- The administrative settlement process granted authority for successively higher thresholds to the RTD and CDOT Real Estate Managers, the T-REX Project Manager/Deputy Project Manager, and CDOT's Chief Engineer.
- The FHWA Regional Office interpreted the Uniform Act procedures.

3. The Lesson

We found that the T-REX Project, combining transit and highway elements involving multiple agencies and/or jurisdictions, benefited greatly from:

- Having dedicated experts (both staff and consultants) involved from the outset.
- Co-locating the personnel from the various agencies, jurisdictions, and consultant firms in a single facility to improve efficiency and effectiveness of communications and activities.

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- Having an Executive Oversight Committee composed of senior executives from all major T-REX Project participants to foster a unified approach to the entire Project, not just the ROW identification, acquisition, and relocation processes.
- Using independent real estate appraisers to make initial ROW acquisition cost estimates.

Having the “right” staff, experts, and consultants available from the beginning of the T-REX Project in 1999 ensured needed resources was both available and familiar with the intricacies and issues of the T-REX Project. The success of this approach was reflected in the nearly \$10 million of ROW cost savings realized on the Project, and the resulting return of significant funds to the participating agencies and jurisdictions. Co-locating key personnel from different agencies facilitated the exchange of critical information on a daily basis and ensured consistent procedures within and between these agencies pertaining to supervising ROW acquisition and relocation activities for the T-REX Project.

A dual-agency project such as T-REX can often result in divided perspectives and priorities. By co-locating all the major T-REX Project managers and other decision-makers in the Project office the real estate managers from CDOT and RTD were able to execute ROW activities in a coordinated manner. The CDOT and RTD managers were able to streamline processes by using only one agency’s forms and technical experts, and coordinate the actions of their internal staff and external ROW consultants.

The Executive Oversight Committee managed the T-REX Project and monitored its progress. The Committee consisted of top-level managers including the following:

- CDOT’s Executive Director
- RTD’s General Manager
- Regional Administrators from the FTA and FHWA
- Senior managers from the D-B contractor and other consultants

These managers had the authority to make critical decisions. By meeting bi-weekly through most of the duration of the T-REX Project they were able to defuse potential problems and deal with issues. In addition to their general oversight roles, each of the Executive Oversight Committee members brought significant knowledge about ROW processes, support for the required acquisition and re-location activities, and commitment to the FTA/FHWA “*One DOT*” approach.

Using services of approved independent real estate appraisers helped us to develop realistic acquisition cost estimates. These estimates helped keep T-REX Project ROW costs under budget and assured affected businesses and residential property owners/occupants fair treatment.

A major benefit and lesson learned across the entire T-REX Project was the agreement between the FTA and FHWA to function as a *One DOT* on the T-REX Project.

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List of Acronyms—Lesson #11

CDOT	Colorado Department of Transportation
D-B	Design-Build
DOT	Department of Transportation
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
IGA	Intergovernmental Agreement
LRT	Light Rail Transit
ROW	Right-of-Way
RTD	Regional Transportation District
T-REX	Transportation Expansion (Project)

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Lesson Learned #12
Utilities

1. Executive Summary

Utility relocations did not cause any significant delays to the Transportation Expansion (T-REX) Project. There were no utility relocation surprises, no issues, and no major utility strikes. Utility relocations as an area returned nearly 25 percent of its budget to the overall T-REX Project budget.

We believe this savings was due in large part to the intensive pre-contract work and coordination we did with the utilities and, later, with the selected Design-Build (D-B) contractor. Specific activities conducted prior to releasing the RFP included:

- Performing in-depth Sub-Surface Utility Engineering (SUE)
- Performing Value Engineering (VE)
- Early communication with utility owners
- Passing specific utility legislation
- Concluding Project-Specific Utility Relocation Agreements (PSURA)
- Establishing a utility relocation budget and preliminary utility relocation schedule
- Forming and using a Utility Task Force

Senate Bill 203, passed in 2000, was a significant success factor for the utility relocation process since it increased accountability and responsibility—on the part of all the participants and affected utilities—for meeting the T-REX Project schedule. Some of the key provisions of Senate Bill 203 were:

- Authorizing the Colorado Department of Transportation (CDOT) to pay for all designs for PSURA-executed relocations.
- Authorizing CDOT to purchase or condemn replacement utility easements on behalf of utility owners.
- Authorizing CDOT to advance funds to utility companies for relocations. Repayments are made with [statutory] interest.
- Encouraging private utility owners to let the D-B contractor perform relocations.

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- Possible sanctions and liability for utility companies if they choose to perform their own relocations and delay the D-B contractor's work schedule.

2. Background

Utility relocations are a major component of any transportation infrastructure project. When the contract delivery method is D-B the risk associated with identifying and relocating utilities is intensified.

The T-REX Project was the first D-B contract ever undertaken by the Regional Transportation District (RTD) and CDOT. The utility owners affected by T-REX were skeptical of the D-B contract approach due to the inherent flexibility of D-B—allowing a design to change and evolve as a project progresses. The ongoing design evolution meant the utilities would lose much of the traditional reaction time normally provided for utility relocations during a major infrastructure project.

To attempt to mitigate the concerns of the utility companies, the T-REX Project Team chose to make a significant up-front investment in Quality "A" SUE. This approach was intended to avoid T-REX Project delays related to utility relocations and allow greater opportunities for VE of potential utility relocations.

The number and variety of the utilities potentially affected by the T-REX Project were significant. Prior to selecting the D-B contractor the T-REX Project Team undertook the following activities:

- Identified the potentially affected private and public utilities—41 owners.
- Identified utility easements requiring replacement.
- Created a utility base map for 30 percent reference drawings for 800 potential utility relocations, including:
 - Type of utility: size, type, and location
 - Right-of-Way (ROW) documents
 - Environmental issues
- Completed line detection—performed by the utility companies using T-REX Project Team surveys.
- Completed SUE:
 - Identified probably conflicts with reference drawings.

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- “Potholed” and surveyed 600 locations.
- Opened and recorded approximately 1,100 manholes.
- Prepared field notes, coordinate information, and log sheets for inclusion in the Request for Proposals (RFP) for the D-B contract.
- Held one-on-one meetings with all affected utility owners:
 - Confirmed the actual location of each affected utility on the utility base map.
 - Reviewed Computer-Assisted Design and Drafting (CADD) drawings to determine the proposed relocation for each utility.
 - Worked with utility owners on a proactive basis to alleviate concerns and obtain “buy-in” to the T-REX Project relocation process.
- Developed Utility Information Sheets (UIS) for each potential utility relocation. The UIS, which became part of the RFP, included:
 - Assigning “conflict numbers” for tracking each relocation
 - Current information about each affected utility
 - Proposed relocation (if required) and expected duration for relocation, shut-off restrictions, and similar relevant data
 - Relocation drawings
 - Cost estimates from the utilities (for internal use only)
 - Included the UIS information as part of the RFP

In order to streamline utility relocations, the Colorado Legislature passed, and the Governor signed into law, *Colorado Senate Bill 00-203 (Section 43-1-1410 through -1412, Colorado Revised Statutes)*, in the spring of 2000. This legislation provided for a master PSURA with each affected utility. In addition, Senate Bill 203 required the new level of utility cooperation and coordination that was essential to expedite T-REX and other statewide D-B projects. The key provisions of Senate Bill 203 included:

- Authorization for CDOT to pay for all designs associated with relocations if a PSURA is executed.
- Authorization for CDOT to purchase or condemn replacement utility easements on behalf of utility owners.

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- Authorization for CDOT to advance funds for relocation of utilities. Repayments are to be made with [statutory] interest.
- Encouragement for private utility owners to use the selected D-B contractor to perform their relocations.
- Possible sanctions and liability for the utility companies if they choose to perform their own relocations and the D-B contractor's work schedule is affected or delayed.
- Increased responsibility and accountability on the part of the D-B contractor.

After *Senate Bill 203* was passed, PSURAs were executed with each utility owner. These agreements between CDOT and the utilities incorporated reasonable terms and conditions for performing required utility relocation work, including:

- Provisions for allocation of design and construction responsibility by work order, with the D-B contractor as preferred design/construction/relocation entity along with damages for delays to the T-REX Project schedule caused by actions or inactions on the part of the utility owner.
- Requirements for the utility owners to ensure prompt performance of relocation work to stay within the D-B contractor's schedule.
- Coordination and cooperation between the utility owner and the D-B contractor.
- A work order process with agreement by all three parties—the T-REX Project Management Team, the D-B contractor, and the utility owners.
- Provisions for sharing relocation work responsibilities between the D-B contractor and the utility owner.

To further expedite the utility relocation process and mitigate schedule disruptions, we created a Utility Task Force that began monthly meetings two years prior to the start of T-REX Project construction. The Task Force included utility representatives from CDOT, RTD, utility owners, and the municipalities along the T-REX corridor. The Task Force provided a mechanism for the development of relocation processes and procedures. The primary objectives of this Task Force were to:

- Get the utility owners (public and private) involved as early as possible in the design and pre-construction process for the T-REX Project.
- Enable and encourage the utility owners to provide input to the relocation process and other T-REX aspects throughout the Project.

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- Create a jointly developed process to encourage coordination, cooperation, communication, and commitment in the utility relocation process.
- Foster partnering between the Project Team, the utility owners, and (once selected) the D-B contractor.

The Task Force approach was invaluable in promoting partnering and a cooperative attitude among all the entities. The level of attendance approached 100 percent, and persisted even when the D-B contractor came on board and we went to weekly meetings.

The D-B contractor, once selected, had the responsibility for confirming utility relocations were necessary and coordinating the details of the relocations. This included scheduling relocations, and in some cases designing and performing the construction for the relocations. The T-REX utility team, D-B contractor, and utility owners worked to minimize costs and impacts by seeking ways to eliminate or reduce utility relocations.

T-REX personnel stayed involved throughout the relocation and other Project construction activities, rather than turning the entire Project over to the D-B contractor. This approach enabled the D-B contractor to benefit from the established relationships the T-REX utility team had developed with the utility owners.

3. The Lesson

Early identification of the public and private utility companies involved allowed us to bring all stakeholders on board as a cohesive team. From there, we were able to hold one-on-one meetings to verify the utility base map and UISs. This proactive approach made it possible to include the UISs in the RFP, where they became requirements for the D-B contractor.

Legislative Support

Senate Bill 203 was a significant success factor for the utility relocation process because it increased accountability and responsibility—on the part of all the participants and affected utilities—for meeting the T-REX Project schedule.

Coordination and Buy-In

Having pre-construction meetings on a regular basis enabled us to present the general scope of T-REX to all affected entities. Involving the utility owners in process and procedure development increased their buy-in and provided valuable input to help keep the T-REX Project ahead of schedule.

Encourage Coordination, Cooperation, Communication, and Commitment

Specific activities conducted prior to releasing the RFP that benefited the overall T-REX Project included:

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- In-depth SUE
- Value Engineering
- Early communication with utility owners
- Specific utility legislation
- Project Specific Utility Relocation Agreements
- Establishment of a utility relocation budget and preliminary utility relocation schedule
- Forming and using a Utility Task Force

There were no utility relocation surprises, no issues, and no major utility strikes. Utility relocations did not cause any delays to the T-REX Project, nor did they result in any additional costs to the T-REX Project Owners (RTD/CDOT).

The overall utility relocation budget was \$42 million. Through the approaches we used on the T-REX Project we were able to return \$10 million to the Project. We believe this savings was due in large part to the intensive pre-contract work and coordination we did with the utilities and later with the D-B contractor. The T-REX utility team received two Federal Highway Administration (FHWA) awards in 2006, one in the category of Innovation and one in Subsurface Utility Engineering.

The T-REX Project required massive support from a huge variety of stakeholders. In the case of utility relocations, the combination of support from the utility owners, D-B contractor, Project Owners, and the Colorado legislature were major contributing factors to the overall success of the Project.

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List of Acronyms—Lesson #12

CADD	Computer-Assisted Design and Drafting
CDOT	Colorado Department of Transportation
D-B	Design-Build
FHWA	Federal Highway Administration
PSURA	Project Specific Utility Relocation Agreement
RFP	Request for Proposals
ROW	Right-of-Way
RTD	Regional Transportation District
SUE	Sub-Surface Utility Engineering
T-REX	Transportation Expansion (Project)
UIS	Utility Information Sheets

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Lesson Learned # 13
Noise Walls

1. Executive Summary

Noise mitigation is one of the aspects of a construction project about which residents are most concerned. Noise walls can significantly decrease the noise impact on residents, but they can also block residents' views. We learned that regular meetings with affected residents *prior* to beginning construction would likely have reduced the number of change orders.

In the case of the Transportation Expansion T-REX Project, to keep residents better informed about the height, location, and design of the proposed noise walls, the Design-Build (D-B) contractor implemented several innovations that helped to improve residents' experiences:

- A 24-hour hotline to call-in noise complaints
- Temporary noise walls (both plastic sheeting and noise trailers)
- The use of hotel vouchers for affected residents during nighttime bridge demolitions.

Additionally, during the course of the project, we learned that aesthetic patterns on the walls should be kept simple and there should be just a few different patterns. Intricate designs and many different patterns added to the cost of the T-REX Project.

2. Background

Noise mitigation on the T-REX Project was a challenging issue from complying with the National Environmental Protection Act (NEPA) process through dealing with residents' wishes through completion of construction. The Team received numerous requests from the public to change the noise walls after issuing a Notice to Proceed (NTP) to our *best value* D-B contractor. Some requests were to eliminate the noise walls, some were for higher noise walls, some were for lower noise walls, and some were for noise walls where they were not recommended.

T-REX developed a "*Policy for Noise Wall Change*" that provided residents living adjacent to the Project a way to request a change to a proposed noise wall. This process allowed certain changes to walls that were to be constructed per the D-B contractor's Final Noise Analysis. The policy, which was approved by the Federal Highway Administration (FHWA), allowed for a change if 75 percent of the impacted property owners agreed to the change. The policy eventually eliminated proposed noise walls in five segments. The policy also allowed affected residents to lower the proposed noise wall to maintain their mountain views. T-REX was sensitive to affected residents who desired to protect their mountain views, provided they agreed to accept a lower level of noise mitigation.

Although the policy did provide for a change request process, the timing of these changes eventually had a personal cost to the local property owner in the cases where we agreed to lower

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a noise wall. The policy stated that the sponsor of the request (the property owner, association, or other non-T-REX entity) would be responsible for implementing the noise wall change, if there were a cost.

An example of a noise wall (during installation) is shown in the figure that follows:



As it turned out, *eliminating* noise walls was considered to be a “no-cost” change since there was no additional cost to the D-B contractor. However, *lowering* noise walls did result in negotiated Change Orders, since most of the noise walls were already built by the time the affected person(s) requested the change. T-REX chose to pay for the costs of those changes for two reasons:

- To be a “*good neighbor.*”
- The fact that the affected property owners often did not have adequate notice of what was being proposed for their noise wall.

From an urban design perspective, T-REX required eight different noise wall art patterns in the contract. These were difficult to produce and it was also difficult to match the patterns from panel to panel.

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3. The Lesson

It is essential to keep affected residents apprised of changes that may impact their quality of life. At the same time it is not possible to keep everyone happy. We found the best way to reconcile conflicting residents' wishes and concerns was through a combination of:

- A written policy governing how changes will be handled, who will pay for them, and when the date for requesting changes has past.
- Holding regular meetings with affected residents before construction began.

T-REX should have required in the contract that the D-B contractor perform more public notification of affected residents after completion of the Final Noise Analysis. Increased public notification could have consisted of small neighborhood meetings that described to adjacent residents the location, height, appearance and proposed construction schedule for the proposed noise walls. Better notification to impacted residents would have reduced the number of noise wall changes that resulted in negotiated Change Orders (CO). The written policy could have been provided at these meetings.

Reducing the number of wall art patterns and possibly simplifying the patterns could have saved money and would still provide positive aesthetic results.

The D-B contractor provided several innovations that smoothed over many potential problem areas:

- A 24-hour noise hotline to report noise complaints.
- Temporary noise walls (both plastic sheeting and noise trailers).
- The use of hotel vouchers for affected residents during nighttime bridge demolitions.

All the innovations were successful and were closely monitored by City and County of Denver (CCD) staff.

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List of Acronyms—Lesson #13

CCD	City and County of Denver
CO	Change Order
D-B	Design-Build
FHWA	Federal Highway Administration
NEPA	National Environmental Protection Act
NTP	Notice to Proceed
T-REX	Transportation Expansion (Project)

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Lesson Learned # 14
Intergovernmental Agreements

1. Executive Summary

Intergovernmental Agreements (IGA) are critical to the Full Funding Grant Application (FFGA) process since they indicate stakeholder and community commitment to a project. Having IGAs in place as early as possible also smoothes the early stages of actual construction. The necessary IGAs should be executed prior to beginning construction.

Our IGA development process included, or allowed for, the following:

- A negotiation phase where agreements are reached on how each entity will pay its share of the matching funds. The agreements need to be included in the applicable IGA.
- Provisions for local entity/stakeholder input to design plans and construction review.
- An agreement on realistic design review timeframes.
- A defined process for obtaining permits that also identifies who is responsible for the permit fees.

It is also important to clearly define the use and purpose of a project's contingency fund to the participating local entities.

2. Background

The Transportation Expansion (T-REX) Project was a \$1.67 billion multi-modal project that involved funding commitments on the part of seven metro area local entities:

- The City and County of Denver
- The City of Aurora
- The City of Centennial
- The City of Greenwood Village
- The City of Lone Tree
- Arapahoe County
- Douglas County

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Prior to seeking a Full Funding Grant Agreement (FFGA) through the Federal Transit Administration (FTA) and Federal Highway Administration (FHWA), the seven local entities committed, in the form of Memoranda of Understanding (MOU), T-REX Project matching funds. Implementing the agreed funding also required Intergovernmental Agreements (IGA) between CDOT, RTD, and the local entities.

Using local matching funds through the execution of IGAs showed the strong level of local support and commitment to the T-REX Project. These matching funds were instrumental in demonstrating our commitment to the FTA and FHWA during the FFGA process. In total there were seven IGAs—one for each local governmental entity. The timeframe to execute the IGAs was 1999-2000.

An MOU committed the Colorado Department of Transportation (CDOT) and the Regional Transportation District (RTD)—the T-REX Project Owners—to spending the full amount of the T-REX Project funds on the Southeast Corridor. In the event there were contingency or other surplus funds left over, these funds would also be used in the Southeast Corridor. As it turned out, construction elements that had been deleted to establish a contingency fund were reinstated under the terms of the MOU. This enabled major additional improvements—including reconstructing the US 285/Hampden and Colorado Boulevard bridges over I-25—to be included as part of the T-REX Project.

In addition, CDOT, RTD, and the seven local entities agreed to work together to fund T-REX Project enhancements that were outside the basic scope of work. These value-added additional elements had to meet various federal requirements before being added to the scope of the T-REX Project. In some cases the enhancements were funded, at least in part, by local or other entities.

3. The Lesson

The widely staggered timeframe for completing the IGAs could have presented a serious T-REX Project schedule problem. In retrospect we should have executed all the IGAs prior to the start of the construction phase.

The IGA development process should have included or allowed for the following:

- A negotiation phase where agreements are reached on how each entity will pay its share of the matching funds. The agreements need to be included in the applicable IGA.
- Provisions for local entity input to and feedback about the design plans and construction review.
- Agreements on realistic design review timeframes. This is particularly important given the fast pace of a Design-Build (D-B) contract delivery approach.
- A defined process for how permits will be obtained and whether permit fees will be waived.

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Having IGAs executed prior to beginning the construction phase of a project like T-REX will minimize the amount of risk and contingency bidders include in their proposals.

It is also important to manage the expectations of the participating local entities, particularly regarding a project's contingency fund status. We had a provision that stated that all budgeted funds would be spent in the Southeast Corridor. This approach is not recommended for future IGAs unless the local entities are willing to provide additional funds in the event a project goes over its budget.

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List of Acronyms—Lesson #14

CDOT	Colorado Department of Transportation
D-B	Design-Build
FFGA	Full Funding Grant Agreement
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
IGA	Intergovernmental Agreement
MOU	Memorandum of Understanding
RTD	Regional Transportation District
T-REX	Transportation Expansion (Project)

Lesson Learned # 15: Third Party Enhancements

1. Executive Summary

Large, multi-modal transportation projects frequently pass through several different municipalities. These third parties have a justifiable interest in infrastructure projects, since these projects directly affect them. They also are the parties that grant necessary permits for these projects. Consequently, working with third parties is a very important aspect of a project such as the Transportation Expansion (T-REX) Project.

We maintained quality, productive relationships with third parties by doing the following:

- Prior to awarding the Design-Build (D-B) contract, we developed an agreement with each third party detailing the processes and procedures for change requests, enhancements, and other pertinent issues.
- Maintaining communication between the project staff and the third parties.
- Providing communities the opportunity to fund enhancements. If the enhancement benefits other communities or agencies, the Project often used contingency funds to repay the original entity since we had funds available at the end of the Project.
- Removing Light Rail Transit (LRT) stations (that will be constructed later) from the D-B contract since they will almost certainly result in significant changes. This helped reduce change requests.

In addition, for federally-funded rail projects, we ensured that any rail-transit enhancements are eligible under a Full Funded Grant Application (FFGA).

Upon completion of T-REX, the consensus was that the excellent relationship between the Project and the community was a key to success.

2. Background

The T-REX Project passed through five cities and two counties. Coordinating a \$1.67 billion project required Memoranda of Understanding (MOU) and Intergovernmental Agreements (IGA) with local governments—the third parties. Third parties have a justifiable interest in any major new infrastructure that is being constructed in their environment, and interactions with these third parties can represent a major risk for any large transportation project.

A project of this scope brings noticeable improvement to an area's transportation infrastructure. However, construction and other activities also impact the surrounding communities' drainage systems, traffic flows, and emergency response requirements, as well as the basic aesthetics and appearance of the communities.

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The T-REX Project had a number of goals, including:

- *Minimize inconvenience to the public.*
- Complete the Project ahead of schedule.
- Complete the Project within budget.
- Provide a quality Project.
- Minimize or avoid claims.

The T-REX Project's scope was defined during the Environmental Impact Statement (EIS) stage. However, the EIS cannot adequately define every project element. In addition, changes in the communities, elected officials, and the Project itself led to numerous requests for changes from third parties during the implementation of the project.

Appropriate MOUs were executed prior to beginning the T-REX Project. The main role of each MOU was to address the funding commitment by third parties (city or county) to the T-REX Project. The MOUs did **not** define in detail areas such as:

- The process and expectations for requiring and granting permits.
- How design reviews would be performed by the impacted communities.
- The process to be used by community staff and officials for participating in the various T-REX design and construction phases.

Permits were required and were usually readily granted by the appropriate third party. The D-B contract delivery method assigned responsibilities for obtaining permits to the contractor. The permitting requirements did not impact the T-REX Project schedule. However, the process was sometimes contentious and required the intense dedication of community, D-B contractor, and T-REX Owner [Regional Transportation District (RTD) and Colorado Department of Transportation (CDOT)] staff. During the design and construction of the T-REX Project, the affected cities and counties evolved into partners in providing the necessary permits.

The City and County of Denver (CCD) maintained a dedicated staff specifically for dealing with permits, third party enhancements, and related activities on T-REX. This staff worked closely with the third parties for approval of permits. With the exception of one county, the communities adapted their approval process to facilitate completion of the T-REX Project with its unique D-B aspects. Although permits were a D-B contractor responsibility, CDOT and RTD staff played active roles in facilitating permit approval, helping keep T-REX on, or ahead of, schedule.

Requests for improvements or betterments from third parties occurred frequently. Each request was evaluated in terms of cost and benefit to CDOT/RTD and the stakeholders. In the early

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stages of the T-REX Project, it was difficult to agree to these requests since there were concerns about being able to stay within the T-REX Project budget. This created some challenges in the relationship between the Project Team and the affected third parties.

In some cases, third parties paid for the improvements, with the understanding that the T-REX Project agreed to fund them if there was money available at the completion of the Project. An example of a third-party request that was funded by the T-REX Project is a plaza above the Louisiana-Pearl Station. The CCD had already funded this element and was reimbursed from “excess” funds upon completion of the Project. If there had been no funds available, the CCD would not have been reimbursed.

The T-REX Project always provided a community or other third party with the opportunity to fund any requested “betterments.” Many communities took advantage of this opportunity and, as a result, third parties funded a significant number of the Project's change orders (CO) that related to enhancements.

3. The Lesson

The divergence of goals between a major infrastructure project and affected third parties could impact the budget and schedule, if not addressed properly. Relationships, planning, coordination, and cooperation are essential to meeting project goals.

The goals to deliver the T-REX project on-time and within schedule were not necessarily compatible with goals of the member communities. Impacted communities (the third parties) often desire construction elements and enhancements beyond the scope and budget of a project. These same third parties are also responsible for issuing permits and related approvals for key elements of a project like T-REX. Also, they were key funding partners for the T-REX Project.

The T-REX Project Team worked continually to develop an excellent relationship with affected communities and other third parties. Some of the specific lessons we learned include:

- It is important to develop an agreement with each potentially affected community prior to awarding the D-B contract. This agreement needs to define the relationships between and among each stakeholder and project team member, the process for requesting changes, and approaches to assessing the financial impact. The agreement should include sections addressing obtaining permits, conducting design reviews, commitment of community staff, and other areas impacting the community. This agreement can be provided to the D-B contractor who will then better understand the responsibilities, requirements, and risks associated with community and other third-party interfaces.
- The assignment of responsibility to the D-B contractor for obtaining permits worked well overall. However, the CDOT/RTD agency staff still interacted with local authorities frequently to achieve the T-REX Project's goals. Community staff is often more comfortable dealing with another agency. Resolution of some issues is not always within a contractor's ability.

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- It is critical to work with the third parties and develop a positive relationship with them. With few exceptions, the elected officials and staff of the communities embraced T-REX as their own project. This required substantial effort on the part of the T-REX staff working with community staff to foster that relationship. If a “betterment” or enhancement request cannot be implemented, it is important to review the basis for this decision with the affected third parties and work to develop alternatives.
- It is difficult to deny a request for betterment/enhancement from a community. In most cases, the request is reasonable and comes from a project and agency supporter. However, agreeing to such requests could have serious impacts to a project's budget and schedule. On T-REX, it was critical that the staff received support from CDOT and RTD executive management in supporting these difficult decisions.
- Provide communities the opportunity to fund betterment/enhancements that can be incorporated into the project. If the betterment provides benefit to the owner or other agency, consider an agreement where the community will fund that element initially and be reimbursed on a contingent basis if there are remaining funds available at the end of the project.
- If an LRT station is clearly planned for future transit oriented development (TOD) that is almost certain to result in major changes to the original design, consider removing that LRT station from the D-B contract. This may cause other problems in schedule and integration but it allows the design to incorporate changes without the pressure or implications of being part of the overall D-B contract.
- For a federally-funded project such as T-REX, it is critical to confirm with the Federal Transit Administration (FTA) that any rail transit-related betterments funded by the project are eligible under the FFGA and Record of Decision (ROD).

In general, communities did not use their ability to grant permits or approvals to secure specific betterments. We attribute this to the leadership shown by elected officials and staff from those communities. CDOT/RTD expended significant energy working with the communities to facilitate a positive relationship, including frequent elected officials meetings, and budget reviews with elected officials and staff on a regular basis so that they could understand the basis for not implementing a “betterment.” CDOT/RTD even conducted partnering sessions with the community's professional staff when necessary.

Upon completion of the T-REX Project, the consensus was that the excellent relationship between the project and the community was a key to success.

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List of Acronyms—Lesson #15

CCD	City and County of Denver
CDOT	Colorado Department of Transportation
D-B	Design-Build
EIS	Environmental Impact Statement
FFGA	Full Funding Grant Agreement
FTA	Federal Transit Administration
IGA	Intergovernmental Agreement
MOU	Memorandum of Understanding
ROD	Record of Decision
TOD	Transit Oriented Development
RTD	Regional Transportation District
T-REX	Transportation Expansion (Project)

Lesson Learned #16
Light Rail Transit Stations and
Transit Oriented Development

1. Executive Summary

Light rail transit (LRT) stations are the primary interface between a transit agency and its customers. Given this importance, LRT stations should receive significant attention during the project from local governments, owners, developers, contractors, consultants, and the public.

On the Transportation Expansion T-REX) Project the stakeholders were concerned that a Design-Build (D-B) form of contract delivery would not incorporate the critical needs of the community or the Regional Transportation District (RTD). To be sure these needs could be incorporated, we decided to tightly define the key parameters of the LRT stations in the request for proposals (RFP) and D-B contract documents. Soon after the D-B contract began, the T-REX Project received numerous requests from the various stakeholders for LRT station design element changes.

Accommodating these numerous requests was challenging, but resulted in LRT stations with better access and aesthetics than the original designs. Some of the lessons we learned include:

- Maximize flexibility in the D-B contract to allow for the inevitable stakeholder requests for changes to LRT station and platform design elements.
- Recognize that many of the requests for changes will provide valuable benefits in terms of access, aesthetics, and future Transit Oriented Development (TOD). Include external cost sharing as a funding source for these changes.
- A low level of LRT station and platform design in the RFP does not lock-in a design, providing more flexibility for design changes as a project proceeds.
- Establish a calendar and procedure for introducing and approving changes.
- The project owner needs to maintain control of the land needed for LRT stations.
- Consider removing stations planned for future development from the D-B contract to reduce the number of change orders.

It was challenging to manage the large number of LRT station change orders and requests for change orders during a fast-paced D-B project, but the successful, early completion of the T-REX Project shows that aesthetics, design, and accommodation of the stakeholders' wishes can go together.

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2. Background

Stations are the primary interface between the transit agency and its customers. They are also an important focus for the communities in which they are located and the foundation for TOD along a transit corridor. Given this importance, stations receive significant attention during the project from local governments, developers and the public. This resulted in numerous requests for changes at stations, which was challenging to manage during a fast-paced D-B project.

During the Environmental Impact Statement (EIS) stage of the T-REX Project, a great deal of input was received about the stations. This input included elements of:

- Design
- Layout
- Aesthetics
- Parking requirements

In addition, the stakeholders were concerned that a D-B form of contract delivery would not incorporate the community's or the RTD's critical needs. To alleviate these concerns, a decision was made to tightly define the key parameters of the light rail stations in the RFP and D-B contract documents.

When the T-REX D-B contract documents were being prepared in 2000 there was a general knowledge of the importance of TOD, but it was still a relatively new concept for the Denver metro area. Therefore, the RFP asked the bidders to provide their approach to TOD but did not provide them with detailed design requirements.

There were two LRT station sites—Dayton and Lincoln—where the property was at least partially controlled by developers. The financial basis for the Dayton Station entailed the developer dedicating necessary Right-of-Way (ROW) to RTD. At the Lincoln LRT station, both the station and a large garage (2,000 parking spaces) were built on a zero-lot-line, requiring developer approval of the design. This also allowed the developer to implement beneficial LRT station and parking structure changes (at the developer's cost).

Soon after the D-B contract began, the T-REX Project received numerous requests from the various stakeholders for LRT station design element changes. Some of the more significant changes made included:

- Changing the station canopy design and colors for the five southernmost LRT stations.

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- Relocating a large parking garage and combining it with a Colorado Department of Transportation (CDOT) maintenance facility at the Arapahoe LRT station to make land available for future development.
- Building a community park over the Louisiana-Pearl LRT station.
- Relocating the Dayton Park-n-Ride and LRT station to suit the land the developer was willing to donate.
- Making significant changes in layout to accommodate TOD at the Belleview and Lincoln LRT stations.
- Providing a commissioned art program at each LRT station.
- Adding three new pedestrian bridges to improve access to surrounding businesses and communities.

The LRT station drawings were defined as T-REX Project contract drawings, so modifications resulted in change orders to the Owners (RTD/CDOT) rather than being the D-B contractor's responsibility. For example, the detention ponds shown on the LRT station site layouts in the contract drawings were based on a 30 percent design and were often changed as the D-B contractor's drainage design evolved.

3. The Lesson

The design, layout, and aesthetic elements incorporated into LRT stations and platforms for the T-REX Project were very well-received in the community. The LRT stations are attractive, provide good accessibility, reflect community wishes, and promote TOD. However, managing stakeholder inputs for desired changes in a fast-paced D-B environment proved to be challenging. Some of the specific lessons we learned when planning for stations and TOD on a large D-B project include:

- **Maximize flexibility** to allow for the inevitable stakeholder requests for changes to station and platform design elements.
- Recognize that many of the requests for changes will provide **valuable benefits** in terms of access, aesthetics, and future TOD. Serious evaluation of these proposed changes can be a win-win situation, particularly when external cost-sharing is included.
- Reduce the **level of design** provided to bidders in the RFP. A lower level of station/platform design in the RFP does not lock-in a design and provides more flexibility in incorporating normal design changes as a project advances.

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- Consider addressing **community and stakeholder concerns** about appearance and desired LRT station layout by defining a general station concept and having proposed station designs provided by bidders as part of the selection criteria.
- **Establish a "hold point" for station designs** during a project. At these “hold points,” LRT station designs are “frozen” until the designs have been presented to relevant stakeholders for input. While this would lengthen the construction schedule in the short-term, producing a well-defined LRT station concept that can be shared with stakeholders, the need for future changes should be greatly reduced. In addition, input from stakeholders needs to be tightly managed to ensure it falls within the project budget.
- The project owner needs to **maintain control of the land** needed for LRT stations through either direct ownership or the ability to acquire land through condemnation or other appropriate means. Some of the larger change orders on the T-REX Project were at LRT stations where RTD did not control ROW decisions due to previous joint development agreements.
- Provide a **clear definition in the RFP** and other contract documents of the role of the D-B contractor in TOD. In the T-REX Project, the Owner ultimately took the lead in coordinating the many TOD interfaces. In general, local communities and developers were more comfortable dealing with the Owner. The contract documents did not define specific D-B contractor requirements for TOD.
- If an LRT station is clearly planned for **future development** that is likely to result in major changes to the original design, consider removing that station from the D-B contract. This approach may cause other problems in schedule and integration, but it allows incorporation of changes without the pressure of being part of the overall D-B contract.
- Assigning **specialized TOD staff resources** to a project would provide needed expertise to deal with the legal, technical, and managerial complexities of TOD. The T-REX Project staff ably managed the TOD process, but the management activities presented challenges since the same staff was responsible for managing the oversight and delivery of the entire T-REX Project.

Overall, the station and TOD effort was a major success for the T-REX Project. We were able to remain flexible enough to accommodate numerous LRT station/platform changes that ultimately led to improved access, aesthetics, and functionality. The passengers, general public, and local communities have embraced the LRT stations. In addition, the changes we made have facilitated TOD along the Southeast Corridor. These benefits were realized while completing the T-REX Project under budget and ahead of schedule.

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List of Acronyms—Lesson #16

CDOT	Colorado Department of Transportation
D-B	Design-Build
EIS	Environmental Impact Statement
LRT	Light Rail Transit
RFP	Request for Proposals
ROW	Right-of-Way
RTD	Regional Transportation District
TOD	Transit Oriented Development
T-REX	Transportation Expansion

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Lesson Learned # 17
Light Rail Transit Systems Engineering

1. Executive Summary

The Transportation Expansion (T-REX) Project Owners developed the systems engineering requirements to the 70 percent design level, even though the contract approach was design-build (D-B). This was done to ensure that new construction would mesh with existing Light Rail Transit (LRT) systems. The approach was successful.

Some of the specific benefits of this approach were:

- The inclusion of systems engineering elements in the D-B contract enabled the contractor to integrate the technical elements and the schedule sequencing, keeping the Project on schedule.
- The flexibility of a D-B contract left room for innovation. In this case, 189 Category B Change Proposals were executed, improving the overall quality of the Project while helping to manage costs.
- Lean staffing in the T-REX Project systems engineering group was sufficient, since the majority of the risk was transferred to the contractor via the D-B contract.
- Using a “best value” contract award approach enabled us to select a D-B contractor who was committed to systems engineering.

2. Background

The Regional Transportation District (RTD) has traditionally placed a major emphasis on systems engineering and operational requirements when building new LRT lines. RTD opened its first LRT line in 1994, with subsequent extensions opened in 2000 and 2002. The LRT system has a record of successful, reliable operation over the past 13 years. RTD was comfortable with the equipment and technology being used, but remained open to considering evolutionary changes in its systems engineering approaches and standards when the T-REX Project was conceived.

Traditionally LRT systems are developed using the Design-Bid-Build (D-B-B) contract delivery method. RTD and the Colorado Department of Transportation (CDOT) decided to streamline the T-REX Project delivery timeline by using the D-B approach. Initially the T-REX Owners (RTD/CDOT) were concerned that a D-B contract could result in the delivery of incompatible or unsuitable LRT equipment or station designs.

Another area of T-REX Project Owner concern was that systems elements would not be given the level of attention required in a \$1.67 billion “mega-project” that included both highway and LRT work. However, there was also recognition that there were potential benefits in terms of:

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- Better integration of systems within the overall D-B contract.
- Assigning the risk of contract interfaces and access dates to the D-B contractor rather than the T-REX Project.

Ultimately, we decided to include the systems elements within the overall T-REX D-B contract. The T-REX Project Owners then took several proactive steps to assure the concerns described above were addressed. These included:

- Developing the systems requirements (specifications) to a 70 percent design level. Although this is a higher level of design than is typical for a D-B contract, RTD had a very good idea of what it wanted in these areas.
- Requiring the bidders to specify their systems installers and suppliers to provide a basis for evaluating each potential D-B contractor's team.
- Including systems engineering elements as one of the selection criteria in the "best value" evaluation for selecting a D-B contractor for the T-REX Project.

In addition, the T-REX Project Team developed a strong oversight organization. The systems engineering group was one of the functional groups reporting directly to the Project Director/Deputy Project Director. The Team was led by an experienced RTD systems engineer, supported by RTD and consultant (LTK) staff. The initial systems staffing was lean (approximately seven to eight full-time equivalent staffers), but could be adjusted based on D-B contractor performance and overall T-REX Project needs.

3. The Lesson

The systems engineering aspects of the T-REX Project were an overall success. The D-B contractor placed a strong emphasis on the systems engineering elements. Some of the specific lessons include:

- There are significant benefits to including systems engineering elements as part of the overall D-B package. The benefits were seen in the integration of technical elements and schedule sequencing, resulting in a better product with less risk to the Owner.
- Since the systems engineering work generally is performed last on a project, any delays could place significant risk on the Owner if there were multiple contracts. Making the D-B contractor responsible for all aspects of the project allowed for successful project sequencing of all activities.
- RTD benefited by developing the systems requirements (specifications) to a 70 percent design level. Since T-REX Owners were definite about the systems engineering elements they wanted, these requirements were defined in the RFP to prevent later disagreements.

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As a result, there were minimal change orders in the systems engineering area and T-REX received the systems elements it was expecting.

- Although the system specifications were developed to an advanced level, the project remained open to innovation. For example, 189 Category B (*no cost, equal or better*) Change Proposals (CBCP) were executed in the systems elements area during construction of T-REX. Some of these CBCPs were significant, including converting the communications system platform from *Sonet* to *Gigabyte Ethernet* and changing the signaling system to coded track circuits.
- The initial lean staffing in the T-REX Project systems engineering group turned out to be sufficient due to the high level of quality performance by the D-B contractor in the systems engineering area and the high level of experience of the T-REX Project staff.
- The use of a “*best value*” contract award approach, with systems engineering elements as one of the selection criteria, let us select a D-B contractor with the appropriate capabilities, resources, and commitment to systems engineering.
- Close coordination with and support by the LRT operations area was critical to success in the systems engineering area. This included close review of all D-B contractor’s systems designs and installations by LRT operations staff, extensive feedback on operational requirements to support design, access to the operating railroad, and support during integrated testing.

Systems engineering elements (traction electrification, signals and communications) are a major component of any new LRT capital project. These elements require significant attention as they are critical to the long-term reliability of the LRT operations. Major T-REX Project decisions were made based on (1) how these systems elements were packaged and (2) the overall process for managing the systems engineering elements. The systems engineering elements could either be included in the design-build package or bid separately. Other key factors to consider were the level of systems element design in the RFP and the structure of the Owner's project management team for oversight of the systems engineering areas.

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[An operational view of T-REX, showing the LRT and highway systems]

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List of Acronyms—Lesson #17

CBCP	Category B Change Proposal
CDOT	Colorado Department of Transportation
D-B	Design-Build
D-B-B	Design-Bid-Build
LRT	Light Rail Transit
RFP	Request for Proposals
RTD	Regional Transportation District
T-REX	Transportation Expansion (Project)

Lesson Learned # 18: Project Acceptance/Close-Out

“Begin with the end in mind” – Stephen Covey’s *Seven Habits of Highly Effective People*

1. Executive Summary

The Transportation Expansion (T-REX) Project Owners benefited greatly by using a systematic approach to tracking and communicating the completion status of Project deliverables. Tracking and communication status information began at project start-up, so that the final decision to accept the T-REX Project was facilitated during closeout.

2. Background

The T-REX Project consisted of two separate transportation modes:

- Expansion and upgrades of existing Interstate highways.
- Installation of a new Light Rail Transit (LRT) corridor.

The nature of the T-REX Project made it necessary to schedule acceptance of deliverables at different times. Therefore, the Project Owners [the Colorado Department of Transportation (CDOT) and the Regional Transportation District (RTD)] set up a tracking and management system for each transportation mode consisting of:

- Milestones
- Interim completions
- Final completions
- Final acceptance

Intelligent Transportation System (ITS) and landscape/wetland elements were handled separately. This approach made it necessary for the Project Owners and Design-Build (D-B) contractor to establish a method for effective tracking and collaboration so agreements could be reached that a work item was complete.

A major challenge for any large project during final acceptance and closeout is how to handle the extensive quality records completed during the course of the work. These records provide evidence and verification that the governing requirements have been achieved. For the T-REX Project, quality records included T-REX oversight generated audits and detected non-conformances (see Lesson Learned #9: *Quality Management*), D-B contractor generated Nonconformance Reports (NCRs), punch list items, and the updated Certifiable Item List (CIL) for LRT-related work. Throughout most of the Project, each of these quality records was generated and maintained using separate database formats. The T-REX oversight staff was able

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to modify the existing Compliance Audit Program database to provide the D-B contractor's staff with an interface for entering non-conformance's punch list items, and CIL updates. This common, centralized database allowed all T-REX Project staff to view the applicable quality assurance (QA) records and make knowledgeable decisions about the status of work items.

As decisions on status of the various contractually-defined conditions were made, a roll-up was presented in a color-coded graphic "dashboard." This graphic provided Project team members with a real-time global view of the progress towards final acceptance. During pre-acceptance meetings, the D-B contractor and T-REX Project Owners were able to access the database and resolve outstanding issues quickly and collaboratively, facilitating the ultimate decision to accept the work items.

3. The Lesson

Linking quality records generated by T-REX oversight staff and D-B contractor QA staff in one common database promotes informed decision-making on final acceptance of the work items.

Summarizing information in an easily read dashboard (shown in Appendix A-Attachment 2) helps provide a common understanding on project status, and keeps all project participants informed.

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List of Acronyms—Lesson #18

CDOT	Colorado Department of Transportation
CIL	Certiifiable Items List
D-B	Design-Build
ITS	Intelligent Transportation Systems
LRT	Light Rail Transit
NCR	Nonconformance Reports
QA	Quality Assurance
RTD	Regional Transportation District
T-REX	Transportation Expansion (Project)

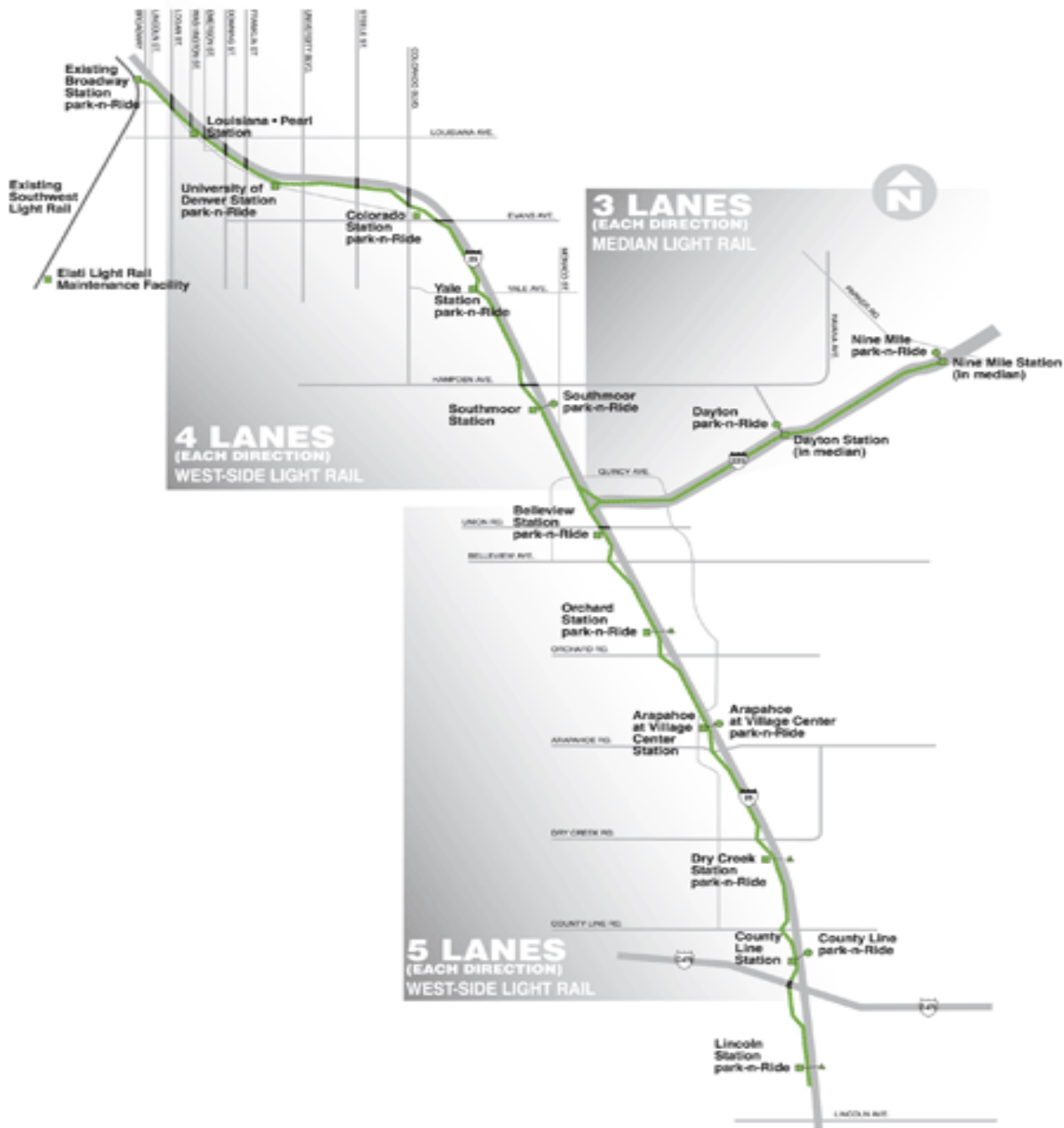
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Appendix A-Attachments

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Attachment #1

The Southeast Corridor



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Attachment 2

T-REX Project Acceptance Dashboard

Acceptance Item	Safe To Open	Milestone Status	Completion Date	Completion Status	Acceptance Date	Acceptance Status	Warranty	Warranty Ends
PROJECT								
HIGHWAY			Sep 2006		Dec 2006			
Segment 1			Sep 2006		Dec 2006			Dec 2007
Franklin Bridge		Aug 2002						
Narrows Bridges		May 2004						
Area 1.1		Aug 2006						
Area 1.2		Aug 2006						
Area 1.3		Aug 2006						
Segment 2			Aug 2006		Nov 2006			Nov 2007
Area 2.1		Aug 2006						
Area 2.2		Dec 2005						
Area 2.3		Oct 2005						
Segment 3			Jul 2006		Oct 2006			Oct 2007
Area 3.1		Nov 2004						
Area 3.2		Oct 2005						
Area 3.3		Jul 2006						
LRT								
University Garage			Sep 2005		Dec 2005			Dec 2006
Arapahoe Park-and-Ride			Dec 2005		Apr 2006			Apr 2007
Segment 1 w/o SCADA			Oct 2005		Feb 2006			Feb 2007
Segment 1 w/ SCADA			Feb 2006		May 2006			May 2007
Louisiana-Pearl p-n-R			Sep 2006		Dec 2006			Dec 2007
University p-n-R			Sep 2006		Dec 2006			Dec 2007
Segment 2			Sep 2006		Dec 2006			Dec 2007
MAINTENANCE FACILITY			Oct 2004		Mar 2005			Mar 2006
MARIPOSA								
Mariposa Phase I			Jan 2006					
Mariposa Phase II			Jun 2006		Aug 2006			Aug 2007
ITS								
Segment 1								
Segment 2								
Segment 3								
Off Corridor								
LANDSCAPE								

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Attachment 3-a

**T-REX Graphics
I-25 Corridor Light Rail**



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Attachment 3-b

**T-REX Graphics
Overview of Post-T-REX I-25 Corridor with Pedestrian Bridge**



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Attachment 3-c

**T-REX Graphics
I-25/I-225 Interchange
(Formerly Referred to as the “Death Merge”)**



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Attachment 3-d

**T-REX Graphics
The Central Valley Highway (I-25 South of Downtown Denver)
Post-T-REX**

