OFFICE OF THE
City Auditor

Metro Line LRT
Signalling System Audit

August 14, 2015

THE CITY OF Edmonton

The Office of the City Auditor conducted this project in accordance with the *International Standards for the Professional Practice of Internal Auditing*

Metro Line LRT Signalling System
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Executive Summary

The information contained in this report is based on document reviews and discussions that took place up to August 14, 2015.

On July 7, 2015, City Council was advised by the Administration that the City is not in a position to put the Metro Line into staged service as the City has not received confirmation from the CBTC engineering consultant verifying the system is suitable for revenue service. On July 31, 2015, the City announced it: "has retained an internationally recognized expert in rail safety auditing to audit the documentation provided by [the CBTC contractor], identify gaps in the documentation and obtain the information the City needs in order to accept the safety certification and open the Metro Line to public service." As of the date on this report, Stage 1 revenue service has not been started.

On August 14, 2015, the Administration announced "line of sight" service would start on September 6, 2015. Line of sight service requires that LRT vehicles run at approximately half the speed planned for Stage 1 service.

This audit was originally scoped as a review of the reasons for the delay of the Communication Based Train Control (CBTC) signalling portion of the Metro Line. During the course of our audit, we also observed project management inadequacies, so we expanded our scope to include those elements.

The following is a high level timeline of events from the Metro Line project approval to the approval to issue a tender for CBTC signalling technology.

- In September, 2008 City Council approved the North LRT Extension Concept Plan (subsequently renamed Metro Line). The concept plan proposed the Metro Line would be open in April 2014.
- In 2009, a decision was made to utilize embedded track to address recently approved urban design guidelines.
- In January 2010, ETS Engineering and Maintenance recommended a CBTC signalling system. The communication identified a 4-6 month delay for additional planning due to the change in signalling technology.
- In February 2010, the Transportation Services General Manager made the decision to split the CBTC signalling contract and civil construction contract based upon operational perspectives and expertise in signals operations.
- In July 2010, LRT Design and Construction staff expressed concerns about potential risks, including delays, due to splitting the CBTC contract.

- On February 23, 2011, Transportation Committee approved the issuance of the tender for the CBTC signalling technology. The report identified the April 2014 opening of the Metro Line.

Both the CBTC signalling and civil construction contracts required “Practical Completion” of work by December 31, 2013 to allow full service implementation in April 2014. We noted that the CBTC contractor began missing contract deadlines soon after contract award and continued to miss milestone dates throughout the course of the contract. Major civil construction milestones (e.g. LRT stations) were not completed until the fall of 2014. LRT Design and Construction advised us the civil construction schedule was altered knowing the CBTC signalling system was not ready. The advice noted the schedule changes would not delay the signals contract and did not delay the opening of the Metro Line for revenue service.

Schedule risks emerged as planning and procurement activities progressed (key project dates are summarized in Appendix 3). However, we found no formal documentation from LRT Design and Construction to the Transportation Services General Manager advising him of emerging issues and potential delays. We were advised by LRT Design and Construction that the culture at the time was to provide verbal rather than written reports.

Additionally, we did not see any evidence that the Transportation Services General Manager informed City Council of emerging issues and potential delays. Council did not receive formal updates on project progress until December 2013 when construction was supposed to be complete.

The NLRT Extension Project Control Manual dated July 2011 indicates that LRT Design and Construction is the key City work unit in charge of the [Metro Line] project. The CBTC Signals System Delivery Strategy (Appendix 2) shows responsibility for day-to-day project management of the CBTC Signalling contract was delegated to ETS Engineering and Maintenance with LRT Design and Construction retaining responsibility for final approval of contract payments and scope changes.

The contractors and consultants are responsible for performance in accordance with their individual contracts. The City is responsible for ensuring project management practices are effective in managing costs, schedule, scope and quality.

Documenting and assigning roles and responsibilities is only one step required to effectively manage a project. Communication of roles and responsibilities, establishing good working relationships, monitoring performance, and taking action to address issues in a timely manner is also required for project success. Based on interviews and documentation, we believe that project management was not effective in the areas of Scheduling, Human Resource, and Communications. Contract management principles were also not applied consistently. This contributed to poor working relationships and failure to achieve project success.

Lessons Learned

Based on our review we believe the following lessons learned need to be incorporated into City processes to improve future project and contract management practices:

- Project Management roles and responsibilities need to be clearly defined and understood for the project in order to ensure that project deliverables are completed as needed.
- Realistic opening or completion dates need to be established and revised in a timely fashion after considering input from all available sources.
- Senior Management should be provided formal written status reports that identify major issues that could impact compliance with specifications (quality) and project schedule.
- Council should be notified on a timely basis of any event or issue that has the potential for negative publicity or citizen feedback so they can be prepared to respond.
- Contract management practices need to be reviewed to ensure the City receives best value and its interests are adequately protected.

We made three recommendations to the Administration to address the issues discussed in this report. The recommendations relate to contract management principles, project management improvement and project reporting. The Administration has accepted all our recommendations and provided action plans to implement each of them.

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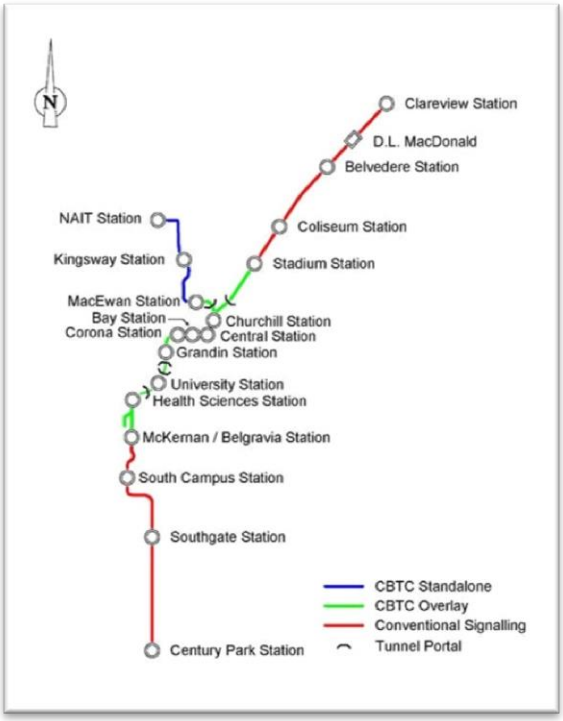
Metro Line LRT Signalling System

1. Background

1.1. Metro Line Project

The 2009-2013 Capital Priorities Plan for the NLRT (Downtown to NAIT) was part of the City's approved capital budget. In 2013, the NLRT was named the Metro Line.



The new line includes dedicated Metro Line track from NAIT to Churchill Station and track shared with the Capital Line from Churchill Station to the Health Sciences/Jubilee Station.

In 2011, the City awarded the contract to design and build the signalling system to Thales Rail Signalling Solutions Inc. (CBTC[1] Contractor).

Revenue service[2] will be introduced in two stages due to CBTC schedule delays. The first stage of service will be opening the Metro Line for revenue service and adjusting Capital Line peak service. As of the date on this report an opening date for the first stage of service has not been set.

The following changes in peak service will be implemented when the first stage of service[3] begins:

- Service to and from Century Park will be at 5-minute intervals. Two trains will follow the Capital Line to Clareview. Every third train will be diverted at the Churchill Station to the new Metro Line.
- Service to and from Clareview will follow alternating 5 and 10-minute intervals. Two 5-car trains will be scheduled at 5-minute intervals and the third 10 minutes later.

[1] CBTC - Communication-Based Train Control systems use radio signals to track train locations and to control signalling operations.
[2] Revenue service begins on the first day of passenger service.
[3] Transportation Services Metro Line Update report dated January 21, 2015. Stage 1 service is different than the "line of sight" service announced on August 14, 2015. Line of sight service will run at approximately half the speed of Stage 1 service.

- Metro Line service to and from NAIT will be at 15-minute intervals.
- Capital Line trains will be increased to 5 cars from current 4 car trains. Metro Line trains will be 3 cars long (the maximum length that can be accommodated at the temporary NAIT Station).

The second stage of service will be implementing full service on the Metro Line and restoration of complete Capital Line service. The second stage will not take place until all light rail vehicles have been retrofitted with CBTC hardware, software, and testing is fully complete.

1.2. Contract Management

Contract management is the process intended to ensure that all parties to a contract fully understand their obligations to enable them to be carried out as efficiently and effectively as possible.

Effective contract management can help ensure cost effective, reliable, and timely completion of the contract at an agreed price and a level of quality consistent with a purchaser's requirements. Contract management also ensures that legal standards, financial integrity, and management accountability are adhered to while maintaining good relationships.

The contract management process has two key objectives:

- Management of the relationship between provider and owner, and
- Identification, allocation, and management of the risks associated with the quality, efficiency, and performance of the contract.

A realistic assessment of risk is essential to the contract management process. The level of risk associated with an individual contract will depend on the type and length of contract. Conditions in the supply market and the risk to the user in terms of cost, quality, and the impact of contract failure also need to be assessed. Risks need to be monitored and reassessed throughout the life of a contract.

Effective contract management goes through four distinct phases: selecting the type of contract, developing the contract, evaluating bids, and managing the contract.

Selecting Contract Type

Three types of contracts commonly used by the City were used for the Metro Line project:

- The CBTC contract is a design/build contract with the contractor being fully responsible for delivery of a product that meets the City's performance specifications. The contractor is responsible for all aspects from design through final testing, including quality control. The City's role is to verify the work (quality assurance) completed by the CBTC contractor.

- The civil construction contract is a construction management contract. The civil construction contractor was responsible for construction and ensuring compliance with the contract specifications (quality control).The City completed the design work and verified the contractor's work (quality assurance).
- Engineering consultants were hired to manage the construction contracts using professional service agreements. The consultants' role included conducting the quality assurance work on behalf of the City. The City's role was to ensure the consultants were completing their responsibilities as defined in the agreements and to approving all deviations from the specifications in the construction contracts.

Developing Contracts

The City used its standard contract templates for the CBTC and civil construction contracts and the consulting agreements. The documents included a summary of the work to be completed, responsibilities, and detailed specifications as required.

Incentives for adherence to contracted milestone schedules included:

- CBTC contract – The payment schedule is based on the completion of predefined milestones, including a 20 percent payment after 6 months of service and 20 percent after another 6 months of service. In addition, the contract requires the CBTC contractor to pay additional costs incurred by the City for failure to meet the scheduled opening.
- Civil construction contract – The contract requires the Construction Manager to pay the additional administration costs for failure to complete the work within the contract time and in accordance with the project schedule. A standard 10 percent holdback on all payments is also included in the contract.
- Consulting agreements – There are no clauses in the consulting agreements to provide incentives for performance.

Evaluating Bids

Lowest price is not necessarily the most significant criterion considered in bid evaluations. Technical evaluations often carry significant weight in the evaluation process.

- The CBTC evaluation was completed in two phases; first the technical evaluation, and second by a price evaluation for bidders who achieved a specified number of points in the first phase. In this instance price was not evaluated against other bids but was within budget.
- Potential civil construction vendors were prequalified against technical criteria that included prior LRT construction experience and team qualifications. The City then issued requests for proposals to the prequalified vendors. Their bids were evaluated using weights of 65 percent for technical criteria and 35 percent for price.
- The consulting agreement evaluations were based solely on technical criteria.

Managing Contracts

Styles of contract management vary depending on the preferences and personalities of the individuals involved in the contract. Styles can range from collaborative (where trust, respect, and interpersonal relationships are highly valued) to compliance based (where the focus is on ongoing risk assessment and compliance with the contract clauses).

Relationship patterns need to be established early (during the procurement process), constantly reviewed, and actively managed. Relationships need to be flexible and open while maintaining proper businesslike and professional conduct.

The City engaged engineering consultants to serve as its contract managers. City project personnel are accountable for the outcomes and they need to use due diligence in managing consulting contracts.

2. Audit Objective and Scope

In July 2014, as part of planning for our 2015 Annual Work Plan, members of Council raised concerns about the delay in opening the Metro Line. Subsequently, the General Manager of Transportation Services requested an audit of the project management for the Metro Line CBTC signals contract.

Audit Objective

To identify events, conditions, and project management processes that resulted in project delays and to identify process changes and/or enhancements that could mitigate the risks of experiencing similar project issues in the future.

Evaluation Criteria

1. Did the project comply with the City's procurement directive and associated guidance?
2. Was the project carried out using the City's established project management processes?
3. Was appropriate due diligence practiced throughout the course of the project?

This review focused on the contract and project management for the Metro Line CBTC system and considered the impacts of coordination efforts with the Metro Line track and related civil infrastructure construction (e.g., tunnels, track, landscaping, stations, and lighting). A comprehensive review of the civil construction contract was not in scope.

3. Methodology

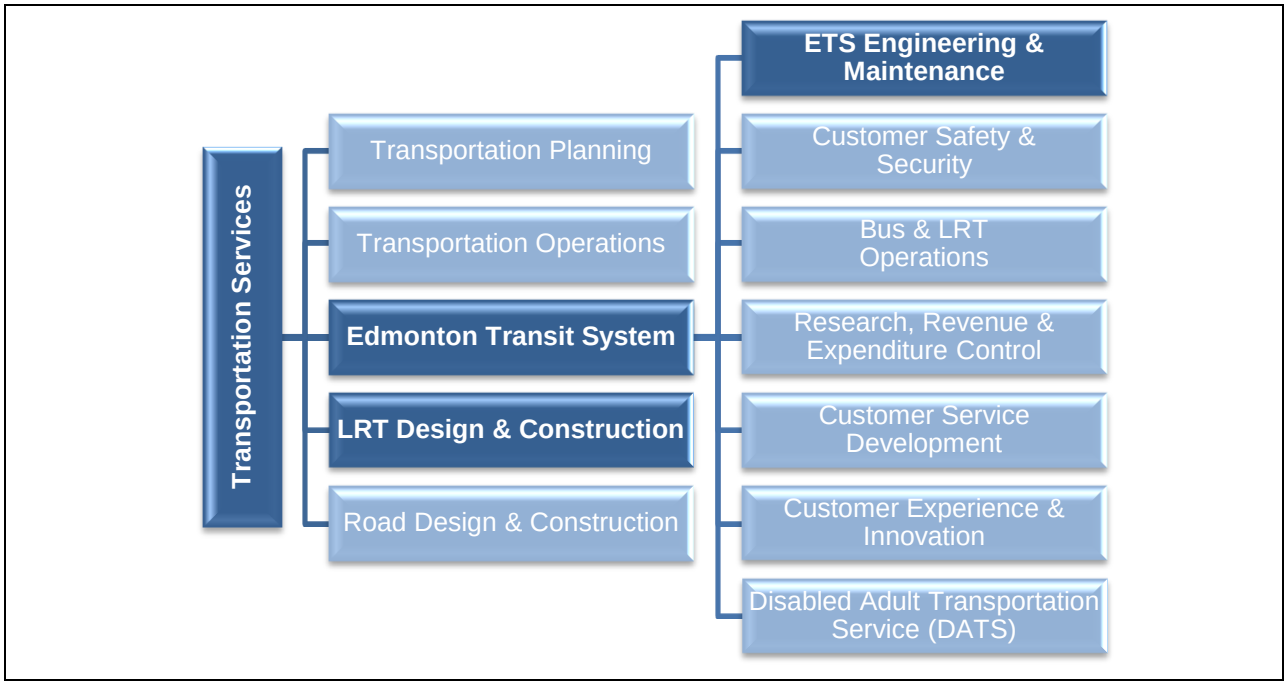
The observations and recommendations contained in this report are based on our review of contracts; field reports; written communications between the City, consultants, and contractors; meeting minutes; and deficiency lists for both the CBTC and civil

construction contracts. We interviewed City staff from both the LRT Design and Construction Branch and the Edmonton Transit Service Branch as well as the CBTC engineering consultant hired to design and monitor CBTC work.

4. Observations

Prior to June 2011, LRT Design and Construction was part of the Capital Construction Department while ETS Engineering and Maintenance was part of Transportation Services. Currently both business units are in the Transportation Services department and share the responsibility for light rail transit. Figure 1 illustrates the current organization structure.

Figure 1 – Current Organizational Structure



LRT Design and Construction provides project management services for planned and approved LRT projects. This branch manages contracts for design and construction, identifies and evaluates project delivery strategies, and coordinates construction with other city departments and utilities.

Edmonton Transit System (ETS) operates and maintains the public transportation services including buses, Light Rail Transit (LRT) and Disabled Adult Transportation Services (DATS).

4.1. Splitting of Contract

Key Points:

- ETS Engineering and Maintenance identified a 4-6 month delay to complete the CBTC signal design.
- Subsequently, the CBTC engineering consultant indicated the design could be completed as originally scheduled.
- We reviewed correspondence that indicated discussions took place weighing the advantages and disadvantages of splitting the contract.
- Prior to start of construction LRT Design and Construction identified increased project management risks due to splitting of the contract.

The projected April 2014 opening date for the Metro Line was established during the concept planning stage, which was completed in 2008. This date was based on the assumption that construction and signal installation would be constructed using the same functional design used for the Capital Line extension.

Prior to the civil construction contract being awarded for the Metro Line, City Council approved an urbanization approach for neighbourhood design. This direction was incorporated into *The Way We Move* Implementation Plan and the specifications for the Metro Line track construction were adjusted accordingly. Urbanization principles led to embedded track being used rather than the direct track fixation method. These methods of construction are illustrated in Figure 2.

Figure 2 – Alternate Track Construction Methods

Direct Fixation Track	Embedded Track
	

In early 2010, ETS Engineering and Maintenance staff identified an increased risk of communications failure if the existing fixed-block train control technology were used with embedded track. Changing the train control system to a CBTC technology addressed this risk and the requirement for trains to run at 2.5-minute intervals on the shared track between Churchill and Health Sciences/Jubilee Stations.

We reviewed a number of email exchanges between the ETS Engineering and Maintenance staff and LRT Design and Construction written between January and July 2010. The following highlight concerns raised by staff:

- An email dated January 15, 2010 from ETS Engineering and Maintenance summarizing a discussion with the Transportation Services General Manager on operational and maintenance concerns with applying urban design features into the Metro Line. The final paragraph includes the statement "I am very concerned that we are able to deliver a safe, quality, reliable service on this line on whatever is planned and built."

  This is the only email, related to splitting the signalling and civil construction, the OCA reviewed that included the ETS Branch Manager in the circulation.

- An email dated January 26, 2010 from ETS Engineering and Maintenance noted that if the originally-planned opening date (April 2014) was to be met, that urban design principles (embedded track) could not be followed. Comments were that if urban design was essential, then CBTC would be required. The email stated, "This would result in a delay of completion of the NAIT design by 4-6 months while a new spec was put together …"

- A February 7, 2010 email indicated a decision had been made to split the CBTC signals contract from the civil construction. The email also discussed splitting the NLRT and NE Signals Upgrade into two contracts. The email ended stating the CBTC engineering consultant "indicated that the design of the signals system can be completed as originally scheduled."

- An email dated July 29, 2010 from ETS Engineering and Maintenance set out the reasons for excluding the signals contract from the scope of the civil construction contract. Factors included the requirement to interface the CBTC system with the existing signalling system and retrofit of the Light Rail Transit fleet. The email concluded: "We really had a frustrating experience dealing with the signal system on the SLRT line and it was basically green field compared to this project."

- On July 30, 2010, LRT Design and Construction staff identified a number of project management risks. Risks included increased effort to coordinate construction activities, increased potential for claims and delays, and safety issues related to Prime Contractor status on site. Concerns were also expressed that the civil construction contract manager would not have the ability to influence the performance of CBTC contractor if schedule slippage occurred. LRT Design and Construction staff concluded that they did not support excluding the signals contract from the civil construction contractor's scope of work.

OCA Observation

All potential risks to the project schedule need to be assessed, formally documented and communicated to the project owner for all future capital projects. Key project dates for the Metro Line project are summarized in Appendix 3.

Recommendation 3

4.2. Leadership and Communications

Key Points:

- LRT Design and Construction is the key City work unit in charge of the [Metro Line] project.
- Responsibility for day-to-day project management of the CBTC Signalling contract was delegated to ETS Engineering and Maintenance. LRT Design and Construction retained responsibility for final approval of contract payments and scope changes.
- The ETS Branch Manager seldom received internal project correspondence on the CBTC contract and Metro Line project progress.
- The Transportation Services General Manager did not receive formal monthly reports showing project progress and potential issues.

Project Management

Success of a large, complex project, such as the Metro Line, requires strong leadership, well-defined chain of command, and open communications among key stakeholders. For the purposes of this report, we identified four key roles: project owner/sponsor, project manager, contract manager, and construction manager. The following roles and responsibilities are required for effective project management:

- Project Owner – A designated project role with the delegated accountability, authority, and responsibility to realize the business value of the project. The project owner/sponsor provides direction and financial resources for the project and is the person through whom the proper authority, responsibility, and accountability flows. Senior City management fulfill this role.
- Project Manager – The project manager is given the delegated accountability, authority, and responsibility to achieve the project objectives. The project manager is responsible for delivering the project, which includes duties related to management, communication, reporting, review, and approval. City staff fulfill this role.
- Contract Manager – The contract manager ensures that all performance obligations specified in a contract are being met. This includes monitoring and tracking of performance over the course of the contract and inspection of services rendered and goods received. There are two contract managers for the Metro Line project: the CBTC engineering consultant and the civil construction engineering consultant.
- Construction Manager – A professional agent engaged by the City to coordinate, communicate, and direct the construction process in terms of scope, quality, time, and cost. The construction manager may provide advice and costing information during the design stage to ensure that the City is obtaining value for money. The civil construction contractor was designated the construction manager for civil construction. The CBTC engineering consultant was assigned the construction manager role for the CBTC contract.

Based on our research, in order to be classified as a project manager, an individual must be responsible and accountable for applying all project management principles contained in the City's Project Management Resource Guide. The four core principles are: scope, budget, time/schedule, and quality. A diagram identifying all 13 principles is provided in Appendix 1. In contrast, a contract manager is only required to make sure the terms of a contract are followed.

The Project Roles and Responsibilities section of the NLRT Extension Project Control Manual dated July 2011 sets out project responsibilities at a high level for LRT Design and Construction, consultants, contractors and other City business units. The manual includes the following statements relative to accountability for the overall Metro Line project:

> LRT Design and Construction is the key City work unit in charge of the North LRT project.
>
> and
>
> The City's roles are to provide overall administrative direction …. The city receives, reviews, approves and/or rejects and ultimately accepts all of the deliverables provided by the Engineer, the Contractors and Internal City Departments.

The responsibility matrix included in the project control manual delegates responsibilities and accountabilities for individual project activities (e.g. overall project schedule control, CBTC LRT signals procurement, public consultation, etc.) Project management responsibilities for the civil construction and CBTC contracts were summarized in a September 2010 document titled "CBTC Signal System Delivery Strategy" (see Appendix 2). Overall, the delivery strategy shows that:

- The civil construction and general communications contract would be managed by the LRT Design and Construction Branch,
- Day-to-day management of the CBTC contract was assigned to the ETS Engineering and Maintenance section. The ETS Branch Manager had no assigned owner responsibilities despite being responsible for operating the LRT system after construction is complete, and
- Overall project management and approval of changes to contracts remained with the LRT Design and Construction Branch.

The communications that we reviewed on CBTC progress and issues dated prior to the fall of 2013 were copied to LRT Design and Construction, but rarely to the ETS Branch Manager. Beginning in the fall of 2013, the ETS Branch Manager was included in the circulation of some documents detailing issues that could potentially impact the scheduled opening, changes in operations, or ongoing budget requirements.

Engineering consultant's responsibilities during the construction phase include:

- Providing contract clarification.

- Acting as the engineer of record and owner's engineer.
- Overseeing and monitoring site activities for the overall Metro Line project.
- Setting up and implementing the Integrated Performance Monitoring plan and overall project risk management.
- Establishing the requirements, plans and deliverables for the commissioning phase of the overall project and working with the Construction Manager to fulfill these responsibilities.

The construction manager and contractors are responsible for performance in accordance with their individual contracts.

We reviewed monthly reports that identified project progress, issues, and concerns related to both the civil construction and CBTC contracts. These reports were circulated to the LRT Design and Construction office. We were advised by LRT Design and Construction that the Transportation Services General Manager was not provided with formal monthly reports, but was provided with regular verbal updates.

We reviewed LRT update meeting notes that took place between January 2012 and February 2013. The only reference to potential schedule slippage was at a January 14, 2013 meeting when the General Manager was advised that:

> Overall schedules look at construction to be completed by February 1, 2014. CBTC signal system to be complete April 1st which makes it tight for the April 27th opening.

As contractual CBTC milestones continued to slip, the City began escalating issues to the CBTC contractor's senior management. However, on the City side, the issues continued to be addressed at the project manager level until late 2013. The project team reportedly believed they were fully responsible to resolve contracting issues. Therefore, the team did not involve the City's senior management when issues required escalation until late in the process.

Finally, we received copies of a number of memos written by staff who had some direct involvement with the Metro Line project. The memos summarized their observations on the way the CBTC and civil construction contracts proceeded and with the communication and relationship that existed between LRT Design and Construction and ETS Engineering and Maintenance. One memo summarized the observations as:

> To summarize my memo, there are a number of concerns that question how the [Metro Line] project was managed and bring to light lots of additional maintenance issues that will be dealt with for years to come. A lot of these maintenance issues could have been dealt with at the time of construction. ….

Contract Management

There were two contracts associated with the Metro Line project. The CBTC contract was managed by ETS Engineering and Maintenance and the civil construction contract was managed by LRT Design and Construction. Each group employed different contract management styles.

1. The CBTC contract was managed primarily following the compliance model. This model focuses on ensuring the contractor's performance is in accordance with the requirements and specifications set out in the contract. Throughout this project there were poor working relationships, frustrated stakeholders, and conflicting opinions on the state of deliverables.
2. The civil construction contract was managed following a more collaborative approach with greater focus on working relationships. An example of this is the acceptance of work that was different than that included in contract specifications.

OCA Observation

The absence of a defined role for the project owner and lack of a common understanding of roles and responsibilities contributed to poor communication with senior management and City Council. It also resulted in a breakdown in the chain of command, project management inadequacies, and impacted the ability to address issues on a timely basis.

Recommendations 2 & 3

4.3. CBTC Contract

The design, software development, hardware installation, and testing/commissioning work to be completed under the CBTC contract included:

- Practical completion of all work by January 12, 2014.
- Provision of CBTC software to allow the safe and reliable operations of trains, level crossing warning devices, and the automobile traffic control system along the Metro Line and portions of the existing Capital Line.
- Provision of central train control software to interface with both the CBTC system and the existing signal system on the Capital Line.
- Provision of Public Address/Variable Messaging System software to interface with the new central train control software.
- Retrofitting all light rail vehicles (trains) with CBTC onboard equipment.
- Installing cable and hardware to implement the CBTC and public address systems (cabling, network equipment, safety critical hardware, public address interface equipment, etc.).
- Training ETS staff on the operation and maintenance of the CBTC system and on vehicle operations under the new control system.

4.3.1. Procurement Process

Key Points:

- Potential contractors indicated CBTC construction could take from 32 to 45 months prior to the request for proposal being issued.
- The request for proposal allowed 32 months for construction to meet the April 2014 opening.
- The bid evaluation process eliminated all but one contractor prior to price consideration.
- The CBTC contractor agreed to the terms in the contract.
- CBTC implementation issues are not unique to the City of Edmonton.

Overall, the City followed its normal procurement practices in establishing contracts for the CBTC system. Although we did not conduct a comprehensive review of the Request for Information processes or Request for Proposal evaluations, they appear consistent with the City's normal processes.

The City, through its CBTC consultant, issued a Request for Information and received seven responses. The Request for Information stated that its objectives were "to provide detailed conceptual information about the planned NLRT extension in order to solicit vendor input on CBTC requirements…" The Request for Information went on to indicate: "Although this project is presently unfunded, the City of Edmonton is targeting a system operational date of April 2014, with a Q4 2013 signal commissioning date." The closing date for responses was August 17, 2010.

Seven companies responded to the Request for Information. Three companies estimated they could complete the work in 36 months. Two companies indicated it would take 32 to 34 months, one indicated it would take at least 42 months, and one 45 months.

Following consideration of the responses to the Request for Information, the City issued a Request for Proposal to design and construct the CBTC portion of the Metro Line project. The Request for Proposal was issued as an open and competitive opportunity on January 31, 2011 and closed on March 18, 2011, allowing proponents about six weeks to respond.

The original Request for Proposal project milestones indicated that the successful proponent would be notified in April 2011, CBTC commissioning would take place in September 2013, and practical completion of work was to be not later than December 2013 (~32 months elapsed time). These dates were based on the planned April 2014 opening.

As shown in Table 1, the City received five proposals to design and build the CBTC system, including retrofits of the entire light rail vehicle fleet. The evaluation process

was completed in two stages. First an evaluation of technical criteria was completed and then price was reviewed.

Table 1 – CBTC Proposals Received

Proponent	Quoted Price	Met Minimum Score Requirement
Thales Rail Signalling Solutions, Inc.	$45.4 M	Yes
A	$75.4 M	No
B	$39.5 M	No
C	$34.7 M	No
D	$35.5 M	No

The City's technical proposal evaluation matrix contained two categories ("Overall Ability, Expertise and Capacity of Proponent to Perform the Work" and "Quality of Proponent's System"). There were 16 evaluation criteria in the first category and 14 in the second. Each proponent was evaluated against the technical criteria and was required to achieve at least 300 points (500 maximum) in both categories to be further considered.

Two criteria dealt with project timelines: 'Compliance with Milestone Dates' and 'Project Schedule Detail and Soundness.' No proponent scored full marks for these evaluation criteria. Proponent scores assigned to these two criteria, coupled with proposal evaluators' comments, indicated that the planned schedule was aggressive. We noted that the Request for Proposal closing and contract award dates were extended by one month but the Practical Completion of work remained unchanged increasing the challenge to achieve the April 2014 opening.

Since only one proponent met the minimum score requirement, pricing analysis was not required. As seen in Table 1, the second highest bid received the contract.

The CBTC contract was awarded on May 19, 2011 for $44.6 million, with practical completion by January 12, 2014 (less than 32 months). Training, full system testing, and commissioning were to take place between January and April 2014. By signing this contract, the CBTC contractor was committing to deliver the system in time for the April 2014 opening.

Eight change orders were processed, bringing the total contract value to $53.4 million. Only one change order (processed in February 2015) identified an impact on the project schedule.

Research into issues faced by other organizations shows that the complexity and time to implement CBTC projects tend to be underestimated. One of the conclusions reached in a US Federal Transit Authority report[4] states:

[4] FTA Report No. 045, "An Assessment of the Business Case for Communications-Based Train Control" published September 2013

> the challenges in upgrading the signalling/train control systems on an existing high-capacity mass transit system should not be underestimated, and any shortcomings in project planning and execution can have significant risk, schedule, and cost consequences.

An article titled "CBTC – A Product or a Strategy?[5]" states the importance of solid project management practices when implementing a CBTC system:

> As with the implementation of any complex signalling system, rigorous design management and project management processes must be instituted in order to successfully implement a CBTC system.

The article list four issues that are critical from the design and project management perspectives:

1. Service-proven products inevitably need to be changed to meet operating requirements.
2. The lack of CBTC interface standards also requires that particular attention be given to the specification of all external interfaces to the CBTC system.
3. Reaching early agreement on the safety assurance/safety certification process is critical.
4. Establishing clear requirements for an overall test, commissioning and cut-over strategy that recognizes CBTC technology requirements.

OCA Observation

Comments made during interviews by stakeholders on system complexity and process challenges, and statements contained in documents we reviewed indicate that the CBTC schedule was aggressive and the City experienced all the issues identified in research documents noted above.

Recommendation 2

4.3.2. Payment Milestones

Key Points:

- As of June 24, 2015 the City has paid 49% of the contract value.
- 40% of the contract value will not be paid until the system has been in operation for at least 6 months.

Planned payments for services under the CBTC contract were based on the CBTC contractor achieving specific milestones. The contract identifies 18 milestones and the portion of the original contract to be paid for each. Table 2 summarizes the milestones, expected date, actual date, the percentage to be paid, and the percentage paid to June 24, 2015.

[5] "CBTC – A Product or a Strategy, written by Alan Rumsey on behalf of the International Technical Committee of the Institution of Railway Signal Engineers (IRSE), February 2011

Table 2 – CBTC Contract Milestones and Payment Schedule

Item	Milestone	Target Date	% of Value	Actual Date	% Paid
1	Notice to Proceed	May 24, 2011	20%	May 19, 2011	20%
2	Concept Design Report	Aug 20, 2011	4%	Oct 5, 2012	4%
	Preliminary Design Report				
3	• Wayside	Nov 13, 2011	3%	Jun 14, 2013	3%
4	• Light Rail Vehicles		3%		3%
5	• CTC		4%		4%
	Final Design Report				
6	• Wayside	Feb 6, 2012	4%	Outstanding	3.4%
7	• Light Rail Vehicles Equipment		4%		4%
8	• CTC		4%		4%
	First Article Inspections[6]				
9	• Older Light Rail Vehicles	Jul 6, 2012	1%	Aug 7, 2014	1%
10	• Newer Light Rail Vehicles	Jul 6, 2012	1%	Sep 7, 2013	1%
11	Training & Spares[7]	May 8, 2013	2%	Outstanding	0%
	Practical Completion of Work[8]				
12	• New Construction	Jan 12, 2014	2%	Outstanding	0%
13	• Existing Line		2%		0%
14	• CTC		2%		0%
	Practical Completion of Work[9]				
15	• LRV 1st 50%	Jan 12, 2014	2%	Outstanding	2%
16	• LRV 2nd 50%	Jan 12, 2014	2%		0%
17	Performance Demonstration[10] – 50%	Jul 12, 2014	20%	Not yet begun	0%
18	Performance Demonstration – 100%	Jan 12, 2015	20%	Not yet begun	0%
		Totals	**100%**		**49.4%**

In June 2015, CBTC software continued to be modified and tested. Installation of retrofit CBTC hardware on light rail vehicles is expected to continue to the end of 2015. The Administration will not release the final 40 percent (approximately $20.0 million) of the scheduled contract payments until full service has been in operation for the specified periods.

[6] Items 9 and 10 (First Article Inspection) – Inspection of the first production unit

[7] Item 11 (Training & Spares) – Completion of all training and associated documentation and provision of required spare parts. (Note: Construction and delivery of the train driving simulators ($2.9 million) is not included in the percentages in Table 2.)

[8] Items 12-14 (Practical Completion of Work) – New Construction is from Churchill to NAIT Station. Existing Line is from South Campus/Fort Edmonton Park to Coliseum Stations. CTC is the overall control system that allows the LRT Controllers to monitor and control both the new and existing signal territories.

[9] Items 15 and 16 (Practical Completion – LRV 1st 50% and 2nd 50%) – 1st 50% means that retrofit is complete on half of the Light Rail Vehicle (LRV) fleet (47 trains) and the 2nd 50% means that retrofit is complete on the entire fleet (94 trains)

[10] Items 17 and 18 (Performance Demonstration 50% and 100%) – 50% means the entire system has been operating with full capability in a test and revenue service environment for 6 consecutive months; 100% means revenue service has been operating for 12 consecutive months.

The CBTC contract incorporated provisions for passing on the City's costs in the event of the contractor's failure to complete the assigned work prior to the scheduled opening date (April 2014). Allowable City costs include: claims from other contractors whose schedules were impacted by the CBTC contractor's delay, additional consultant fees, additional City personnel costs, and any additional costs or loss of revenue due to the delay.

We were advised by ETS that the City released partial payments for payment milestones 2 through 8 prior to the vendor actually completing the work. A letter dated March 30, 2012 indicates these payments were made "as a gesture of goodwill, and to recognize the level of effort recently put forth …"

OCA Observation

The contract provisions for recovery of damages, payment holdbacks, and goodwill payments have not proven to be sufficient to ensure the CBTC contractor's compliance with the contracted milestone dates. The Administration needs to review their application of contract management principles and determine whether there are opportunities that could improve project outcomes.

Recommendation 1

4.3.3. Schedule Challenges

Key Points:

- The CBTC contractor started to change staff assigned to the project prior to the project kick-off meeting.
- The CBTC contractor underestimated the effort needed to retrofit light rail vehicles with their technology.
- Retrofit is not expected to be complete until the end of 2015.
- Some design documents were not finalized prior to the CBTC contractor issuing the CBTC safety certification on March 23, 2015.
- 20 critical safety issues and operational concerns were identified after the CBTC contractor issued its safety certificate.
- Capital Line LRT service will be modified when the first stage of Metro Line service is started.

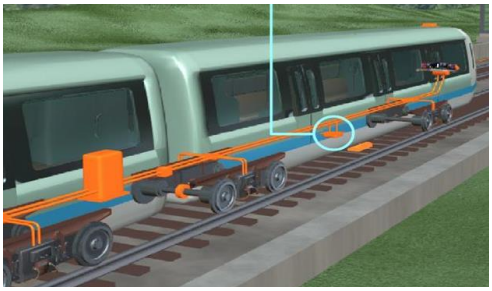
Key milestone dates for system design and handover as well as opening date commitments by the CBTC contractor's senior officials were not met. Based on our review, the following six areas have had the greatest impact on failure to achieve the contracted milestones and future operations.

1. CBTC Contractor Staff and Process Changes

The CBTC system contractor changed key project staff numerous times throughout the course of design and construction. The first key personnel changes were made before the City's initial kick-off meeting with the CBTC contractor.

2. Light Rail Vehicle Retrofit

CBTC LRV Hardware



All light rail vehicles in the City's fleet need to be equipped with hardware capable of interfacing with the CBTC system before full LRT service can be implemented using CBTC technology.

There are 94 light rail vehicles in the City's fleet; 57 newer model vehicles and 37 older model vehicles. Less than one year into the contract, the risk of a significant delay to the April 2014 scheduled opening of the Metro Line was identified due to light rail vehicle retrofit issues. The February 2012 Project Monthly report produced by the CBTC engineering consultant stated: "Mitigation measures are being taken to prevent this risk from materializing including accelerating the LRV equipment CBTC design and retrofit…"

Comments made by individuals we interviewed and review of recent retrofit schedules indicated that the amount of time it would take to retrofit the light rail vehicles had been underestimated. The CBTC contractors' estimate to retrofit one vehicle was 94 hours. With the majority of the fleet retrofits complete, it currently takes about 200 - 300 hours to complete one light rail vehicle retrofit.

To help accelerate the retrofit process, the City increased the resources and space available to the CBTC contractor. The CBTC engineering consultant also increased its consulting resources. The cost of these extra resources is billed to the CBTC contractor in accordance with the terms of the contract.

An April 30, 2015 report[11] prepared by the CBTC engineering consultant noted the number of deficiencies for [retrofit of newer] light rail vehicles were minimal. The high level of Train Operator Display (TOD) failure was identified as a deficiency with the potential to impact the reliability of revenue service.

As of June 24, 2015, the 57 newer model vehicles have been deemed suitable for use in CBTC revenue service. However, ETS Engineering and Maintenance staff noted that there are deficiencies on the newer model retrofits that are expected to reduce the reliability of the CBTC system and make maintenance more difficult.

None of the 37 older model vehicles have been certified for CBTC service. ETS Engineering and Maintenance staff noted there are deficiencies on completed work.

Examples of deficiencies affecting the light rail vehicle fleet include:

- Automatic Train Operation modes are not operating as designed;
- Light rail vehicle coupling and uncoupling does not function reliably as designed;
- Unexplained losses of power in antenna circuits on vehicles;
- Higher than expected failure rates of Train Operator Displays; and

[11] CBTC Revenue Ready Status, Report of Findings

- Older vehicles retrofits are not yet complete and the vehicles cannot operate in any mode except non-CBTC without impacting the motorman's ability to control propulsion and braking

The Administration has indicated that full payment for light rail vehicle retrofits will not be released until the City is satisfied that the deficiencies have been addressed.

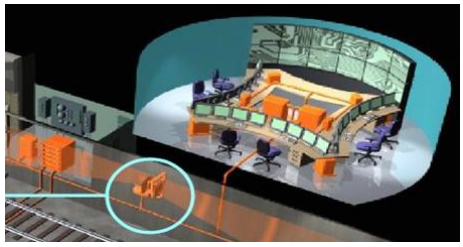
At the current rate, the CBTC contractor does not expect retrofit and correction of deficiencies for all light rail vehicles to be complete until the end of 2015. Automatic Train Control (ATO) functionality is not expected to be implemented until May 2016. In the interim, staged service will be implemented. The plan for Stage 1 service would provide the following service frequency and capacity during rush hour:

- Capital/Metro Line service between Century Park and Churchill stations will be at 5 minute intervals using three and five car trains. Overall passenger capacity will increase by 8%.
- Capital Line service between Clareview and Churchill Stations will follow alternating 5 and 10-minute intervals using five car trains. Overall passenger capacity will decrease by 17%.
- Metro Line service between NAIT and Churchill stations will be at 15-minute intervals using three car trains. Passenger capacity will be 33% below that planned for full revenue service.

On August 14, 2015, the Administration announced "line of sight" service would start on September 6, 2015. Line of sight service requires that LRT vehicles run at approximately half the speed planned for Stage 1 service.

3. Design Process

CBTC Wayside Communications System



The CBTC contract required that the CBTC contractor submit conceptual design, preliminary design, and final design documentation to the CBTC engineering consultant for review. The final design documents were due 180 working days after the award of the contract (the first quarter of 2012).

The April 30, 2015 report prepared by the CBTC engineering consultant noted that shortly after the CBTC contract took effect the CBTC contractor streamlined its system engineering management process eliminating the need for creating subsystem requirement documentation. Based on the design/build contract this change is allowed.

Documentation maintained by the CBTC engineering consultant showed that the design documents provided by the CBTC contractor for review were frequently returned with the status "revise and resubmit." Design documentation was returned as it lacked the necessary detail to properly define the functionality of the system.

Based on the June 24, 2015 payment information provided in Table 2, *CBTC Contract Milestones and Payment Schedule,* the wayside final design report is outstanding.

4. System Testing

Under the CBTC design/build contract, the CBTC contractor is responsible for:

- Designing a CBTC system that meets the contract specifications.
- Developing the software and installing hardware based on the design.
- Developing system test plans and procedures and submitting them to the CBTC engineering consultant prior to the start of testing.
- Testing the system (quality control) to ensure it is safe, reliable, and satisfies contract specifications.

The CBTC engineering consultant is responsible for:

- Reviewing and accepting CBTC contractor test results. This includes conducting spot tests prior to CBTC system handover to the City.
- Full system review and acceptance (quality assurance).
- Reviewing CBTC contractor documentation, verifying compliance with the contract and issuing a letter stating that the CBTC signalling system is suitable for revenue service.

In response to CBTC project concerns documented by ETS Engineering and Maintenance staff in March 2015, LRT Design and Construction confirmed that the CBTC contractor was responsible for fulfilling contract requirements and would need to resolve any identified safety issues before the City accepted the system into revenue service. The response also states that “the CBTC contractor will also have to provide ongoing support with training, commissioning, and maintenance as we move forward.”

The CBTC contractor issued safety certification indicating the system was ready for handover to the City on March 23, 2015. Between March 23, 2015 and June 24, 2015, the CBTC contractor made 13 system changes to address deficiencies. The CBTC system changes are supported by Field Change Bulletins or Limited Deviation Permits rather than issuing new safety certifications.

5. Documented Deficiencies

We were provided access to the project records maintained by the CBTC engineering consultant. We reviewed thousands of documents, including correspondence between the City, the CBTC engineering consultant, and the CBTC contractor; meeting minutes; and issues lists. Project documentation included deficiency lists used to track issues and their resolution throughout the life of the project. The most recent “master” deficiency lists maintained by the CBTC engineering consultant were dated April 2015 and identified a total of about 1,600 issues. Approximately 300 were labeled as closed; the remaining 1,300 were classified as open. Deficiencies ranged from minor to major.

The CBTC contractor advised the City on April 10, 2015 that they do not intend to populate the issue tracking worksheet that supports the deficiency list because they have their own system to track issues identified during installation and testing. As a result, the status recorded on the City's deficiency list may not accurately reflect the status of deficiencies at the time of our review. Transportation Services advised us that: " It was decided to direct project team energies into implementing Stage 1 service rather than pursuing deficiencies that did not advance Stage 1."

We noted that the contract requires the CBTC contractor to "arrange for the timely execution of corrective action to rectify Contract Deficiencies during the Warranty Period."

On April 10, 2015, LRT Design and Construction provided the CBTC contractor a list of 11 critical safety and 9 operational items that needed to be resolved prior to the start of training for ETS staff. LRT Design and Construction subsequently advised us that the issues were addressed sufficiently when evaluated by the CBTC engineering consultant so that the City could initiate training and orientation on May 9, 2015. They also indicated that key safety related functions are currently being mitigated with Safe Operating Requirements agreed to by ETS. The requirements include reducing planned speed of trains by 5 to 10 kilometers per hour in some areas between the Grant MacEwan and NAIT stations. We noted that this Safe Operating Requirement is listed as "Temporary". We have not been provided with information on the impact it will have on Metro Line service and traffic flow at level crossings along the route, or when this requirement will be lifted.

LRT Design and Construction indicated that they would seek formal acknowledgement by the CBTC engineering consultant that the system was suitably safe and reliable prior to initiating revenue service.

6. Maintenance and Operations

The contract required that the CBTC contractor train ETS maintenance staff to facilitate smooth handover of maintenance responsibilities. The contract also required the CBTC contractor to train ETS motormen on equipment operations to facilitate smooth handover of operations.

The CBTC contractor has committed to providing support for the staged implementation and will provide maintenance support for a two-year warranty period which begins when CBTC components are put into service. The Administration will need to negotiate a maintenance agreement prior to the end of the warranty period.

Currently, the City has knowledge of the inputs and outputs of the CBTC system, but does not have the knowledge needed to maintain the software. ETS Engineering and Maintenance staff members believe they will be able to operate and maintain the CBTC system as long as LRT operations are normal.

A memo dated March 21, 2015 from the CBTC contractor confirmed their commitment to provide ETS with post-handover maintenance support from the handover of Stage 1 service to acceptance of the Automatic Train Control functionality (expected May 2016). The memo states:

> Thales and ETS have a mutual interest for ETS to achieve maintenance and operations self-sufficiency therefore ETS shall perform 1st line diagnostics of all maintenance issues. If ETS is unable to resolve, they shall contact Thales 24/7 call centre …

The CBTC system will be under warranty for 24 months from the date stated in the Construction Completion Certificate. A maintenance agreement for service after the warranty expires has not been negotiated. We were advised by LRT Design and Construction that a maintenance agreement will be negotiated at the appropriate time and in a manner that best serves the City's interests.

OCA Observation

Remaining light rail vehicle retrofit and automatic train control activities should be closely monitored, frequent updates provided to senior management, and regular reports provided to City Council relating to implementation of full revenue service.

Recommendation 1 & 3

The Administration needs to ensure that all final design documents are received to minimize the risk to longer-term maintenance needs.

Recommendation 1

The CBTC contractor began missing milestone dates very early on in the contract. As time went on, milestones continued to slip until the planned opening date became unattainable. The Administration did not notify Council of its concerns with CBTC contractor performance and milestone slippage until December 2013.

Recommendations 1 & 3

4.4. Civil Construction Contract

In its September 17, 2008 report to City Council, Transportation Services indicated that, "Detailed design will commence in 2009, with construction starting in 2010 and finishing in 2013. The extension would be open for service in 2014." An attachment to that report showed that the Metro Line would be ready for service in April 2014.

The work to be completed by the construction contractor included:

- Completion of construction by December 31, 2013.
- Excavation and Construction of a tunnel from the Churchill Station to MacEwan Station.
- Construction of three LRT stations and a Transit Centre.
- Track construction and traction power installation.
- Installation of communication systems and signalling equipment.
- Installation of duct banks/conduit for power, general communications, and CBTC communications.

- Installation of cable for general communications.

A number of activities completed under the CBTC contract required that schedules be coordinated with civil construction activities. For example: the design and placement of conduit required for CBTC purposes is required prior to installation of duct banks, installation of duct banks and conduit need to be complete prior to installation of cable, and installation of cable by two companies needed to be coordinated as it required working in confined spaces.

The contracts for both civil construction and CBTC construction required that the contractors submit detailed project schedules to demonstrate that the work will be performed as scheduled. The contracts also required that monthly updates be provided to the City's consulting engineers to demonstrate actual progress against the project schedule.

Engineering consultant contracts were also in place to provide design, engineering, contract management, and inspection services, including project schedule reviews. The CBTC engineering consultant advised us that efforts to encourage the contractors to maintain a coordinated schedule were not successful.

4.4.1. Tunnel Construction

Key Points:

- The delay in tunnel construction impacted some CBTC contract activities. This delay was less significant than other CBTC activities (e.g., LRV retrofit).

The most significant civil construction activity that had potential to impact the CBTC construction schedule was a delay in completion of the tunnel from Churchill Station to MacEwan Station.

The original construction schedule prepared by the contractor shows the tunnel connecting the Churchill and MacEwan Stations was to be complete in December 2012. The February 2012 civil contract manager monthly project report indicated that there was a risk of delay in completion of the tunnel: "Mitigation measures are being taken to prevent this risk from materializing including … developing tunnel construction staging that could allow work to progress on one completed tunnel before the other is ready." The August 2013 "Project Monthly Report" prepared by the civil construction engineering consultant indicates that some civil construction work was still underway. LRT Design and Construction advised us that the cable pathway required for CBTC was installed in July 2013.

The CBTC contractor's April 2012 monthly report first highlighted a concern with revised tunnel access dates that could impact cable installation. The CBTC contractor's updated schedule dated May 2013 showed cable installation in the tunnel was planned for June 2013. The cable pathways through the southbound tunnel (where the cables were to be strung) were completed by the civil construction contractor on July 2, 2013. By

September 2013, the CBTC contractor noted that their testing that was originally scheduled for October 2013 would not be achieved because testing by the civil construction contractor would continue until January 2014.

Although there was a civil construction delay in the tunnel, the CBTC contractor was even further behind in completing the light rail vehicle retrofits and system design. Key project dates are summarized in Appendix 3.

OCA Observation

The delay in completing the tunnel delayed the installation of cable and associated testing. However, the delay in completing the light rail vehicle retrofits and CBTC system work was more significant than cable installation. The civil construction delay did not impact the overall CBTC system delay. Disagreement among stakeholders should be documented and reported to senior management.

Recommendation 2

4.4.2. Civil Construction Quality Assurance

Key Points:

- The civil construction contractor was responsible for quality control and quality assurance over their own work.
- The civil construction engineering consultant may perform spot checks at their discretion.

The Quality Management and Control section of the NLRT Project Control Manual set out the responsibilities for the civil construction contractor and civil construction engineering consultant.

- The contractor was to ensure appropriate quality control and quality assurance processes and procedures were implemented to provide the City with confidence in the quality of the workmanship. The contractor was to endeavor to reduce deficiencies by being proactive and showing commitment to continual improvement of the quality management system. They were also required to prepare non-conformity reports for deviations to project requirements and communicate them to the engineering consultant.
- The engineering consultant “may perform reviews, surveillance, inspections, testing and auditing at their discretion.” Potential deficiencies identified through these actions are documented on field reports. The manual states “Any of these actions must be considered extraneous to the Contractors’ quality management obligations and in no way will alleviate the ultimate responsibility for quality from the Contractors.”

Early in our review we were made aware of a deficiency report produced by one of the civil construction engineering consultants’ sub-consultants. In the summer of 2013, LRT Design and Construction received a report titled “NLRT Duct Bank Deficiencies Overview, Impacts and Recommendations. Section 1 of the report summarized the issues, identifies short-term and long-term impacts on LRT operations and

maintenance, and concludes with four recommended actions to address the deficiencies.

Based on our discussions with LRT Design and Construction staff, review of a July 24, 2015 letter from the civil construction engineering consultant on the handling of the report, and review of non-conformance and deficiency reports it appears issues identified in the report were handled through standard project processes.

We were provided access to the project records maintained by the civil construction engineering consultant. We reviewed field reports prepared by the engineering consultant related to duct banks and communications. We also scanned Non-Conformance and Deficiency reports to see how the responsibilities set out in the control manual were implemented.

The last full Non-Conformance Report was dated August 2014. It included 215 entries with 30 classified as open. One of the open items was the blocked duct line noted in the summer 2013 report. Subsequent Non-Conformance Reports listed only open items. The last report on file was dated May 2015 it included 3 entries; the blocked duct line was not listed.

We reviewed two Non-Conformance Reports related to the disposition[12] of the blocked duct line. The original non-conformance report for the blocked duct line, dated November 14, 2013, indicated the blocked conduit was unacceptable. The disposition was classified as "Repair." A revised report signed on January 21, 2015 indicated attempts to clear the blockage were unsuccessful and alternate actions were discussed. The classification of the disposition changed to "Use as is." We were advised that the Non-conformance Report was "closed off with the agreement that the commercial compensation to the City will be dealt with through the Change Management process."

A total of 73 field reports were issued for duct bank and communication inspections completed by the civil construction engineering consultant. We reviewed field reports related to duct bank/conduit construction and communication because they had the greatest potential to impact the CBTC contractor's milestones. We randomly selected seven field reports to determine how the observations/issues were resolved.

In response to our request for documentation showing the actions taken to address field reports, LRT Design and Construction indicated there were a number of methods of closing field reports, including verbal discussion. We were provided with a letter dated June 4, 2015 that described the field report issues, action taken to resolve the issues and the status on each. Five field reports were shown as closed and two as open. On July 24, 2015, we received additional information on the two open field reports. The

[12] Methods of resolving non-compliance issues:

- Use as is – accept the work as technically equivalent,
- Repair or Rework – require repair or replacement of the work, and
- Reject – an alternate method of disposition must be proposed and approved. This includes determining the difference in value of the asset and accepting compensation.

status on both was changed to closed. The following is a summary of the information we were provided for the seven field reports.

Sample 1 - Field Report dated January 10, 2012

Issue: Multiple fibre optic cables were used instead of a single cable specified in the design.

Action Taken: The response indicated that the contractor was required to replace the cables with a single cable. A non-conformance form was not completed because the problem was corrected while the work was in progress.

Status: Closed

Sample 2 - Field Report dated August 30, 2012

Issue: Conduit installed with low points, preventing natural drainage. This was observed prior to conduits being enclosed in concrete, but was not fixed prior to the concrete pours.

Action Taken: The response indicated that review of as-built drawings revealed a number of locations where low points existed, contrary to project specifications. The agreed-upon mitigation strategy was to have the contractor clean the conduits and install caps on the ends of the conduit.

Status: Closed

Civil Construction engineering consultant update:

The duct bank is being used for its intended purpose, and in most respects, it is of similar quality to the South LRT duct banks. There was a desire by the designers to improve on that by eliminating sags, but to that end the contractor achieved only partial success.

Sample 3 - Field Report dated October 22, 2012

Issue: Incorrect size of conduit was installed.

Action Taken: There was a discrepancy between the electrical and the communication system design specifications. The contractor installed the smaller conduit in the electrical design instead of the larger conduit required by the communication system design. The City accepted the smaller conduit that was installed in error.

Status: Closed

Sample 4 - Field Report dated April 1, 2014

Issue: A new Variable Message Sign was mounted adjacent to and touching a suspended gas heater.

Action Taken: The response indicated that the issue was the result of an older sign being replaced with a larger sign that could not be installed in the same location. The sign is being observed for signs of degradation.

Status: Closed

Sample 5 - Field Report dated April 11, 2014

Issue: Cameras were installed without the specified bracket.

Action Taken: The field report speculates that the mounting method may not provide insulation from power surges. This was not specified as the protection as it is provided through the lightning rods and grounding of the poles. The specified duel camera bracket would not provide insulation. The two brackets used are an acceptable alternative.

Status: Closed

Sample 6 - Field Report dated May 28, 2014

Issue: Cameras were installed that were discontinued and not compliant with specifications.

Action Taken: The cameras were ordered several months before the manufacturer announced that it would be discontinuing the cameras. The response further indicated that there is no concern regarding camera performance or support since the camera manufacturer will continue product support beyond the civil construction contractor's warranty period.

Status: Closed

Sample 7 - Field Report dated January 14, 2015

Issue: Cable markings (critical for maintenance and trouble-shooting) were rubbed off due to observed non-standard installation method.

Action Taken: The response indicated that "…there are some clarifications that are working their way through the as built drawing review/record drawing preparation process." The response also indicated that cables were tested for signs of over-stress during installation and results were normal.

Status: Closed

OCA Observation

Project managers need to be more transparent and ensure senior management and Council are informed on major deficiencies in a timely manner.

Documentation practices need to be improved to include resolution of issues noted during inspections.

Recommendations 1 & 2

4.5. Project Completion and Commissioning

4.5.1. Civil Construction Completion and Commissioning

Key Points:

- Civil construction milestones were not enforced due to CBTC contract delays.
- Civil construction was not completed on-time.

The original commissioning plan indicated that commissioning[13] would include all aspects of the civil construction and the CBTC system: "The objective of the commissioning program is to turn over a fully operational North LRT Extension to the City of Edmonton."

On March 25, 2015, The City received its first letter from the commissioning agent for the Metro Line civil construction contract. The letter identified a number of "show stoppers" and high impact items that needed to be addressed before revenue service could commence. The "show stoppers" were:

- Correction of guard rail issues from MacEwan to NAIT Station.
- Successful retest of emergency phones.
- Successful installation and testing of an uninterrupted power supply (UPS) in the tunnel.
- Approval of fire alarm testing by the Fire Marshal and the [Engineer of Record].
- Correction of an error in the conventional signal system logic for University territory.

The civil Construction Completion Certificate[14] was issued on May 29, 2015 and showed the actual completion dates for major milestones:

Table 3 – Overall Milestones vs. Actual Completion Dates

Overall Milestones	Planned	Actual
Stations complete	November 28, 2012	October 20, 2014
LRT Signals Equipment complete	January 30, 2013	October 20, 2014
Traction Power complete	February 20, 2013	August 27, 2014
Commissioning complete	August 30, 2013	June 8, 2015*
Construction Completion Certificate	December 31, 2013	May 29, 2015

* The commissioning letter identified several deficiencies that were still outstanding.

[13] Commissioning and testing procedures are intended to ensure that all safety and quality standards are met.

[14] The City's Project Management Reference Guide definition: "A certificate confirming the City's acceptance of the amenity or landscape built by either in-house…or Third Party Contractor for the start of a warranty/maintenance period. The certificate confirms that the construction meets City standards and has been inspected by a qualified inspector of the City."

The City indicated that "substantial performance lagged in some work packages due to the fact that the [CBTC] signal system…was not ready and therefore there was not a need for the [construction manager] or the City to rush to complete [these milestones]."

We compared the "show stoppers" in the first commissioning letter dated March 25, 2015 against the construction completion dates noted in the Construction Completion Certificate and found two inconsistencies. The Construction Completion Certificate:

1. Indicated that the completion date for track construction was July 2014, but the commissioning letter identifies "guard rail track issues" from MacEwan to the NAIT station.

   Cause - During a full system demonstration test on March 21, 2015 sections of guardrail came loose partly due to drainage issues. In one case a guardrail dislodged, damaging a light rail vehicle. This resulted in all system tests being suspended due to the potential for derailment. On March 25, 2015 a new installation procedure and bonding material was identified and by March 30, 2015 testing resumed.

Figure 3 – Guardrail Track Issues

Loose Guardrail

Dislodged Guardrail

2. Indicated that the communication systems were completed in February 2015, but the commissioning letter indicated that the Fire Marshal still needed to approve fire alarm testing.

   Cause - The outstanding need to approve the alarm system resulted from an error in the original design, which missed one aspect of the 2006 Alberta Building Code requirements. A change order to address the requirement was issued on June 3, 2015.

On June 8, 2015, the commissioning agent issued a civil construction commissioning letter that identified nine lists of deficiencies reported by the Engineers of Record and two newly-identified problems that needed to be corrected. The letter stated that all five "show stopper" issues had been or were being addressed. The letter closes with:

> …the North LRT system is ready for operations with the understanding that outstanding deficiencies noted in this letter will be completed to confirm the North LRT operational requirements. As before, this letter does not address turnover of the train signal CBTC system under a separate contract with the City of Edmonton.

4.5.2. CBTC Commissioning

Key Points:

- Completion of the CBTC system is 18 months behind schedule.
- The CBTC engineering consultant documented concerns with the CBTC contractor processes.

The Commissioning and Testing section of the LRT Design Guidelines state that:

> Start-up and activation work must be performed by an independent agency … approved by ETS.

The Project Commissioning Plan developed for the Metro Line identifies the requirements that:

- Acceptance and integration test plans and procedures were to be prepared by the Engineer of Record. (Under the CBTC design/build contract the CBTC contractor filled this role.)
- Test plans and procedures were to be reviewed and approved by the commissioning steering committee with representation from all stakeholders, including the City and the CBTC engineering contractor.
- Tests were to be performed and approved by an independent commissioning team. For the CBTC contract this was a separate work unit within the CBTC contractor organization.
- Witnessing of tests, and final review and approval of the test results were to be completed by the commissioning steering committee.

We were advised that for the first stage of service there is no contract requirement for commissioning to be complete. Final testing and commissioning is to be complete prior to the Metro Line being placed into full service.

The Systems Assurance section of the CBTC contract includes the following clauses that required the CBTC contractor to:

> Provide a Software Assurance Plan to the [CBTC engineering consultant] prior to commencement of the design. … The [CBTC engineering consultant] will review the plan for quality and completeness.
>
> Develop a performance demonstration test plan for acceptance by the [CBTC engineering consultant].
>
> Participate with the [CBTC engineering consultant] in identifying the activities performed in support of the safety certification of the system, including the status of the submittals identified above. Sign appropriate certificates, as prepared by the [CBTC engineering consultant], in support of these activities.

The Commission section of a CBTC Revenue Ready Status Report[15] dated April 30, 2015 includes the following statements:

Verification and Validation Process

> [The CBTC contractor] appears to have a clear and well defined System Verification and Validation Plan and System Test Plan. … for commissioning a safe and operationally reliable CBTC system.
>
> and
>
> There is no evidence available to the City team to confirm that [The CBTC contractor] followed these plans and no documentation has been supplied to support any alternate course of action.

Regression Testing

> It has been observed by both the City team and [The CBTC contractor] on several occasions, and for all subsystems, software has been released to site with fundamental failures that were not captured prior to installation.

Failure Mode Testing

> [The CBTC contractor's] test program tends to focus on the normal operating or "sunny day" scenarios. They do not comprehensively test all failure modes to establish if the system fails to the safe condition as identified in the hazard analysis. It has been noted however, that some failure mode testing is done through informal analysis in-house.

The executive summary of the report ends:

[15] North LRT Extension, Downtown to NAIT, CBTC Revenue Ready Status Report, April 30, 2015. Prepared by the CBTC engineering consultant.

> Since [the CBTC engineering consultant] does not currently have the necessary visibility into [the CBTC contractor's] documentation and procedures to authenticate [their]' safety claims, and in the absence of any other such evidence, our review has to be considered limited by such constraints and as such the City will need to rely on the [CBTC contractor's] Final Safety Report, Safety Certificate and any Field Change Bulletins (FCB) amongst other things, as opposed to our report, as the final substantiation to place the CBTC Plan B system into revenue service.

On May 8, 2015 the CBTC engineering consultant provided the City with a letter stating:

> [The CBTC contractor has] provided the minimum necessary outstanding documentation and validation to indicate that the CBTC system on the Metro Line is safe and ready to be placed into service for the sole purpose of the training and orientation …
>
> and
>
> It needs to be noted that [the CBTC engineering consultant] consider that the Metro Line cannot be placed into revenue service at this time …

As of June 15, 2015 only one of six major CBTC sub-systems had been classified as "suitable for revenue service" by the CBTC engineering consultant.

In early July 2015, the CBTC engineering consultant worked with the CBTC contractor to obtain and review the CBTC process and test results in order to provide an opinion whether the Metro Line is ready for revenue service. On July 7, 2015, Council was advised that the City is NOT in a position to put the Metro Line into Staged Service.

On July 31, 2015 the City issued a Public Service Announcement titled: "*City initiates independent safety audit of Metro Line signalling system*." The announcement included the following statements:

> The City has a responsibility to ensure all aspects of its public transit system are safe for public use. In order to ensure that the Metro Line is safe for public operation the City requires certification from its signalling system contractor. Unfortunately, [the CBTC contractor] has failed to provide some essential documentation required for the City to accept [the CBTC contractor's] safety certification. The City has retained Rail Safety Consulting, an internationally recognized firm, to review all documentation provided by [the CBTC contractor] and to identify and obtain the missing documentation.
>
> At the same time, the City is exploring interim options to bring the Metro Line into public service without using the communication-based train control signalling system that [the CBTC contractor] has been contracted to provide. Such options would not offer the frequency of LRT service that communication-based train control will eventually provide, but they are being

explored in order to open the Metro Line to public service as quickly and safely as possible.

As of the date on this report, a commissioning letter has not been received and Stage 1 revenue service has not been started.

On August 14, 2015, the Administration announced “line of sight” service would start on September 6, 2015. Line of sight service requires that LRT vehicles run at approximately half the speed planned for Stage 1 service.

OCA Observation

The roles of contract managers under design/build and construction management contracts need to be clearly defined and communicated to staff. The City should also ensure that an appropriate balance of collaborative and compliance-based contract management styles is used. This approach will help ensure contract success for both contracted schedules and compliance with specifications.

Recommendations 1 & 2

5. Conclusions and Recommendations

Overall Conclusions

1. We found that procurement practices for the CBTC contract complied with the City’s procurement directive and associated procedures.
2. Project management practices for the Metro Line project were not effective in 3 of the 13 project management knowledge areas (see Appendix 1).
   - Time/Schedule – Neither the CBTC contractor nor the civil construction contractor met the originally-scheduled full-service opening date of April 2014. As of the date of this report, a commissioning letter stating that the CBTC system is ready for first stage of revenue service on the Metro Line has not been received.
   - Human Resource – Overall Metro Line project roles and responsibilities were not clearly defined and understood by the entire Metro Line project team resulting in ineffective leadership.
   - Communications – Failure to define roles and responsibilities also resulted in poor communication within the Metro Line project team and to senior management and Council. For example, potential CBTC project delays were known early in the project, but neither senior management nor Council received reports of those potential delays until it was too late to recover contracted milestone slippages.
3. Based on our review, there are opportunities to improve due diligence for contract management. Roles and responsibilities related to quality control and quality

assurance should be reviewed to ensure the City receives best value for money and its interests are adequately protected.

CBTC Contract

Our review showed that the April 2014 opening date was established prior to CBTC system design. The risk that the opening date might not be achieved was identified prior to awarding the CBTC contract. ETS indicated early in 2010 that the change to CBTC technology could delay the project by four to six months. During the procurement process, there were also indications that the planned timelines could be quite challenging. Effectively, during contract finalization, the CBTC construction timeline was shortened rather than extending it.

Regardless of the risk of delay, the CBTC contractor agreed to the construction timelines and the April 2014 opening date for the Metro Line when they signed the contract. The Administration viewed the contractors' willingness to sign a contract with challenging timelines as sufficient evidence that the timelines were reasonable. The CBTC contractor began missing construction milestones shortly after the contract started and then failed to deliver on assurances that it would meet future milestones.

There is no documentation showing that the project team advised senior management or Council of the CBTC contractor's ongoing failure to meet contracted milestones until December 2013. Being proactive, open, and transparent with senior management and City Council from the start of the project onward could have reduced the negative publicity directed against the City in 2015.

Civil Construction Contract

LRT Design and Construction announced in the spring of 2014 that civil construction was complete and ready for service. However, the attachments to the Construction Completion Certificate dated May 29, 2015 show that major civil construction activities were not complete until the fall of 2014 and that landscaping was pending. The City received a letter from its commissioning agent on June 8, 2015 indicating that the civil construction elements for the Metro Line were ready for operations, but some deficiencies remained outstanding.

Recommendations

We provided three recommendations to the Administration to address the issues we observed during this audit. The Administration has provided its responses to these recommendations.

Recommendation 1 – Contract Management Principles

The OCA recommends that the General Manager of Transportation Services ensure that for all major projects consistent principles and methodologies of Contract Administration are adhered to including quality assurance and quality control activities.

Management Response and Action Plans

Accepted

Action plan:

Administration will assess potential gaps in adhering to consistent Contract Administration principles and methodologies. Following this assessment an implementation plan will be developed to identify improvements through training or enhanced project management tools.

Planned Implementation Date: Gap Analysis December 31, 2015; Implementation Plan March 31, 2016

Responsible Party: General Manager of Transportation Services

Recommendation 2 – Project Management Improvement

The OCA recommends that the General Manager of Transportation Services ensure that project roles, responsibilities, lines of communication, management of working relationships, and decision authority levels are clearly defined, assigned, and communicated for all major projects.

Management Response and Action Plans

Accepted

Action plan:

Administration will review all major projects and ensure that Roles, Responsibilities and Authorities are in place.

Planned Implementation Date: December 31, 2015

Responsible Party: General Manager of Transportation Services

Recommendation 3 – Project Reporting

The OCA recommends that the General Manager of Transportation Services in conjunction with Financial Services and Utilities' and the Corporate Centre for Project Management staff develop a standard corporate reporting methodology for major capital projects which includes schedule, scope, and budget status as well as overall risk assessment and quality management.

Management Response and Action Plans

Accepted

Action plan:

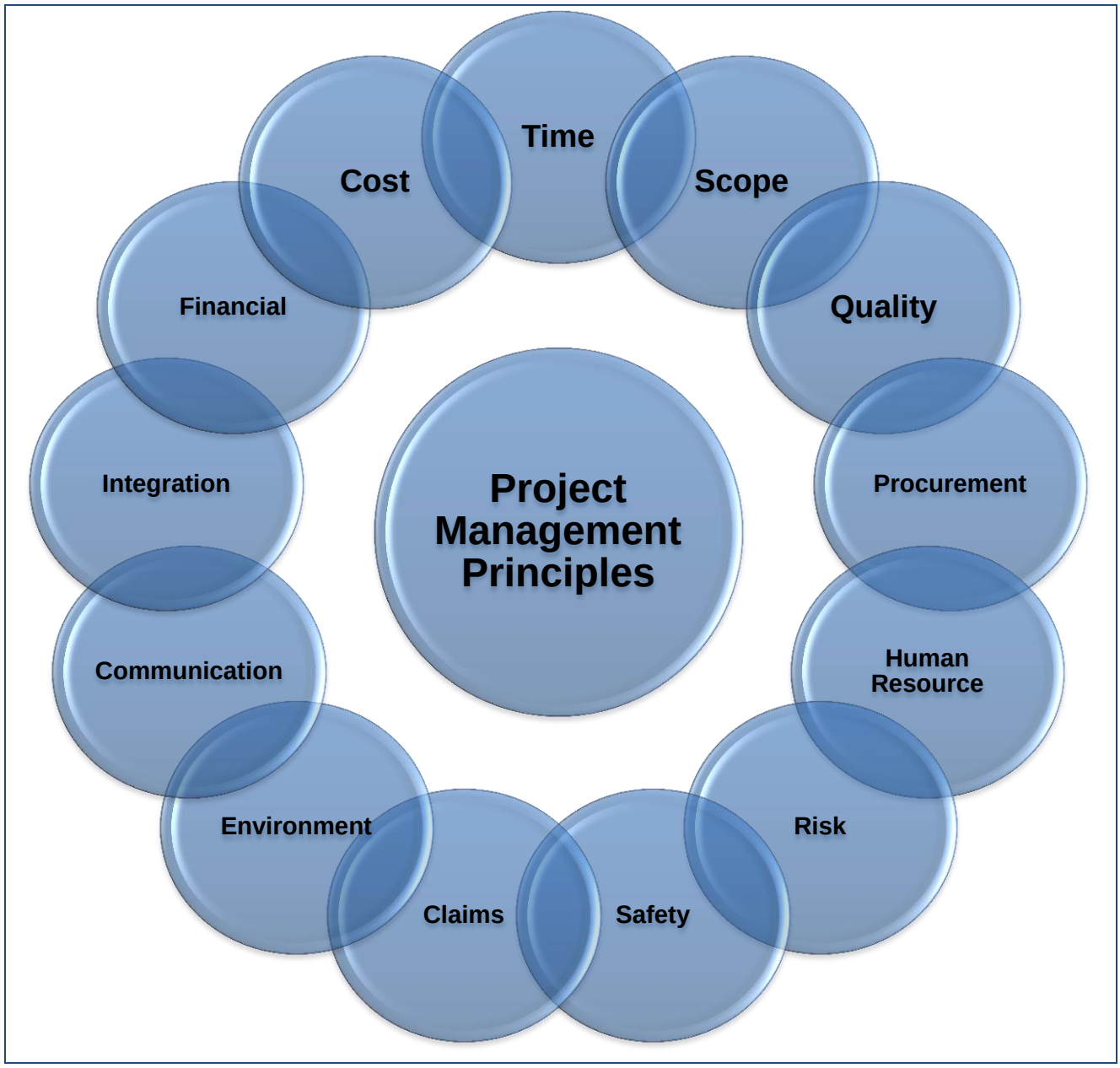
Administration will complete a best practice scan and develop a standardized corporate reporting methodology for Corporate Projects incorporating Schedule, Scope, Budget, and Risk dimensions.

Planned Implementation Date: Best Practice Scan December 31, 2015; Initial Reporting June 30, 2016

Responsible Party: General Manager of Transportation Service

Appendix 1 – Project Management Principles

The project management principles set out in the City's Project Management Resource Guide cover 13 project management knowledge areas (or principles) based on the Project Management Body of Knowledge (PMBOK).[16] These principles are depicted below:



[16] The Project Management Body of Knowledge is published by the Project Management Institute (PMI)

Appendix 2 – CBTC Signals System Delivery Strategy[17]

	North LRT Construction Management Contract [civil construction]	CBTC Design-Build Contract
Scope	Construction of conventional wayside equipment on the new line, including: • Ductbank • Pole and Antennae Bases • Transponder Installation • Crossing Protection • Bungalows Supply and Installation	Overall CBTC design and implementation, including: • Installation of all antennas, cabling, and connections for wayside equipment on the new line • Transponder Supply • LRV retrofits. • Existing downtown signal room upgrades • Installation of antennas, conduit, cabling, and connections within downtown tunnels
City Branch Responsible for day to day project management	LRT Design and Construction	ETS-LRT
City Branch Responsible for processing contract payments and scope changes (Same as LRV contract)	LRT Design and Construction	ETS-LRT signs first LRT Design and Construction final approval
Consultant	Team North LRT with engineering consultant responsible for signals design as a sub	Engineering consultant as a sub to Team North LRT
Consultant Scope	Overall project design and construction coordination, resident engineering, contract administration, commissioning of all NLRT systems except CBTC, integration of CBTC design into Civil design	• Integration of CBTC design into Civil design • Integration/interface with other systems such as traffic signals, communications systems, CTC, PA/VMS • CBTC resident engineering/ inspection, signal contract administration, commissioning of CBTC system.

Benefits:

- Enables CBTC contract to be awarded by April 2011 to meet April 2014 opening date (CM will be awarded in March 2011)
- LRT D&C manages new construction (greenfield)
- ETS-LRT has direct control of construction within existing facilities (brown field)
- Overall project budget and scope management maintained by LRT Design and Construction with support of ETS-LRT on the CBTC contract.
- One integrated engineering team (eliminates scope gaps, disagreements)

[17] Source: LRT Design and Construction, September 2010.

Appendix 3 – Summary of Key Dates

Metro Line Project Timelines		
	Planned Date	**Actual Date**
Metro Line Concept Plan Approved	-	January 2009
Civil Construction Contract		
Awarded	-	May 2011
Completed/Substantially Completed	December 2013	October 2014
Commissioned	-	June 2015
CBTC Contract		
Awarded	April 2011	May 2011
Completed	January 2014	In progress
Commissioned	-	Unknown
Metro Line Opening		
Stage 1 Service (limited)	Unplanned	Unknown
Stage 2/Full Revenue Service	April 2014	Unknown

Potential Delays Identified Prior to Tendering of CBTC Contract		
	Date Risk Identified	**Anticipated Delay**
Planning delay due to change in technology	January 2010	4-6 months
Construction delay	August 2010	approx. 6 months

Civil Construction and CBTC Completion Delays			
	Planned Date	**Actual Date**	**Actual Delay**
Civil Construction Contract			
LRT Stations	November 2012	October 2014	23 months
LRT Signals Equipment	January 2013	October 2014	21 months
Traction Power	February 2013	August 2014	20 months
Tunnel Construction	December 2012	October 2013	10 months
CBTC Contract			
Final Design Report	November 2011	Outstanding	Unknown
Practical Completion of Work	January 2014	Outstanding	Unknown
Light Rail Vehicle Retrofit	January 2014	Outstanding	Unknown
Potential impact			approx. 36 months
City Council first notified of opening date delay		December 2013	