Transit-Insight

Understanding Transit Performance.

410 – 700 West Pender Street
Vancouver, British Columbia
Canada, V6E 2E9
Phone/Fax: 1 (866) 996-9247
Web: www.TransitInsight.com

Discover Correlations and Causality of Vehicles' Systematic Faults

Implementation of TI-Analytics for Operations on the Canada Line, Vancouver

Case Study

Table of Contents

1.Introduction

Transit authorities delivering low headway, high frequency services with minimal delays must stay on top of train control and vehicle relates faults. From the earlier days of testing and commissioning to the first months of operation it is important to drive out systematic failures to enable the line to operate at its most efficient, and to maintaining that high degree of availability requires continued monitoring of equipment failures and trends.

As technology embedded within and data collection capabilities of today's train control systems and vehicles increases it is not always easy to understand and locate failures and trends within the tens of thousands of events being collected every day.

TI-Analytics for Operations reporting function manages and presents that data in a way that allows operators and maintainers to focus on critical failures, the events leading up to them and what happen after. A failure is *not* always random often it is systematic, ***TI-Analytics*** tending and analysis functions allow these failure to be clearly identifying relationships between particular vehicles, particular locations or combinations.

With ***TI-Analytics*** your data is not lost at the end of the day, week, month. ***TI-Analytics*** stores every event allowing historical views to be generated of train control faults, vehicle faults and collection of vehicle mileage.

By collecting, managing and organizing these events in a user friendly web enabled environment, ***TI-Analytics*** allows the maintainer to understand and react to failures in a timely fashion, minimize no faults found, detect trends and proactively increase fleet availability and optimize maintenance by careful balancing of usage and mileage.

This paper provides overview of ***TI-Analytics*** reporting module implementation for Canada Line rapid transit, Vancouver, Canada. We are to demonstrate here the way maintenance division uses ***TI-Analytics*** to discover correlations and causality of systematic system faults.

2.Disclaimer

IMPORTANT: All data, pictures, layout and screenshots presented in this paper are based on ***TI-Analytics*** implementation at Canada Line before its Test and Commissioning stage. Guide way layout represented on ***Figure 3*** has been modified intentionally and does not represent real Canada Line guide way.

Information provided in this paper is only for demonstrating capabilities of ***TI-Analytics*** reporting component. Data, pictures, layout and screenshots presented in this paper do not reflect any fault trends or state of Canada Line operations.

3.Real Time Active Fault notification for Maintainer

TI-Analytics reporting provides one stop shop for the maintenance manager for making decision regarding if and when to rout train with active faults out of service for repair.

To make such decision maintenance manager has two real-time views on the current status of all vehicles in the fleet – active faults for each fleet unit (called Active Fault Report) and real-time fleet positioning with fault notification capabilities.

Figure 1 represents realization of Active Fault Report for Canada Line.

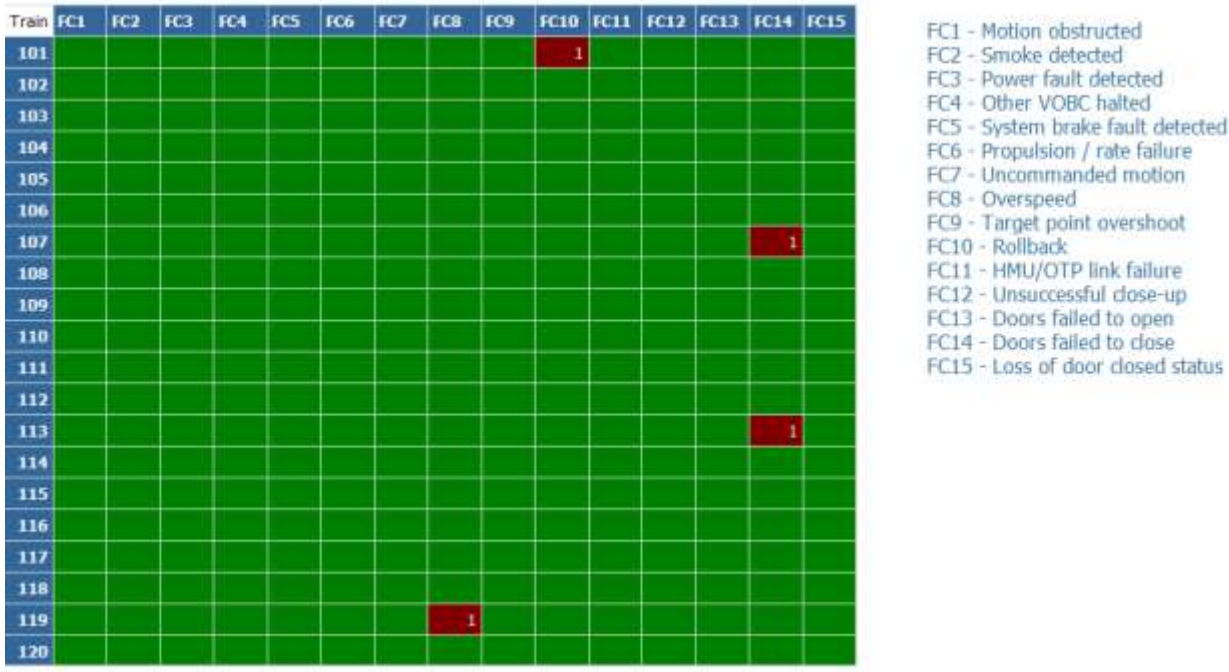

Figure 1 - Realization of Active Fault Report for Canada Line

Each ***TI-Analytics*** report supports drill-down capability. This provides the maintainer with a tool to get to the actual event of interest. By clicking on the report hot-spots the user is taken into greater detail associated with the fault or faults. At its lowest level, the event of interest is displayed along with preceding and following ten events as it's shown on ***Figure 2***.

Detailed Fault Context

Event log prior to the Current Fault

Train ID	Time	Category	Velocity	Location	Track	Section	Event Text
113	7/23/2009 8:03:17 PM	0	34	RB-TE-O	715	3347	C1.CPU1 20:03:17 113 213 0A1 3347 715/ 12 34 0 40 8 84 0 CL 7 1 10 -6 STN- SII 0 14 13 pbasfgtr.c 275
113	7/23/2009 8:03:36 PM	0	39	RB-TE-O	716	3356	C1.CPU1 20:03:36 113 213 0A1 3356 716/ 46 39 0 70 8 151 0 CL 5 1 10 +27 STN- SII 0 14 13 pbasfgtr.c 275
113	7/23/2009 8:03:56 PM	0	69	RB-TE-O	716	3368	C1.CPU1 20:03:56 113 213 0A1 3368 716/ 95 69 0 90 8 208 0 CL 9 1 10 -8 STN- SII 0 29 8 pbasfgtr.c 275
113	7/23/2009 8:04:15 PM	0	63	RB-TE-O	716	3385	C1.CPU1 20:04:15 113 213 0A1 3385 716/160 63 40 90 8 217 0 CL D 1 10 VE-45 STN- SII 0 29 8 pbasfgtr.c 275
113	7/23/2009 8:04:35 PM	0	37	RB-TE-O	718	3395	C1.CPU1 20:04:35 113 213 0A1 3395 718/202 37 40 40 8 245 0 CL 8 1 10 VE -3 STN- SII 0 14 8 pbasfgtr.c 275
113	7/23/2009 8:04:54 PM	0	40	TE-SI-O	720	3405	C1.CPU1 20:04:54 113 213 0A1 3405 720/237 40 35 40 8 274 0 CL 7 1 10 VE +11 STN- SII 0 7 28 pbasfgtr.c 275
113	7/23/2009 8:05:14 PM	0	34	SI-TE-I	654	3541	C1.CPU1 20:05:14 113 213*0A1 3541 654/270 34 0 35 8 342 0 CL 9 1 10 -6 STN- SII 0 28 22 pbasfgtr.c 275
113	7/23/2009 8:05:17 PM	4		SI-TE-I	654	2651	C1.CPU2 20:05:17 TRAIN 113 VOBC 213 CLEARS FAULT IN CATEGORY 4 pdlpuv1m.c 373
113	7/23/2009 8:05:17 PM			SI-TE-I	654	2651	C1.CPU2 20:05:17 TRAIN 113 EB ACTIVE• pdlputad.c 1068
113	7/23/2009 8:05:17 PM			SI-TE-I	654	3541	C1.CPU2 20:05:17 TRAIN 113 EMERGENCY BRAKE ON pdlpuv0m.c 356

Current Fault

113	7/23/2009 8:05:18 PM	8		SI-TE-I	654	2651	C1.CPU2 20:05:18 TRAIN 113 VOBC 213 REPORTS FAULT IN CATEGORY 8• pdlpuv1m.c 283

Event log after the Current Fault

113	7/23/2009 8:05:19 PM	8		SI-TE-I	654	2651	C1.CPU2 20:05:19 TRAIN 113 VOBC 213 CLEARS FAULT IN CATEGORY 8 pdlpuv1m.c 373
113	7/23/2009 8:05:36 PM			SI-TE-I	654	2651	C1.CPU2 20:05:36 TRAIN 113 EMERGENCY BRAKE OFF pdlpuv0m.c 362
113	7/23/2009 8:05:41 PM	0	8	SI-TE-I	654	2651	C1.CPU1 20:05:41 113 213 0A1 2651 654/282 8 0 70 8 385 0 CL 7 1 10 ST +6 STN- SII 0 28 22 pbasfgtr.c 275
113	7/23/2009 8:05:41 PM	4		SI-TE-I	654	2651	C1.CPU2 20:05:41 TRAIN 113 VOBC 213 REPORTS FAULT IN CATEGORY 4• pdlpuv1m.c 283
113	7/23/2009 8:06:00 PM	0	64	SI-TE-I	654	2661	C1.CPU1 20:06:00 113 213 0A1 2661 654/321 64 0 70 8 385 0 CL 9 1 10 ST -6 STN- SII 0 23 22 pbasfgtr.c 275
113	7/23/2009 8:06:20 PM	0	36	SII	655	2672	C1.CPU1 20:06:20 113 213*0A1 2672 655/ 6 36 0 70 8 25 0 CL 8 1 10 ST +2 STN- SII 0 23 8 pbasfgtr.c 275
113	7/23/2009 8:06:39 PM	0	5	SII	655	2677	C1.CPU1 20:06:39 113 213 0A1 2677 655/ 24 5 0 40 0 25 1 CL 9 1 10 ST -5 STN- SII 0 23 25 SII pbasfgtr.c 262
113	7/23/2009 8:06:59 PM	0		SII	655	2677	C1.CPU1 20:06:59 113 213 0A1 2677 655/ 25 0 0 40 0 25 1 OP 9 1 10 ST -5 STN- SII 0 23 25 SII pbasfgtr.c 262
113	7/23/2009 8:07:18 PM	0		SII	655	2677	C1.CPU1 20:07:18 113 213 0A1 2677 655/ 25 0 0 40 0 25 1 OP 9 1 10 ST -5 STN- SII 0 23 25 SII pbasfgtr.c 262
113	7/23/2009 8:07:38 PM	0		SII	655	2677	C1.CPU1 20:07:38 113 213 0A1 2677 655/ 25 0 0 40 0 25 1 OP 9 1 10 ST -5 STN- SII 0 23 25 SII pbasfgtr.c 262

Figure 2 – Active Fault Details as well as Preceding and Following Events

Real-time fleet position and re-play interface is available for Maintainer at his workstation (***Figure 3***). This interface includes such features as color coding of trains with active faults, real-time and re-play of fault notification, voice announcement for most important events and faults.

Aggregated and detailed views (***Figures 1 and 2***) on active faults and their context as well as real-time fleet positioning view (***Figures 3***) provide all necessary information for Maintainer to make decision if and when given train should be taken out of service.

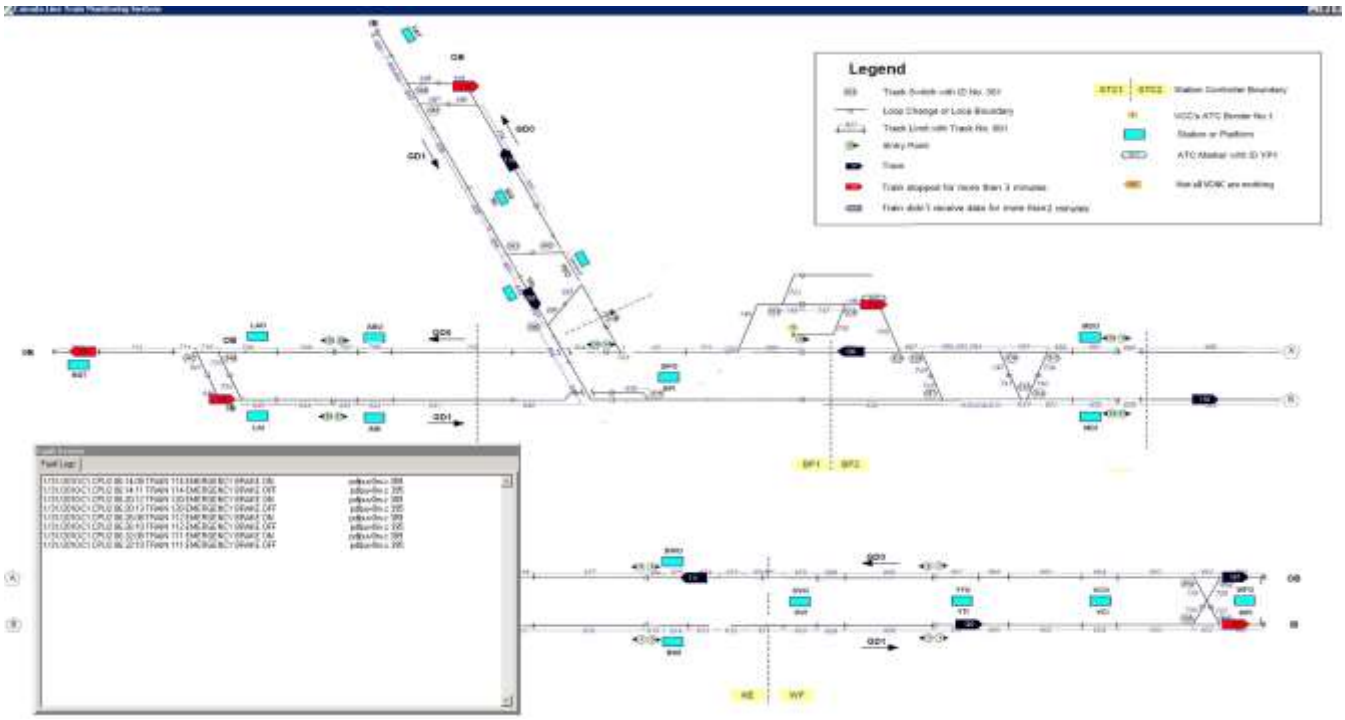

Figure 3 – Real-Time Fleet Position and Re-play Interface Available at Maintainer's Workstation

4. Reliability, Availability and Maintainability Analysis

TI-Analytics reporting component addresses needs in monitoring system's reliability, availability and maintainability (RAM) key indicators. This component provides full visibility on faults' trends and discovers correlations between system configuration, external parameters and systematic faults. Below are examples of fault related features that are used for accessing system compliance to RAM requirements.

Fault Summary Feature

The fault summary feature allows a quick summary to be generated showing the faults on the system today, yesterday, over the last week and month. This simple report gives management a quick insight to overall fleet performance trend.

FC Category	Current Active	Last Day	Last 2 Days	Last 7 Days	Last 30 Days	Last 182 Days	Last 365 Days
FC1	0	0	0	0	6	26	94
FC2	0	0	0	0	0	4	26
FC3	0	0	2	2	8	62	107
FC4	1	1	1	3	9	129	522
FC5	0	0	0	0	0	5	132
FC6	0	0	0	0	0	49	83
FC7	0	0	0	0	0		
FC8	0	0	1	4	12	251	384
FC9	0	0	0	0	0		
FC10	0	1	1	4	12	73	113
FC11	0	0	0	0	0	12	106
FC12	0	0	0	0	0		
FC13	0	0	0	0	0	2	2
FC14	0	0	0	6	68	537	589
FC15	0	1	2	2	16	74	126
Total	1	3	7	21	131	1,224	2,284

FC1 - Motion obstructed
FC2 - Smoke detected
FC3 - Power fault detected
FC4 - Other VOBC halted
FC5 - System brake fault detected
FC6 - Propulsion / rate failure
FC7 - Uncommanded motion
FC8 - Overspeed
FC9 - Target point overshoot
FC10 - Rollback
FC11 - HMU/OTP link failure
FC12 - Unsuccessful close-up
FC13 - Doors failed to open
FC14 - Doors failed to close
FC15 - Loss of door closed status

Figure 4 – Fault Summary

Train Fault Histogram Features

The train fault histogram graph and table feature allows a summary of all faults on a per vehicle basis to be shown. The graphs and tables can be tailored by specifying the period of which the report will span or by specifying the types of faults to be reported. Drill-down is enabled. These reports are great for providing feedback to the maintenance team and management on a regular basis.

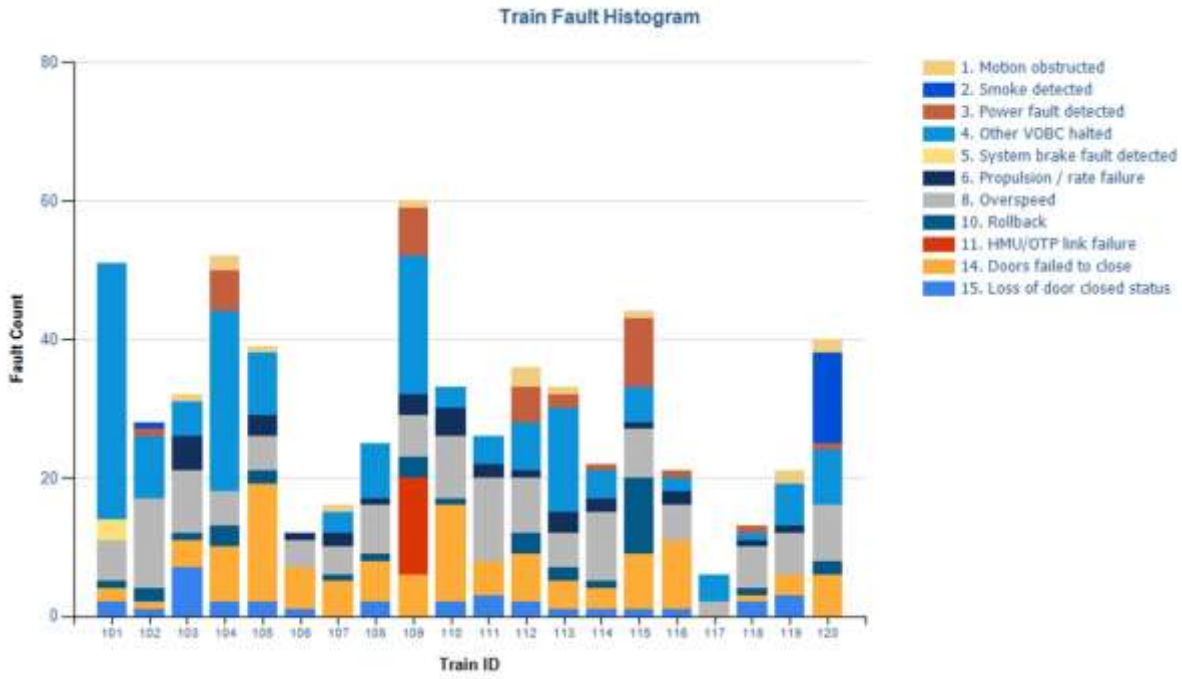

Figure 5 – Fault Train Historic Accumulative Histogram for Given Period

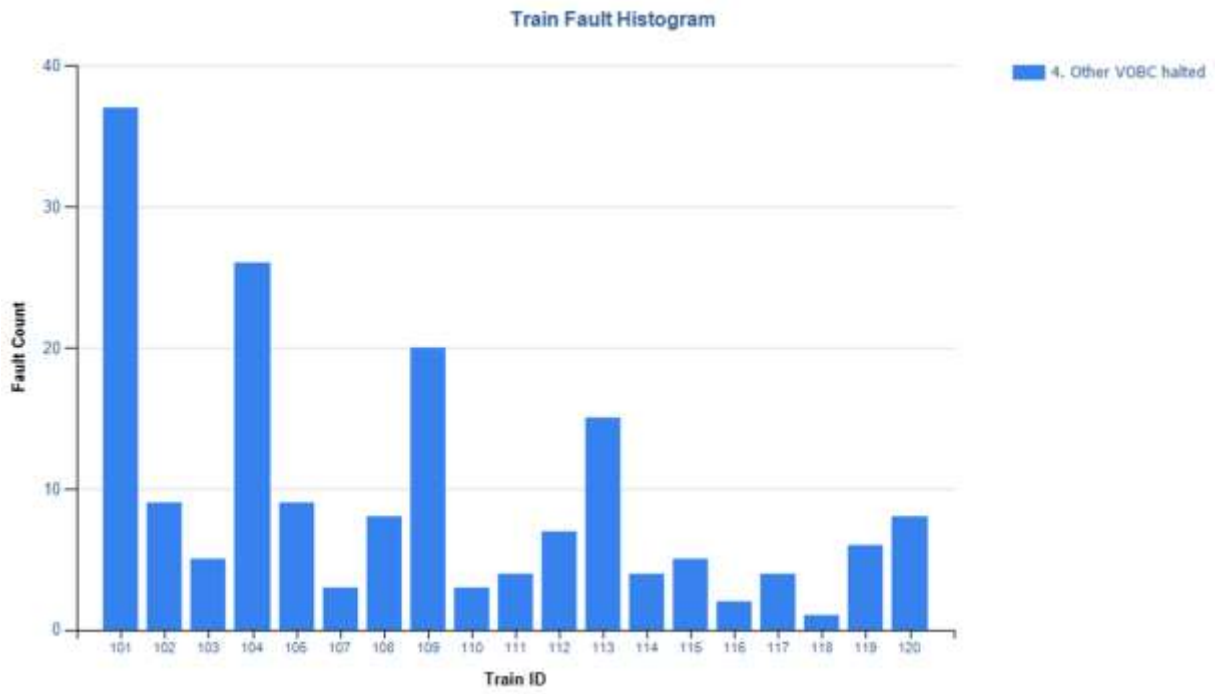

Figure 6 – 'Other VOBC Halted' Statistic for the period of Test & Commissioning, June – August 2009

Daily Fleet Statistics Feature

The daily fleet statistics graph (***Figure 7***) shows over the specified period the quantity of faults on each day. The faults and trains of interest can be tailored to best meet the objective of the investigation. This graph is great for showing trends and to demonstrate repairs or changes to system configuration have had the desired result on the overhaul performance. Drill-down to detailed views (as shown on ***Figure 2***) is available.

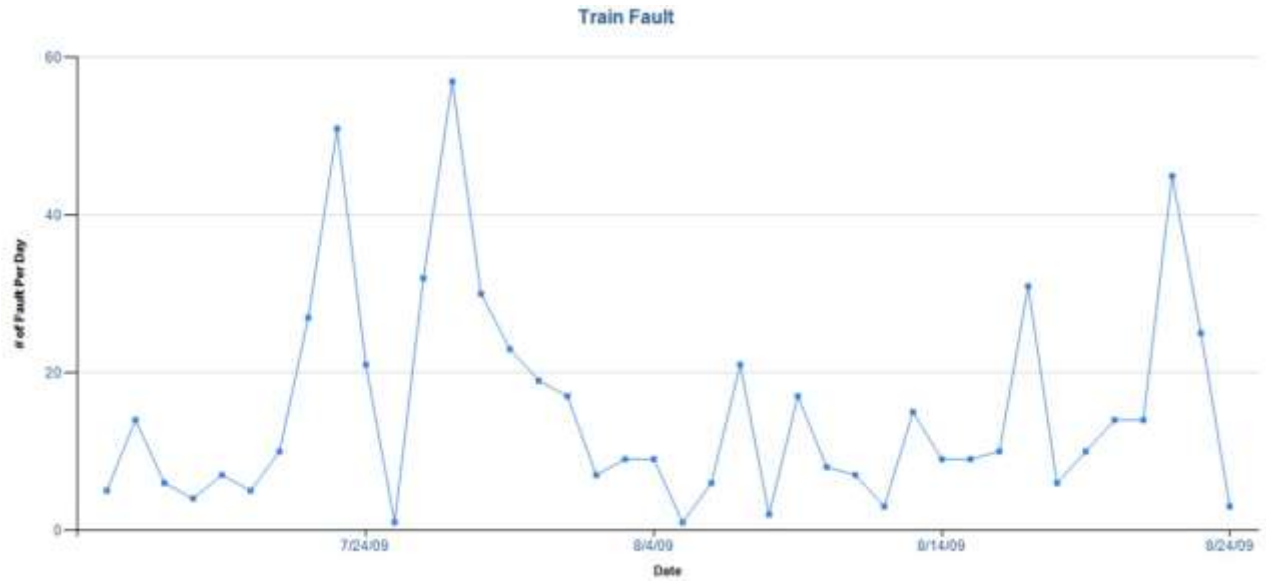

Figure 7 – Daily Fault Trends

Track-Fault Correlation Feature

While relating a fault to a particular train is important it is also important to understand the relationship of the train to location on the guide-way where the fault originated. The track-fault correlation feature does just this using the bubble chart (***Figure 9***), where bubble size indicates level of correlation between faults, trains and locations. Fault tailoring and drill-down are enabled. This chart and the drill-down capability really let the maintainer understand and investigate the causes and effects of failures.

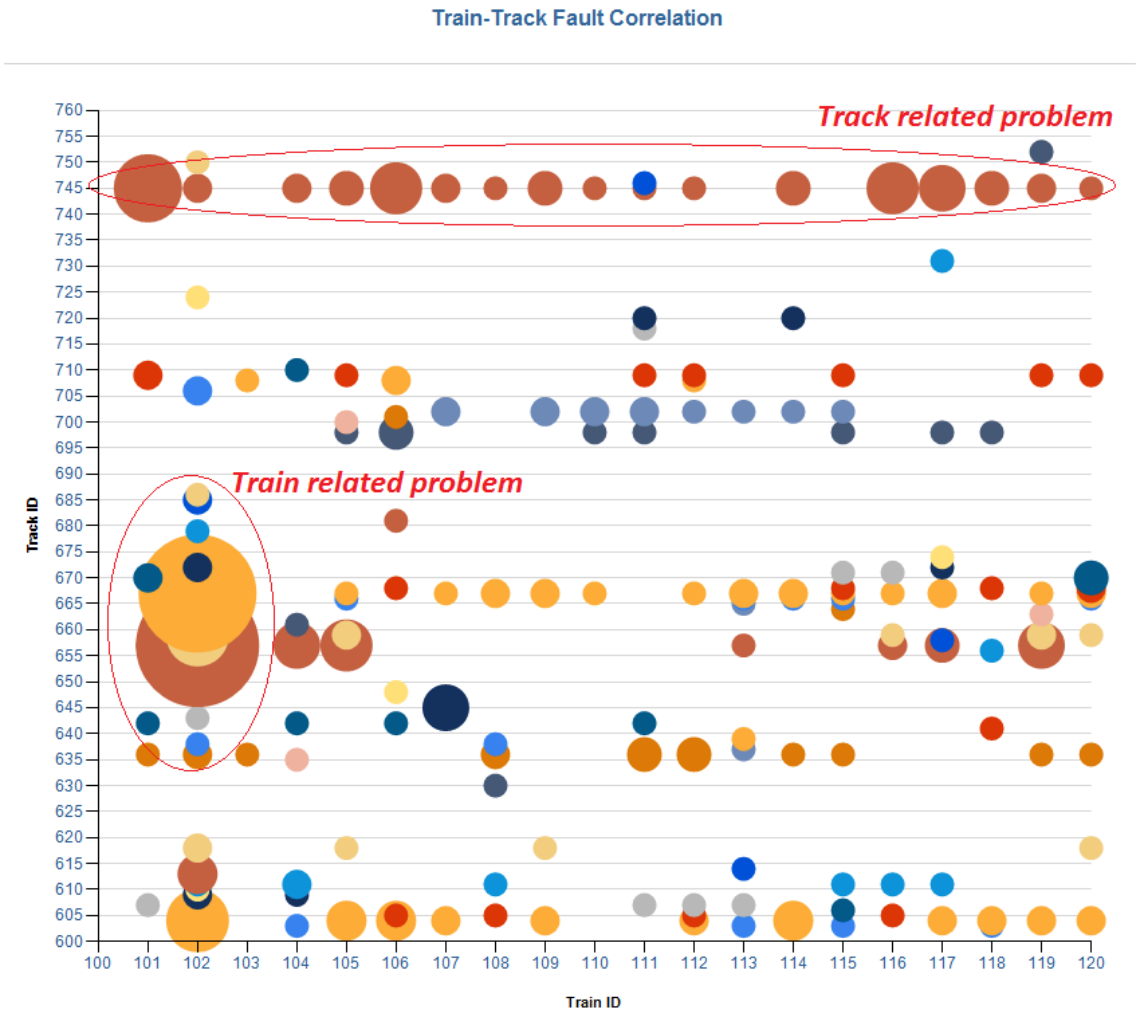

Figure 9 – Correlation between 'Over speed' Fault, Location and Train

Mileage Features

Train location is known every second of every day but determining the mileage travelled by each train can be time consuming without automation. Just keeping statistics by visiting each train on a regular basis cannot give the operator the confidence to plan maintenance to its optimum level.

TI-Analytics collects that train positioning data and provides real-time accumulated mileage reports for all trains continuously. Typical reports show daily mileage, accumulated fleet mileage, train mileage histograms, and train mileage over time.

Determination of mileage and faults within the same environment opens for the first time real tracking of mean distance between failures and mean time between failures, key parameters required for the operator and maintainer to accept vehicles and systems suppliers.

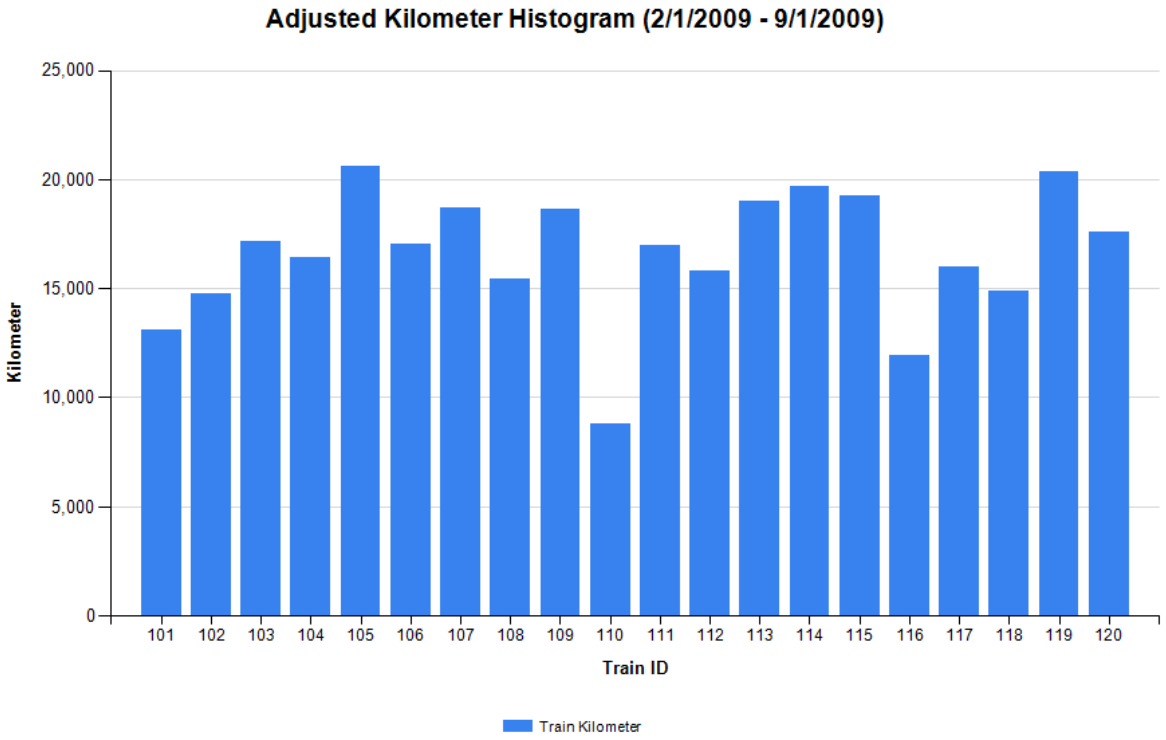

Figure 10 – Fleet Mileage for given period

Train ID	KM for the Duration
101	67,375
102	63,074
103	72,826
104	73,857
105	77,017
106	81,630
107	82,289
108	68,337
109	84,388
110	61,090
111	83,705
112	73,109
113	71,968
114	68,212
115	74,479
116	60,808
117	66,021
118	71,840
119	70,929
120	64,569

Figure 11 – Accumulative Fleet Mileage

8/1/2009 Train 101 Kilometer

Half Hour	Station	Track	Distance (Meters)
⊞ 12:00 AM			604,512.50
⊞ 12:30 AM			596,562.50
⊞ 1:00 AM			545,568.75
⊞ 1:30 AM			258,037.50
⊟ 2:00 AM			44,175.00
	⊞ OMC		20,637.50
	⊟ TEO		25.00
		719	25.00
	⊟ TE-SI-O		162.50
		720	162.50
	⊞ TE-362-363		68.75
	⊟ SI-TE-I		1,618.75
		653	193.75
		654	1,425.00
	⊞ SII		356.25
	⊞ YA-SI-I		3,925.00
	⊞ YAT		137.50

Figure 12 – Drill-down detailed report of how train mileage has been calculated

5.Manageability

TI-Analytics reporting is web application. It doesn't require any deployment on user's workstation. Configuration of user's access to certain reports is centralized and secured.

User could customize or create new reports. User could subscribe also for receiving given reports on scheduled basis or based on certain conditions of consistent negative trends.

TI-Analytics reporting component scales out. It doesn't require any significant investments in hardware.

6. Business Case for TI-Analytics for Operations

Today's operators and maintainers are expected to delivery highly available and efficient operations, each train is a major investment and must be operated to its maximum capability. A train failure affecting passenger service is not acceptable and costly. Optimizing maintenance staff to ensure preventative maintenance is performed at the right time while minimizing corrective maintenance is the balancing act every O&M organization must stay on top of to control budgets and keep customers satisfied.

An investment in ***TI-Analytics*** Reporting provides that overview and feedback that allows proactive Maintenance Manager's the visibility needed to determine their current asset performance and track the affects of improved maintenance practices and procedures on asset reliability and cost of ownership.

7.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.

8.About Transit-Insight Systems Ltd

Transit-Insight Systems Ltd. is a vendor of ***TI-Analytics*** (www.TransitInsight.com) platform for monitoring and improving transit maintenance and performance.