

Use Of Hi-Rail Light Geometry Vehicles To Monitor Track For Compliance And Safety

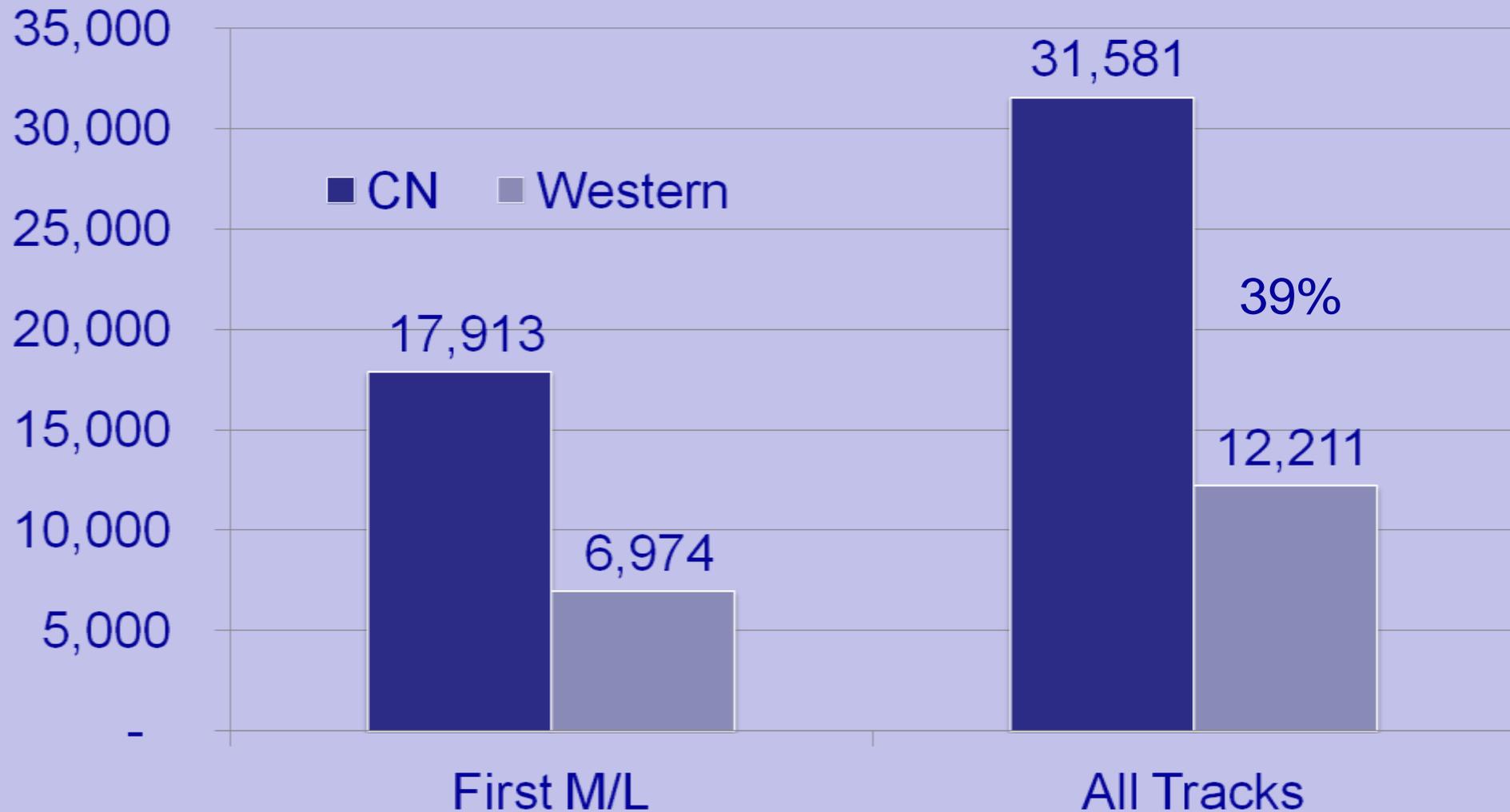


Tom Bourgonje
Chief Engineer
Western Region, CN

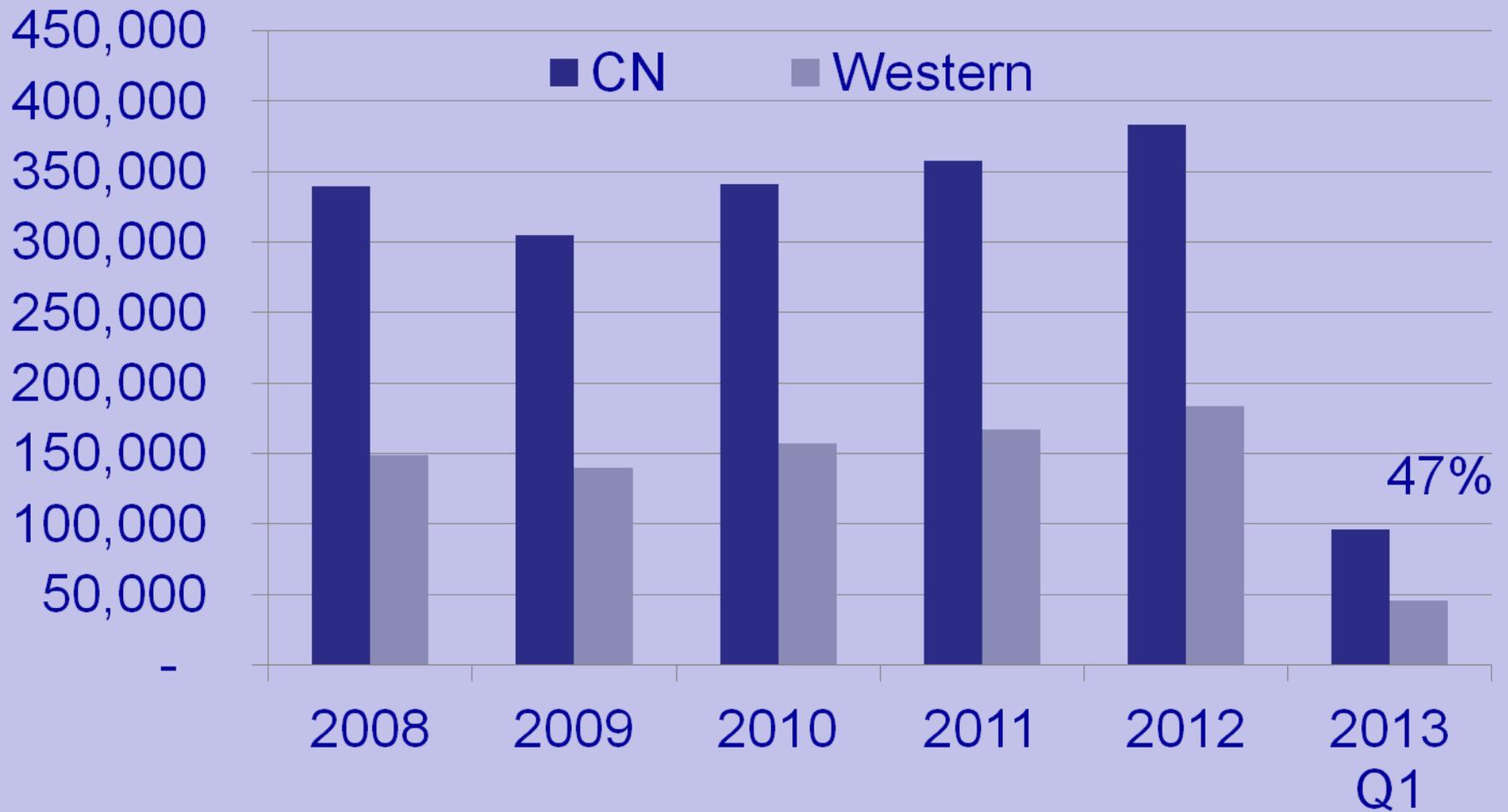




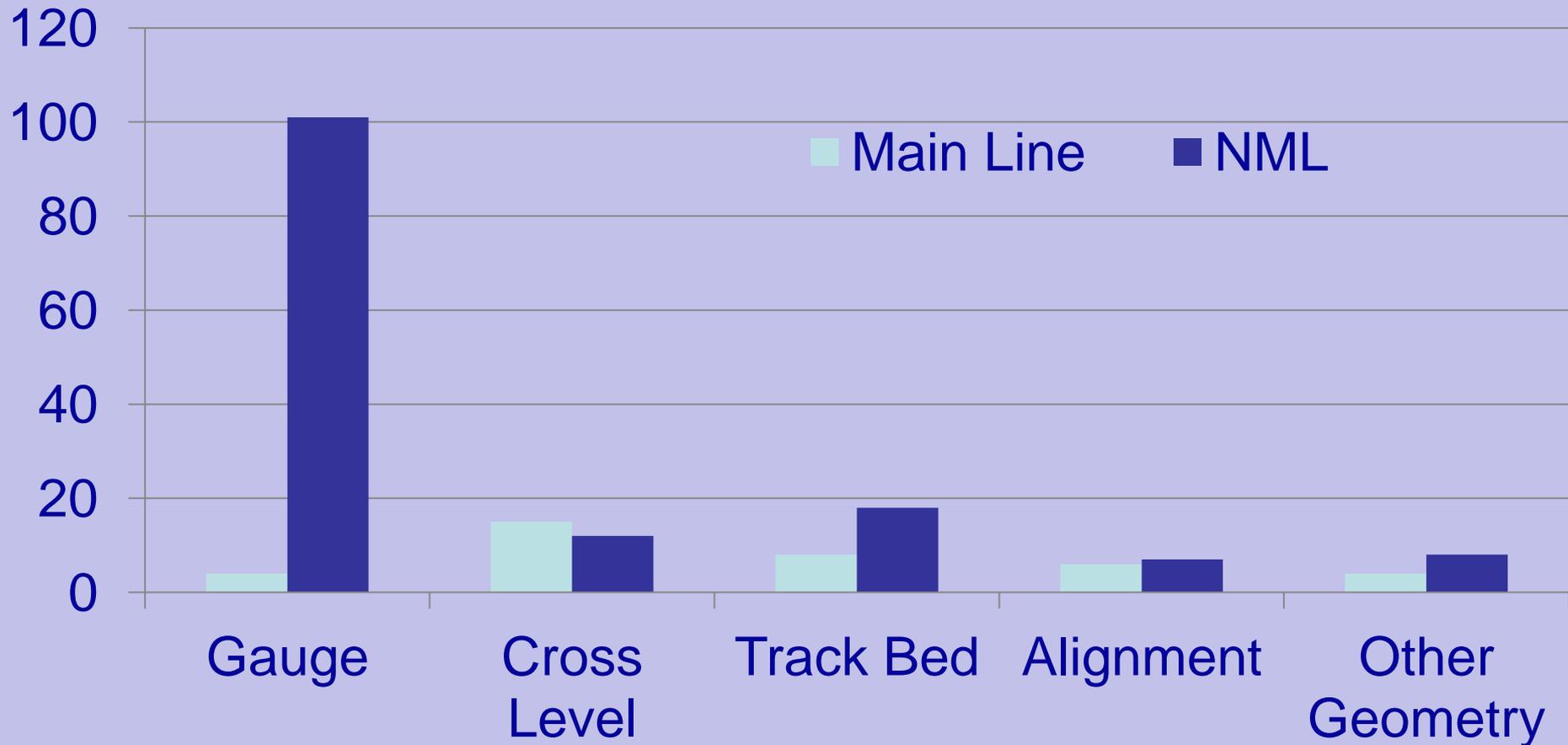
Trackage Statistics (Miles)



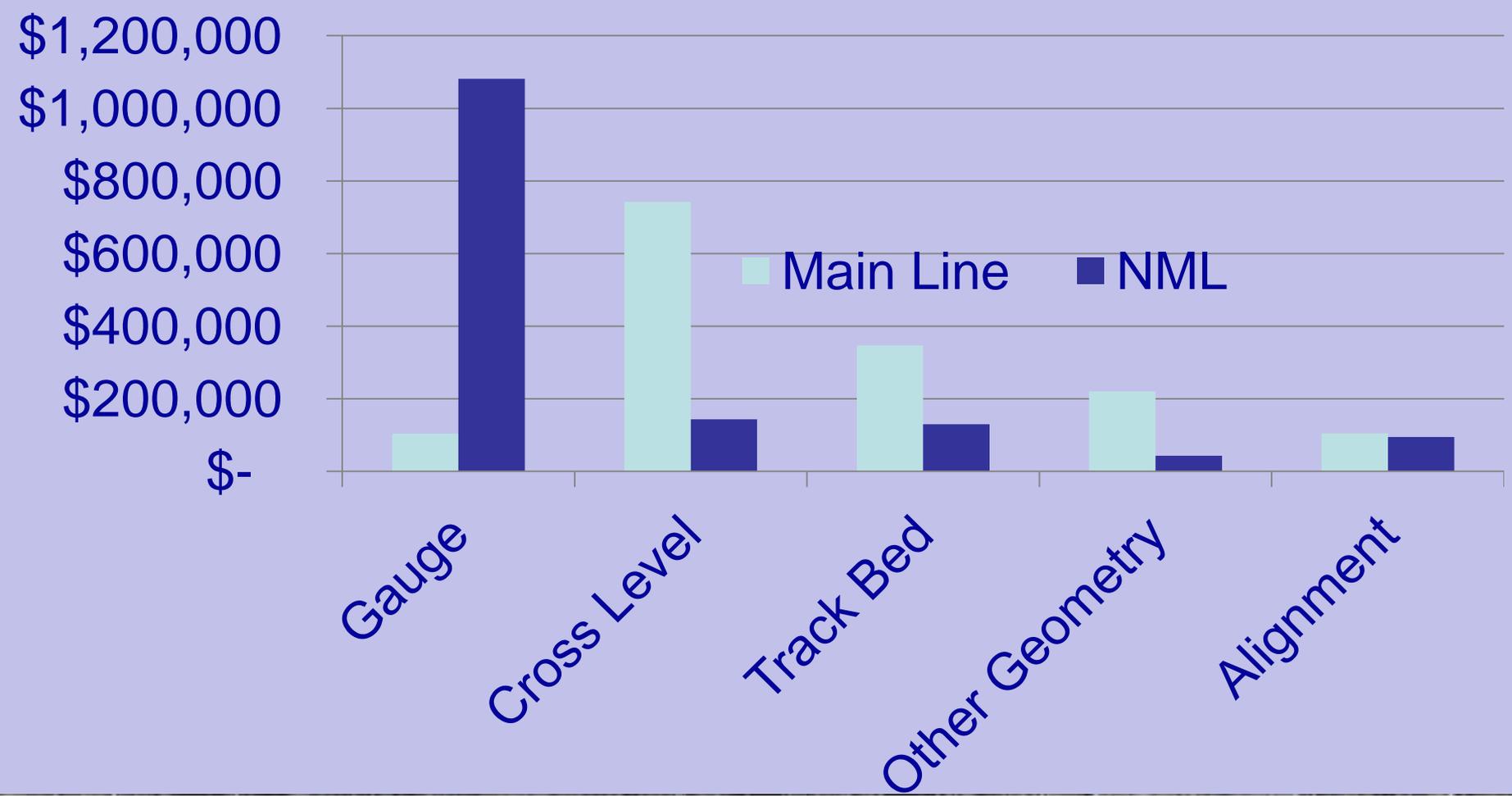
Annual Tonnage GTM (Millions)



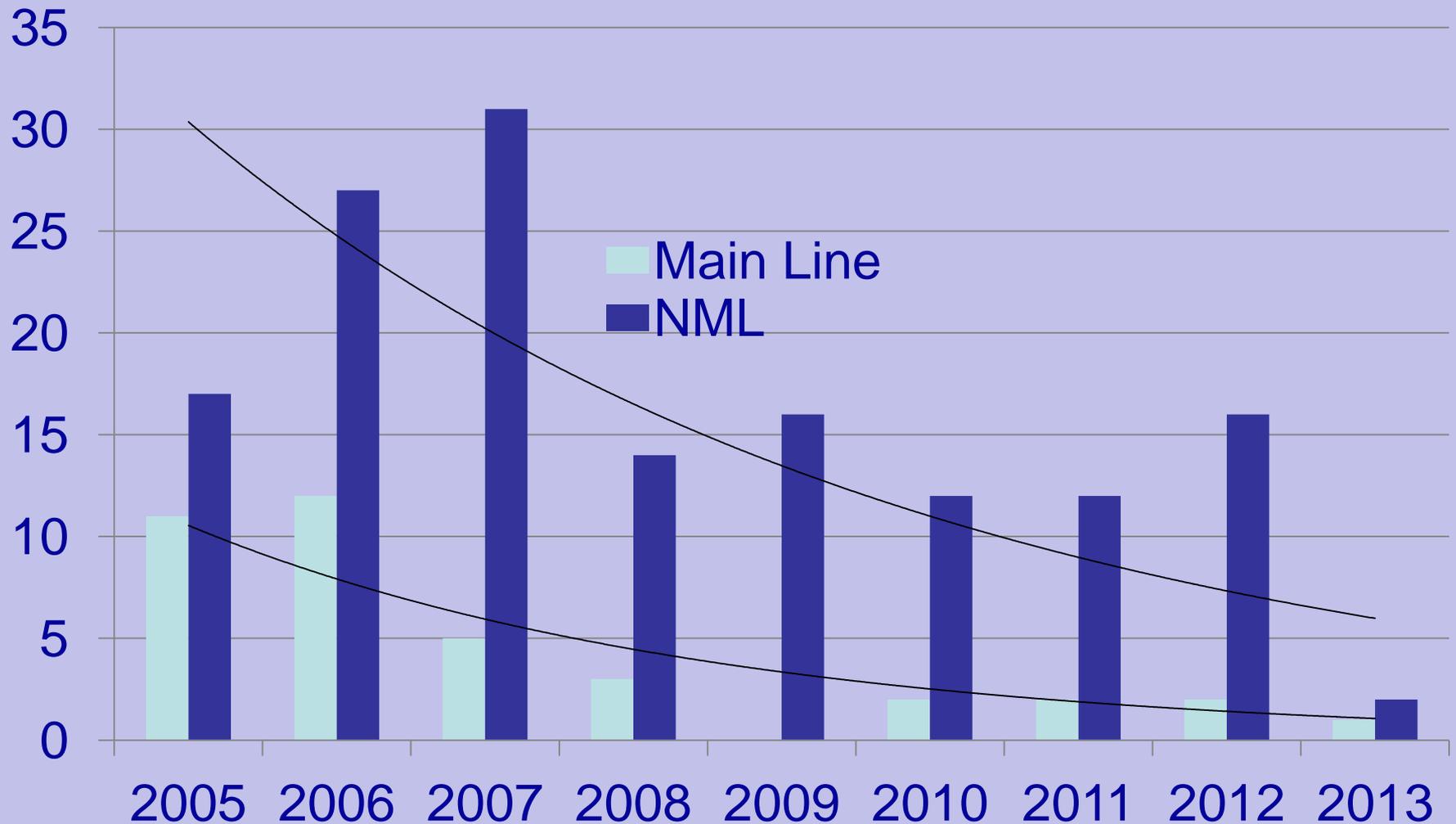
Number of Geometry Derailments by Exception (2005 to 2013)



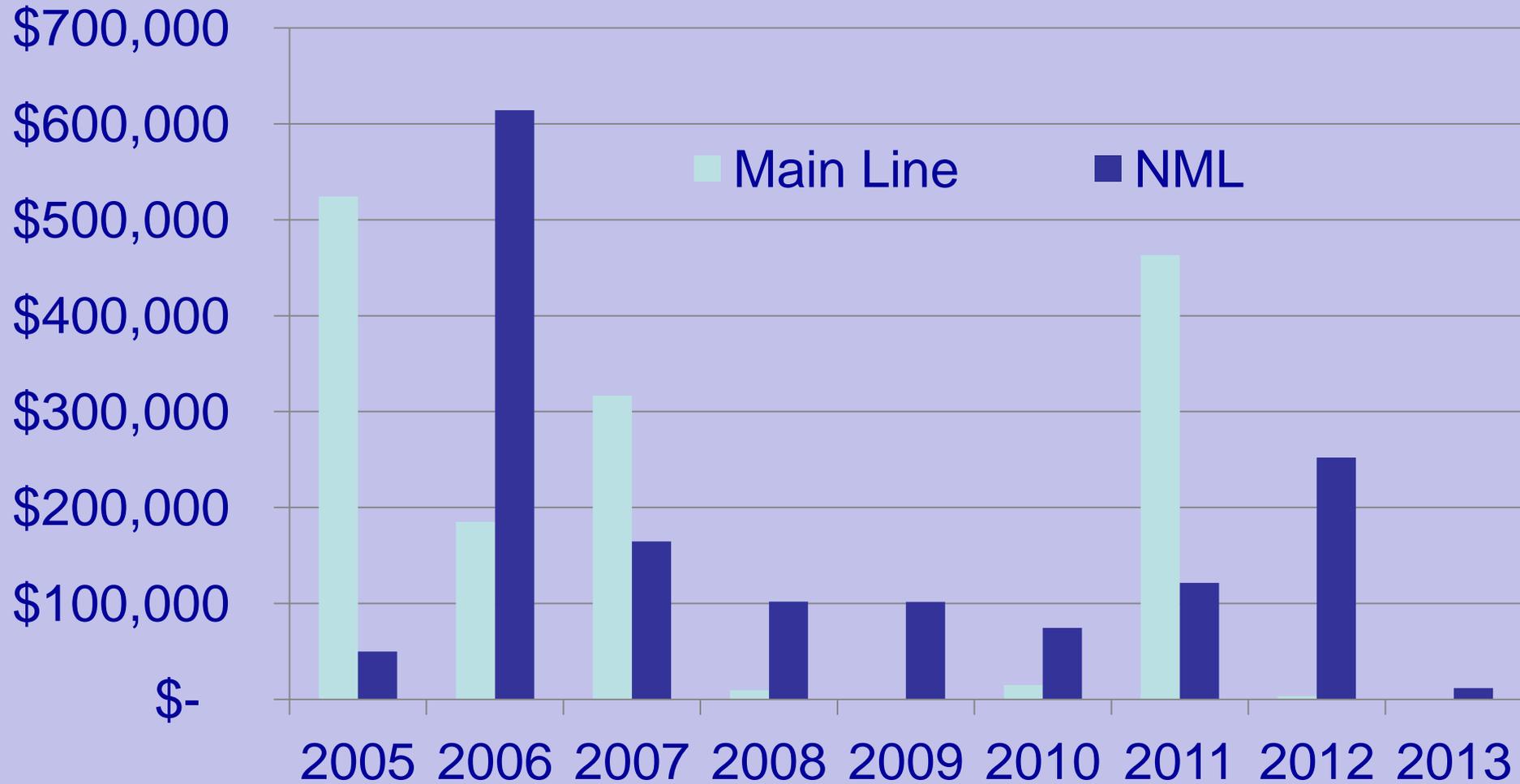
Cost of Derailment by Exception Type (2005 to 2013)



Geometry Caused Derailments by Year



Cost of Geometry Caused Derailments by Year



Find Defects Before They Find Us...



What is the result of limited track geometry testing?

- Increases in slow orders and derailments reduce train velocity
- Wasted energy, higher cost of maintenance



Some exceptions are difficult to identify visually



What is the Ideal Testing Frequency? What Do We Gain?

What affects the changes in track geometry?

- Weather (frost heaves, soft track condition due to saturation)
- Influences in track substructures (Ballast, sub ballast, subgrade)
- Structural influences (bad wheels, poor track hardware, and/or lack of good track maintenance)



How Can We 'Control the Controllable'?

- Prediction is the best way to be proactive
- Identify geometry issues before any negative impacts on traffic (speed restrictions, train delays)
- Increase “Proactive” and decrease ‘Reactive’ approach



Geometry Exceptions Severity

CN's Geometry Cars classify exceptions
in three severity levels:

1. Urgent
2. Near Urgent (90% of urgent +/-)
3. Priority



Geometry Exception Types

- Gauge
- Rail wear/Cant
- Alignment and curvature
- Cross level, Superelevation
- Vmax
- Warp (31/62 ft), Twist
- Surface, Rock & Roll, Runoff



CN 15008/15009 (ImageMap System)



CN 1501 (ENSCO System)



Autonomous Vehicle/Track Interaction (VTI) Monitoring (ENSCO)

It's a tool that:

- Detects vehicle and track interaction deviations
- Provides a proactive approach to reducing damage to vehicles and track
- Improves the track inspection process
- Quantifies and prioritizes the exceptions
- Can prevent costly service and equipment failures



Holland Company's GRMS TrackStar Contracted as required



Light Geometry Inspection Vehicle (LGIV)

CN currently has 10 hi-rail based Andian SolidTrack systems in Western region, 6 on Eastern region, and 2 on Southern region.

All units are operated by local engineering managers / supervisors.



The Anatomy of an Andian SolidTrack System

Mechanical gauge sensor



Single person operation with laptop at the driver's finger tips.



Storage and electronic inertial module



Operator's view with real time geometry data





Pre test preparation



Getting on track



Verify Measurement



Lifting Gage System Prior Of Passing A Switch

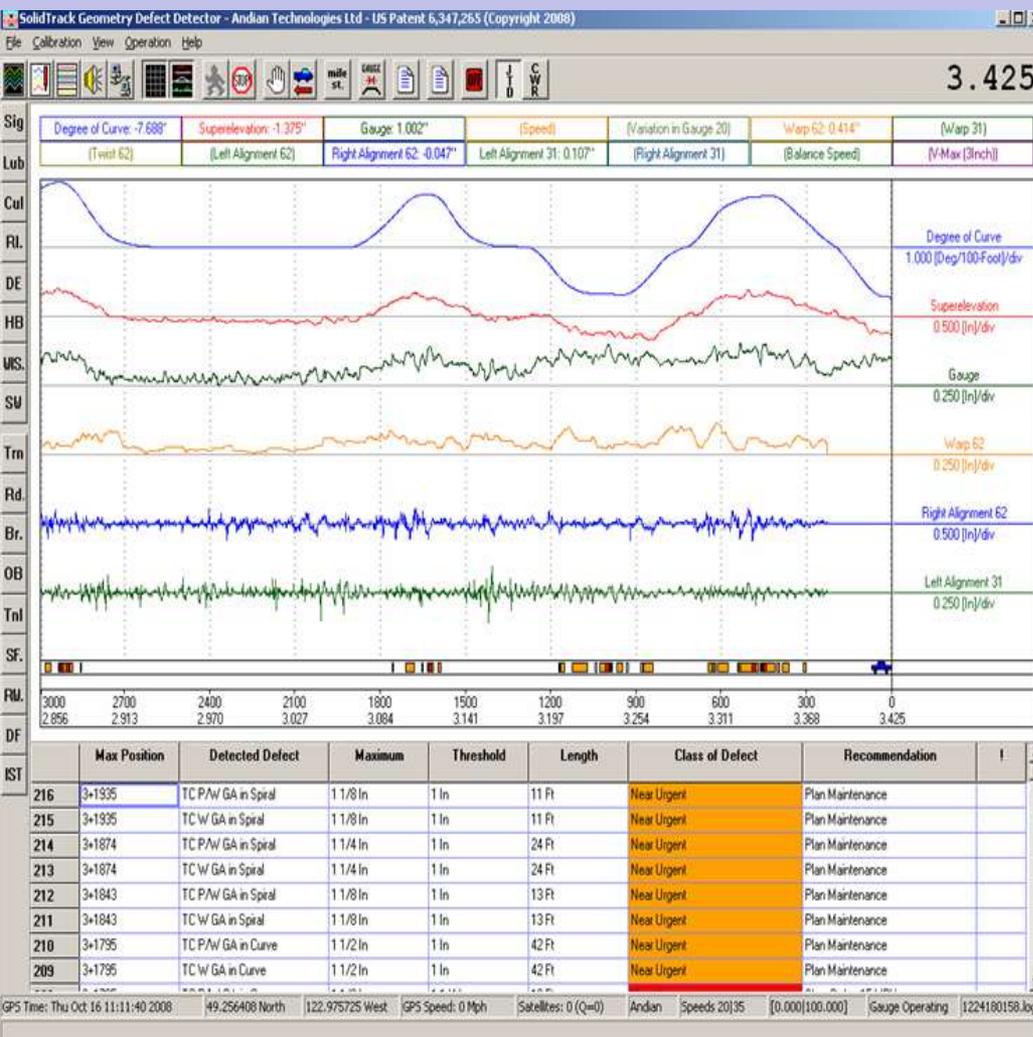


SolidTrack Overview Video



What SolidTrack Measures:

- Gauge
 - Alignment/Curvature
 - Cross level, Superelevation
 - Warp/Twist
 - Surface, Rock & Roll
 - V-Max
- Defects are displayed in real time allowing user to immediately validate the identifies conditions
- User is alerted to defects with color and audio cues



Benefits of SolidTrack Geometry Testing

- Increased fluidity/ flexibility (Take off and run)
 - Better organization of maintenance and repairs
 - No train crew/ Loco unit required
 - Maximized track time
 - Reduced derailments
 - Stop and verify
 - Reduced rail wear
 - Reduced wheel wear
 - Lower fuel consumption
-
- Training oversight for young supervisors (Seeing Eye Dog)



SolidTrack System and Data Management Software

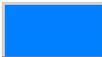
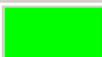
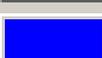
- Slow orders rapidly removed
- Hi-rail geometry allows for rapid deployment
- Highly effective for monitoring rapidly changing track environments
- Ensures total track safety and compliance to enhance and maintain track velocity
- Allows for rapid traceability of defects
- Assures any speed restrictions are warranted
- Capital planning
- Comprehensive software package for better management of scheduling and forecasting of maintenance



SolidTrack Channel Setup (1)

Channels Configuration

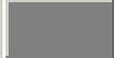
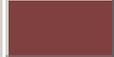
Channels

| | Colour | Units | Name | Round | Scale | |
|-----|-------------------------------------|---|-----------|---------------------------|------------|-------|
| 1. | <input checked="" type="checkbox"/> |  | deg/100ft | Degree of Curve | 3 Decimals | 1.000 |
| 2. | <input checked="" type="checkbox"/> |  | in | Superelevation | 3 Decimals | 0.250 |
| 3. | <input type="checkbox"/> |  | in | Crosslevel (From Balance) | 3 Decimals | 0.500 |
| 4. | <input checked="" type="checkbox"/> |  | in | Gauge | 3 Decimals | 0.250 |
| 5. | <input type="checkbox"/> |  | in | Driver-Side Gauge | 3 Decimals | 0.250 |
| 6. | <input type="checkbox"/> |  | in | Passenger-Side Gauge | 3 Decimals | 0.250 |
| 7. | <input type="checkbox"/> |  | mph | Speed | 3 Decimals | 3.000 |
| 8. | <input type="checkbox"/> |  | deg/100ft | 155 Curvature | 3 Decimals | 1.000 |
| 9. | <input type="checkbox"/> |  | in | Variation of Gauge 20 | 3 Decimals | 0.125 |
| 10. | <input type="checkbox"/> |  | in | Warp 31 | 3 Decimals | 0.250 |
| 11. | <input type="checkbox"/> |  | in | Warp 62 | 3 Decimals | 0.250 |
| 12. | <input type="checkbox"/> |  | in | Twist 62 | 3 Decimals | 0.250 |



SolidTrack Channel Setup (2)

Channels Configuration

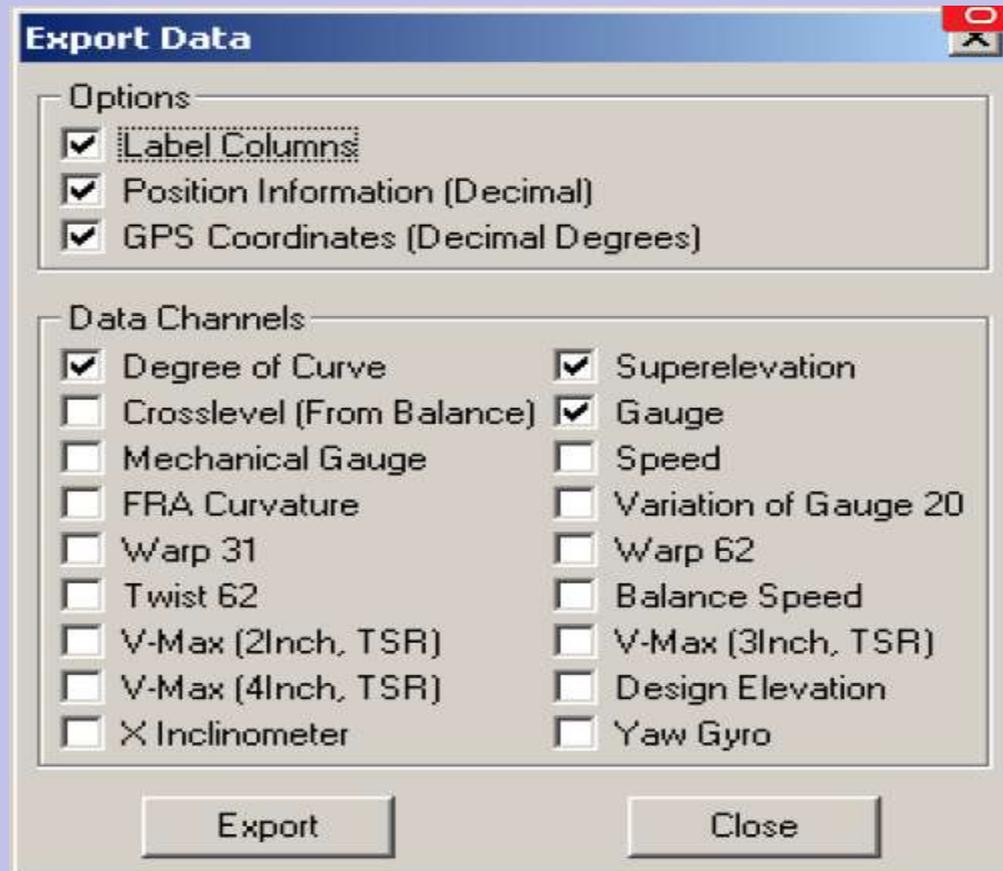
| | | | | | | |
|-----|--------------------------|--|-----|--------------------|------------|-------|
| 13. | <input type="checkbox"/> |  | mph | Balance Speed | 3 Decimals | 5.000 |
| 14. | <input type="checkbox"/> |  | mph | V-Max (2Inch) | 3 Decimals | 5.000 |
| 15. | <input type="checkbox"/> |  | mph | V-Max (3Inch) | 3 Decimals | 5.000 |
| 16. | <input type="checkbox"/> |  | mph | V-Max (4Inch) | 3 Decimals | 1.000 |
| 17. | <input type="checkbox"/> |  | mph | V-Max (2Inch, 155) | 3 Decimals | 5.000 |
| 18. | <input type="checkbox"/> |  | mph | V-Max (3Inch, 155) | 3 Decimals | 5.000 |
| 19. | <input type="checkbox"/> |  | mph | V-Max (4Inch, 155) | 3 Decimals | 1.000 |
| 20. | <input type="checkbox"/> |  | in | Design Elevation | 3 Decimals | 1.000 |
| 21. | <input type="checkbox"/> |  | mph | GPS Speed | 3 Decimals | 1.000 |

Accept Apply Cancel



Exporting data to CSV Format

(useable for any database application)



Comprehensive Software Package

SolidTrack (Client/Server)

- Records geometry data real time with GPS
- Integrated DefectFinder module to overlay and compare previously collected data while testing

GeoPrint

- Post run viewing and data comparison
Custom report generation.
Bring the field to the office.



SolidTrack Graphic User Interface (Client)

SolidTrack Geometry Defect Detector - Andian Technologies Ltd - US Patent 6,347,265 (Copyright 2013)

File Calibration View Defect Finder Operation Help

TIE [Icons] STOP SPEED 17.8 GAUGE 0.244 Trk. st. mile st. TSO LIMITS 15+224

| | | | | | |
|-----|--------------------------|---------------------------|----------------------------|--------------------------|---------------------------|
| Cr. | Degree of Curve: 10.317° | Superelevation: 2.897" | Gauge: 0.244" | Speed: 17.848MPH | Warp 62: 1.109" |
| Cul | V-Max (3Inch): 0.000MPH | Left Alignment 62: 0.084" | Right Alignment 62: 0.014" | Left Surface 62: -0.597" | Right Surface 62: -0.123" |

| | | | |
|-----|-----------------|-----------------------|-------------------------|
| DE | Degree of Curve | 2.000 [deg/100ft]/div | Live Reading: 10.317° |
| DR | Superelevation | 0.500 [in]/div | Live Reading: 2.897" |
| HB | Gauge | 0.200 [in]/div | Live Reading: 0.244" |
| Lub | Warp 62 | 0.250 [in]/div | Current Reading: 1.109" |

| | | | | | | | | | | | |
|-----|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|--------|
| Br. | 2500 | 2250 | 2000 | 1750 | 1500 | 1250 | 1000 | 750 | 500 | 250 | 15+224 |
| DF | 14+3015 | 14+3265 | 14+3515 | 14+3765 | 14+4015 | 14+4265 | 14+4515 | 14+4765 | 14+5015 | 14+5265 | |

| | Position | Description | Maximum | Threshold | Length | Class of Defect | Recommendation | ! | |
|-----|----------|-------------|------------------------|-----------|----------|-----------------|------------------|-------------|--|
| IST | 5 | 15+8 | T.C.6.6 WARP 62 - | 2 1/8 in | 1.800 in | 10 Ft | URGENT WARNING | PLAN MAINT. | |
| OB | 4 | 14+5277 | T.C.6.6 WARP 62 - | 1 7/8 in | 1.800 in | 6 Ft | URGENT WARNING | PLAN MAINT. | |
| | | 15+0 | Milepost 15 | | | | | | |
| Rd. | 3 | 14+4895 | T.C.6.6 WARP 62 - | 1 7/8 in | 1.800 in | 4 Ft | URGENT WARNING | PLAN MAINT. | |
| RW. | 2 | 14+4845 | T.C.6.6 WARP 62 - | 2 1/8 in | 1.800 in | 12 Ft | URGENT WARNING | PLAN MAINT. | |
| | 1 | 14+2158 | MC.TC.21 WGA CONCERN - | 7/8 in | 0.700 in | 16 Ft | PRIORITY WARNING | | |
| SF. | | 14+2112 | Milepost 14.4 | | | | | | |
| SP | | | | | | | | | |

GPS Time: Fri May 03 09:56:08 2013 49.412387 North 123.240124 West GPS Speed: 18 Mph Satellites: 3 (Q=1) Squamish Speeds25|25|--- [10.900|42.000] Gauge Operating Squamish 14.4 N.log



Zone, PSO, TSO speed elevation

SolidTrack Geometry Defect Detector - Andian Technologies Ltd - US Patent 6,347,265 (Copyright 2013)

File Calibration View Defect Finder Operation Help

TIE
YARD
STOP
SPEED 19.7
RETEST
GAUGE 0.352
Trk. st.
mile st.
TSO
LIMITS
15+680

| | | | | | |
|-----|-------------------------|----------------------------|-----------------------------|-------------------------|--------------------------|
| Cr. | Degree of Curve: 1.685° | Superelevation: 0.057" | Gauge: 0.352" | Speed: 19.709MPH | Warp 62: 0.577" |
| Cul | V-Max (3Inch): 0.000MPH | Left Alignment 62: -0.220" | Right Alignment 62: -0.316" | Left Surface 62: 0.245" | Right Surface 62: 0.094" |

TSO Listing

Subdivision: subs\Squamish.sub

| From | To | F-Speed | P-Speed | L-Speed | Reason |
|---------|---------|---------|---------|---------|--------|
| 15.0000 | 15.6000 | 20 | 20 | | |

Enter TSO Information

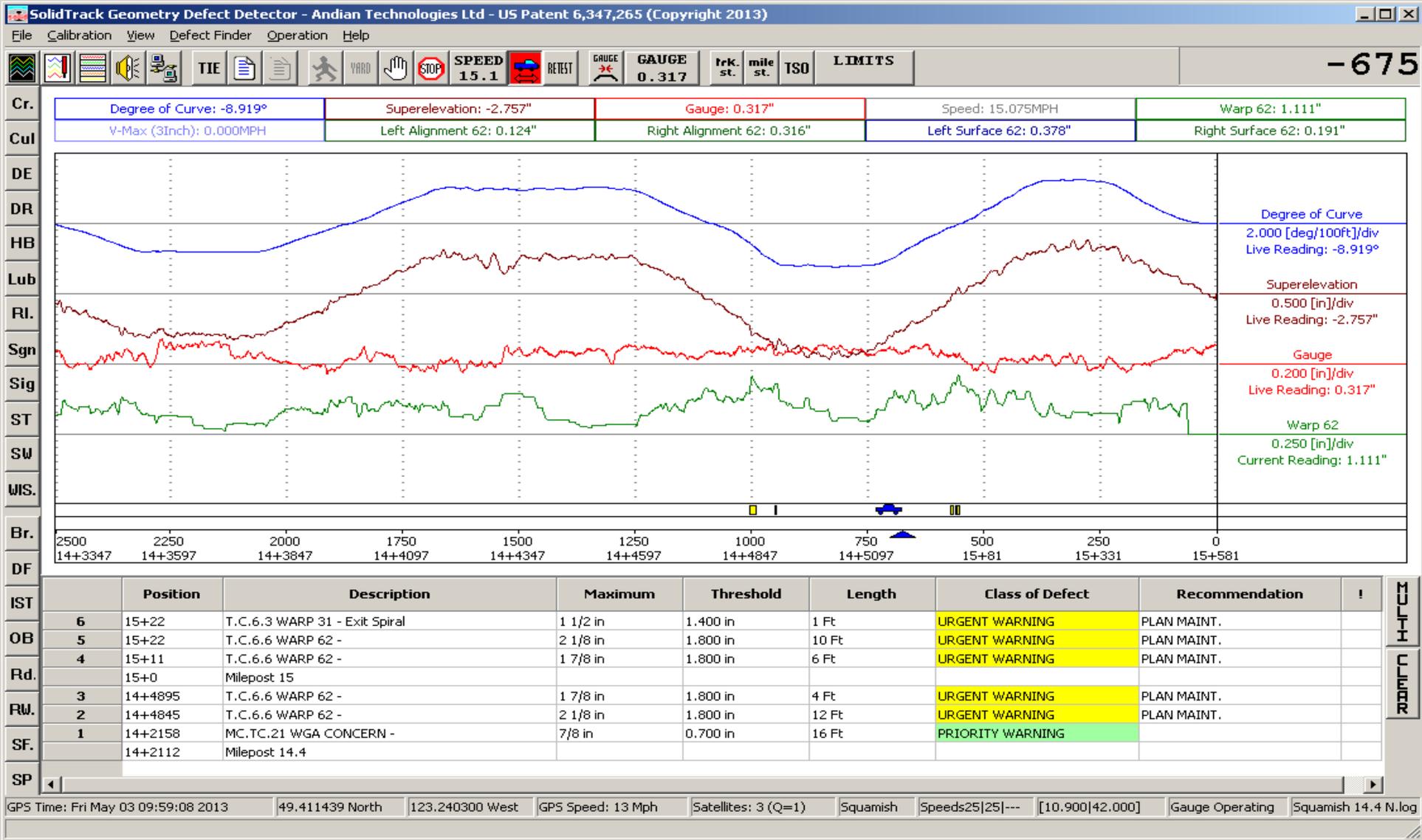
| From | To | F-Speed | P-Speed | L-Speed | Reason |
|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| <input type="text"/> |

| Position | Description | Maximum | Threshold | Length | Class of Defect | Recommendation | ! |
|----------|---|----------|-----------|--------|------------------|----------------|---|
| 15+680 | Comment: TSO 15.0000, 15.6000, 20, 20,, | | | | | | ! |
| 6 | 15+22 T.C.6.3 WARP 31 - Exit Spiral | 1 1/2 in | 1.400 in | 1 Ft | URGENT WARNING | PLAN MAINT. | |
| 5 | 15+22 T.C.6.6 WARP 62 - | 2 1/8 in | 1.800 in | 10 Ft | URGENT WARNING | PLAN MAINT. | |
| 4 | 15+11 T.C.6.6 WARP 62 - | 1 7/8 in | 1.800 in | 6 Ft | URGENT WARNING | PLAN MAINT. | |
| | 15+0 Milepost 15 | | | | | | |
| 3 | 14+4895 T.C.6.6 WARP 62 - | 1 7/8 in | 1.800 in | 4 Ft | URGENT WARNING | PLAN MAINT. | |
| 2 | 14+4845 T.C.6.6 WARP 62 - | 2 1/8 in | 1.800 in | 12 Ft | URGENT WARNING | PLAN MAINT. | |
| 1 | 14+2158 MC.TC.21 WGA CONCERN - | 7/8 in | 0.700 in | 16 Ft | PRIORITY WARNING | | |
| | 14+2112 Milepost 14.4 | | | | | | |

GPS Time: Fri May 03 10:03:21 2013 | 49.413316 North | 123.239030 West | GPS Speed: 20 Mph | Satellites: 3 (Q=1) | **Squamish** | Speeds25|25|--- | [10.900|42.000] | Gauge Operating | Squamish 14.4 N.10g



Auto Backup and Re-test Features



Track ID and Speed Over-ride Mode

SolidTrack Geometry Defect Detector - Andian Technologies Ltd - US Patent 6,347,265 (Copyright 2013)

File Calibration View Defect Finder Operation Help

TIE YARD STOP SPEED 19.7 RETEST GAUGE GAUGE 0.352 Trk. st. mile st. TSO LIMITS 15+680

Cr. Degree of Curve: 1.685° Superelevation: 0.057" Gauge: 0.352" Speed: 19.709MPH Warp 62: 0.577"

Cul V-Max (3Inch): 0.000MPH Left Alignment 62: -0.220" Right Alignment 62: -0.316" Left Surface 62: 0.245" Right Surface 62: 0.094"

DE

DR

HB

Lub

RI.

Sgn

Sig

ST

SW

WIS.

Br.

DF

IST

OB

Rd.

RW.

SF.

SP

GPS Time: Fri May 03 10:06:23 2013 49.413316 North 123.239030 West GPS Speed: 20 Mph Satellites: 3 (Q=1) Squamish Speeds25|25|--- [10.900|42.000] Gauge Operating Squamish 14.4 N.10g

Track Override

Override Track Speeds:

Override Subdivision Speeds

Freight Traffic Speed: Not Tested

Passenger Traffic Speed: Not Tested

LRC Traffic Speed: Not Tested

Override Track:

Override Track

Track Selection: M1 - Main Track 1

Override Remove

Track Override

Override Track Speeds:

Override Subdivision Speeds

Freight Traffic Speed: Not Tested

Passenger Traffic Speed: Not Tested

LRC Traffic Speed: Not Tested

Override Track:

Override Track

Track Selection:

Override Remove

| Position | Description | Maximum | Threshold | Length | Class of Defect | Recommendation | ! |
|----------|---|----------|-----------|--------|------------------|----------------|---|
| 15+680 | Comment: TSO 15.0000, 15.6000, 20, 20,, | | | | | | ! |
| 6 | 15+22 T.C.6.3 WARP 31 - Exit Spiral | 1 1/2 in | 1.400 in | 1 Ft | URGENT WARNING | PLAN MAINT. | |
| 5 | 15+22 T.C.6.6 WARP 62 - | 2 1/8 in | 1.800 in | 10 Ft | URGENT WARNING | PLAN MAINT. | |
| 4 | 15+11 T.C.6.6 WARP 62 - | 1 7/8 in | 1.800 in | 6 Ft | URGENT WARNING | PLAN MAINT. | |
| | 15+0 Milepost 15 | | | | | | |
| 3 | 14+4895 T.C.6.6 WARP 62 - | 1 7/8 in | 1.800 in | 4 Ft | URGENT WARNING | PLAN MAINT. | |
| 2 | 14+4845 T.C.6.6 WARP 62 - | 2 1/8 in | 1.800 in | 12 Ft | URGENT WARNING | PLAN MAINT. | |
| 1 | 14+2158 MC.TC.21 WGA CONCERN - | 7/8 in | 0.700 in | 16 Ft | PRIORITY WARNING | | |
| | 14+2112 Milepost 14.4 | | | | | | |



YardMaster Mode

SolidTrack Geometry Defect Detector - Andian Technologies Ltd - US Patent 6,347,265 (Copyright 2011)

File Calibration View Defect Finder Operation Help

0+0

| | | | | | |
|-----|-------------------------|---------------------------|----------------------------|-------------------------|--------------------------|
| Cr. | Degree of Curve: 0.000° | Superelevation: 0.000" | Gauge: 0.000" | Speed: 0.000MPH | Warp 62: 0.000" |
| Cul | V-Max (3Inch): 0.000MPH | Left Alignment 62: 0.000" | Right Alignment 62: 0.000" | Left Surface 62: 0.000" | Right Surface 62: 0.000" |

Yard Testing

WARNING: Vehicle must be stationary to initialize run!

File Information

Yard Name: ...

Yard File: ...

Test Name:

Run Information

Description:

Operator:

Customer:

Facing Direction

Increasing Mileage

Decreasing Mileage

Testing Direction

Testing Forward

Testing in Reverse

Track and Location

Track: ...

Location:

Defect Analysis

Urgent Defects

Urgent Warnings

Priority Warnings

Potential Urgent Defects

Potential Urgent Warnings

Confirm Input

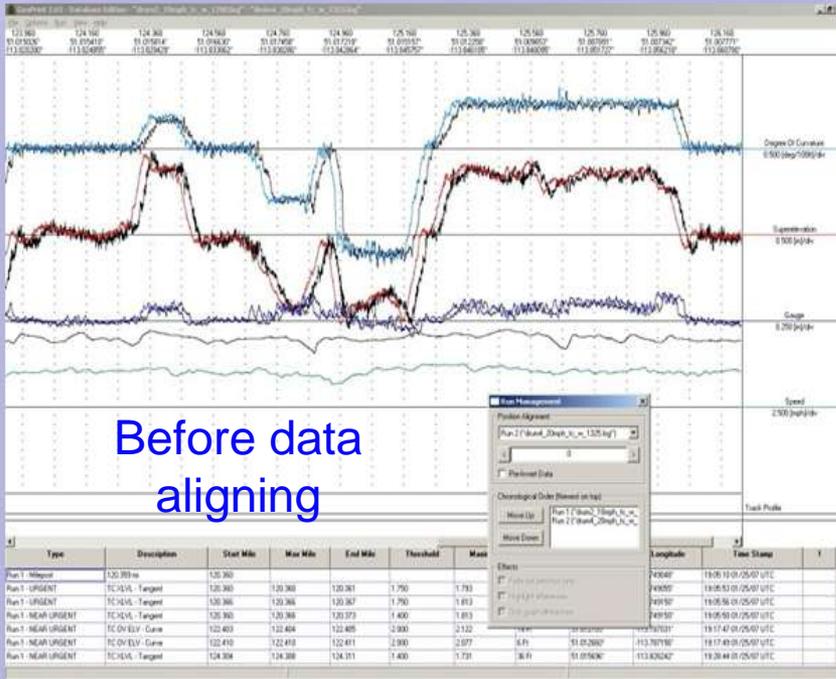
| | | | | | |
|------|-------------|-------------|-------------|-------------|---|
| DE | | | | | |
| DR | | | | | |
| HB | | | | | Degree of Curve 2.000 [deg/100ft]/div Current Reading: 0.000° |
| Lub | | | | | Superelevation 0.500 [in]/div Current Reading: 0.000" |
| RI. | | | | | Gauge 0.200 [in]/div Current Reading: 0.000" |
| Sgn | | | | | Warp 62 0.250 [in]/div Current Reading: 0.000" |
| Sig | | | | | |
| ST | | | | | |
| SW | | | | | |
| WIS. | | | | | |
| Br. | 2500 0+0 | 2250 0+0 | 2000 0+0 | 1750 0+0 | |
| DF | | | | | |
| IST | | | | | |
| OB | | | | | |
| Rd. | | | | | |
| RW. | | | | | |
| SF. | | | | | |
| SP | | | | | |

| Class of Defect | Recommendation |
|-----------------|----------------|
| | ! |

GPS Time: Fri May 03 10:12:29 2013 49.413316 North 123.239030 West GPS Speed: 20 Mph Satellites: 3 (Q=1) Speeds ---|---|--- [---|---] Gauge Operating Not Logging



Post-run Viewing (GeoPrint)



- Aligning two separate runs to examine geometric properties that may have changed over time.
- Measurements can be made in both magnitude and distance.
- An excellent tool for the analysis, measurement, display, and printing of geometry data.

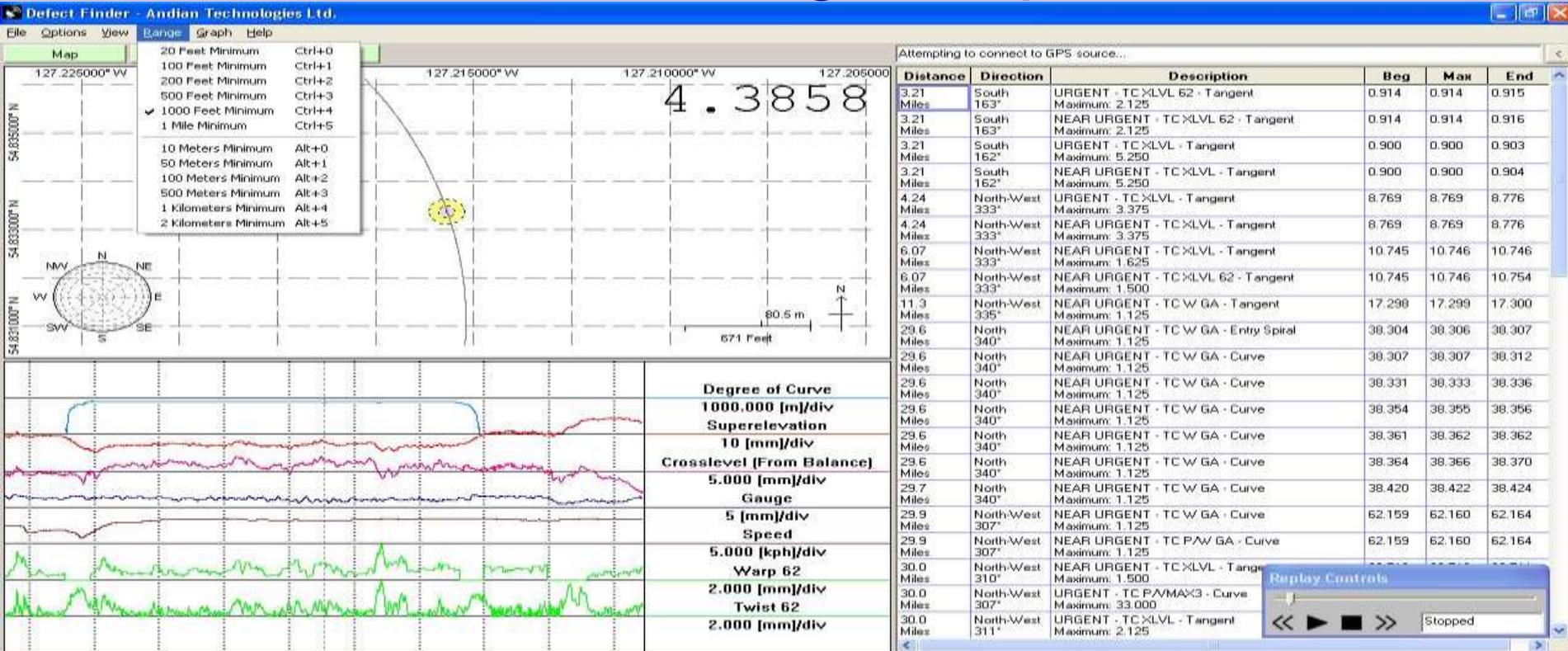


DefectFinder (Stand-alone software)

- Assists in finding recorded defects with GPS accuracy.
- User can access geometry data with a portable computer.
- Uses any type of waypoint file.
- Other considerations:
Solid Track data for maintenance and capital planning .



DefectFinder – Locating Exceptions with GPS



Loaded a previous Log file onto a laptop computer coupled with a GPS receiver, which allows crews to drive up to the defect location quickly and accurately.

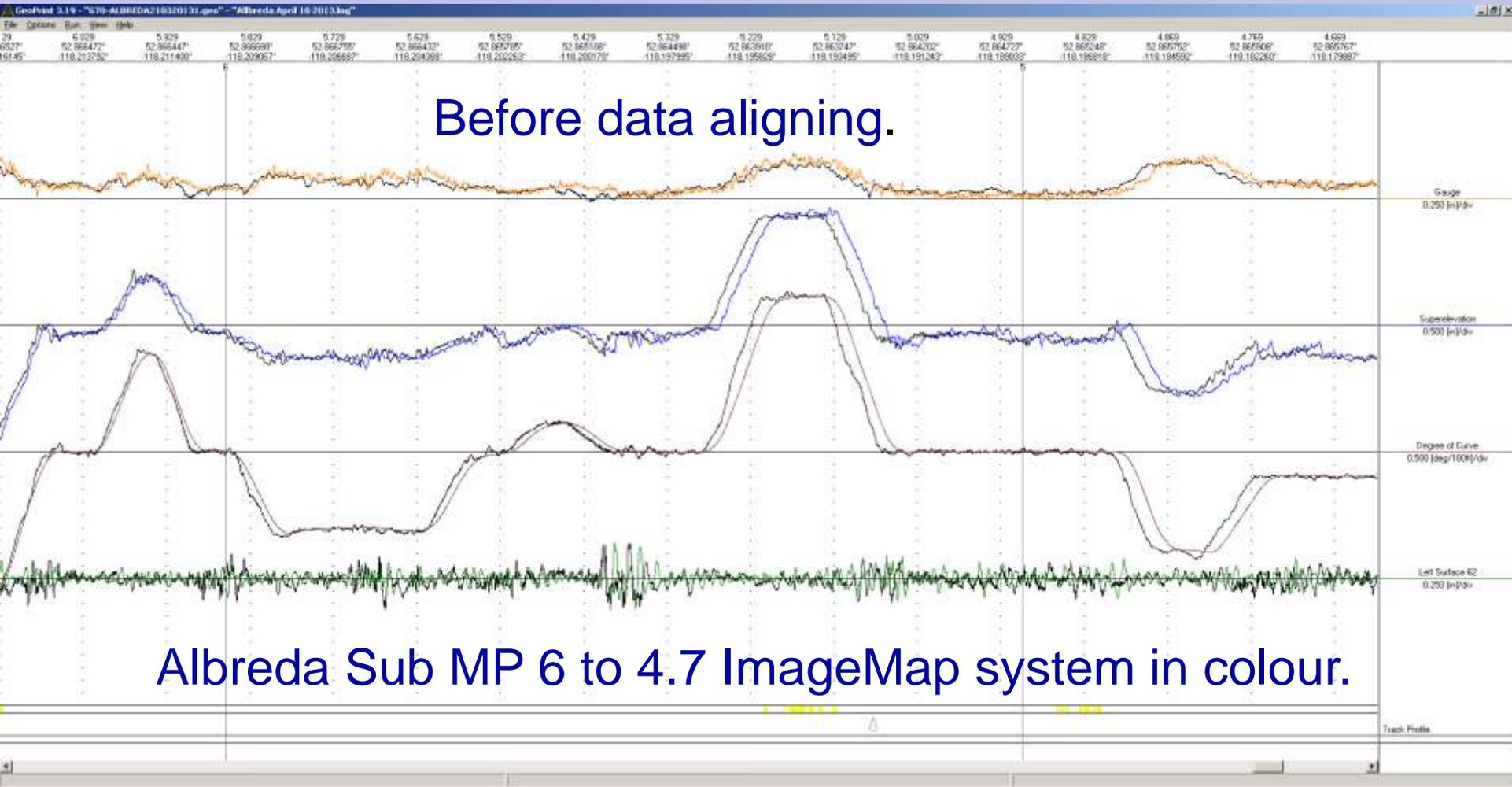
Load up TEST car, railwear, RFD defects, track features, any standard waypoint file.



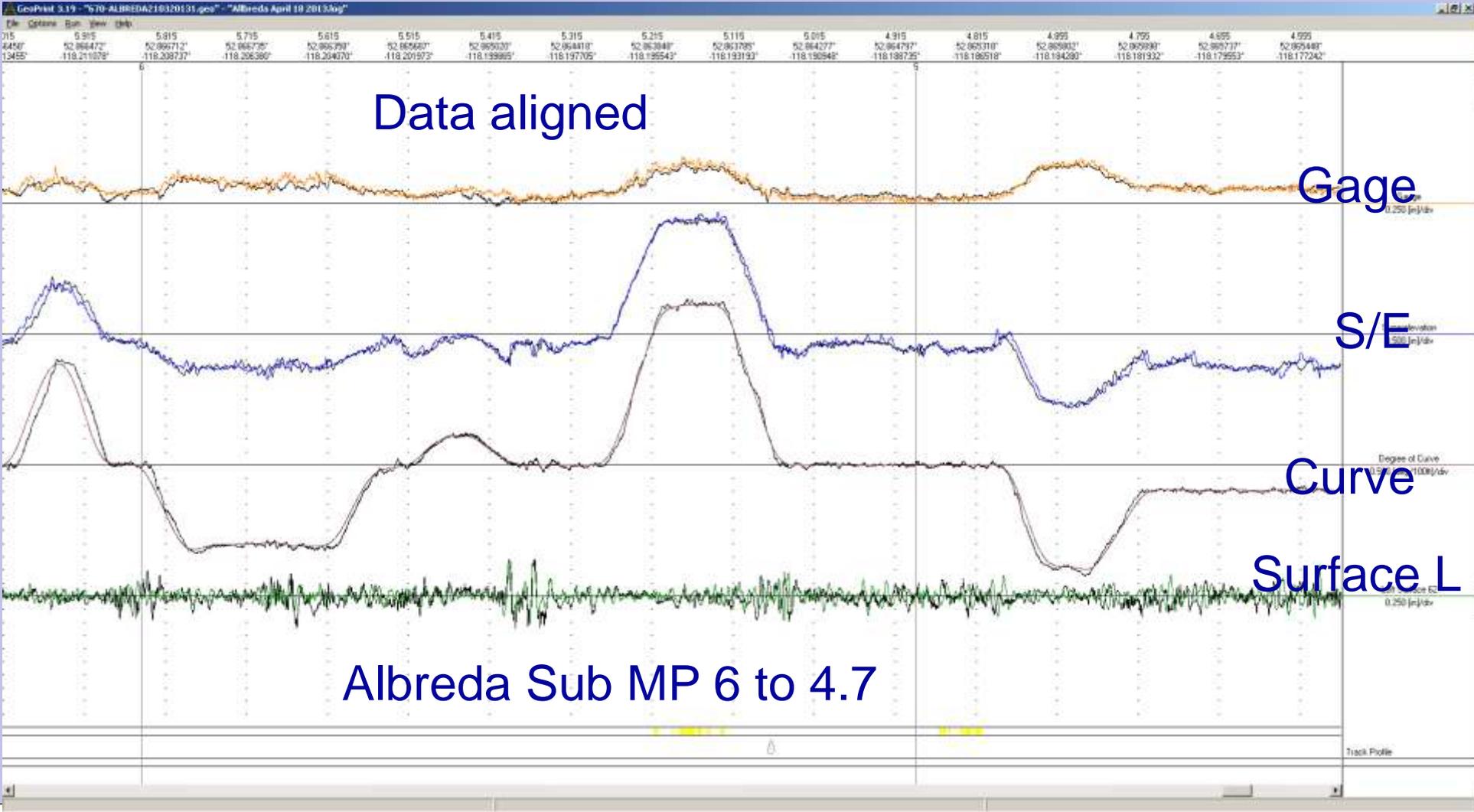
How Does It Compare?



Comparison Between Heavy Geometry System (ImageMap) and SolidTrack



Comparison Between Heavy Geometry System (ImageMap) and SolidTrack



Summary

- Affordable electronic track geometry inspection system.
- Simple, Accurate, Reliable, and Robust
- Most of the travelling can be done on public roads, before getting on track
- Evaluate track condition while inspection are being complete



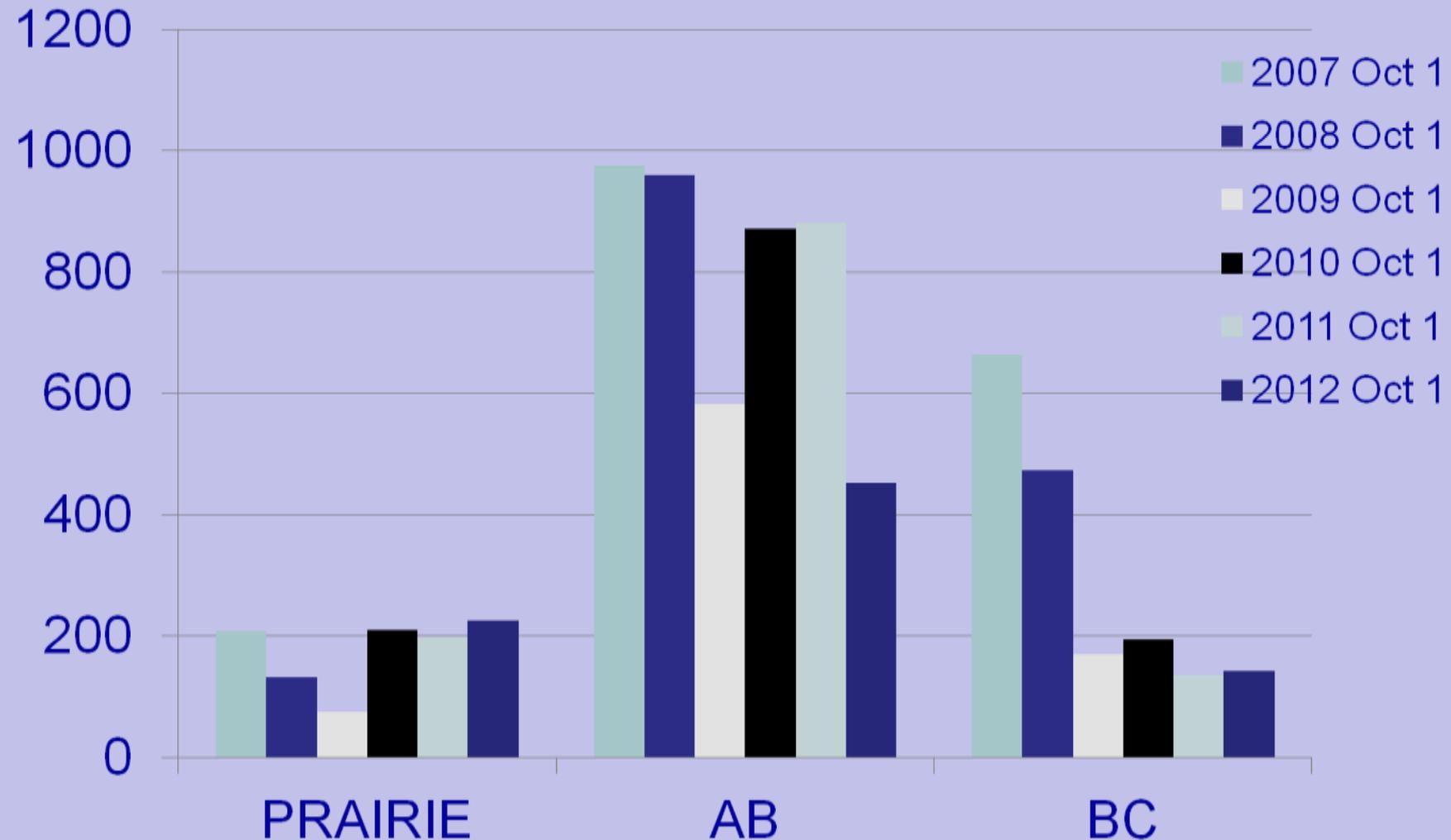
- On/off track within minutes, to maximizes track time
- Rapid deployment to any questionable locations, unlike heavy geometry car testing is based on a schedule and is rail bound. Immediate response to emerging issues
- Great supplemental geometry testing tool.
Some low density trackage only receive one or two heavy track geometry tests per year



- Ease of training within a very short period of time
- Honing experienced supervisors' inspection skills
- On track, real time scenario for knowledge transfer and discussion
- Development tool for young supervisors with less experience. Training oversight for in track geometry exception recognitions (Seeing Eye Dog)
- Observed significant decrease in geometry caused derailments and overall reduction in slow orders in face of >30% increase in rail traffic.



Total October 1st TSO minutes by Sub Region



•Accepted as electronic geometry testing for Class 1 and Class 2 track by Transport Canada (RRTS - 4)

Track

Designated Minimum Electronic Geometry Inspection Frequency Table

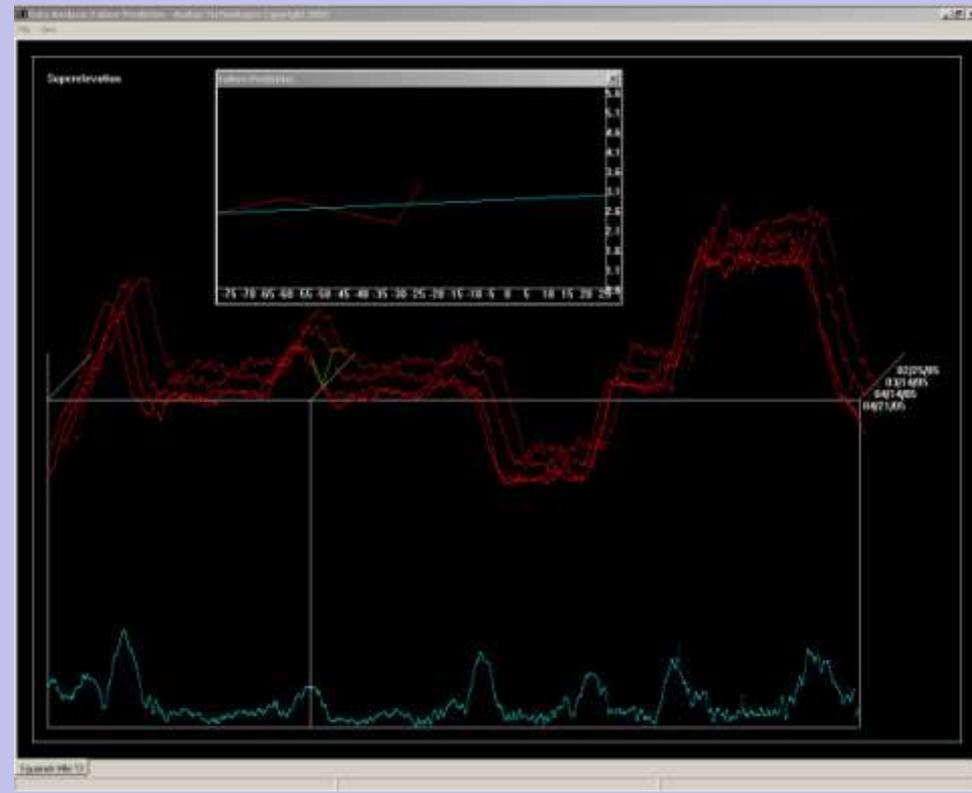
| Class of Track | Annual Frequency Requirements | | | |
|--------------------|-----------------------------------|---|---|---|
| | < 5 MGT | 5 – 15 MGT | 15 - 35 MGT | > 35 MGT |
| Class 1 | N/A | LGIV – Twice Or HGIV - Once | LGIV – Three times Or HGIV - Once | LGIV – Three times Or HGIV - Once |
| Class 2 | LGIV – Twice Or HGIV - Once | LGIV – Three times Or HGIV - Once | LGIV – Three times Or HGIV Twice | LGIV – Quarterly Or HGIV Twice |
| Class 3 | HGIV - Once | HGIV – Once | HGIV – Twice | HGIV – Twice |
| Class 4 | HGIV – Twice | HGIV – Twice | HGIV – Twice | HGIV - Twice |
| Class 5 | HGIV – Twice | HGIV – Twice | HGIV – Twice | HGIV – Three times |
| Crossovers* | LGIV – Twice Or HGIV - Once | LGIV – Twice Or HGIV - Once | LGIV – Twice Or HGIV - Once | LGIV – Twice Or HGIV - Once |



Where will we go next?

We will be elevating SolidTrack “Predictor” software in the coming weeks to extend data capabilities.

“Predictor” software plots successive geometry runs and forecasts future geometry values for greater asset utilization.



Questions ?



HEAVY HAUL SEMINAR • MAY 8 - 9, 2013

WRI 2013