



# WMATA'S Automated Track Analysis Technology & Data Leveraging for Maintenance Decisions



# WMATA System

- 6 Lines: 5 radial  and 1 spur 
- 234 mainline track miles and 91 stations
- Crew of 54 Track Inspectors and 8 Supervisors walk and inspect each line twice a week.
- WMATA's TGV and 7000 Series revenue vehicles, provide different approaches to automatic track inspection abilities.



# Track Geometry Vehicle (TGV)

- Provides services previously contracted out.
- Equipped with high resolution cameras inspecting ROW and tunnels, infrared camera monitoring surrounding temperatures, and ultrasonic inspection system.
- Measures track geometry parameters, and produces reports where track parameters do not meet WMATA's maintenance and safety standards.



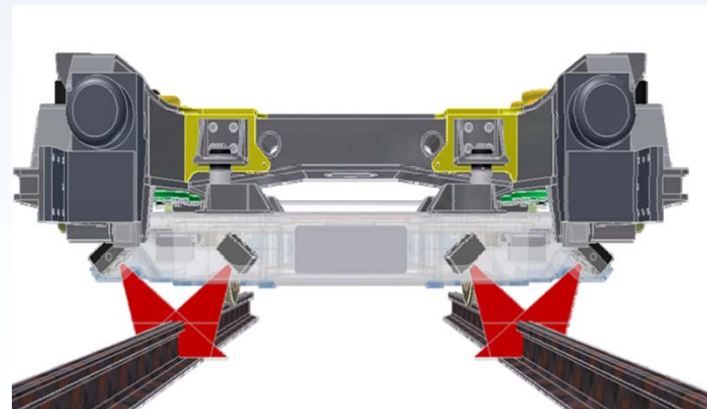
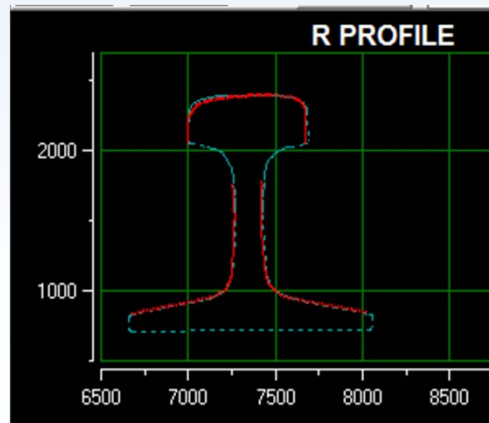
# TGV Measured Parameters

- Track gage, rail profile, cross level, alignment, twists, and warps.
  - Platform height and gap,
  - 3<sup>rd</sup> rail: height, gage, missing cover board, and temperature.
- Inspects track circuits transmitting speed commands and signals for train occupancy detection with different carrier frequencies and code rates.



# TGV Technology

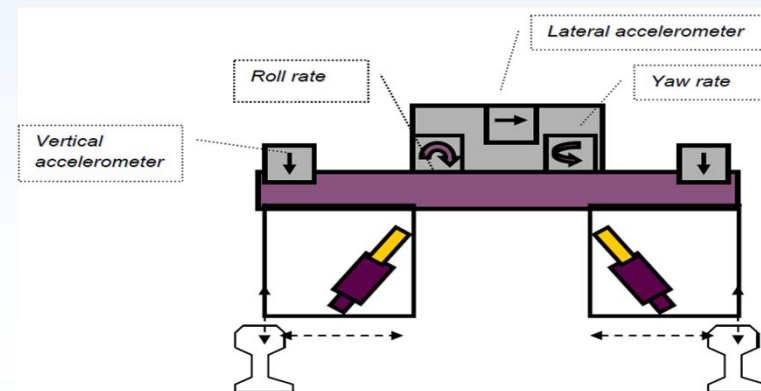
- Parameters such as rail profile, gage distances, 3<sup>rd</sup> rail and platform gap distances are measured via laser beam shot across running rails, and platforms.
- High-speed/high-resolution cameras take high resolution images of the surface where lasers makes contact with the rail.





# TGV Technology

- Track profile is measured via vertical accelerometers, and an algorithm converting acceleration into displacement.
- Track alignment is measured with a lateral accelerometer in combination with image analysis.
- Warps, twists, and cross levels are measured via gyros and inclinometers, along with distance measurements.



# Kawasaki 7000 Series Cars

- Cars are assembled into 4-Pack sets for operation.
- 7K cars are equipped with a system of accelerometers that are mounted on 15% of the B cars.



- Vehicle Track Interaction dynamic monitoring system (V/TI) built by Ensco, with primary purpose to identify poor track conditions & ride quality.

Can also identify truck anomalies on vehicle with the technology installed.



# 7000 Series Track Analysis

- V/TI is capable of measuring any abrupt lateral or vertical movement affecting the axle, truck, or car body where mounted.
- Data sent wirelessly to end user through commercial wayside cellular towers. Provides alerts in case of extreme exceptions.
- The collected data is marked with track location determined via GPS and the vehicle mounted data system (VMDS).
- Data reviewed via protected web application and/ or strip chart.





# V/TI Monitoring System

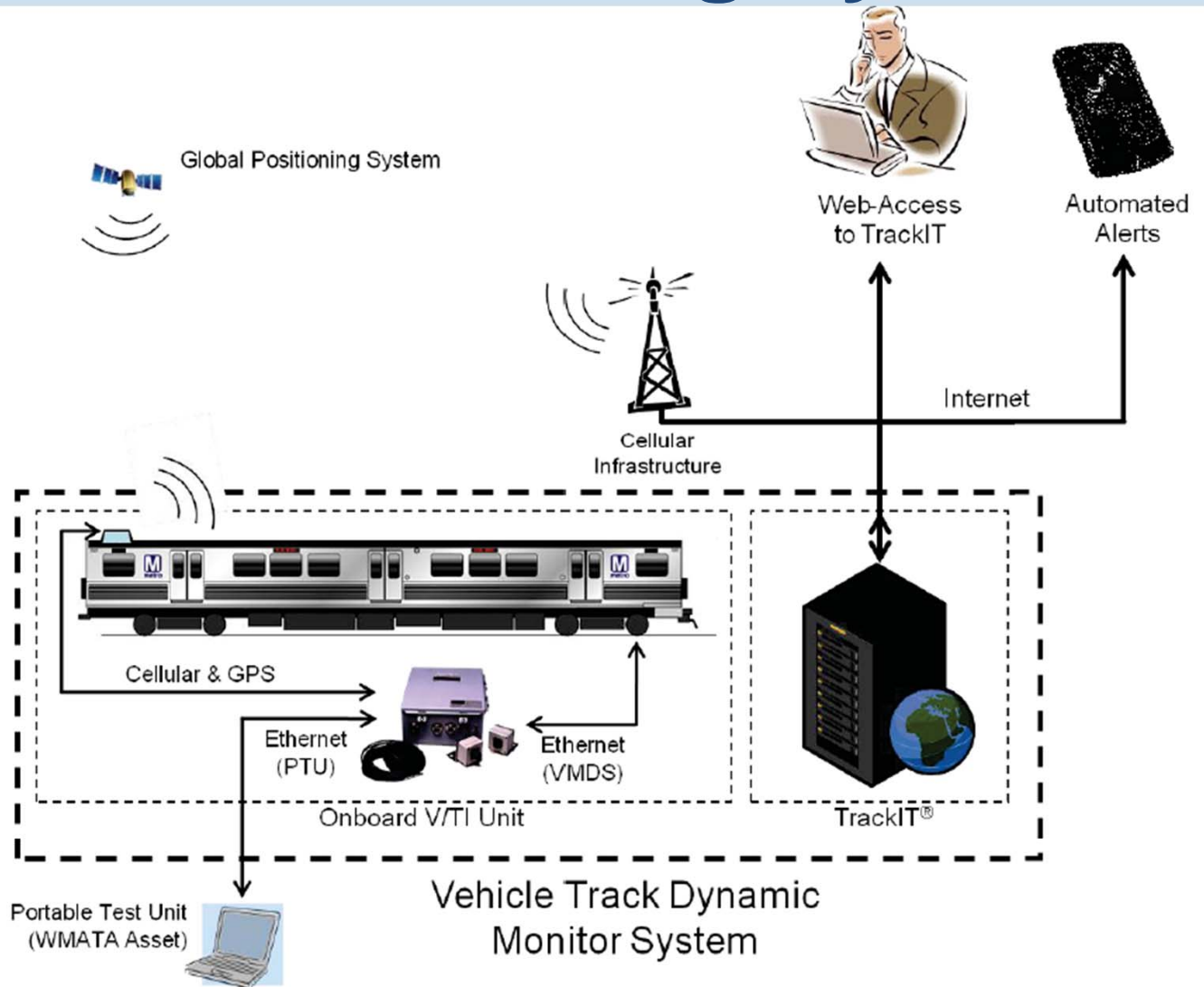


Figure 1: Vehicle/Track Dynamic Monitoring System



# V/VI DATA REPORT

Table		Report									
Date Range		From: 03/09/2015	To: 03/17/2015								
Line Code		All									
Results											
ChainMarker	Level	Latitude	Longitude	GPS Speed	ATC Speed	Dir	Car#	Trainset	Date	Value	Type
447.03	Near Urgent				41		7005	TestCar	03/12/2015 13:16:55	41236.52	AXV1-PEAK
447.08	Near Urgent				41		7001	TestCar	03/10/2015 11:19:12	41161.75	AXV1-PEAK
566.24	Near Urgent	39.030740	-77.104518	39	43	339	7001	TestCar	03/13/2015 15:06:42	46052.04	AXV1-PEAK
566.28	Near Urgent	39.030727	-77.104528	37	42	340	7001	TestCar	03/11/2015 15:15:44	43719.06	AXV1-PEAK
566.38	Near Urgent	39.030778	-77.104528	39	43	340	7001	TestCar	03/17/2015 13:28:02	44212.57	AXV1-PEAK
566.38	Near Urgent	39.030778	-77.104522	39	43	342	7001	TestCar	03/13/2015 12:44:48	45588.43	AXV1-PEAK
566.43	Near Urgent	39.030652	-77.104445	36	42	338	7005	TestCar	03/10/2015 14:12:59	45872.57	AXV1-PEAK
707.69	Near Urgent	39.064112	-77.122998	47	47	138	7001	TestCar	03/12/2015 13:07:20	41086.98	AXV2-PEAK
707.74	Near Urgent	39.063990	-77.122853	48	48	138	7001	TestCar	03/17/2015 11:10:49	41161.75	AXV2-PEAK
707.87	Near Urgent	39.064088	-77.122937	48	48	138	7001	TestCar	03/13/2015 13:06:30	40129.86	AXV2-PEAK
<b>Total no. of records 10</b>											
Total no. of records 10											



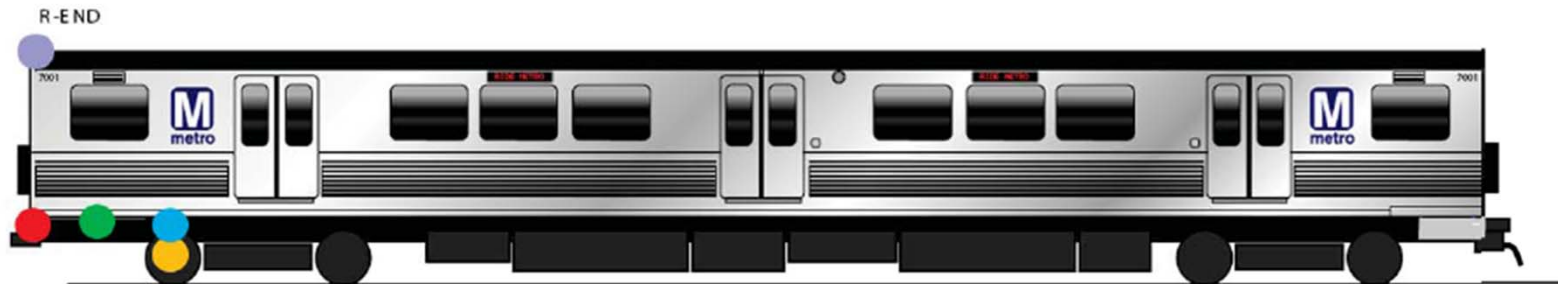
# V/T I Technology

- Total of 4 accelerometers in each system. 400 Hz sampling rate:
  - Car body (one) sensing vertical exceptions from poor vehicle suspension, and lateral accelerations from to track alignment. (+/- 2g)
  - Truck (one), sensing lateral accelerations and exceptions due to needed truck maintenance. (+/- 5g)
  - End of the axle (two) sensing vertical accelerations due to rail profile issues. (+/- 100g)

Axle vertical exceptions are typically associated with rail head defects, issues with welds, or joints.



# V/TI Equipment Positioning



7000 EXTERIOR ILLUSTRATION B-CAR



7000 INTERIOR FLOOR PLAN B-CAR

- Main V/TI Unit
- Carbody Sensor
- Truck Sensor
- Axle Sensors
- Antenna

Figure 4: VTI Equipment Positioning



# TGV vs. 7K Measuring Systems

- The two technologies measure track conditions, but differences in detail, scope of analysis, and frequency of measurements set them apart and specify their roles.
- The V/TI is revenue vehicle based, provides extensive and continuous measurement coverage through the railroad. Track surface and vehicle conditions.
- The TGV provides a deep level of inspection and analysis, identifying exceptions in track geometry, rail profile, train control circuits, and infrastructure position.



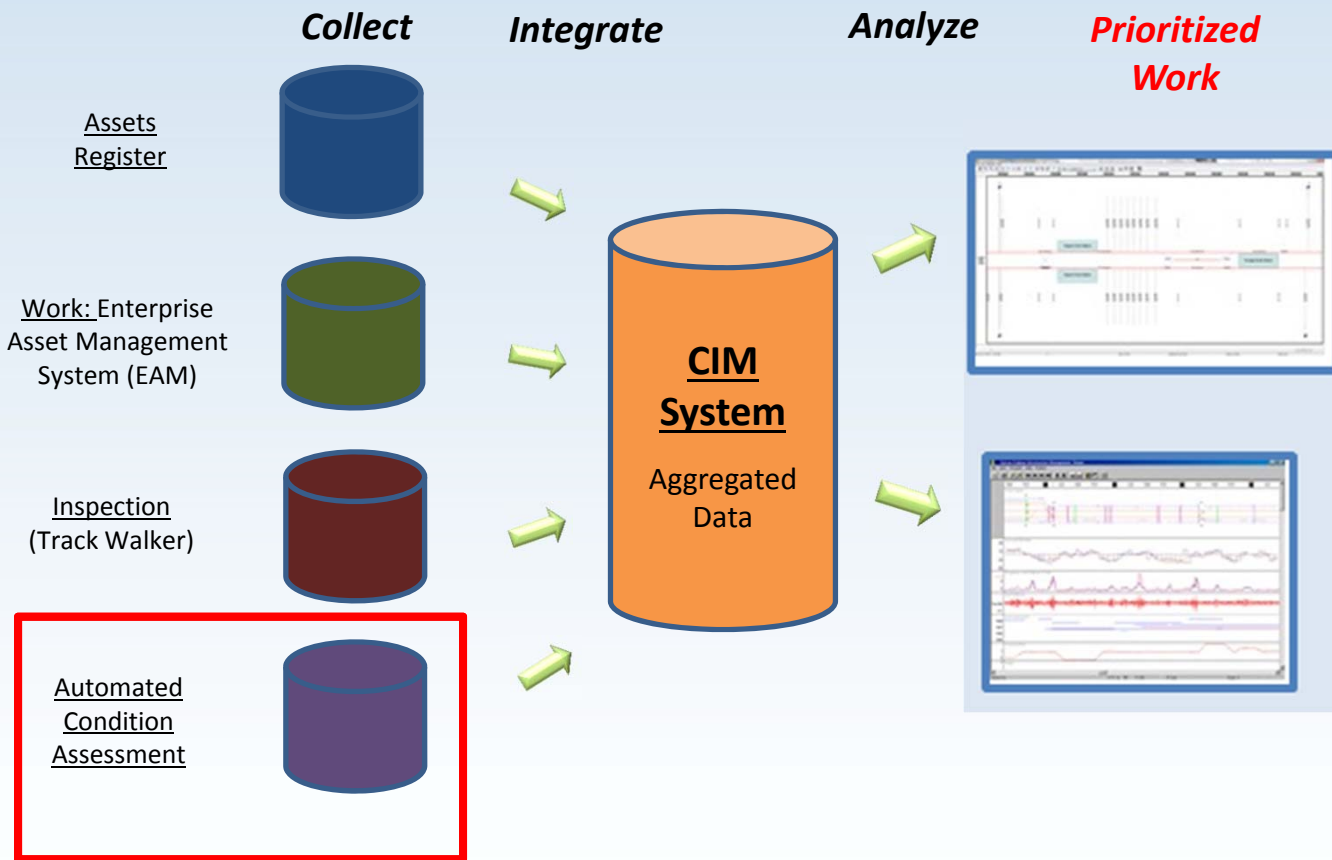


# How Is This Data Used?

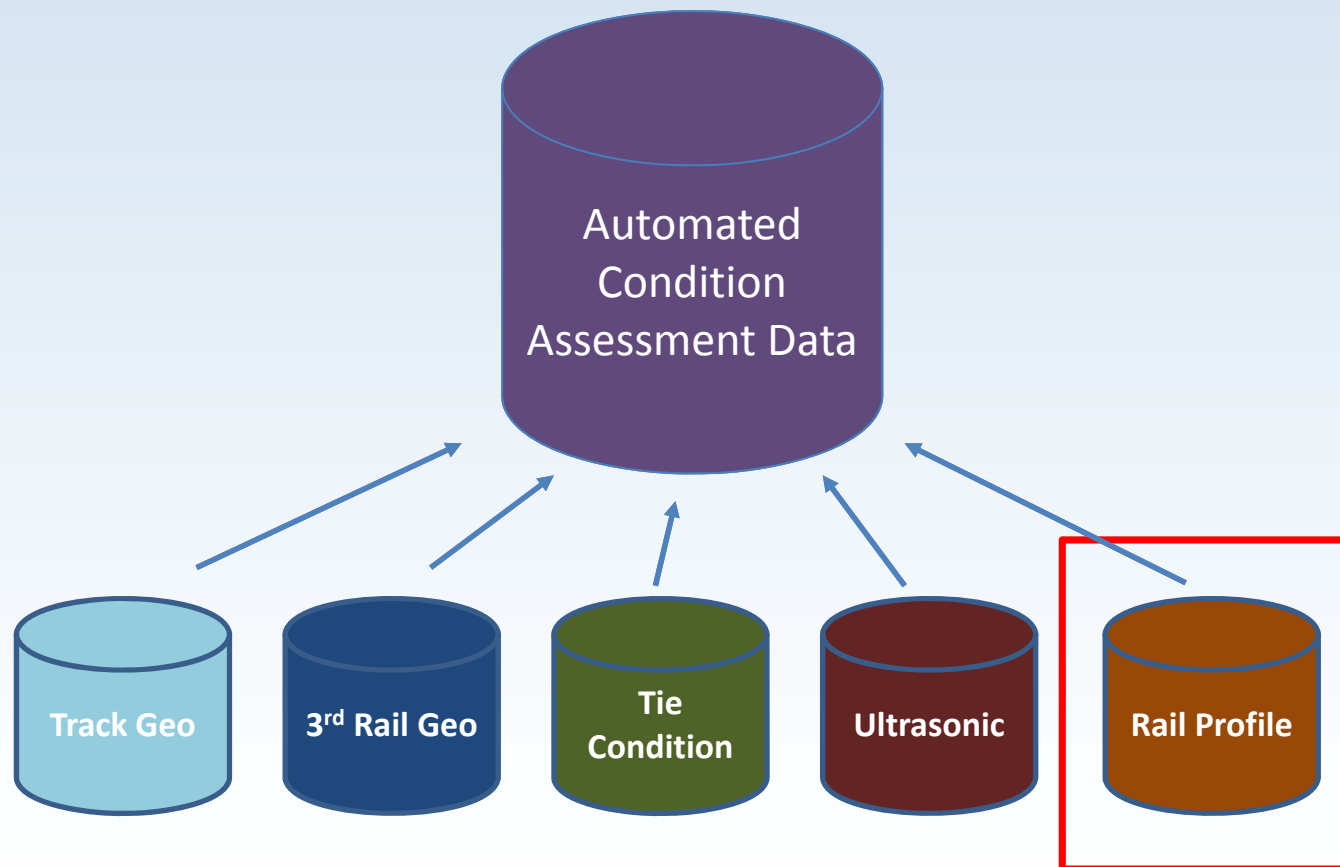
- Find the unseen problems (Ultrasonic Testing)
- Monitor the state of the track structure and ride quality
- Forecast wear rates and plan certain track maintenance activities



# Corridor Infrastructure Management



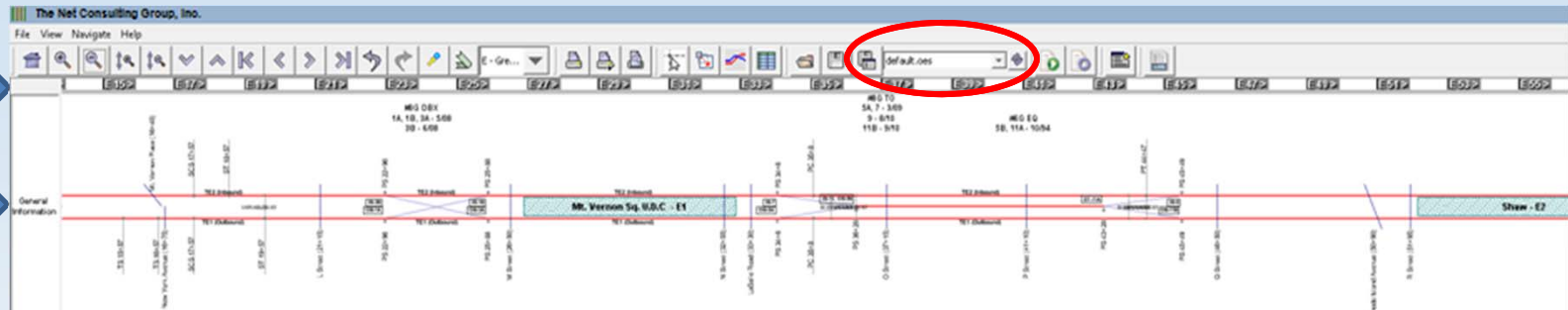
# Automated Condition Assessment



# Track Chart

Station Markers

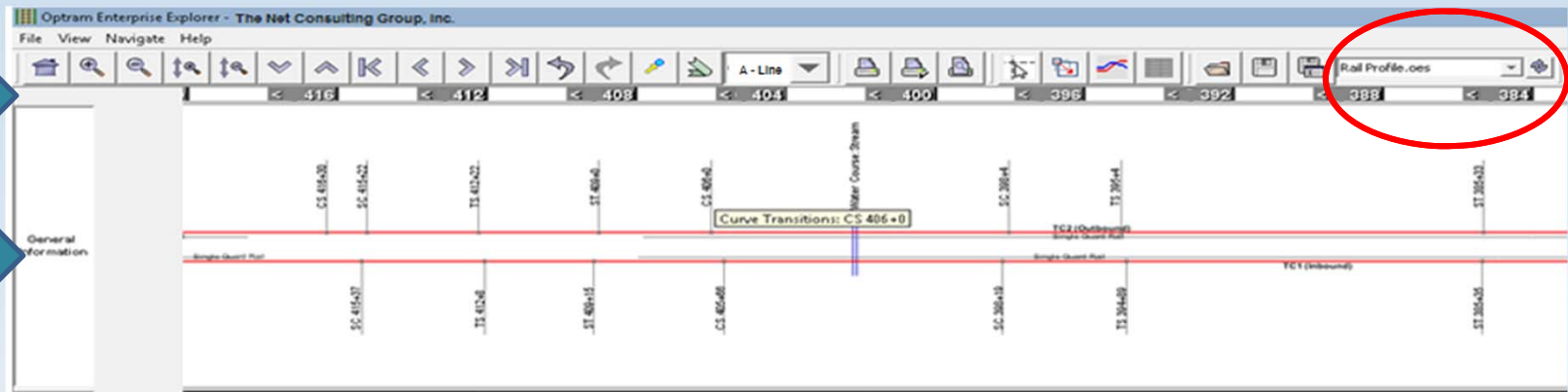
Track Layout



# Rail Profile

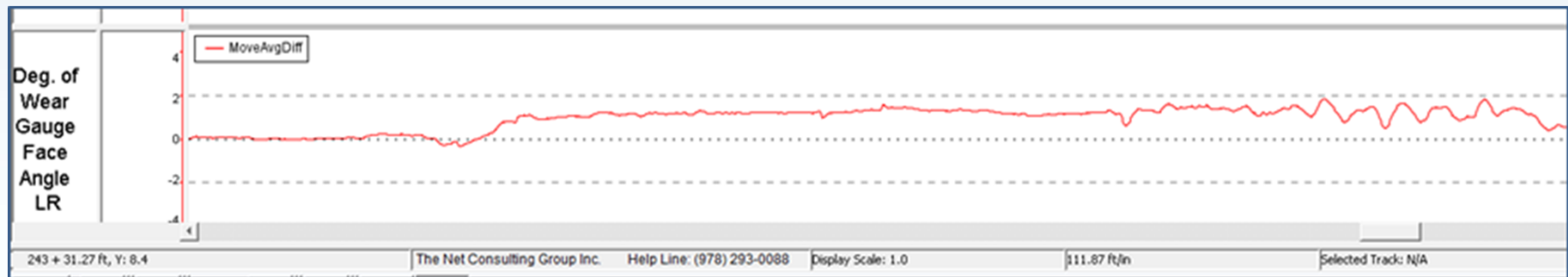
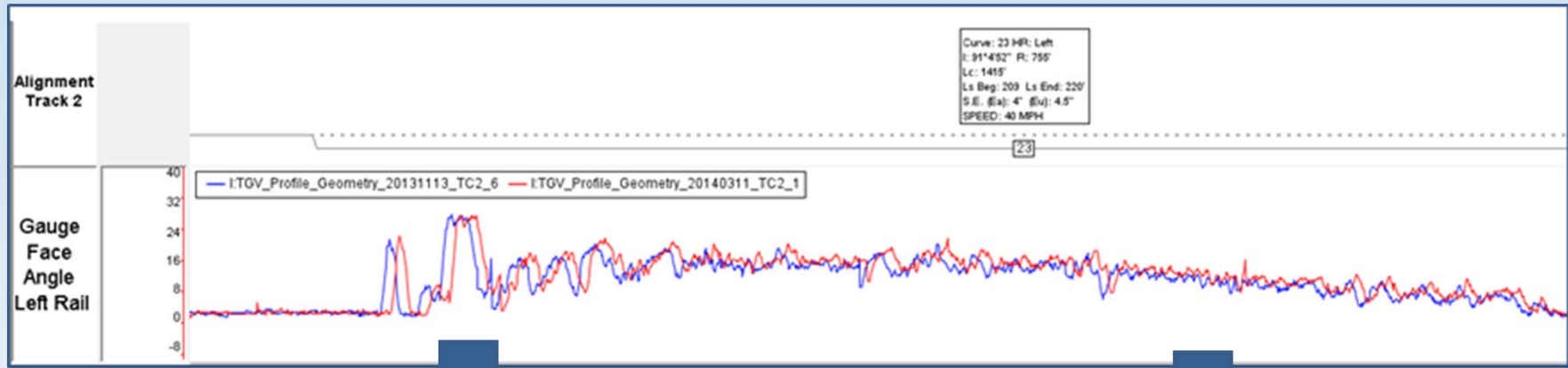
Station  
Markers

Track  
Layout &  
Assets



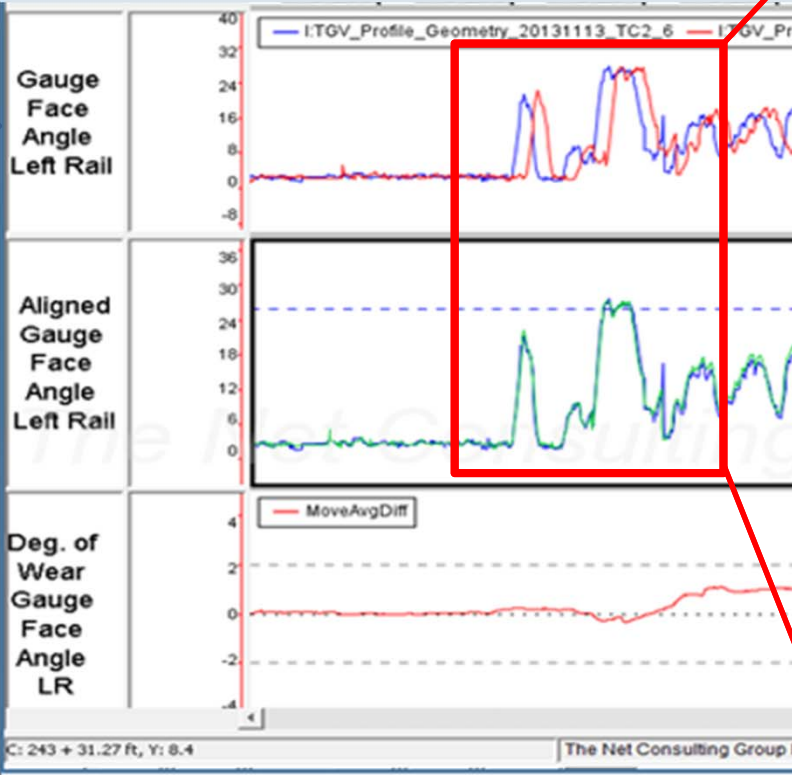


# Analytics



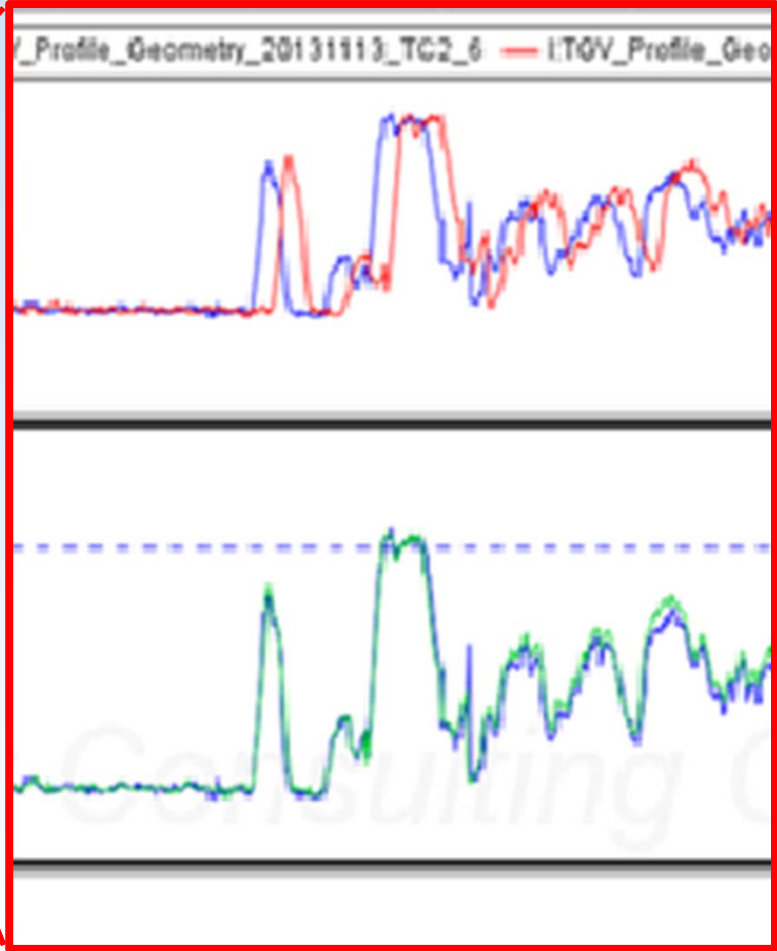
# Analytics

Raw Data



Aligned Data

Rate of Change



# Work Prioritization



# Work Prioritization

**Line A: 557 + 50ft, Track: TA2 (3)**

Date	Right_GFA_Peak
11/05/2013	21.2
03/29/2014	21.9
10/30/2014	22.8

Legend:  
■ Trend Rail Wear Matrix Last Survey - Right\_GFA  
■ Trend Rail Wear Matrix - Right\_GFA

Chart By Attribute: **Right\_GFA\_Peak**

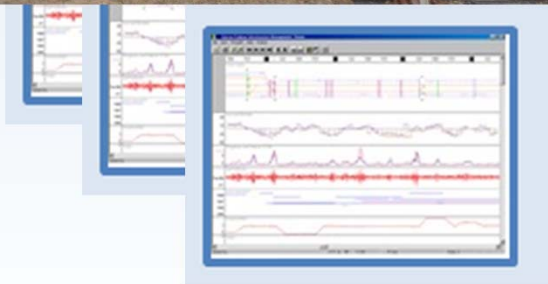
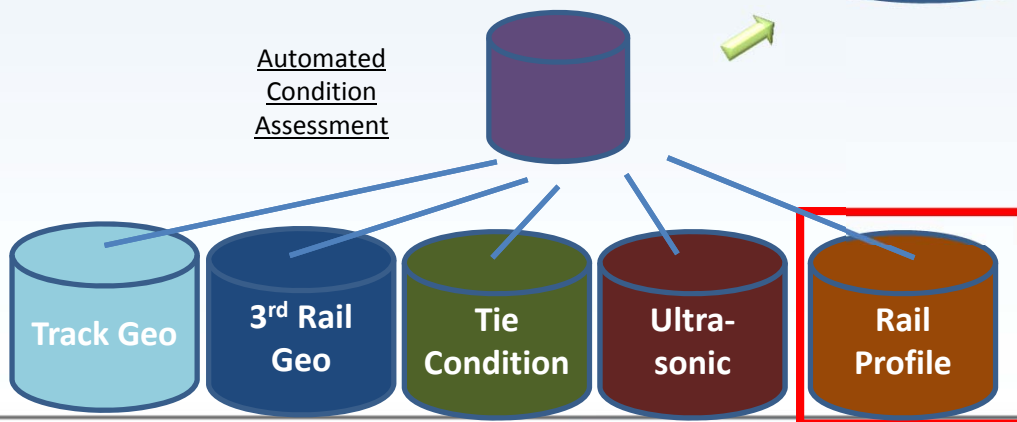
Buffer Size: 25 ft

Show Events: Trend Rail Wear Forecast - Right





# Corridor Infrastructure Management





# QUESTIONS ?

Ravi Amin, P.E. – Assistant Chief Engineer (Acting)  
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