Revealing Negative Trends
to
Enable Proactive Maintenance

TI-Analytics for Maintenance

White Paper

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1.   Introduction

TI-Analytics for Maintenance is an analytical platform for improving service performance. ***TI-Analytics*** monitors Communications Based Train Control (CBTC) Systems by collecting and aggregating data to provide instant visibility of key performance indicators (KPIs) impacting reliability, availability and maintainability.

As a result ***TI-Analytics*** provides an analytical workspace for the Maintainer through an interactive dash board. The Maintainer is able to drill down from top level specific KPIs to low level technical details to:

- Conduct comprehensive faults' root-cause analysis in time efficient manner;

- Discover and monitor indicators leading to vehicles, communication or infrastructure faults for proactive maintenance.

Case study 'Discover Correlations and Causality of Vehicles' Systematic Faults' outlines capabilities of ***TI-Analytics*** for minimizing cost and time for faults' root-cause analysis.

This document describes ***TI-Analytics*** functionality of revealing negative trends and alerting Maintainer for necessity to conduct proactive maintenance for eliminating causes before fault happens to prevent service disruption.

2.   Disclaimer

Information provided in this paper is strictly for demonstrating capabilities of ***TI-Analytics*** in context of enabling predictive maintenance for Maintainer of rapid transit system.

All analysis, pictures, layout and screenshots presented in this paper are based on data provided by Thales Transportation.

3. Discover Indicators Leading to Service Disruption

Maintainer need to know negative trends of fleet and infrastructure. In this case Maintainer could implement predictive maintenance practices to keep system reliability at the highest level by addressing issues before they may happen. Such proactive practices lead to preventing services disruptions and optimizing maintenance schedule based on factual state of fleet, guide-way, communication and infrastructure.

TI-Analytics provides ability to define and monitor negative trends (future - **leading indicators**) that may lead to service disruption. Below are typical examples how **TI-Analytics** reporting component is used for discovery and investigation of negative leading indicators.

Guide-way Monitoring, Switch Movements

Figure 1 represents top level report of switches 'movement duration for last 4 months (for example). For each switch report

- indicates minimum and maximum movement duration;
- represents time range, where 50% of all durations of switch movement falls to, as red or green rectangle;
- depicts average movement duration as horizontal bar in the middle of red or green rectangle;
- highlights in red color switches, which average movement duration exceeds predefined threshold (5 seconds for an instance).
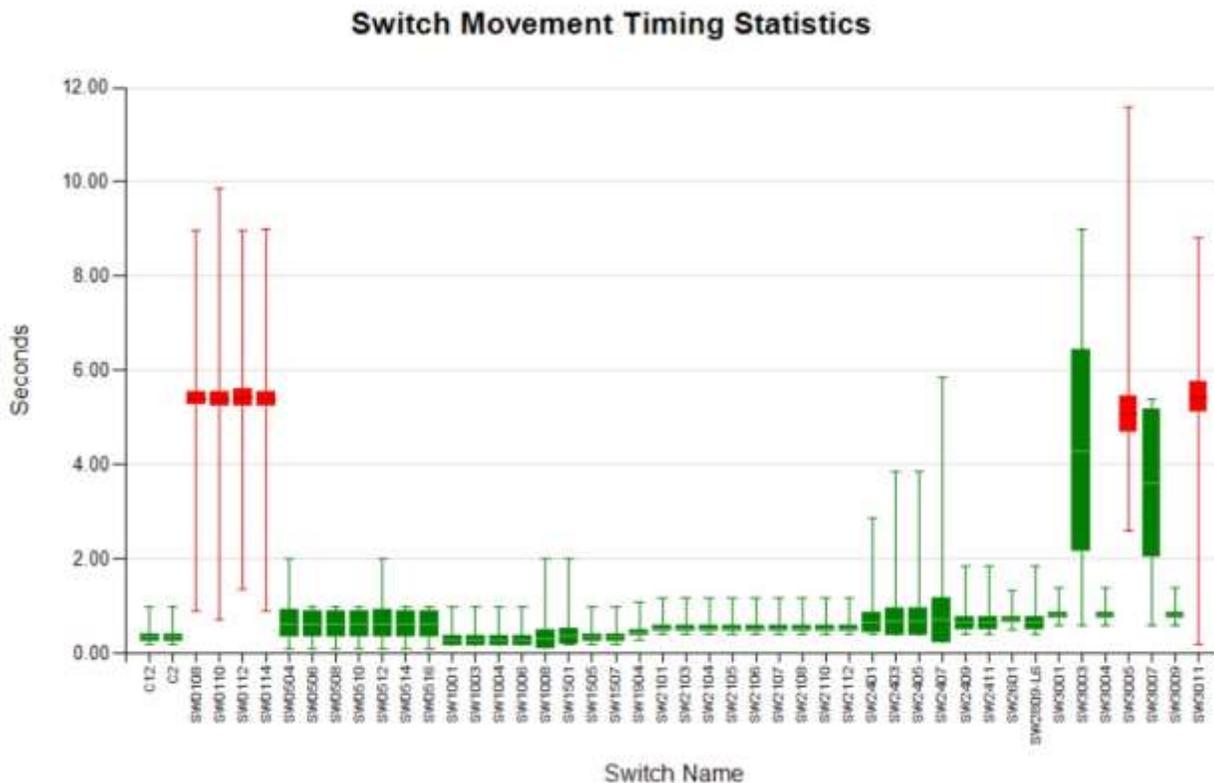

Figure 1 – Statistic of Switches`Movement for Given Period

Such top level report flags out switches that should be investigated future to determine if average movement time is consistently increasing over the reporting period (last 4 months). Maintainer

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could drill-down from top level report to the view on behavior of given switch during the reporting period (***Figure 2***).

Switch SW3005 Movement Timing Trend

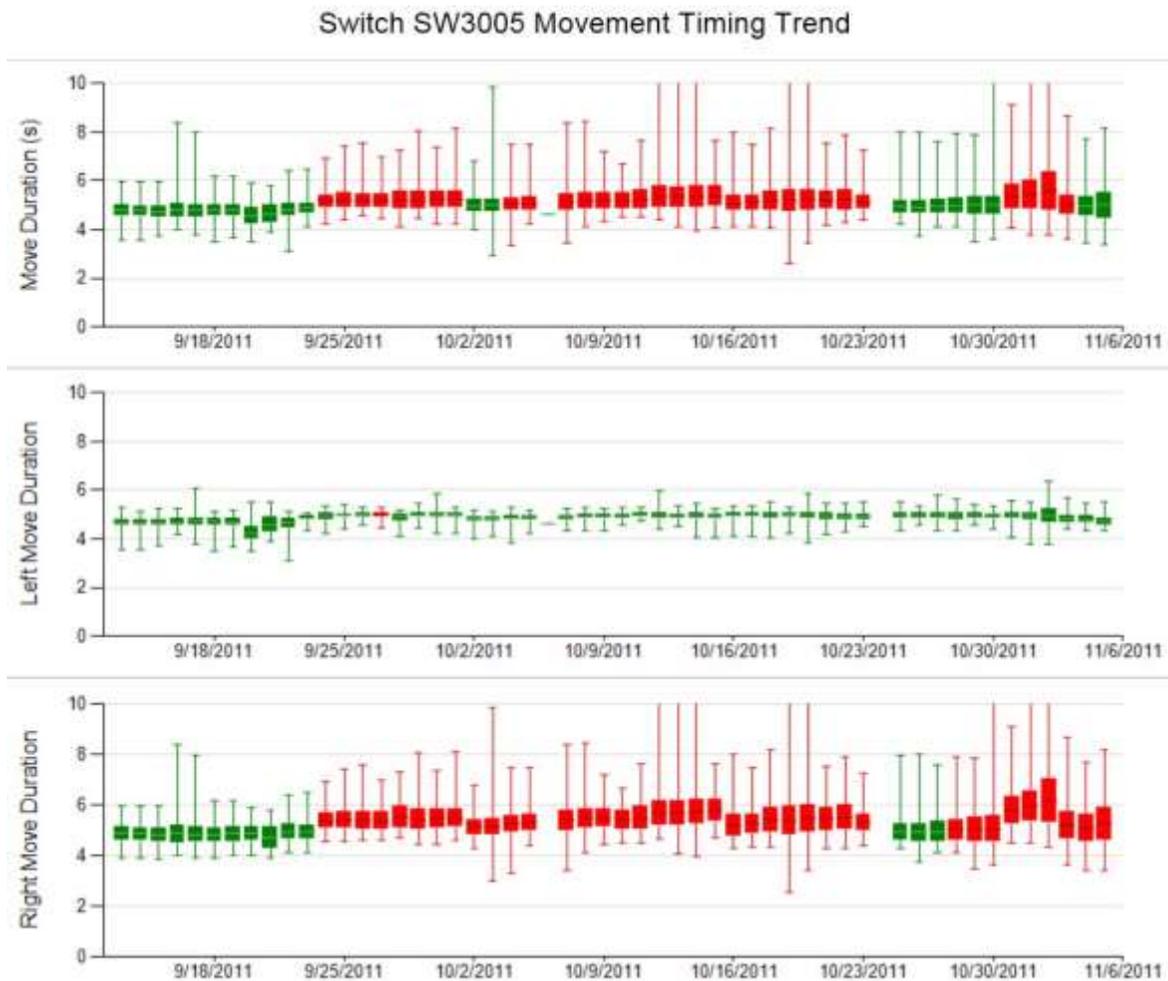*Figure 2 – Switch Movement Trending Report*

This report indicates clearly that given switch is `slowing down` for the last 4 months when it moves to the right direction. As a result Maintainer finds leading indicator to malfunctioning switch that needs specific preventive actions.

Note that full statistics of switch movement for given date is also available as a drill-down, low level report (***Figure 3***).

Logged At	Lock Status	Commanded Position	Position	Switch Move Delay	Switch Move Duration
11/2/2011 12:00:49 AM	Locked(1)	Right(2)	Right(2)	0.00	5.62
11/2/2011 12:03:09 AM	Locked(1)	Left(1)	Left(1)	0.00	4.78
11/2/2011 12:04:10 AM	Locked(1)	Right(2)	Right(2)	0.00	6.42
11/2/2011 12:05:58 AM	Locked(1)	Left(1)	Left(1)	0.00	5.08
11/2/2011 12:06:59 AM	Locked(1)	Right(2)	Right(2)	0.00	6.04
11/2/2011 12:07:55 AM	Locked(1)	Left(1)	Left(1)	0.00	4.98
11/2/2011 12:08:52 AM	Locked(1)	Right(2)	Right(2)	0.00	6.20
11/2/2011 12:10:12 AM	Locked(1)	Left(1)	Left(1)	0.00	4.63
11/2/2011 12:11:11 AM	Locked(1)	Right(2)	Right(2)	0.00	6.10
11/2/2011 12:12:02 AM	Locked(1)	Left(1)	Left(1)	0.00	4.76
11/2/2011 12:12:58 AM	Locked(1)	Right(2)	Right(2)	0.00	6.50
11/2/2011 12:14:10 AM	Locked(1)	Left(1)	Left(1)	0.00	5.11
11/2/2011 12:15:11 AM	Locked(1)	Right(2)	Right(2)	0.00	5.83
11/2/2011 12:16:51 AM	Locked(1)	Left(1)	Left(1)	0.00	4.86
11/2/2011 12:17:47 AM	Locked(1)	Right(2)	Right(2)	0.00	6.18
11/2/2011 12:18:48 AM	Locked(1)	Left(1)	Left(1)	0.00	5.11
11/2/2011 12:19:44 AM	Locked(1)	Right(2)	Right(2)	0.00	5.28
11/2/2011 12:20:34 AM	Locked(1)	Left(1)	Left(1)	0.00	4.14
11/2/2011 12:21:29 AM	Locked(1)	Right(2)	Right(2)	0.00	6.38
11/2/2011 12:22:36 AM	Locked(1)	Left(1)	Left(1)	0.00	3.79
11/2/2011 12:23:37 AM	Locked(1)	Right(2)	Right(2)	0.00	9.02
11/2/2011 12:24:39 AM	Locked(1)	Left(1)	Left(1)	0.00	4.89
11/2/2011 12:25:41 AM	Locked(1)	Right(2)	Right(2)	0.00	9.64
11/2/2011 12:26:51 AM	Locked(1)	Left(1)	Left(1)	0.00	5.80

Switch Specification	
Zone Control Name	ZC-2110
Switch Name	SW3005
Expected Time Delay	.5 (s)
Input Edge	90
Connected Edge 1	88
Connected Edge 2	87
Position Name 1	Right
Position Name 2	Left
Edge End	False

Figure 3 – Details About Switch ZC-2110 Movement for Given Day

In general, such low level, detailed technical reports as **Figure 3** are to provide information for Maintainer necessary for decision of what particular action(s) should be taken as a preventive procedure to eliminate negative leading indicator for given asset or infrastructure unit, i.e. switch in current example

4. Root-Cause Analysis of Leading Indicators

It`s not trivial to find leading indicators to potential service disruption. It`s even more difficult to provide quick and conclusive analysis that results in narrowing down reasons caused that negative trend.

TI-Analytics allows the Maintainer to define his/her own views on leading indicators to find correlation between given negative trend and system parameters, fleet, guide-way, way-side, external parameters, etc. Below is an example of how **TI-Analytics** helps to determine causality of consistent increase of train stop deviation.

Monitoring and Analyzing Train Stop Deviation

Figure 4 represents top level report of trains' stop deviations at all platforms for given period. Report filters in only stop deviations that are greater than 50 centimeters. Note that size of the bubble indicates total numbers of stop deviations of given train at certain station while bubble's color corresponds to absolute value of deviation.

Report makes apparent that train 1024 needs to be investigated since it deviates consistently from stopping position at most stations.

To narrow down casualty of train 1010 stop deviation at platform NRJ2 we have to drill-down to next level of reports – comparative analysis of fleet stop deviations at particular station over the same period of time (**Figure 5**).
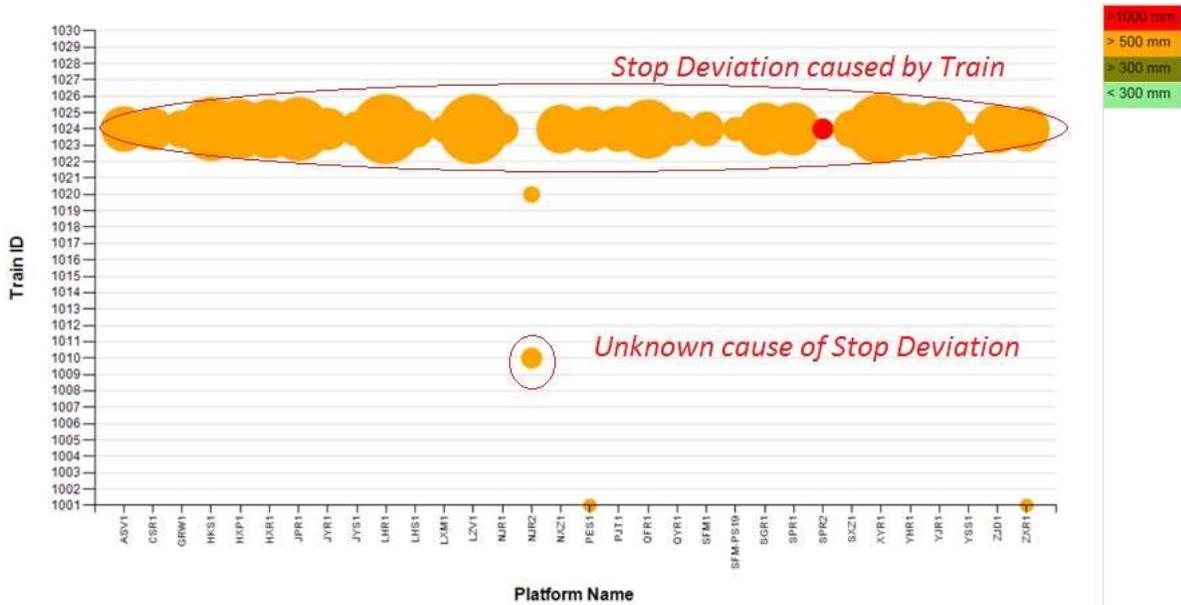
Figure 4 – Report of Train's Stop Deviations at All Stations
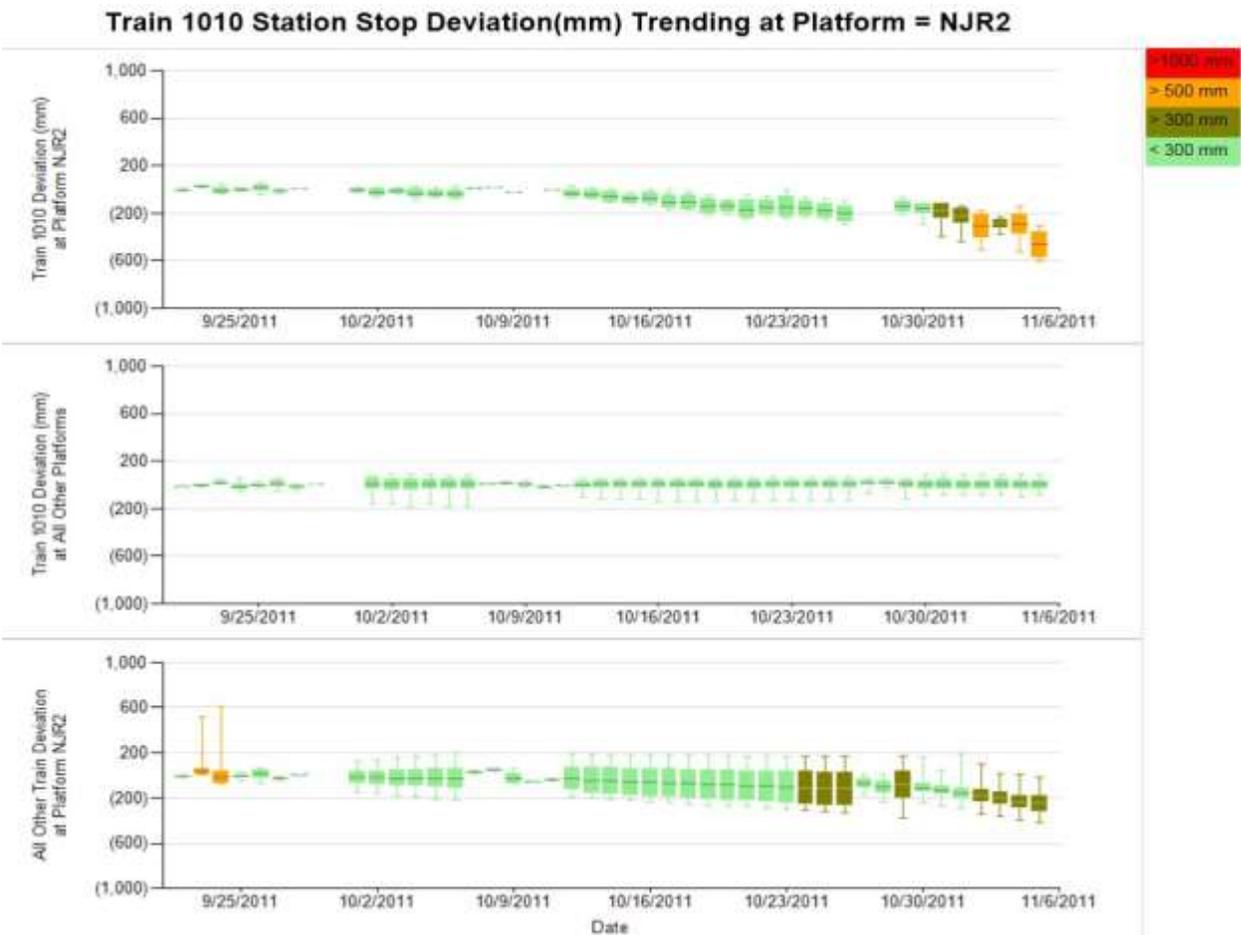

Figure 5 – Comparative Analysis of Fleet Stop Deviations for given Platform-Train Combination

Composited report **Figure 5** provides vitalization of fleet stop deviations over the certain period of time in context of given train and platform.

Maintainer has ability to compare trend of how train #1010 deviates at platform NRJ2 over time (top graph) with similar behavior of the train #1010 at all other platforms over the period same time (graph in the middle). Bottom level of report presents trend analysis of stop deviations of other trains at the platform NRJ2 during the same period of time.

As result it becomes apparent that there is consistent and growing trend of increasing stop deviations of all trains at NRJ2 platform. Thus, Maintainer should focus on investigation of particular station train controller or/and preventing maintenance of station infrastructure to avoid potential service disruption due to exceeding maximum allowed train stop deviation at platform NRJ2.

5. Monitoring and Alerting Leading Indicators

After discovery of indicators leading to service disruption Maintainer faces necessity to monitor indicators and corresponding trends. Maintainer needs to know when leading indicators have reached certain threshold to take preventive measures. Conductive manual monitoring of leading indicators could be labor intensive and error prone procedure.

TI-Analytics paddresses the issue of "too many reports to monitor" by providing an alert's rule engine for setting threshold for negative trends of given report, monitoring this trend and notifying Maintainer when certain leading indicator has reached its threshold.

As result **TI-Analytics** becomes the maintenance domain expert responsible for system health check analysis and notification of negative trends.

Note that **TI-Analytics** has web user interface for defining negative trends of given report and correspondent thresholds for triggering alerting. As result **TI-Analytics** end user can manage library of events or trends to monitor.

Content of alert message may contain reference to detailed report that triggered this alert as well as proactive action items for maintainer required to eliminate trend and prevent service disruption.

TI-Analytics includes Alert Starter Pack – set of predefined monitoring and alerting rules for monitoring system components including quality of communication for forecasting and preventing train communication timeouts.

6. Business Case for TI-Analytics for Maintenance

Service performance depends highly on fleet and system availability. **TI-Analytics** gives the Maintainer opportunity to make objective and proactive decisions based on factual data and trends. **TI-Analytics** reveals and monitors negative trends providing foundation for implementing predictive, cost effective maintenance practices that lead to maximizing fleet and system availability.

7.   *About Thales Transportation*

Thales Transportation (http://www.thalesgroup.com/transportation) is leading supplier of wide range of railways signaling solutions and integrated transportation systems, to ensure safe and secure transportation of goods and people.

8.   *About Transit-Insight Systems*

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