ABSTRACT

The first phase of Dallas Area Rapid Transit’s (DART’s) light rail build-out is scheduled to be completed and open for service in 2003. The DART Light Rail Build-out – Phase 1 incorporates two corridors into the existing 20-mile system: The North Central Corridor, consisting of 12 miles of light rail with 10 stations, including DART’s first four aerial stations; and the Northeast Corridor comprised of 11.4 miles of light rail with four stations. LAN/STV, a joint venture of Lockwood Andrews & Newnam Inc. and STV Inc., is DART’s General Engineering Consultant responsible for managing the design and construction of the light rail build-out program. This paper will present DART and LAN/STV’s construction management approach on the program, including contracting strategy, organization, and lessons learned.

The guideway construction was divided into six line sections. After evaluating several alternatives, LAN/STV recommended letting one facilities contract for each line section, a contract to cover miscellaneous construction, and systemwide contracts for the trackwork, traction electrification, signals, communications, and landscaping. The facilities contracts covered the construction of the guideway up to subballast, the bridges, and the stations. Specific topics of discussion will include; track procurement, scheduling, avoiding delay claims from the follow-on contractors, and the benefits of a miscellaneous construction contract.

LAN/STV organized the construction management team into resident engineer teams responsible for administering the contracts with several chief engineers responsible for providing technical support, training, and establishing consistency within the program. This section will present organizational charts for the construction management
team, the resident engineer team, and the extended resident engineer team, highlight team interaction with DART’s managers and the design consultants providing design support during construction, and describe the team’s approach to managing the interfaces between contracts and stakeholders. It will also summarize the key attributes of the organization, such as, communication, interaction with DART, and resource allocation.

Lessons learned during construction include administering a systemwide track contract, accelerating project schedules, dealing with right-of-way encroachment issues, and utilizing existing buildings for field offices. The paper will close with a short discussion on the changes between this program and the construction management on the Light Rail Starter System completed in 1996, as well as, the construction management improvements planned for the Light Rail Build-out – Phase 2.

INTRODUCTION

On June 14, 1996, the DART Light Rail Starter System celebrated its grand opening on time and on budget. The first light rail system in Dallas consisted of approximately 23 miles of light rail with 22 stations, a three-mile long tunnel, and a bridge over the Trinity River. Initial train ridership exceeded all expectations and DART began preparing for the first phase of the light rail Build-out.

Design and construction of the $1 billion Light Rail Build-out began in 1997 and is scheduled to be completed six months ahead of schedule, opening for revenue service in 2002. It consists of two corridors: the NC Corridor, consisting of 12.5 miles of light rail and 10 stations including DART’s first 4 elevated station structures 20 feet above ground level; and, the NE Corridor comprised of 11.2 miles of light rail and 4 stations. A system map delineating both the Starter System and light rail Build-out is presented in Figure 1.
**Program Organization**

DART teamed up with several consultants to accomplish a Build-out program. DART’s General Engineering Consultant (GEC) performs all structural engineering, architectural, surveying, track design, and construction management functions for infrastructure. DART also has a System Design Consultant (SDC), for interface with the GEC, who provides design review, construction management and coordination of Traction Electrification, Signals, Communications, and Fare Collection contracts.

DART teamed with a Vehicle Design Consultant (VDC) who provides interface with Light Rail Vehicle (LRV) design, production, inspection and assembly/testing services to meet scheduled vehicle demands for line section openings.

DART also has a Project Controls/Systems Integration Consultant (PCSI) who monitors program budgets, schedules and serves as an independent reviewer in the areas of contract modifications.

**LAN/STV Joint Venture**

The LAN/STV Joint Venture was organized to manage design and construction of the light rail Build-out with a single program manager supported by an Assistant Program Manager, and four Deputy Program Managers, responsible for design, architecture, construction, and administration. The organization also includes a Quality Control Manager for both design and construction management which reported directly to the Program Manager.

**LAN/STV CONSTRUCTION MANAGEMENT**

The keys to LAN/STV’s construction management approach were teaming with DART to develop an effective contracting strategy based on lessons learned from building the starter system and an organizational structure designed to emphasize teamwork. These two elements, combined with DART and LAN/STV’s practices and procedures for managing the interfaces between projects, safety, partnering, and quality assurance provided the construction management approach for the highly successful light rail Build-out.
Contracting Strategy

Based on DART’s experience building the starter system and LAN/STV’s recommendations, the construction work was divided into six line section contracts for the guideway facilities, two facilities contracts for the expansion of the Service and Inspection (S&I) Facility and the Vehicle Acceptance Facility, four track material procurement contracts, a systemwide track installation contract, a systemwide landscaping contract, and a miscellaneous construction contract. Systemwide contracts for traction electrification, signals, communications, and fare collection were not managed by LAN/STV; although, close coordination was required between LAN/STV and DART’s SDC. This division of projects resulted in the fifteen construction contracts summarized in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>CONTRACT BID AMOUNT</th>
<th>MILES</th>
<th>STATIONS</th>
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<tr>
<td><strong>North Central Corridor</strong></td>
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<tr>
<td>Line Section NC-3</td>
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<td><strong>Northeast Corridor</strong></td>
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<td></td>
<td></td>
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<td>2</td>
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<td><strong>S&amp;I Facility</strong></td>
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<tr>
<td>S&amp;I Facility Expansion</td>
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<td>VAF &amp; Yard Expansion</td>
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<td>$8,474,522</td>
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<tr>
<td><strong>Miscellaneous Construction</strong></td>
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<tr>
<td>$3,686,358</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>$280,888,837</td>
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Table 1.
Facilities Contracts

The guideway and stations were split into contract bid packages sized to result in competitive bidding and still attract large contractors with the resources and experience to successfully complete the projects. The project was divided into six 3 to 5 mile line sections as shown on Figure 1. These line section contracts included all bridge structures, the roadbed construction up to top of sub-ballast, the stations and parking lots, retaining walls, utility modifications, drainage improvements, street improvements and structures for system elements. The system elements infrastructure, included ductbanks, manholes, catenary pole foundations, and cable troughs. The remaining systems work was performed by the SDC.

Another advantage of breaking the corridors into line sections was schedule flexibility with the systemwide track installation contract. When a line section contractor fell behind schedule, resequencing allowed an alternative place for the track installation contractor to work thereby mitigating a potential delay claim.

Track Material Procurement Contract

DART and LAN/STV managed the procurement of all of the welded rail, special trackwork, concrete ties, and direct fixation rail fasteners for the Build-out utilizing four separate material procurement contracts. By procuring these long lead-time items separately, DART realized significant cost and time savings. The rail was welded in lengths of 660 feet, 1,200 feet, and 1,440 feet and transported via train on the existing rail line prior to demolition. The rail was stored in five rail piles strategically located along the proposed alignment. The rail lengths were predicated on the available space at the rail storage piles. Both the contractor and LAN/STV performed on-site inspection at the welding plant. LAN/STV also performed quality assurance inspection on the quality control at the steel mill, as well as, quality assurance plant inspection and random concrete testing on the concrete ties.

Systemwide Track Contract

Installation of the track including the welding rail, special track work, concrete ties, and direct fixation rail fasteners in the NE and NC corridors was performed under a systemwide track installation contract. This contract was a
change in methodology from the starter system where the track installation was included with the line section contracts.

By excluding the trackwork from the facilities contracts and utilizing a systemwide contract, DART realized the following benefits:

- Significant cost savings due to economy of scale
- More competitive bidding on simpler facilities contracts with less specialized work
- More attractive track contract for large track installation contractors
- Higher quality track installation

The systemwide track installation contract included access dates for each line section phased according to the projected line section contract completion dates with several weeks float. This method was effective in reducing the overall project cost; however, DART is considering a longer window for access dates in the future. Dividing the rail line into six facilities contracts provided additional flexibility in the access dates in case one of the line section contractors fell behind schedule.

Another advantage of the systemwide track contract was that only the trackwork resident engineer team required specialized inspectors for track installation. This team received special training on track installation including training on equipment DART provided to measure the stress free temperature of the continuous welded rail.

Systemwide Landscaping Contract

DART and LAN/STV elected to bid all of the landscaping work under a systemwide contract to achieve many of the same benefits recognized in using the systemwide track contract. The size of the contract attracted large contractors with the resources and experience needed to successfully perform the work to DART’s quality standards and schedule requirements.

The systemwide landscape contract was procured through a two-phase bid process. The solicitation required offerors to submit an unpriced technical proposal for DART’s evaluation. DART evaluated the proposals
considering firm capability and qualifications, prior experience, key personnel, and their work plan including a project schedule and developed a short list based on the rankings. Contractors short listed during the first phase, were invited to submit sealed bids.

_S&I Facility and Vehicle Acceptance Facility Contracts_

DART’s S&I Facility was designed for routine maintenance and inspection of DART’s light rail vehicles (LRV’s). This facility was utilized for vehicle assembly on the starter system. DART built a vehicle assembly facility to free up space for routine service and inspection operations. DART also expanded the service and inspection capacity in conjunction with the fleet size demands due to the Build-out program expansion. The vehicle assembly facility can also be utilized for routine inspection and vehicle service needs.

_Miscellaneous Construction Contract_

Recognizing that several opportunities to perform miscellaneous small projects, change work, and emergency repair work, would present themselves over the life of the project, DART and LAN/STV created a miscellaneous construction contract to provide a mechanism for constructing these small projects. This contract was bid as a fixed-unit price, indefinite quantity, indefinite delivery construction contract with which DART can procure construction work by issuing task orders. The contract was bid with approximately one hundred and fifty bid items covering general requirements, systems elements, paving, drainage, and utility, architectural, structural, and landscaping. Examples of bid items include fencing, catenary pole foundations, bridge handrail, bicycle racks, fire hydrants, and asphalt pavement. Each item was bid for an estimated quantity based on the anticipated utilization and unit of measurement, or as an allowance.

The Miscellaneous Construction contract has proved especially useful in performing changes. LAN/STV has been able to achieve more competitive change order pricing by comparing a Contractor’s change order price against the miscellaneous construction contractor and using this option as leverage during change order negotiations. The contract also gives DART some flexibility by providing another option for getting work done. Change orders arising toward the end of a contract are often performed under the Miscellaneous Construction contract to avoid
extending contract milestones. The Miscellaneous Construction Contract has been heavily utilized. To date, over 75 task orders have been issued and it is anticipated that over 100 will be issued.

**Construction Management Team Organization**

The Deputy Program Manager for Construction leads the LAN/STV Construction Management Team and is 100% accountable for the oversight of the construction phase. He is supported by eleven resident engineer teams, a Chief Field Engineer, a Chief Office Engineer, and a Chief Field Architect. The organizational chart for the LAN/STV Construction Management Team is presented in Figure 2.

Resident Engineers administer the construction contracts and serve as the single point of contact for all communication to and from the contractors. The typical structure of a LAN/STV Resident Engineer Team is presented in Figure 3. Each Resident Engineer is supported by an Office Engineer who is responsible for change management, pay requests, and submittal coordination, and, a Field Engineer who is responsible for field oversight and Quality Assurance (QA). The Field Engineer directly supervises a team of inspectors that provide quality assurance over the contractor’s quality control program. On average, LAN/STV staffs each team with two to three QA Inspectors. Specialty inspectors for electrical and mechanical work are assigned to each corridor. In addition, a full time scheduler is assigned to each corridor to monitor the contractor’s progress and review the monthly schedule updates.

The Chief Field Engineer, Chief Field Architect, and Chief Office Engineer establish consistency of service within the program, provide training, communicate lessons learned between projects, and provide technical support to the Resident Engineer Teams. The Chief Field Engineer and the Chief Architect float between projects and emphasize the quality of the finished work. These positions also provide some redundancy within the organization in the event of absence or turnover. On several occasions, the Chief Field Engineer temporarily filled a vacant position or covered for a team member on vacation. In addition, these individuals can provide additional support to a team during a period of peak activity.
DART and LAN/STV practice an integrated team approach in which all entities, DART, LAN/STV, LAN/STV subconsultants, and other DART consultants perform as one team. This team performance is best exemplified by the organizational chart (Figure 4) for the Extended Resident Engineer Team showing all support team members.

Managing the Interfaces

LAN/STV managed the interfaces between contracts through controlled access of the guideway and station areas. Upon notice to proceed of each Line Section Contract, the respective contractor and assigned RE Team controlled access to the guideway and station areas. Anyone needing access was required to coordinate with the controlling contractor through the Resident Engineer. The Line Section Contracts were issued with interim milestones for the completion of each bridge structure, an interim milestone for substantial completion of the guideway, and a final milestone for completion of the stations. As each milestone was achieved, access control of the area was transferred to the respective follow-on contractor. In the case of the bridges and the guideway, this was the track installation contractor. Once control was transferred, the Line Section contractor would have to coordinate with the track installation contractor, through the resident engineer, to access the guideway as needed to complete punch list items or perform maintenance and warranty work. At the stations, control was transferred to the systemwide landscape contractor upon substantial completion. This same concept was carried through from track installation to the systems contractors.

Safety

Safety is DART’s highest priority. All DART construction contracts, regardless of size, include the “Construction Safety Plan for DART LRT Projects” which requires the Contractor to employ a full time Safety Supervisor to perform safety administration, enforcement, and training services. The Contractor Safety Supervisor must report to a manager of the company other than the project superintendent thereby separating him from the contractor’s production operations. The DART safety plan specifies minimum qualifications for the Safety Supervisor including a college degree in safety, engineering or the physical sciences from an accredited college or university and seven plus years full time safety experience, preferably in the construction industry.
In addition, the Safety Supervisor must be validated through professional certification registration, or licensing from a recognized organization. The Safety Supervisor or an approved alternate must be physically present on site at all times during progress to provide continuous safety surveillance and supervision. DART and LAN/STV enforce the DART Safety Plan under all circumstances and have temporarily stopped work for not having an approved Safety Supervisor on-site on several occasions. Many contractors believe this policy is extreme; however, DART believes the results more than offset their investment. A comparison of DART’s safety ratings with national averages is summarized in the following table.

<table>
<thead>
<tr>
<th>TABLE 2 – DART Safety Performance</th>
<th>DART *</th>
<th>National **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recordable Rate</td>
<td>4.2</td>
<td>12.7</td>
</tr>
<tr>
<td>Last Time Rate</td>
<td>1.69</td>
<td>5.05</td>
</tr>
</tbody>
</table>

- Light Rail Build-out as of February, 2002

Another facet of the DART Safety Program is the Construction Safety Advisory Committee, which meets monthly to provide coordination, formal training, leadership and direction for the Construction Safety Program. The membership of the committee includes the DART Construction Safety Officer, DART Senior Managers, all Resident Engineers, all Contractor Safety Supervisors, and the Insurance Administrators Safety Consultant.

**Partnering**

DART and LAN/STV strongly support the “partnering process.” The contract documents require the contractor to participate in the partnering process. An allowance is included in the bid to compensate the contractor for half of the partnering expenses, which DART and the contractor share equally. The partnering process is started at the beginning of the project with a partnering workshop during which DART, LAN/STV, applicable governmental entities, the contractor, and the contractor’s key subcontractors and suppliers establish common project goals and align each entity’s interests as much as possible. LAN/STV’s approach to continuing the partnering process is maintaining an open door policy and working with the contractor as much as possible to resolve issues in a timely manner without exposing DART to additional risk or liability. When resolving problems, LAN/STV construction
managers will first work with the contractor to find a resolution and get the project moving again in order to minimize delays.

Quality Assurance/Quality Control

DART has invested heavily in establishing a high benchmark for construction quality on DART projects and has clearly defined their expectations in the Resident Engineer’s Manual, the DART Quality Assurance Program Plan, and Standard Specification Section 01400 – Procedures and Quality Control. LAN/STV is responsible for utilizing these guidelines to assure that each project meets or exceeds DART’s quality expectation as defined by the contract drawings and technical specifications.

DART practices a true Quality Assurance/Quality Control program in which the contractor, the entity in the best position to control the quality of the work, is responsible for quality control and LAN/STV, as DART’s representative, is responsible for quality assurance. In accordance with Specification Section 01400, the contractor is required to provide a quality control organization and system to perform inspections and tests to ensure compliance with the contract documents. Three key elements of this program are the Contractor’s Quality Control Representative (CQCR), the Contractor’s Quality Control Plan, and the three phases of control approach adopted from the Corps of Engineers. Both the CQCR and the Quality Control Plan must be approved prior to the start of construction.

LAN/STV performs quality assurance through preparation, QA inspections, and project audits thoroughly documenting compliance with the contract. LAN/STV’s Field Engineer leads the quality assurance team by conducting bi-weekly QA/QC meetings on-site to coordinate with the CQCR, LAN/STV QA Inspectors, and construction materials testing firms.

LAN/STV actively participates in all preparatory meetings by reviewing the contract requirements, serving as a technical resource, and sharing lessons learned on previous DART projects. LAN/STV’s main objective for this meeting is to confirm the contractor is organized and prepared to start the activity.
In the field, LAN/STV QA inspectors monitor the CQCR’s activities and confirm initial and follow-up inspections are performed. These QA inspectors also perform their own inspections and provide a second set of eyes checking the work. LAN/STV has developed several standardized inspection checklists for routine inspections. All deficiencies observed are reported to the CQCR, noted in the Daily Quality Assurance Report, and tracked with a Verbal Deficiency Log. Uncorrected deviations are documented using Non-Conformance Reports for the CQCR to disposition.

LAN/STV also conducts QA surveys and QA materials testing on the contractor’s testing lab. In addition to LAN/STV’s efforts in the field, RE Teams also perform monthly audits on the contractor’s quality control program to confirm all required documentation is provided. Any missing documentation is obtained by issuing an Audit Finding Report, which the contractor is required to close to achieve final acceptance of the project.

CONCLUSION

The result of community involvement, the LAN/STV construction management approach combined with DART staff and member cities participation is a 24-mile program concluding six months ahead of schedule and on budget. Five line sections are already in operation and one more will open by December 2002. At the same time DART is starting the process for Build-out II, which consists of a 47 mile expansion program.

Success is most attributed to a Team approach, incorporation of “Lessons Learned” from the previous program, a wealth of cooperation and knowledge from the Project Management Oversight consultant and several APTA member agencies and a true partnering spirit exhibited from FTA Region 6 personnel.

However, the best demonstration of the success of LAN/STV managing the Build-Out Program is the repeat business. STV was selected as part of the new GEC that would build upon the success of this first phase.

“ACT 21”, The Accelerated Cost-Effective Transit for the 21st Century, will be in charge of the design and construction management of the Build-Out Phase II.
ACT 21 is a partnership between STV, Inc. Carter and Burgess, Jacobs, and KAI, and will continue with the tradition established by their predecessors, of quality and innovation in the development of DART’s light rail system.
Figure 1
Figure 2
Resident Engineer
LAN/STV

Field Engineer
- QA Inspectors
- Corridor QA Inspectors

Office Engineer
- Corridor Scheduler

Administrative Assistant