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Toronto District School Board: Innovative Solutions for Building Infrastructure Asset Management

In recent years, infrastructure assessment and renewal have received considerable attention in North America and worldwide. While infrastructure is the foundation for economic growth, a large percentage of the existing facilities are rapidly deteriorating due to age, aggressive environment, outdated technology, and insufficient capacity for any population growth. Many organizations have recognized the importance of directing research and development activities towards their infrastructure. According to Statistics Canada, the yearly average expenditure on infrastructure is about $53 billion, distributed as non-residential buildings (40%), oil and gas (21%), transportation (14%), electric (10%), communication (4%), sewage (3%), water (2%), marine (1%), and 5% for other projects. It is noted that non-residential buildings followed by oil and gas, and transportation are areas involving most infrastructure expenditures. It is clear, therefore, that above surface infrastructure has been given more attention than underground infrastructure.

This article provides some examples of the very recent innovative solutions which are being implemented by Toronto District School Board (TDSB). These solutions are the result of creative research that is seeking excellence in Building Infrastructure Management at the largest school board in Canada, which owns 45 million square feet of properties distributed at 600 facilities. In order to manage its infrastructure assets, TDSB utilizes a limited budget to implement diverse programs, which involve a large number of simultaneous projects that have to be completed in tight time frames to keep schools functioning. The recent innovations in TDSB to deal with these challenges are the establishment of an accurate Facility Condition Assessment tool, utilizing an integrated Enterprise Resource Planning System, creating an experienced and well trained in-house work force and implementation of a Resource Optimization tool.

Facility Condition Assessment for Building Infrastructure Assets

TDSB has realized that a computerized Facility Condition Assessment tool is the most effective route to sustainable infrastructure management, preserving asset performance, optimizing the benefits of the infrastructure renewal program, prioritization of projects and identifying the critical building components that need urgent replacement. Therefore, TDSB has taken a proactive approach to its assets condition assessment, and worked with Physical Planning Technologies Inc. (PPTI) to develop a professional tool that determines the condition of its building infrastructure components. This tool has now been adopted by the Ontario Ministry of Education to become the assessment tool for all school building infrastructure in Ontario. Extensive research was undertaken in order to develop this tool and its quantifiable measurements. It was developed based on the concept of component Life Cycle Analysis. This tool surpasses other infrastructure asset management models by accurately predicting how the future condition of assets affects the required funding. This is accomplished through a quantifiable and objective condition measurement known as the Facility Condition Index (FCI). Utilizing the FCI, the organization is able to prioritize its many infrastructure programs. The system can also demonstrate graphically the consequences of deferring these programs through a Backlog Funding Model. The system is an object-oriented, relational database design, which is developed to model life cycle cost performance and physical assets. Furthermore, the system provides three output plans: 1) the Approved Capital Plan — for the "actual" budget year and highlights the immediate requirements and current backlog; 2) the Tactical Plan — for the first five years and prioritizes all deteriorating components based on the specific conditions and needs; 3) the Strategic Plan — beyond the five-year period and aims at evaluating the future capital renewal needs.

Currently, TDSB is planning a detailed survey, in cooperation with PPTI aimed at upgrading and updating its building infrastructure assets database. Also, TDSB is planning to conduct an effective scientific research to further enhance the quantifiable condition assessment models for each building infrastructure components.

Enterprise Resource Planning System

Enterprise Resource Planning (ERP) is an emerging technology with billions of dollars worth of investments, and a business management tool which enables the organization to manage different job functions in a timely and cost-efficient manner.

The TDSB utilizes an Enterprise Resource Planning tool named System Applications Products in Data Processing (SAP) as a collective business management tool that has integrated modules for Finance, Procurement, Plant Maintenance, and Project Management. The Plant Maintenance module provides a platform for Preventive Maintenance programs. Unlike the condition assessment tool, which assists with the evaluation of the capital expenditure, the Plant Maintenance tool provides support to the daily maintenance routine of the infrastructure assets. It keeps track of all the past, current and future daily maintenance activities for the building assets. After a lengthy research effort, it was configured to include a functional location for every component as a micro-asset management mechanism. The Project Management module is called Project System and is used to manage infrastructure renewal programs at both the macro-management and micro-management levels. The Project System module is fully integrated with the other modules within the (SAP) family. This level of integration provides a higher level of control of the cost and time aspects of asset upgrades. It also provides timely updates of cost and schedule-related activities.

Establishing an In-house Work Force

The question of utilizing in-house construction trades versus outside contractors in the implementation of infrastructure programs has been a major dilemma for the various government agencies and private sector corporations. The problem exists for organizations that own and need to maintain and upgrade the functional performance of a large inventory of infrastructure assets. TDSB has conducted an exhaustive research on different project delivery methodologies. The investigation included different experimentations in delivering different building infrastructure programs via in-house or through external contractors. It was concluded that the main characteristics of the projects best delivered by in-house forces are: 1) urgent projects resulting from the sudden failure of one of the building infrastructure components; 2) high level of risk associated with the project; 3) inadequate scope definition due to the age of the infrastructure assets and unforeseen site conditions. Outsourcing these types of projects exposes the owner to a large number of changes and the consequent cost overruns and delays. Based on the above analyses, TDSB established a well-trained work force that is capable of undertaking asset upgrade programs that fit the above criteria. The availability of these crews became essential to timely and cost-effective response to such programs, and minimized any interruption to the education operations.

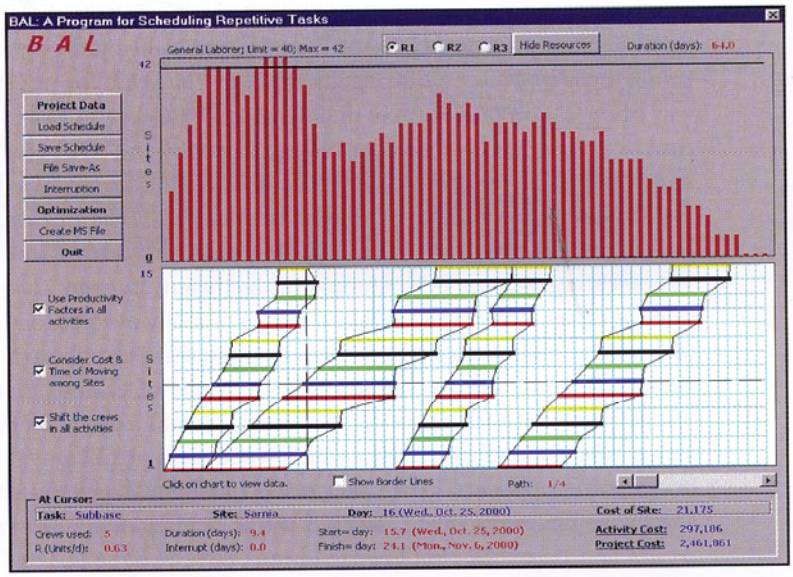
Resource Optimization Tool (BAL)

The utilization of an in-house work force to undertake infrastructure asset management programs has initiated the need for a tool to ensure resource optimization and efficient delivery of these programs. However, this is not straightforward due to the diversity of the operations, the fact that projects are spatially distributed, the difficulties associated with resource assignments, repetitive tasks, and the large amount of resources. In this environment, scheduling of resources becomes a greater challenge, for the following reasons:

- *Multi-site distributed work* — with multiple sites, the proper number of crews and the correct order of routing crews among the sites needs to be optimized, considering the time and cost of moving resources from one site to the other;
- *Varying work conditions* — due to the distributed nature of TDSB projects. Local work conditions vary from one site to another and a practical plan schedules the work of each site at the time when productivity is the highest; and
- *Time and resource constraints* — infrastructure management operations for TDSB schools are mostly carried out during the short summer vacation before the schools are open.

While various scheduling tools were in use at the TDSB, project managers felt such tools were not particularly suited to the multi-site, multi-resource nature of their operations. To address the challenges, TDSB collaborated with OPTEAM

Figure 1. Efficient Scheduling for Infrastructure Management Programs



Inc. to develop a customized tool (BAL) for distributed scheduling and resource optimization in large building infrastructure management programs. Given the sites, activities, and work constraints in a complete program, BAL determines the number of crews needed, the methods of construction to use in each activity, and the best site routing, so that work continuity is maintained among the sites, resource limits are observed, and program deadlines are met at the minimum cost. The software uses Genetic Algorithms as an optimization tool and a simple GIS system to easily define the school sites involved in the program. To be practical, BAL incorporates some useful features, including: 1) site-dependent productivity factors; 2) up to three methods of construction for each activity with varying quantity of work from one site to another; 3) a full database of resources, sites, activities, and construction methods to facilitate automated generation of the various activity estimates; 4) user-defined order of execution for the various sites; 5) time and cost associated with the crews moving from one site to another is considered in the scheduling process; 6) a comprehensive scheduling, and using Genetic Algorithms for cost optimization; and 7) various progress reporting options.

The main BAL scheduling screen, shown in Figure 1, illustrates the complete schedule data including different color-coded crews, construction site order along the vertical axis, the activities of one path at a time to avoid overlapping, and the resource histogram/cost curve in the top window. Using BAL, TDSB experimented with various resource options, crew numbers, possible formations, optional construction methods, crew mobilization options, crew work interruption, and crew routing order among sites. Based on several uses of BAL, it can be considered as one of the key success factors in scheduling the large building infrastructure assets programs. ■