Implementation of TI-Analytics for
Canada Line Rapid Transit, Vancouver, Canada

Case Study

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1.Executive Summary

How did my Railway perform today? Do I have the right information at the right time to make the right decision? The modern day maintenance and operations executive is required to have access at any given moment to real time performance data because today's Public-Private-Partnership, PPP Mass Transit projects demand so. PPP projects are a highly visible business and business success is based on performance success. Many stakeholders all expecting the maintenance and operational contractor to meet certain performance and reliability targets as per the contract. The O&M executive demands the right information at the right time so that issues or bad actors can be identified early on and rooted out before revenue service is disrupted.

In the past, performance metrics were often assembled manually via the analysis of schedules, audits, field reports, data logs, and possibly even interviews with staff and passengers. This process could, and did, take days, weeks, and sometimes months, to complete and was always subjective to some degree and only valid at the time of the reporting.

An Automated Performance Reporting System that is integrated with the day to day operations and maintenance systems of a state-of-the-art mass transit railway can provide comprehensive performance reports and metrics within minutes of the last trip of the business day.

This paper presents the importance of an Automated Performance Reporting System (APRS) within today's performance driven mass transit operational environments. The benefits of implementing APRS in both the commissioning and trial running phase and the revenue operations phase of a mass transit system is executed and documented.

2. Introduction

Automated Performance Reporting System (APRS) for Canada Line P3 Rapid Transit Project has been developed based on Transit-Insights **TI-Analytics for Performance**.

APRS integrates with the operational systems and the asset management systems of a mass transit railway, provides timely reports on the performance of the transit system, based on adjustable service plans.

These reports also known as Key Performance Indicators (KPIs) are critical in measuring success in various business models used to realize our mass transit goals:

- PPP (Public-Private Partnerships),
- DBOM (Design-Build-Operate-Maintain), and
- DB (Design-Build and transfer to existing operator)

The KPI functionality of the APRS provides for:

- automatic data gathering from automated train control (ATC) or operation (ATO) systems,
- automatic data gathering from maintenance and incident management systems,
- analysis of collected data to determine the performance of the system, and
- generation of reports that provide the required performance metrics.

The APRS is also a key element in assuring the performance defined in the construction contract has been successfully delivered prior to revenue operation.   Key performance indicators (KPIs) specified in requirements can be measured during the commissioning of the system to verify the acceptance criteria.

The Canada Line is a PPP Project constructed by SNC-Lavalin Inc and Operated and Maintained by PROTRANS B C. Examples throughout this paper are based on this deployment of **TI-Analytics for Performance**. However **TI-Analytics** is highly configurable and extendable platform designed for automation of transit performance monitoring and reporting. It could meet requirements of other mass transit system environments via configuration and application adaptors to underling ATC, CBTC or ATO systems.

Figure 1 - Canada Line Rapid Transit System, Vancouver, British Columbia

3. The Automated Performance Reporting System

The Automated Performance Reporting System (APRS) is specific realization of **TI-Analytics** component for automated measurement of transit performance. APRS controls the business logic for the automatic calculations of asset availability and quality, arrival credits and deductions, service plans, inflation impacts and other parameters that drive key performance indicators (KPIs) for the transit operator. Train and station assets are combined and measured through a parameter known as the arrival credit. An arrival credit is generated when a train meets the following criteria:

- has travelled the length of the line, stopping at all required stations for at least the minimum dwell
- has completed the journey in the scheduled time
- has arrived within the scheduled headway and
- has not exceeded the scheduled number of arrivals for that hour

The APRS is also manages the Payment Performance Regimes (PPRs) that are typically used in PPP and DBOM contracts. The PPRs are algorithms that are used to calculate the payments due based on the operational performance of the transit line.

A daily performance report is automatically generated by the APRS to provide a summary of the key performance indicators for the transit business day. A typical report is presented in Figure 1 and includes items such as vehicle availability indicator, station availability indicator, vehicle and

station quality indicators, passenger volume, and attachments that provide the report audience the opportunity to drill down for additional details as required. Metrics that are encompassed within the daily performance reporting can include the following:

- train service availability
- planned trips / delayed trips
- train service punctuality
- train mileage
- platform screen door availability
- train door availability
- escalator and elevator availability
- ticket vending machine availability
- ticket gate availability.

DAILY PERFORMANCE UPDATE

	Min Target	Daily Score	Comments
Vehicle Availability (Peak)	88.5%	99.06%	TOTAL VEHICLE AVAILABILITY = 99.62%
Vehicle Availability (Off-Peak)	90.5%	100.00%	At approx 08:00, a field staff reported reduced acceleration on Train 104, which ran increasingly late from WFO to ORO. The train was pulled out of service at BPO at 08:20 and replaced by the YVR Pocket Track spare. 2.5 minutes late. 2 credits lost. At 14:05, several trains were held at MDO, BPO, BPI, and TEI to facilitate a planned restoration of power to the Pocket Track at YP2. 2 minutes delay. 1 credit lost. At least 3 Arrival Credits (2 at 07:00, 1 at 23:00) were lost due to Interval Failures at Transition Periods.
Vehicle Quality	100%	100.00%	No Work Order raised on this date.
Station Availability	95.1%	100.00%	No Work Order raised on this date.
Station Quality	100%	99.43%	WO # Category Loc. Deduct 532808 S-ESCALATOR UNAVAILABLE KES Yes
Volume	Approx. 105431 (uncalibrated)		

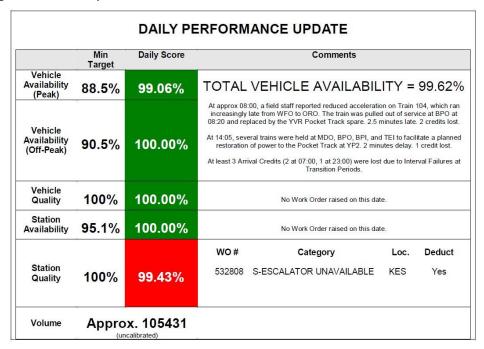*Figure 2 - Typical daily performance update report generated by*

the Canada Line Automated Performance Reporting System

4. APRS Conceptual Architecture

The Canada Line APRS is integrated with Thales's SelTrac® Automatic Train Control system and the J.D. Edwards EnterpriseOne® Asset Management System (AMS). These systems provide data to APRS for measuring operational performance and payments, as shown on **Figure 3**.
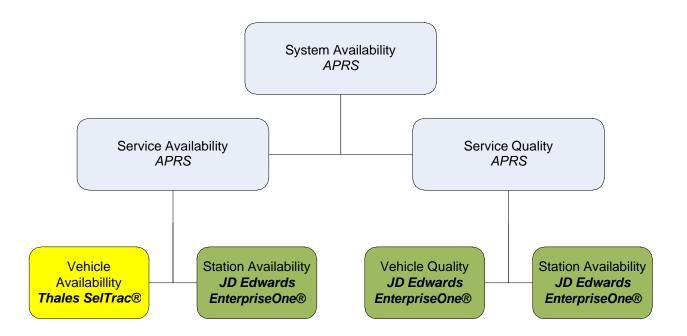
Figure 3 – APRS Conceptual Architecture

APRS controls the business logic for automated calculations of asset (station, vehicle) availability, arrival credits/deductions, service plans, inflation impacts and other parameters that drive key performance indicators of system availability and, ultimately, payment for Canada Line operations.

5. The APRS In-Depth

The APRS deployed on the Canada Line has been designed to be flexible and configurable so that it can be easily integrated into both existing and new transit systems by creating adaptors to data providers and configuring APRS's business rule engine.

The APRS provides the following major functionality for measuring, managing, and forecasting a transit line's performance as well as for identifying operational problems:

- aggregated and auditable view on service performance from both availability and quality perspectives

- drill down capabilities from the aggregate view into the detailed results for each operational event. This functionality permits an APRS user to explore all details of when, why, and where problems occurred that result in decreased operational performance

- management and assignment of service plans and adjusted service plans (to accommodate special and emergency events with respect to performance metric calculations)

- simple management of algorithms and formulae for calculation of final invoices based on key performance metrics

- comprehensive "What If" analysis for understanding potential impacts on the final invoice value caused by changes to system settings (inflations, special events, etc.), performance data (vehicle and station availability, and vehicle and station quality factors), and / or payment calculation formulas

- secured and auditable APRS activities and data management including: system configuration updates, PPR management and data acquisitions from other operational

systems (Automatic Train Control System, Asset Management System, etc.); access to other operational systems requires authorization, is traceable, and requires optional approval workflows as implemented by the APRS

- key APRS settings configurable by the end-user, including the APRS system settings, inflation, measurement settings, business rules, user permissions, etc.
- complete reporting solution with a comprehensive set of pre-defined reports as well as the ability for the end-user to create and define custom reports.

Figure 4 provides a screenshot of the Train Hourly Chart that includes the quantity of Arrival Credits for each train on an hourly basis.

The Canada Line APRS is designed to accommodate 100,000 events per day and 50 concurrent users. The APRS is a scalable system and is capable of handling significantly larger service levels and concurrent number of users with no impact on its functionality, performance, or reliability.

Figure 4 - The Canada Line Train Hourly Report as produced

by the APRS depicting the number of Arrival Credits per Train per Hour

6. The Business Benefits

An APRS provides a rich set of features and configurability to report the operational performance metrics of a mass transit system which in turn can be used to generate invoice data to a concessionaire in a Public-Private Partnership contractual arrangement, or other similar type of financial arrangements. The cost benefits of an APRS as described in this paper are substantial, typically providing savings in cost of reporting (no surveys, no consultants), removal of ambiguity from reports (only deals in facts) and maximizes income from performance, which in turn leads to increased customer satisfaction and more business.

Figure 5 provides a screenshot of the Payment Performance Regime calculation online report that is available via the APRS. **Please note that financial data is simulated and/or obscured.**

Figure 5 - The Payment Performance Regime Calculation online APRS report

In 2 (two) clicks APRS user can drill down from aggregated performance view shown on **Figure 5** to lower level details to find reasons why and when system has underperformed. **Figures 6** and **7** represent lower level drill-down views on vehicle availability for given months and details of what, when and why contractual performance requirements have not been fully met.

Figure 6 - APRS report on Vehicle availability

Arrival Detail Report

AC = Arrival Credit, QAC=Quality Arrival Credit, DW=Dwell Failure, SG=Full Segment Failure, TT=Max Travel Time Failure, FQ=Frequency Failure, IV=Interval Failure, FT=First Trip Failure, LT=Last Trip Failure

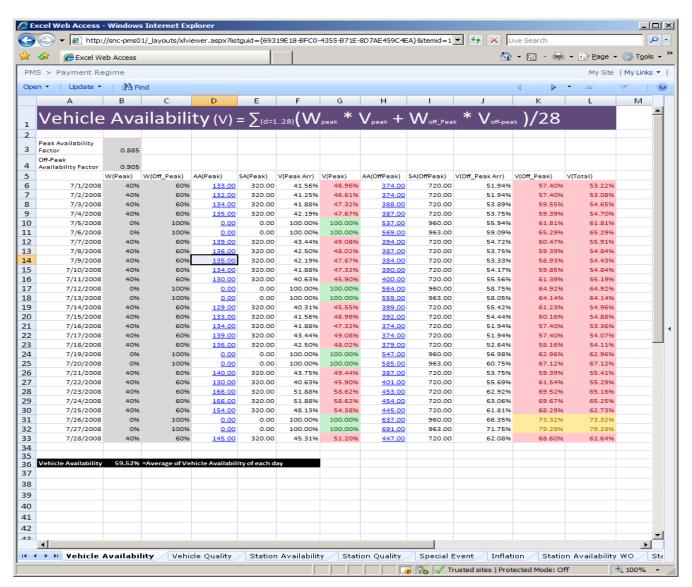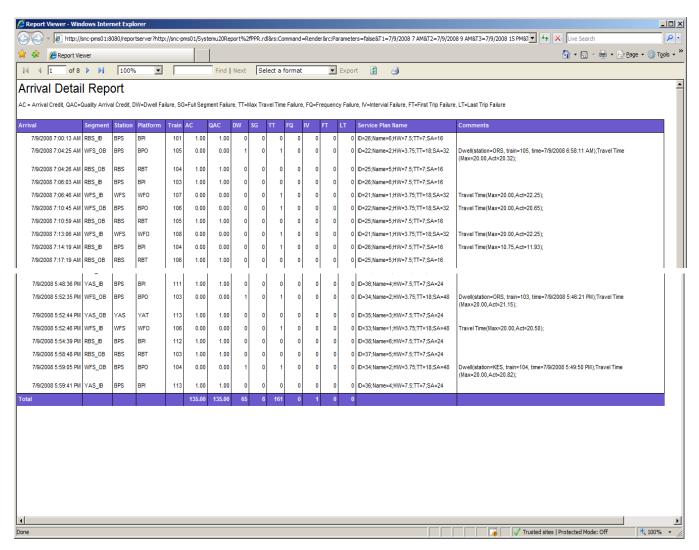| Arrival	Segment	Station	Platform	Train	AC	QAC	DW	SG	TT	FQ	IV	FT	LT	Service Plan Name	Comments
7/9/2008 7:00:13 AM	RBS_IB	BPS	BPI	101	1.00	1.00	0	0	0	0	0	0	0	ID=26;Name=6;HW=7.5;TT=7;SA=16	
7/9/2008 7:04:25 AM	WFS_OB	BPS	BPO	105	0.00	0.00	1	0	1	0	0	0	0	ID=22;Name=2;HW=3.75;TT=18;SA=32	Dwell(station=ORS, train=105, time=7/9/2008 6:58:11 AM);Travel Time (Max=20.00,Act=20.32);
7/9/2008 7:04:26 AM	RBS_OB	RBS	RBT	104	1.00	1.00	0	0	0	0	0	0	0	ID=25;Name=5;HW=7.5;TT=7;SA=16	
7/9/2008 7:06:03 AM	RBS_IB	BPS	BPI	103	1.00	1.00	0	0	0	0	0	0	0	ID=26;Name=6;HW=7.5;TT=7;SA=16	
7/9/2008 7:06:46 AM	WFS_IB	WFS	WFO	107	0.00	0.00	0	0	1	0	0	0	0	ID=21;Name=1;HW=3.75;TT=18;SA=32	Travel Time(Max=20.00,Act=22.25);
7/9/2008 7:10:45 AM	WFS_OB	BPS	BPO	106	0.00	0.00	0	0	1	0	0	0	0	ID=22;Name=2;HW=3.75;TT=18;SA=32	Travel Time(Max=20.00,Act=20.65);
7/9/2008 7:10:59 AM	RBS_OB	RBS	RBT	105	1.00	1.00	0	0	0	0	0	0	0	ID=25;Name=5;HW=7.5;TT=7;SA=16	
7/9/2008 7:13:06 AM	WFS_IB	WFS	WFO	108	0.00	0.00	0	0	1	0	0	0	0	ID=21;Name=1;HW=3.75;TT=18;SA=32	Travel Time(Max=20.00,Act=22.25);
7/9/2008 7:14:19 AM	RBS_IB	BPS	BPI	104	0.00	0.00	0	0	1	0	0	0	0	ID=26;Name=6;HW=7.5;TT=7;SA=16	Travel Time(Max=10.75,Act=11.93);
7/9/2008 7:17:19 AM	RBS_OB	RBS	RBT	106	1.00	1.00	0	0	0	0	0	0	0	ID=25;Name=5;HW=7.5;TT=7;SA=16	
7/9/2008 5:48:36 PM	YAS_IB	BPS	BPI	111	1.00	1.00	0	0	0	0	0	0	0	ID=36;Name=4;HW=7.5;TT=7;SA=24	
7/9/2008 5:52:35 PM	WFS_OB	BPS	BPO	103	0.00	0.00	1	0	1	0	0	0	0	ID=34;Name=2;HW=3.75;TT=18;SA=48	Dwell(station=ORS, train=103, time=7/9/2008 5:46:21 PM);Travel Time (Max=20.00,Act=21.15);
7/9/2008 5:52:44 PM	YAS_OB	YAS	YAT	113	1.00	1.00	0	0	0	0	0	0	0	ID=35;Name=3;HW=7.5;TT=7;SA=24	
7/9/2008 5:52:46 PM	WFS_IB	WFS	WFO	106	0.00	0.00	0	0	1	0	0	0	0	ID=33;Name=1;HW=3.75;TT=18;SA=48	Travel Time(Max=20.00,Act=20.50);
7/9/2008 5:54:39 PM	RBS_IB	BPS	BPI	112	1.00	1.00	0	0	0	0	0	0	0	ID=38;Name=6;HW=7.5;TT=7;SA=24	
7/9/2008 5:58:48 PM	RBS_OB	RBS	RBT	103	1.00	1.00	0	0	0	0	0	0	0	ID=37;Name=5;HW=7.5;TT=7;SA=24	
7/9/2008 5:59:05 PM	WFS_OB	BPS	BPO	104	0.00	0.00	1	0	1	0	0	0	0	ID=34;Name=2;HW=3.75;TT=18;SA=48	Dwell(station=KES, train=104, time=7/9/2008 5:49:50 PM);Travel Time (Max=20.00,Act=20.82);
7/9/2008 5:59:41 PM	YAS_IB	BPS	BPI	113	1.00	1.00	0	0	0	0	0	0	0	ID=36;Name=4;HW=7.5;TT=7;SA=24	
Total					135.00	135.00	65	8	161	0	1	0	0		

Figure 7 - APRS technical report on why system has underperformed

Within the Canada Line Rapid Transit System, the APRS has proven to be invaluable in the short history of the transit system. It enables instant visibility on system performance and provides decision support tool for quick resolution of availability and quality issues. APRS is one of the key instruments that allowed Canada Line to achieve **99.97%** of average system availability during the first 3 years of operations.

According to Mr. Lee Cockrill, the PROTRANS BC Operations Director, *"The Canada Line Performance Reporting System provides me with the data I need every day to deliver the reliable service demanded by my customers and my business partners."*

7. *Summary and Conclusions*

An Automated Performance Reporting System (APRS) controls the business logic for the automatic calculations of asset availability, arrival credits and deductions, service plans, inflation impacts and other parameters that drive key performance indicators for the transit operator. The APRS is also

capable of managing the Payment Performance Regimes and providing invoices based on performance indicators and passenger loading.

In the commissioning environment of a mass transit system, an APRS can be utilized to provide input into the acceptance criteria for the critical operational systems. In revenue service, an APRS in a mass transit system provides management the opportunity to view and understand the performance metrics of their operations in near real-time. This quick response time is due to the automated and highly integrated nature of the APRS which requires little manual input to obtain its end results.

The ability to accurately monitor the performance of a transit system provides the opportunity to enhance and optimize the system's performance. The Automated Performance Reporting System is the tool to provide this capability.

8. About SNC-Lavalin

SNC-Lavalin is one of the leading engineering and construction groups in the world, and a major player in the ownership of infrastructure and in the provision of operations and maintenance services. SNC-Lavalin companies provide engineering, procurement, construction, project management and project financing services to a variety of industry sectors, including agrifood, pharmaceuticals and biotechnology, chemicals and petroleum, environment, heavy construction, mass transit, mining and metallurgy, power and water management.

SNC-Lavalin's Mass Transit Group specializes in the efficient, cost-effective delivery of rail-based rapid transit projects, particularly light rail, conventional heavy rail and advanced automated systems. SNC-Lavalin is an independent transit developer, not aligned with any component manufacturer or supplier. This autonomy empowers SNC-Lavalin to work with owner-preferred service and equipment providers, procure equipment from multiple sources and secure competitive pricing and financing.

9. About the Canada Line Rapid Transit System

The Canada Line Rapid Transit System, which connects the cities of Vancouver and Richmond with the Vancouver International Airport, opened to the public on August 17, 2009 more than three months ahead of schedule. SNC-Lavalin built the entire 19-km automated system, including an underground tunnel through Vancouver, an elevated guideway over the Fraser River to Richmond, 16 stations, and an operations and maintenance centre.

10. About PROTRANS BC

PROTRANS BC is a wholly own subsidiary of SNC-Lavalin Inc and reports to SNC-Lavalin Operations and Maintenance and has a 35 years contract to operate and maintain the Canada Line.

11. About Transit-Insight Systems Ltd.

Transit-Insight Systems Ltd. is the vendor of **TI-Analytics** (www.TransitInsight.com) platform that provides 360° view on operational performance to the transit operator. This platform includes also forecasting, risk management and decision support tools.