

# **Implementation of Project Management Approaches on Toronto Traffic Control Centre Renovation Projects (2015 CITE Conference in Regina, Submission # 27-2015)**

Stephen Q. Huang, P. Eng and Rajnath Bissessar, P.Eng

**Abstract.** The City of Toronto's Traffic Operation Centre (TOC) has been in place since January 1994. The utilities and equipment were aging and required replacement and upgrade in order to improve work efficiency, capacity and productivity, and bring cost savings through reduction of power consumption and maintenance. The renovation project was initiated in 2012. After a two-year journey, on July 26, 2014, the City of Toronto Transportation Services Division unveiled its new Traffic Operation Centre (TOC) to help improve safety and traffic flow on City roadways. Committed to the new and ambitious Congestion Management Plan (CMP), the renovation and upgrade project consisted of needs assessment, architecture design, renovation construction, video display system and control system procurement and installations. The scope of the project strategically aligned with Transportation Services mission "to provide safe, efficient and effective transportation solutions to serve the needs of our residents, businesses and visitors in an environmentally, socially and economically prudent manner". In order to suit both the current and projected functional needs of the City, the project management team applied various technical and managerial approaches to ensure the operational expectations were met and the project was completed under the budget and on time. The paper describes the project management practical techniques that were utilized on this project, including project planning, critical path control, project organization and information flow management, and Pareto improvement. It also provides details on analyzing TOC operation needs to determine the layout, size of display wall, use of display wall with ergonomic factors being considered during the planning stage. A 3D modelling technique was established to assess the view distance and angle, and lighting design for TOC operators. A solution of network topology to suit the need of both Corporate IT and Traffic Management Centre was outlined. This paper illustrates project management approaches undertaken over the project implementation and administration stage, including schedule, miscellaneous tasks, dealing with obstacles, command chain and breadth of communication, cost control, and lessons learned.

## **1. BACKGROUND**

The City of Toronto's Traffic Operation Centre (TOC), with an area of approximately 350 m<sup>2</sup> inside an office building, is the control centre within the City's Traffic Management Centre (TMC) of the City of Toronto. It serves a critical role in managing corridor traffic, responding to inquiries, monitoring traffic incidents, acting upon incident occurrences, providing centralized command/control and active traffic management through Road Emergency Situation Communication Unit (RESCU) operations and Transportation Dispatch services. The TOC is operated on a 24/7 basis by a third party contractor.

Adjacent to the TOC is Transportation Services Divisional Operations Centre (TSDOC), also called the Viewing Room (VR) which is roughly sized 11m × 6.7m and serves as the Transportation Services command centre during special events (e.g. Caribbean Carnival, CNE and Grey Cup) and emergency events (e.g. recent widespread flooding). The VR also serves as a TMC boardroom when not being used as a TSDOC.

The TOC and VR, located on the 5th floor of 703 Don Mills Road, City of Toronto, have been in place at the Traffic Management Centre since 1992 when a state-of-the-art facility was built. Most of the equipment in the TOC, e.g., video display wall, lighting system, electrical system, heat ventilation/air conditioning and operation console, etc, has reached the end of its useful life and needs replacement.

As a result, a renovation project was initiated in early 2011. The City procured a third party consulting service to provide an assessment and recommendations for upgrades to the video wall system, furniture, layout and utilities, and to identify work function efficiencies within the TOC and VR. Reflecting some of the recommendations from the report, the City launched a complete renovation program which contained two projects: the architectural project (Reno Project) and the video display and control system project (Video Wall Project). The former was handled separately by the City's Facilities Management while the latter (TMC Video Display and Control System Project) was led by Transportation Services TMC.

The actual implementation of the two projects started in September 2013 (Video Wall Project) and February 2014 (Reno Project) respectively. The newly renovated TOC and VR were unveiled in July 2014, with a total cost of \$3.1 million.

## **2. PROJECT PLANNING**

### **2.1. Operational Needs Analysis**

#### **2.1.1. Display Wall**

The planning stage for upgrades to the display wall started in early 2011. It was to be a main focus of the renovation due to the need for 24 by 7 operations and its importance to Toronto corridor traffic monitoring and management responsibilities. Four principals <sup>[1]</sup> were taken into account during the project planning stage, including operational effectiveness improvements, achieving routine goals, achieving strategic goals and system sustainability development.

As the single most important component within the TOC, the video wall itself plays a critical role in determining the project scale. Due to its significant cost, the use of the video wall must be carefully assessed to meet operational needs rather for its ancillary value (e.g., as a show case). The previous video wall consisted of 57 cathode ray tube (CRT) display unit which could not display all 76 RESCU Camera images on Expressways at the same time. With an expected 150 arterial traffic road cameras being added in the next three years as part of the Toronto Congestion Management Plan (CMP), the TOC operations will be expanded from Expressway Management to City-Wide traffic monitoring and management. The previous CRT video wall would not support this new mandate from either a capacity or flexibility perspective. Therefore, upgrading this equipment became a priority.

Some factors that limit the benefit of the traditional video wall include:

- The display capacity of a CRT based video wall was constrained by the number of monitors. When the camera number increases, it is likely that camera displays must be placed on “touring” for operators to view, which is not considered “full coverage” of the network.
- The CRT video wall was built to display camera images only and provided no flexibility in either displaying map images or manoeuvring camera images (e.g., resizing).

- The technology used by CRT generated limited visual effects that don't support wide horizontal and vertical viewing angles. This in turn capped the number of cameras that can be monitored by TOC operators from their workstations.

On the other hand, the reasoning of upgrading the Video wall was debated. Due to rapid technological progress, the operator's need to view and switch camera streams can now be easily accommodated by many off-the-shelf software products which can run on workstations with user-friendly interfaces. These products are commonly used for command centres and security centres where either space is limited or has budget constraints.

However, modern display products allow for more than simple camera image monitoring. Through the operational needs assessment, the key justification for an improved display was that the operations oriented GIS map display requires a large high resolution display area. This could only be supplied by DLP technology-based display units. Thus, the display wall really should be called a "GIS Map Display Wall" rather than "Video Wall".

The City is also displaying an advanced transportation management systems (ATMS) which is a GIS map based application for managing the road network. This important functionality demanded the use of an improved video wall that would allow for the display of map-based interface, traffic flow data, camera streams, and traffic control device status, etc, on the map.

### 2.1.2 Layout

Figure 1 shows the "before" layout for the TOC and VR. There were 15 workstations within the TOC room which belonged to two groups, namely TMC Dispatch and RESCU. The former, handled by City employees, contained four seats on the second row. The latter, run by a third party contractor, occupied the front row. Since March 1, 2013, the TMC Dispatch job function has been outsourced. TOC operators are required and able to conduct RESCU monitoring and TMC Dispatch duties at the same time on a routine basis. From the operational perspective, when the contracted service combining these two functions started, there was a need to bring these previously separated staff into a close proximity working environment where they would share facilities (such as the display wall).

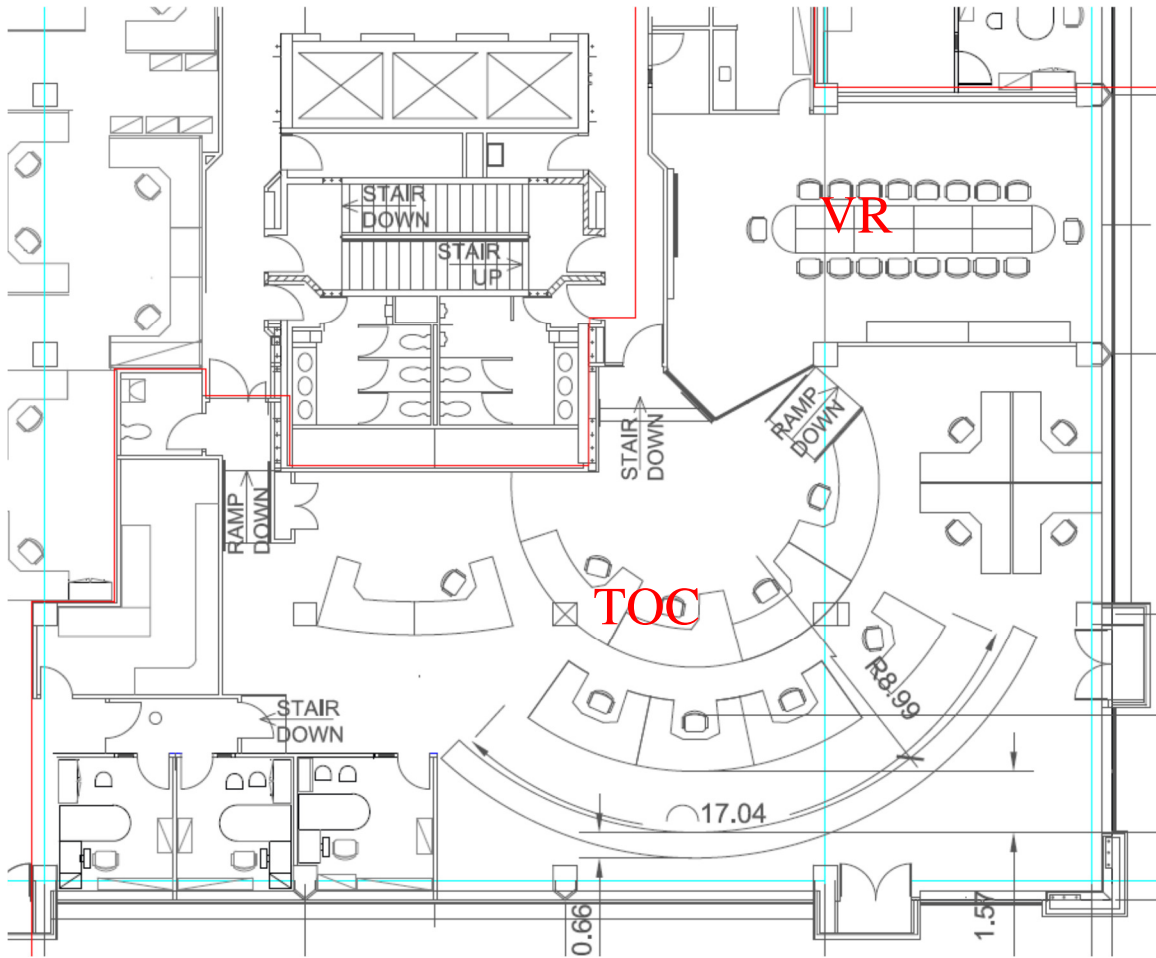


Figure 1. Layout of TOC and VR Before Situation

The following analysis illustrates how the rough size of video wall and number of seats in the TOC were defined:

First, the ultimate capacity of TOC was determined by:

- a 15-year of life cycle
- 24 by 7 operations by a third-party contractor comprised of one supervisor and 15-20 staff
- a total of 300 cameras with 80-90 on the City's Expressways, and 180-200 on 20 major arterial roads, and 10-20 on critical locations, e.g., flooding area.

Second, the display of ATMS applications on the display wall considers:

- When traffic incidents occur, only those involving multiple locations within a large geographic area will be displayed on the wall; other incidents to be handled by desktop workstations.
- The number of concurrent traffic incidents is estimated to be around 3 - 5 based on TOC previous incident logs.
- Each individual operator would be able to monitor a geographic area sized by 5 - 8 km long and 4 - 6 km wide.

An operator with normal vision (20/20) is estimated to be able to see 8.86mm tall letter (e.g., "E"), from a distance of 6.1m (20 ft). This is a reference to the operator's "visual acuity". Assuming there is a linear relationship existing between the view distance and the object height, when the distance decrease to 2.74m (9 ft), the object height would be around 1.24 mm. Given that the common pixel pitch distance for normal computer monitors range between 0.25mm to 0.365mm<sup>[2]</sup>, it is estimated that the 1.24 mm object requires 4 pixels to display ( $1.24/0.3 \approx 4$ ). Thus the resolution of display area roughly measures four (4) times of the computer resolution.

For instance, a 24" monitor with 1600 × 900 resolution can display a map of approximately 8 km (length) by 6 km(width) geographic area, which is adequate for a person looking from a 0.91 m (3 ft) distance. When the distance increases three (3) times, the resolutions expand three times assuming they are linearly related <sup>[3]</sup>.

Thus, Table 1 shows that a rough pixel dimension estimate of the monitoring area for an individual, which is (4800~6400) × (2700~3600).

Display Pixels	Geographic Range (length ×Width)	View Distance
1280×768	5 km × 3.5 km	0.91 m (3 ft)
1600×900	8 km × 6 km	0.91 m (3 ft)
(4800~6400) × (2700~3600)	8 km × 6 km	2.75 m (9 ft)

Table 1. The rough pixel estimate sheet

Multiplying the average display area resolution (5600 × 3150) for each operator by the average number of concurrent incidents (4), we had the total required display pixels estimated blow:

$$(5600 \times 3150) \times 4 = 70,560,000 \text{ pixels}$$

This formed the selection criteria for the video wall. In other words, the total display pixels must be within the range of  $70,560,000 \pm 3\%$  pixels. Based on the analysis, we assigned four (4) operators at the front row whose major duty is to monitor the display wall, one (1) senior operator seat with a supporting role and kept one (1) as spare (Figure 2). The second row also had four (4) seats with two positions being used for Dispatcher duty, one (1) as traffic signal communication operations and one as spare. The spare two seats were reserved for future expansions.

As a result, the number of seats has been changed based on two factors. First was the staff's screen viewing capability, which in turn determines the total display area of video wall based on the maximum staffing number. The second factor was the TOC future expansions potential, i.e., new functions on signal timing changes or being a backup control centre of other agencies.



Figure 2. 3D Rendering of TOC layout After Renovation

Figure 3 shows the After-Reno layout which consists of 10 operator workstations, one supervisor office and one kitchenette. The contractor thus has a closed space for their own staff which is segregated from City employees.

The rough display size of the wall was determined by its proposed contents and the setup of TOC operations. Due to space constraints ( i.e., two columns functioning as structural elements) and the elevation clearance, it was impossible to provide an unobstructed view of a complete video wall. As shown on Figure 2, the video wall contains two separate walls, a large wall on the south side and a small wall on north side of the TOC. The wall alignment was adjusted to minimize sight line disruption caused by the north column.

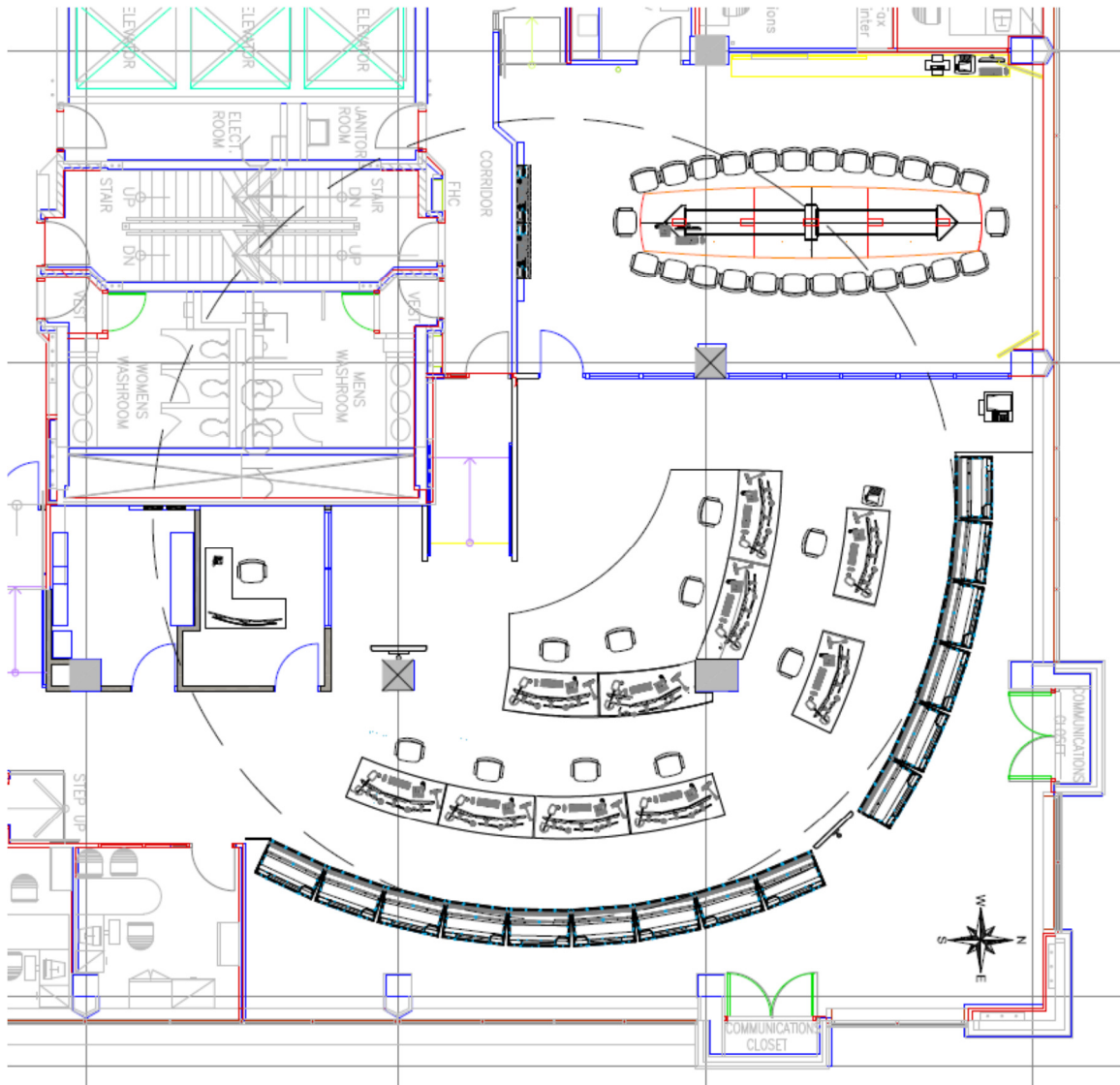


Figure 3. The After-Reno Layout

### 2.1.3 Redundancy Design

This mission-critical environment requiring round-the-clock operation demanded the delivery of system redundancy for power supply, computer networks, and various application systems. The following features were provided:

- Facility Power Supply which is backed up by UPS array and emergency power generators. All TOC workstation computers are connected to the UPS array in order to maintain uninterrupted operations.
- The Video Display and Control Systems have redundant designs built-in to support hot-swap capability between multiple servers.
- The display wall is capable of automatically switching to alternative signal sources within seconds after the "no signal" status is detected to minimize the downtime.

### 2.2. Ergonomic Requirements

## 2. 2.1 View Distance

The critical viewing distance (CVD) from the display wall to the console was fixed given the nature of TOC operations. The CVD design was conducted after the video wall cube module (Mitsubishi 62" DLP Cube) was selected. The optimum distance should balance picture quality and ergonomic requirements. The former was determined by material resolution (i.e., too near causing pixilation; too far causing motion sickness and loss of details), brightness and view ability angle. The latter was dictated by focusing area of individual and human spatial vision perceptions.

Although the specifications for the display cubes indicated their wide range of viewing capability (as outlined below), pragmatic considerations needed to be taken into account.

View ability Angle	Horizontal	1/2 gain: $\pm 35$ Degree, 1/10 gain: $\pm 57$ Degree
	Vertical	1/2 gain: $\pm 16$ Degree, 1/10 gain: $\pm 28$ Degree
Vertical Dimension	32.81" (833.5mm)	
Horizontal Dimension	52.5" (1333.5mm)	

Table 2. Mitsubishi 62" WUXGA DLP Cube View Ability Angle<sup>[4]</sup>

A literature review indicated that there are various calculation methods for CVD (e.g., determined by 3-4 times cube vertical dimension <sup>[5]</sup>, or 1.5-2.5 times cube diagonal dimension <sup>[6]</sup>). After consulting the manufacturer, we chose a 9.2 ft viewing distance with a horizontal viewing angle ranging from  $-31^\circ$  to  $+31^\circ$  for 1/2 gain and a vertical viewing angle of  $16.5^\circ$  for 1/2 gain.



Figure 4. View Ability Analysis of TOC layout After Renovation

However, 1/2 view gain applies on the extreme conditions that the operator may be capable of viewing 50% of the displayed information on the wall from the angles defined above. With the ATMS software, the focus of operator's view will be on the centre of the display area in front of them (e.g., incident icons on the maps) thus the view gain should be higher than 1/2.

### 2.2.2 View Angle



The original video wall layout was a circle with a radius of 30 ft (9.1 metre), which was suitable for 27" CRT display units. The new wall consists of 62" 4:3 aspect ratio display cubes which are 2.3 times larger in size than the CRT units. A rigid adherence to the original circular layout for the new display wall arrays would have negatively affected the view quality for displays across the two walls. To address this issue, the connection angle between two stacked units was adjusted to 6° against the original 9°. As a result, the two walls follow separate curves in order to create a flat and smooth appearance for each of them. This setup also utilized the space efficiently.

### 2.2.3 Lighting

There were five fluorescent lights perpendicular to the video wall right above the first row and three additional lights over the second row, each comprised of two 32 watt lamps. The lights in the first row were located above operator's work stations, at 1.56 meters to the top of workstations. Four lights were located above the second row work stations at 1.44 meters to the top of workstations. All fluorescent lights in TOC except for two over the Road Dispatch desk were controlled by a single dimmer switch located close to the north entrance which often triggered staff conflicts. Due to the uneven ceiling cavity, the reflectivity above the RESCU operator work stations is much lower and hence the overhead lights above the second row should be controlled individually.

Through the architecture design, the TOC room was updated to include a total of five lighting zones with energy efficiency lights being provided.

### 2.2.4 HVAC system upgrade

The building central HVAC system provides heating, ventilation and air conditioning for all floors. The air vents are mounted along the entire window sill of each floor, and so extended along the north and east walls of the TOC. The air conditioner system rotates between day-mode and night-mode daily in summer. During the night-mode, from 23:00 to 4:00 of next day, one of two condenser units on the roof level is shut down as an energy-saving measure. Night shift staff previously raised concerns that the temperature in the TOC increased significantly when only one condenser unit was operating during summer time. An ancillary air conditioning system was installed to provide relief for TOC staff but it was rarely used because of noise issue.

The mechanical assessment identified the needs for an individual in-door air conditioning unit to provide an additional air cooling capacity of 13,000 BTHR and to maintain the noise level below 30 dB. The unit was mounted on the ceiling at the north-west corner behind the display wall. With all gaps being sealed, TOC operators in the control room can barely hear any operating noise.

### 2.2.5 Height Adjustable Console

The old consoles for the TMC dispatchers and RESCU operators were in place since 1994 (Figure 5). The console board was comprised of several units of standard office furniture. Surface load, knee well space, view/reach distance and keyboard height were considered in the original console design. However, further flexibilities were required to accommodate the requests for variable height work surfaces, robust chairs appropriate for long shift operations, task lighting and locations for office devices in accordance with the City's workplace ergonomic requirements (e.g. computer box, printer, copy machine and fax machine, etc).



Figure 5. Operation Consoles Before Situation



Figure 6. The Current Operation Console

The original console was made on site as one complete piece per row thus the console height was fixed for all workstations. For the renovation, multiple seats must be separated so that individual can adjust the workstation to his/her own comfortable level. As well, the space must be utilized efficiently to provide a tidy and clean environment and improve productivity (e.g., provide a dedicated cabinet underneath the surface for computers, and provide a dedicated cable management system, etc)

Ten height-adjustable consoles with height being adjustable from 25" to 55" were procured, each equipped with three 24" monitors (Figure 6).

#### 2.2.6 Viewing Room (VR) Upgrade

There were several changes made to the VR, aesthetically and functionally, including:

- Replacement of the whiteboard and drop down screen with a 2x2 ultra-thin Bezel Mitsubishi LCD panel, each sized 55" with LED illumination and Full HD native resolution. The display panel is under control by Activu display control suite.
- Replacement of the existing modular meeting table by a complete-piece conference table.
- Demolishing of the triangular shape access entrance between TOC and VR, and the rebuilding of an entrance in-line with the new glass wall.
- Replacement of the drywall between TOC and VR by a glass wall that provides a better view of the TOC for senior management when the VR is used as the Transportation Service District Operation Centre (TSDOC).
- Readjustment of the ceiling and lighting in VR.



Figure 7. Viewing Room Before Situation



Figure 8. The Current Viewing Room

Figure 7 and 8 illustrate the before and after scenarios.

### 2.2.7 Workstation Design

As a command centre, the TOC requires an instant response when the incidents occur. Therefore ease of use is important. From an operator's perspective, all operational tools and computer software shall be integrated into one complete interface, i.e., single keyboard, mouse and joystick to be equipped at each workstation, and all software interfaces can cross monitors smoothly and seamlessly. In other words, multiple keyboards, mice and joysticks, individual software running on specific monitors in this mission critical environment would not be acceptable.

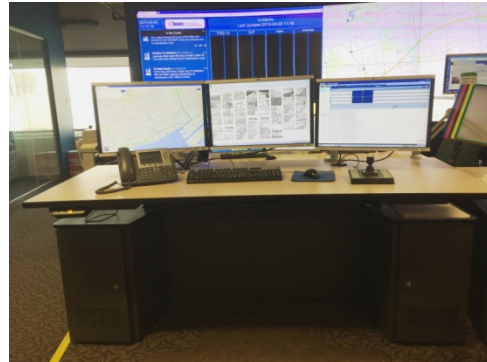
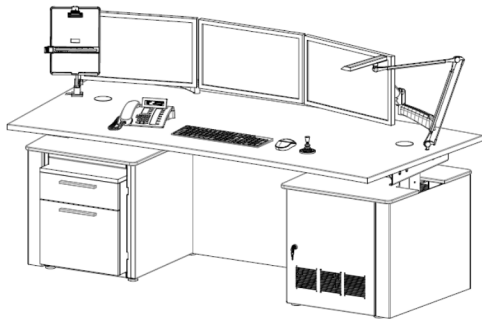


Figure 9. Typical Setup of Workstation (courtesy of Sustema Inc)

Prior to the renovation, all TMC operator workstations were on the City's Corporate IT network with typical applications, such as Windows Login, GroupWise, Microsoft Office Suite, Toronto Transportation Maintenance Systems (TMMS) and Cisco UCCE call centre management system. With all new software and new workstations being added as part of the project, we originally expected that there would be no difference in terms of one complete interface for operators. After multiple rounds of discussions with Corporate IT in this regards, a compromised solution was deployed.

However, due to data transferring capacity constraints, i.e., the high volume of data traffic (mainly video streaming) generated by two new systems, (namely Activu Video Wall Display Management System and Genetec Video Control System), two computers were installed at each workstation, one on our Corporate IT network with regular applications and another on a private network to carry the Activu and Genetec applications. AKVM software, called Input Director was

deployed to bring a seamless operation interface between these two computers. The Corporate IT firewall had specific ports opened to accommodate the instant communication via UDP and TCP protocol for this purpose.

## Toronto TMC Video Display and Control System Network Diagram Option 1

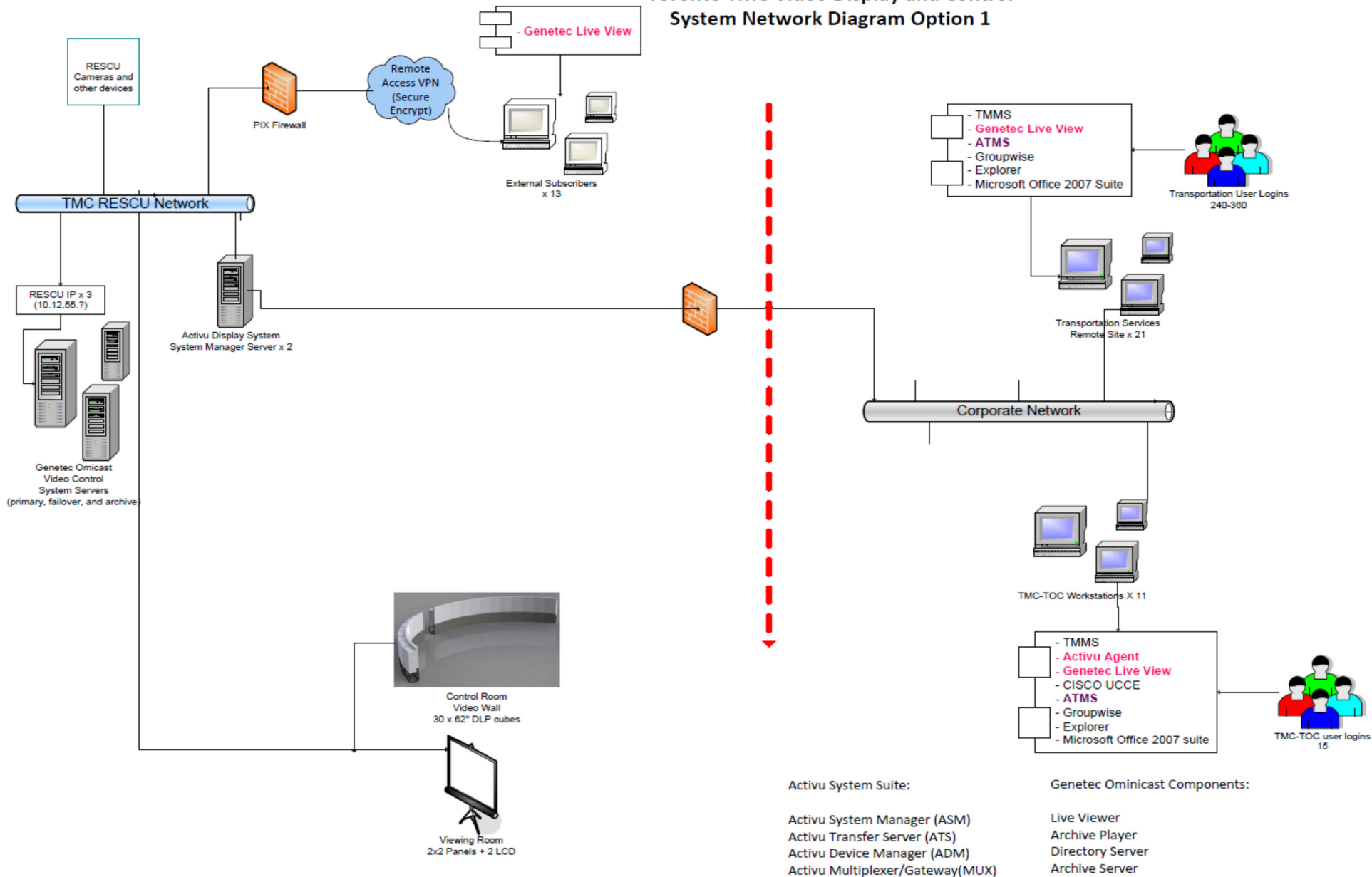


Figure 10. Toronto TMC Video Display and Control System Network Diagram

### 2.3. Project Scope Determination

The TOC inner facilities, video display and control systems were to be built to operate at their full capacity with an expected design life of 15 years. The project scope for the Renovation and Video Wall Projects were determined as follows:

#### Video Wall Project

- Video Display Systems and associated Display Controllers and Control Software comprised of multiple video display devices, to be installed in two areas within the City's TMC. These are:
  - ◇ TOC - A video display wall consisting of 30 (2×9 plus 2×6) Mitsubishi 62" DLP cubes with view size approximately 21.5m (width) by 1.5m (height) which allows TOC to display up to 156 steamed video feeds as well as multiple Windows applications, i.e., GIS maps.
  - ◇ VR - A video display wall view consisting of a 2×2 Mitsubishi 55" LCD panel (LM55S1, Full HD, Direct –Lit LED Super-Narrow Bezel LCD Monitors) and two 52" SONY panels, which fits the functional needs of the VR as a Divisional Operation Centre as well as a conference room.
- Video Control Systems consisting of three servers and one network devices (HP 48 port Giga Bit, three layer) , video encoder/decoders, and software for video management and camera control for RESCU cameras monitoring the City's road network. These allow TOC and Transportation remote sites to view and control traffic cameras through the intranet.
- Performance dash board development.

#### Renovation Construction Project

- HVAC revitalization in control room
  - ◇ Liebert Mini-Mate2 In-door air conditioning unit, CRU-9;
  - ◇ Fan Motor horsepower: 149 Kw
  - ◇ Air Volume – High Speed: 750 CFM / Low Speed: 600 CFM
  - ◇ Sensible cooling – 13,000 BTHR
  - ◇ Moderate noise level: 30 dB
- Glass wall installation
  - ◇ One-way see through full glass wall between the TOC and the VR
  - ◇ Balance of aesthetics and functionalities
- Power supply revision
  - ◇ Reduced redundant power outlets previously installed
  - ◇ Reorganized power supplies for TOC equipments to bring energy efficiency
  - ◇ Reduced total power consumptions by 30%
- Control room console and meeting room conference table procurement and installation
  - ◇ 10 height-adjustable console, height ranging from 25" to 55"
  - ◇ Each equipped with three 24" monitors
  - ◇ In accordance with human factors and ergonomics
- Lighting and ceiling installation in control room
  - ◇ Energy efficient lighting provided

- ◇ Five lighting zones
- Raised floor revision in control room
  - ◇ Balance of accessibility requirements with functional factors
- Building security revision
  - ◇ Enhanced access management policy
- New conference table in the viewing room
  - ◇ A 24 ft by 5ft boat shape conference table
  - ◇ Five top-mounted power and communication modules

#### 2.4. Project Coordination

The Video Wall and Renovation projects running in parallel were handled by the TMC Project Manger and the City's Facility Project Manager respectively. The command chain was setup such that management within the TMC provided oversight for two project managers to provide advice and make final says in case there are conflicts between two teams as illustrated in the below project structure diagram (Figure 11).

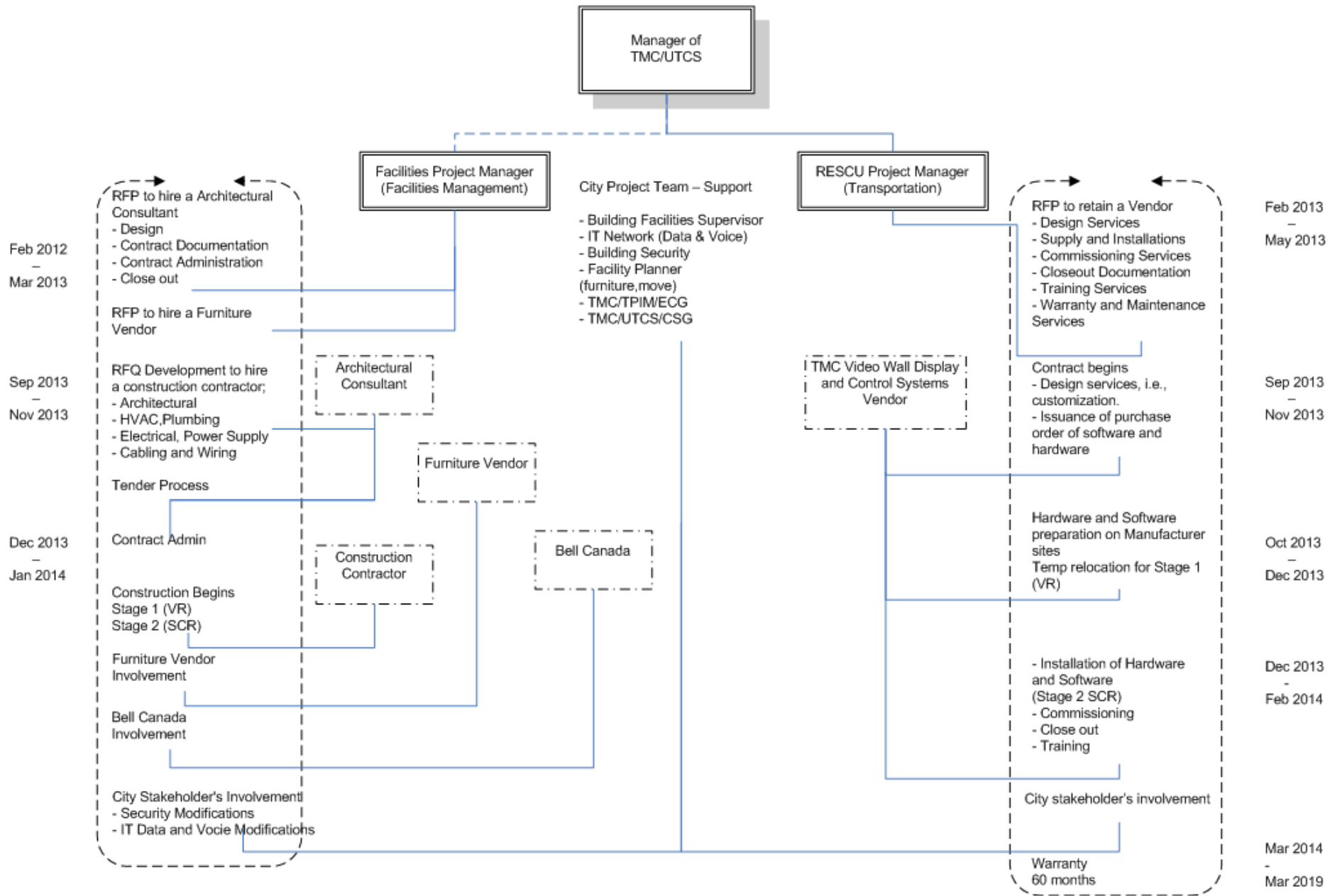


Figure 11. Toronto TMC Video Display and Control System Project Structure Diagram



Team work certainly was a vital component of our success. Mutual trust was built between the two project managers. A work environment that was conducive to effective teamwork was fostered such that all external and internal stakeholders were involved. Communications on controlling time, cost and performance adherence to contractual requirements were maintained through the joint project meetings held on a weekly basis.

## 2.5. Project Phasing

The project had to be implemented to maintain the 24 by 7 operations already underway. Thus, the project contained three construction stages in order to provide a seamless transition.

- Stage 1 – Construction in the Viewing Room; system integration in the VR and the associated 4<sup>th</sup> floor equipment room. Once completed, the existing TOC operations were temporarily relocated into the VR.
- Stage 2 – Construction in TOC, and system integration in TOC including the new furniture, new AC unit, and dimmable sectionalized lighting, etc.
- Stage 3 – Construction in TOC completed and operations restored in TOC. The VR was then restored to its normal configuration.

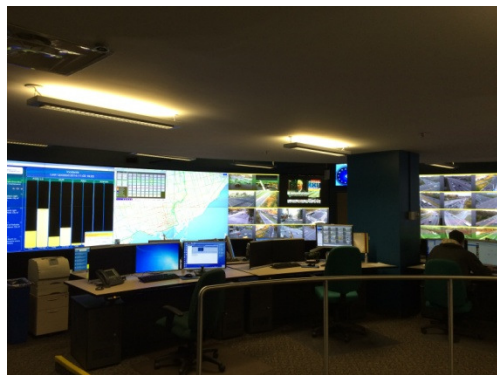
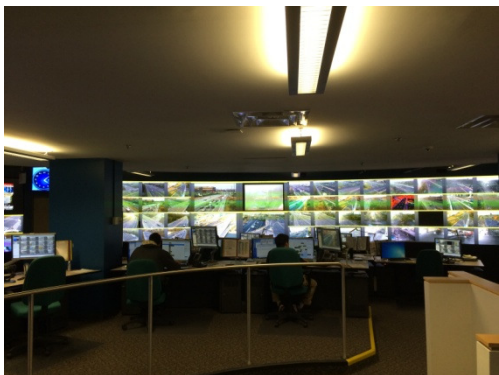




Figure 12. Toronto TMC-TOC After-Reno Photos

### 3. PROJECT IMPLEMENTATION AND CONTRACT ADMINISTRATION

#### 3.1. Project Schedule

Figure 13, the Project Schedule Overview illustrates that the two projects started at different time resulting in a long process from beginning to completion ranging about 1.5 years. For the Video Wall Project, the TMC had a clear idea about the required project outcome thus was able to develop a RFP with a preliminary design entirely with internal resources. By contrast, for the Renovation Project, Facility Management retained an architecture firm first to develop a RFQ. They then hired the construction contractor to complete the construction work. The procurement process at Facility Management started after the TMC awarded the contract to the Video Wall vendor.

During the construction implementation stage, the project schedule was dictated by two important dates reflecting the switch-over milestones in Stage 1(March 14, 2014) and Stage 2 (May 26, 2014), respectively. The former was the date that the TOC operations moved to the temporary setup in the VR. The seamless transition requirement mandated two contractors to provide a work environment close to or equivalent to a fully functional TOC by supplying a complete set of facilities to maintain the communication capability, camera operation, view capability and ergonomic suitability.

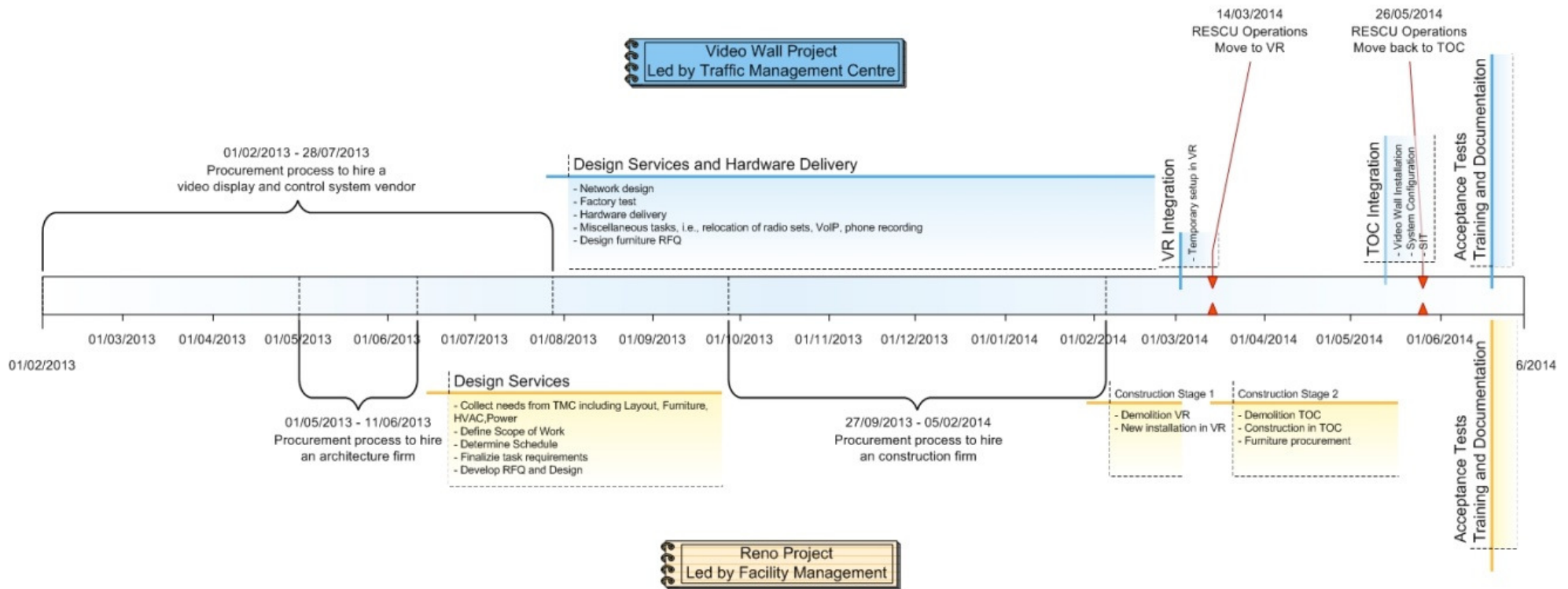


Figure 13. Project Schedule Overview

In order to delineate two contractors and maintain safe work environments for each, protocols between the two contractors were established such that one could come to site and work only after another left the work zone. This approach relied on close communications between the contractors and careful consideration of the contractors' understanding about the scope of work as there was no room for anyone to come back and fix the leftovers. For example, the Video Wall contractor is a US based company. Because they were coming in from out-of-town, our project needed to efficiently use their time and services while they were on-site at the TMC. For each stage, they came to Toronto once and worked for one entire week. Thus, we incorporated their planned on-site service dates as part of the critical path for the project schedule. The local Renovation contractor had to ensure that pre-requisite tasks were completed before these visits on the critical path at each stage, (e.g. the power outlet installations needed to be complete for specified locations, cabling and wiring works, etc).

### 3.2. Miscellaneous Tasks

The two project contracts did not cover everything that was needed for the new TOC. A few miscellaneous tasks were undertaken separately by the TMC PM and Reno PM outside of projects in order to fasten the project pace and bring savings to the City. Those tasks were:

- Procurement of TOC consoles and TSDOC conference table
- Procurement and installation of Phone recording system
- Installation and configuration of VoIP phone system
- Supply and installation of power outlets for system racks in the computer room.
- Procurement and installation of desktop computers for TOC workstations.
- Procurement and installation of network switch for TOC private network.
- Relocation of dispatch radio sets
- Moving surplus office furniture
- Performance dashboard development

Those small but important tasks shared the commonalities such as:

- relatively small cost
- non-critical with flexible slack or float on project schedule
- mainly involved internal stakeholders within the City
- easy to be dealt with by the City rather than through contractors
- has clear boundary between itself and the contracted work

A few of those tasks involved other departments within the City. For example, the voice over IP phone system conversion led by Corporate IT group was essential to the temporary setup in VR as the needs of Cat 3 cabling for analog phone lines could be completely removed if the VoIP conversion project went through before the Reno construction started. The planning stage of this project went back to early 2013. However, due to our requirement of phone recording could not be accommodated by the Cisco solution. The TMC had to procure a separate phone recording system which is compatible with the Cisco UCCE VoIP system. The cutover from analog phone system (CCMIS) to VoIP was intentionally scheduled three weeks before the switch-over date in stage 1 of the Reno project in order to test out all vital functions and features. After the temporary setup was established in VR, the phone system actually worked out very well with respect to restoring the communications and reducing the redundant work.

### 3.3. Lessons Learned and Dealing with Obstacles

A number of unpredicted obstacles, major and minor, were encountered through the course of the project, including long procurement processes, subcontractor schedule adherence, complex coordination problems, problematic layout designs and project scope changes, etc. It is our opinion that no amount of planning would have prevented these challenges but developing contingency plans, building in additional schedule slack and making decisions following project management principles upon crisis occurrence may prevent or soften the impact of some.

The total project duration for the two projects was about 8 months longer than originally planned. Because the contracting process represents such a large time investment, a recommendation arising from our project was that when dealing with projects of this scale, advanced notice and close coordination with Purchasing is needed to reduce the overall duration of the project.

In retrospect, a single project structure combining the Reno Project and Video Wall Project would have been more appropriate and efficient from a project management, and communication efficiency and effectiveness point of view.

The number of sub-contractors in the Reno construction contractor proved difficult to manage. A lesson learned here was that future contracts should require the prime contractor to limit the number of sub-contractors, have the prime be more accountable for their sub-contractors, and/or have the prime completing the work themselves.

The architect design was based on the original blue prints made in the early 1990s and some on-site measurements. When it came to the equipment location stage for video wall and consoles, a survey report indicated that the building was distorted to some degrees such that the north wall is not exactly perpendicular to the east wall. This finding differed from the contact blue print. In order to sort it out, the TMC PM arranged the Video Wall vendor to ship the video wall cube bases to site earlier than originally scheduled, and sent a staff to assembly them on site. Based on the actual base placement and the view ability design parameters, the base array was adjusted to fit the room and meet the design requirements (Figure 14).



Figure 14. The Video Wall Cube Base Array

The coordination between the TMC PM, the Video Wall vendor and the City's Corporate IT personnel regarding our network designs started in November 2013 and involved a number of meetings. The TMC's initial design envisioned placing the Activu and Genetec systems on the Corporate Directory. However, Corporate IT was concerned about network security and their facility's capacity to handle the anticipated high volume of video traffic. As a compromise, both systems were placed on a private network with certain applications across Corporate IT firewall. During the first stage of switching over RESCU operations to VR, an important task was to establish camera control in VR over Genetec software and to eliminate the use of the analog based PTZ control keyboard which required firewall and network routing configuration changes. This request was resolved by Corporate IT before the switch-over deadline which was the key to keep the project schedule on track.

Each of the analog RESCU traffic video was split into two channels via a temporary amplifier distribution system; one signal went to the old America Dynamic switch matrix and another entered into the encoder chassis and became IP video stream. The former was used to keep the existing video feed mechanism for media subscribers. The latter was for Genetec applications and video wall displays. During installation phase, the cabling work unavoidably caused disruptions to RESCU operations and external media subscribers as well. To minimize interruptions, the majority of installation work was conducted during the off-peak periods, i.e., over the weekend, and all media subscribers were notified in advance for scheduled system configurations and integrations.

### 3.4. Communication Plan

Over two projects, a communication mechanism was established amongst all participants, which included:

- The two City PMs took the lead on all formal communications between the City and the Vendor/Contractor for their respective projects.

All decision communications for each project were to be generated by a PM with the other PM being acknowledged. The two PMs worked closely to ensure that all key milestones were met within the time, cost, and performance constraints, and the operational needs were reflected during the design stage in accordance to quality control standards.

- Joint Project Meetings were arranged on a monthly basis and Reno Construction coordination meetings were held on weekly basis.

The TMC PM took the lead on all Joint Project meetings for scheduling, conference call arrangements, and meeting minutes preparation. The Reno contractor was the organizer for weekly construction coordination meetings.

### 3.5. Cost Control

Figure 15 shows the costs summary (exclusive of tax) of two projects, in which the Reno Project cost \$483K, the Video Wall Project was \$2,174K and the cost of additional miscellaneous items was \$219K. Of the total cost of Video Wall Project, 45.11% of the cost related to services and software licenses. The renovation construction cost took 77.7% of the total Reno project cost and the rest of that project went to the architectural costs.

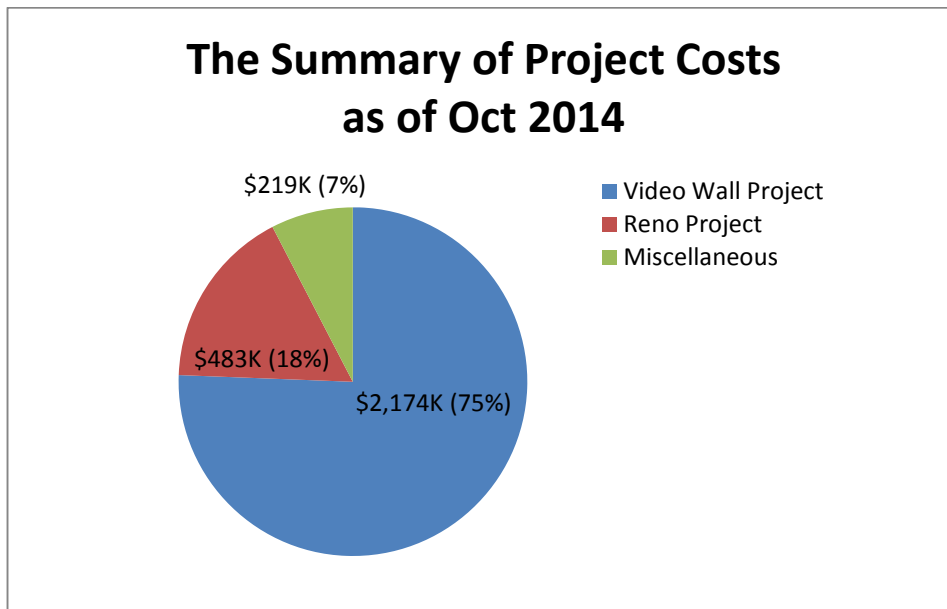


Figure 15. The Summary of Project Costs

A great majority of all decisions made in the course of managing a project were actually made under conditions of uncertainty. Over the project progress, some costs were related to unplanned changes on scope of work for both projects, e.g., the ceiling work in the VR and the fibre cable

protection tasks. When initiating these changes orders and handling change order requests, the project management team applied Pareto Efficiency principles by allocating provisional funding in a way such that made one contractor better off without making other contractor worse off.

#### **4. CONCLUSIONS**

Overall, the project was successful and met the objectives. A number of project goals were accomplished through the project, including:

- Display wall and interior work environment upgraded
- IP video stream established
- Facility improvements, such as lighting, power supply, HVAC, layout, consoles and conference tables were completed
- Future expansion capability

Most importantly, City staff handled and involved all critical project phase items and thus ensured that all operational, agronomical and sustainable needs were met.

#### **5. ACKNOWLEDGMENTS**

The authors would like to thank TMC director Myles Currie for his support and assistance with this project and for his appreciation of the benefits to be gained from it.

Special thanks also go to Angie Chung - City Facility Management Project Manager, Bob Puckering - City Road Operations Supervisor, Stephen Bon - City of Toronto, Engineering Tech, TMC/TPIM, Peter Yzenbrandt - City Facility Management Supervisor, Lind Lee -TMC ITS Operations Senior Engineer, John Papaconstantinou - City Road Operations Supervisor, for their advice, counsel, expertise and support throughout the project.

The authors would also like to especially thank Andy Lok - City of Toronto, I&T, Manager, Infrastructure Management Services, Vince Barone - City of Toronto, I&T, Senior System Integrator, Rukmini Madduluri - City of Toronto, I&T, Senior System Integrator, Michael Chai - City of Toronto, I&T, Enterprise Tech Support Specialist, Gohar Khera - City of Toronto, I&T, Senior Tech Support Specialist, Alex Osloversky - City of Toronto, I&T, Enterprise Tech Support Specialist, Brian Hu - City of Toronto, I&T, Enterprise Tech Support Specialist, Roger Browne - City of Toronto, Senior Engineer, TMC/TPIM, Stephen So - City of Toronto, I&T, Manager, Voice and Wireless Communications, Susan Anderson - City of Toronto, I&T, Senior Tech Support Specialist.

Special thanks also go to Gregg Loane – City TMC ITS Capital Delivery Manger for his concrete advice on this paper and the related presentation.

Last, but certainly not least, Dennis Nuutinen- Activu Corporation, Regional Sales Manager, Chris Villani- Activu Corporation, Project Manager, Mark Roy-Activu Corporation, Senior Sales Engineer, Sanal Sreedharan- Manager, Display Wall Systems, Mitsubishi Electric Sales Canada Inc., Ken Tanner- Director KPAC Group (Local Genetec Dealer), Paul Venier-Director KPAC Group (Local Genetec Dealer), Eugene Kuan-Principal, Eugene Kuan Architect, Brian Soltanzadeh- Manager, Pegah Construction, Matt Saberi -Site Supeirvisor, and Pegah Construction. They conducted the project, created designs and made the designs become reality. Without them, the project wouldn't have been a success.



## REFERENCES

- [1]. Project Management A Managerial Approach, 7th Edition, Jack R. Meredith and Samuel J. Mantel, Jr., 2009 John Wiley & Sons, Inc., p 6-7.
- [2]. The Great Dot-Pitch Swindle, Copyright © 1990-2011 by DisplayMate Technologies Corporation  
<http://www.displaymate.com/dotpitch.html>
- [3]. Optimum HDTV viewing distance, from Wikipedia  
[http://en.wikipedia.org/wiki/Optimum\\_HDTV\\_viewing\\_distance](http://en.wikipedia.org/wiki/Optimum_HDTV_viewing_distance)
- [4]. Display Solutions: Display Wall Systems - 62" LED Display Wall, 2014 Mitsubishi Electric Sales Canada.  
[http://www.mitsubishielectric.ca/en/displays/displaywall/prod\\_displaywall-LED\\_62.html](http://www.mitsubishielectric.ca/en/displays/displaywall/prod_displaywall-LED_62.html)
- [5]. Waveform 03 Viewing Distance, by Richard Fisher, originally published 09/23/2004, HDTV Magazine, editor Dale Cripps.  
<http://www.hdtvmagazine.com/forum/viewtopic.php?t=5282>
- [6]. Angles, Distance Key to Home Theater Design, December 25, 2007 by Barbara Roth  
[http://www.electronichouse.com/article/comfort\\_angle\\_seating\\_distance/D2](http://www.electronichouse.com/article/comfort_angle_seating_distance/D2)

### **Author Information:**

Stephen Huang, M.Sc., P. Eng  
Project Manager/Transportation Engineer  
ITS Capital Delivery  
City of Toronto - Traffic Management Centre  
703 Don Mills Road, 4th Floor  
Toronto, ON M3C 3N3  
Phone: 416 397 0615  
E-mail: [shuang2@toronto.ca](mailto:shuang2@toronto.ca)

Rajnath Bissessar, M.Sc, P. Eng.  
Manager, ITS Operations  
City of Toronto - Traffic Management Centre  
703 Don Mills Road, 5th Floor  
Toronto, ON M3C 3N3  
Phone: 416 397 5769 Fax: 416 397 5777  
Email: [rajnath\\_bissessar@toronto.ca](mailto:rajnath_bissessar@toronto.ca)