The benefits of applying Geographical Information Systems (GIS) and electronic mapping technology to railroad business applications

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ABSTRACT
Since its inception in the mid-1800s, the railroad industry has used mapping as a medium to communicate important information. For many years, maps were railroads’ only effective way to display entire track systems over large geographic areas in a single view. Because it was difficult to create and maintain paper maps, railroad maps of the past included very basic information: track, state boundaries, cities, rivers, and a few other geographic features. At the time, it was also very difficult to produce and maintain discipline-specific variations of maps (i.e., marketing demographics, traffic volumes, and capital plans). Even with the advent of the computer, mapping required complex software and hardware systems with specialized technical skills that limited integration of business information.

With the advent of Geographic Information Systems (GIS), global positioning system (GPS) and aerial satellite photography in the 1980s, mapping has been transformed from a hard copy medium to an accessible electronic medium that can effectively integrate everyday business applications. This paper will highlight several BNSF applications where the integration of GIS with a map-user interface has a beneficial impact in the performance of the target business activity, revenue growth, and customer service, monitoring operational conditions, mechanical defects and track production gangs.

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INTRODUCTION
BNSF Railway operates over 32,000 route miles of track in 28 states and two Canadian provinces, approximately 2.2 million square miles of land area. Now take that land area and break it up into three regions, 13 operating divisions, and a multitude of subdivisions combined with a myriad of territory types to cover all the business needs. It becomes very apparent that communicating important facts for everyday business is a challenge for the most common forms in today’s reporting technologies like text reports, charts and graphs. Maps have a history with the railroad industry since their inception in the 1800’s. Railroad maps were initially created from the federal government’s land surveys of the original routes. Then commercial railroad maps become readily available in the 1870’s with the formation of Rand-McNally Company. The improvements in cartography and printing did little to increase the integration of business information with a map. The time it took to render information on a map, the value of the information quickly became worthless; hence, maps in the railroad industry were basely a route feature on commercial geographic maps or corporate territory information that did not change frequently.

Figure 1 – Historical Growth Map for Burlington System

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Geographic Information Systems (GIS) originated in late 1950s, with commercial software not appearing until the late 1970’s from Environmental Systems Research Institute (ESRI). Corporate use of GIS began in the 80’s when Global Positioning System (GPS) became available to the general consumer population; this greatly lowered the cost of collecting geographic information. In the 90’s GIS applications accelerated in the business market place with emergence of software on personal computers. Finally, the explosion of mapping in the consumer world with internet content providers like MapQuest and Google virtually eliminated the need for paper road maps and made map usage common in many daily activities.

The railroad industry began using GIS in areas where knowledge of location, proximity and directions is critical; Resource Protection, Emergency Response and Hazardous Material Management. Railroad land holdings made the Real Estate sector one of the earliest business functions to utilize GIS to assist in all aspects of land management. It became evident to the business community that making connections between activities based on geographic proximity and looking at data geographically can often suggest new insights and explanations. Normally these connections are often unrecognized without mapping technology, but can be vital to understanding and managing activities with respective resources. For example, the ability to locate business opportunities by the proximity of manufacturing firms to rail lines or intermodal facilities.

A key to the successful utilization of GIS and electronic mapping within all business sectors of the railway is the ability to associate a business location to a geographic location. Railroad location systems are akin to postal address but are a mix of diverse parameters (subdivision, milepost, line segment, milepost suffix, station, control point, etc) that provides a unique location depending on the business discipline (control systems, engineering, mechanical, etc.). The complexities are a product of consolidation of different railway companies that make up today’s large Class I railroads and the business requirements for business development, train scheduling, track maintenance and train tracking. The key to making GIS work effectively is connecting that railroad
location to geographic locale without having to physically connect longitude/latitude via some type of field GPS survey or aerial photo process. GIS technique of geo-coding or geo-referencing connects business data with railroad location information to railroad features (track, milepost, stations, etc) with geographic locations.

This paper will take the benefits of GIS and electronic mapping, breaking them down into four categories;

- Productivity and Efficiency
- Expanding the Audience
- Bring in the Outside World
- Finding the Way and Keeping Track of It

**Productivity and Efficiency**

The focus of railroad engineering by its very nature is based on geographic location and the need for geographic information and management systems. The use of GIS significantly improves the efficiency and productivity of those processes and has introduced dynamic new capabilities compared to the original railroad location systems. The foundation of track information is the location (railroad address) which includes a territory designation, track segment, track identification milepost and milepost suffix. Errors in the railroad location can skew results by excluding information from the correct territory. Railroad location issues occur more frequently with highly dynamic information, the stuff that is collected through manual means or changes year-to-year; gang daily production, maintenance plans, etc.

**Map Generation**

The first commercial railroad maps were routes consolidated with typical geographic features such as political boundaries (country, state, county). Originally map production is all by manual means but with the advancement of computer systems came the adoption of Computer Aided Design (CAD) software that took over the task of map creation and maintenance. Even though
the CAD software process improvement is great over manual drafting it still requires expensive software and special skill sets to maintain the railways consistent need for information on a map. Computers just increased the demand because many different types of information could be placed on a map; territory (Figure 2) and supervisory boundaries, station locations, traffic volumes, capital projects, etc. The issue concerning CAD maps occurs when base information changes (tracks, stations, primary territories, etc) requiring a vast amount of touchups to the CAD drawing files, and a lot of work when a division boundary changes.

![Figure 2 - BNSF Subdivision Map](image)

Today, map information resides in a GIS database and programs perform the map generation at the touch of a button or at regularly schedule times. Stations are point features, tracks are line features, territories are polygons, and geographic features come from commercial data sets with state boundaries, roads, water features, etc. When changes occur common map regeneration is accomplished without the manual effort, this includes BNSF system maps for General Managers, General Directors Maintenance, Division Engineers, Roadmasters, Signal Engineering Territories, Structures Territories and Flood Mapping. Currently 99 percent of CAD map files are now produced from a GIS application.
The next step in mapping automation came in business mapping that allowed maps to be produced with a wide variety of tailored information related to specialized areas of responsibility. Demand has greatly increased once the value of presenting information where it happens became widely understood. A business map drawn manually took a large amount of time due to the information type and special skills to render the results in a presentable fashion. To address the increasing load of business mapping a web application provides “Self Service” or “Map on Demand” functionality to the end user to perform the map production. Web applications provide the functions to the select information layers, map size, extent and type of electronic output (PDF, etc.). One essential feature allows the user to save the composition for later or repeated use.

Benefit of GIS in handling increase in mapping demand is the ability to manage through automation over increasing resources or extending delivery lead-time. This provides existing mapping resources time to address custom requests not possible with automation such as special local area maps (Figure 3) for a construction project. GIS enables same level of resources to handle ever-growing mapping needs of BNSF business community in a timely manner.

Figure 3 BNSF Special Area Map
Track Chart Automation

One of the founding sets of documents for the Engineering department are Track Charts, schematic views of five mile track segments containing track asset and maintenance information.

- Tracks & Track designations
- Curves
- Operating Speed
- Signals
- Road Crossings with warning system
- Structures: Bridges, Culverts, Snow Sheds, Tunnels
- Turnouts
- Diamond/Interlocking
- Station
- Milepost with length
- Tie type and last program date
- Rail weight and last replacement date
- Surfacing
- Yard, Terminal, Industrial track schematics

Track chart organization is by Subdivision where 32,000 route miles represents 6400 pages in 275 Subdivision books which does not count the special schematic inserts to cover yard and industrial track diagrams. In the 1970’s, track chart maintenance moved into the computer age where it is maintained by special CAD applications like AutoCAD or Microstation. Railroad infrastructure is not static, every year large capital expenditures take place to accommodate the needs of changing the transportation market; double track, new sidings, yard expansion plus maintenance. Keeping track charts up to date requires considerable effort and over the years railways use of contracting firms for engineering design eliminated drafting skills from most engineering departments. Because of this, track charts suffer by going for long periods of time between updates, in some cases as much as four years.
Today with the utilization of the mainline and primary track GIS data, the combined information of the CAD drawing which contained Engineering data allowed the railway to produce a revised track chart on a weekly basis. This process is especially valuable when territory boundaries change, once the geographic boundaries (polygons) are complete, track and features adjust automatically to the new boundaries due to the geographic (spatial) relationship.
BNSF operates a work allocation model to support allocation of operating funds throughout the budget year. The model utilizes a considerable amount of track asset data; track, features (curves), assets (turnout, road crossing, etc.), tonnage, mileage, location of maintenance plans and the operating budget. Originally, the process was done outside BNSF where BNSF extracts the data from corporate repositories then transfers it to a consulting firm for model execution and results return to BNSF. Issues with data accuracy increased the overall effort required and extended the results delivery cycle to only four times a year.

Today the Work Unit Allocation model operates solely within BNSF information systems where the required data is drawn directly from corporate repositories. This alone greatly increases the productivity and efficiency of the process by assembling the information though a geographic means over the previous railroad location system and significantly improved the accuracy of the results. The productivity increases GIS makes possible on a daily basis aligns more favorably with the ever changing distribution of operating budget resources throughout the year.

**EXPANDING THE AUDIENCE**

How many times has the work program of a system gang adversely affected an adjacent territory when the schedule changes due to unanticipated conditions? This issue arises because neighboring territories do not have the capably to understand what is going on adjacent to them. That is a problem when a territory needs to provide support services to system capital maintenance gangs. The solution was to provide a visual map interface where information on all system gangs is available to all Engineering territories instead of the typical tabular text report where information was related through row and column reports. This map interface includes how much work the gang has completed, and conveys the information before moving on to the next location that may affect a different territory.

**Engineering Gang Production**

Capital production gangs are a normal part of railway maintenance operation and perform different types of physical component replacement of the track structure. BNSF operates
approximately 45 production gangs per year staffed by more than 1200 scheduled employees. Planning is done at the system level, with execution greatly affecting the local MOW (maintenance of way) forces. This is due to fact that local MOW operation is responsible for supplying support resources when a production gang is in their territory. The typical production reporting systems were tabular text based on territory location with other daily production information geared toward conveying information about a single gang at a single location. However it does not provide any visibility related to neighboring territories or provide useful information to businesses outside of MOW. Even a single report with all territory information present makes it impossible to understand relationships between territories.

Production information delivery is through a combined system of tabular and map interface (Figure 6). A tabular format is retained for users familiar with the report form so it is easy to pick a desired gang for review. A mapping interface displays gang locations with a popup feature providing the gang number, type, task, responsibility, and production information. Color-coding of gang locations conveys all the daily productions goals. Drill-down capabilities allow one to see exactly where the gang is located on a common street map plus arrows to indicate start and end location for the day. Pop-ups provide additional details about the gang’s daily actives, even comments from local supervision. Mapping expands the visibility across territories and allows other business disciplines to easily understand daily gang activity. One example is planning weekly maintenance of way windows between Engineering and Operations. Everyone can see where the high cost activities are taking place to keep them on schedule or effectively move them to their next work location.
BRINGING IN THE OUTSIDE WORLD

The ability to merge information from outside sources is yet another benefit GIS and electronic mapping brings to BNSF. Today, there are vast world’s of business information available via the internet, from government agencies, non-profit organizations and for profit businesses. The value becomes obvious when relevant corporate data is viewed with the external sources to provide more valuable insight and information to improve decision-making.

Monitoring Water from Stream Gages

The United States Geological Survey (USGS) provides real-time water data for the United States. Information categories include stream levels and water flow direction. BNSF’s 32,000 route miles of track crosses over and parallels rivers, streams and lakes throughout the United States. Rising water levels in areas where track exists increases the risk of washouts or water over the track. By integrating the real-time USGS water data with BNSF track locations through GIS, water level information in conjunction with track elevation computes how water level relates to the top of rail.
at any given location. This provides BNSF with a tool that is more proactive in the warning of possible dangers to track from water and to be more precise in the location of the event.

![Cell phone signal strength](image)

**Figure 7 – Stream Gage Site**

**Cell phone signal strength**

Portable communication devices are the indispensible tools of today's railway employee. Railroads have some of the most extensive telecom systems outside major communication companies but railway employees spend a high percentage of their working day outside the office so landlines are of little use. Now with cell phones providing more than just voice communication, it has become an important means to deliver information to the field organization. So contracting the best service for a given area of work responsibility is important to staying connected. BNSF contracts with all the major cell providers. In heavily populated areas those providers greatly overlap but once outside those densely populated areas one particular provider may have better service for the rural areas.

BNSF provides geographic information (mainline tracks, major station locations, subdivision and division territories features) to the cell service providers to overlay their respective signal strength information. BNSF employees in their respective home location have access to the signal maps

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to make a more informed decision on the best provider. This has become even more important with the consolidation of service providers and continuing changes in the different types of service offered.

Figure 8 – BNSF Map with Cell Coverage

FINDING THE WAY AND TRACKING IT

The explosion of electronic mapping and GPS happened in the consumer world with the advent of companies, like MapQuest and Google, creating very simple web mapping applications free to the internet user. This led to the development of portable GPS device that contain maps capable of displaying the devices location and directions. Further evolution of portable GPS devices involved smart phones with even more. This technology first appeared in the railroad industry when demand for laptop computers began to take over the use of desktop computers. Laptops, coupled with inexpensive consumer mapping software and plug-in GPS devices, helped field personnel get around, typically system personnel who are not as familiar with all territories. Widespread use, however, did not occur until the introduction of inexpensive handheld GPS that could realistically be supported by local division operation budgets.

Help Find Specific Location

The first heavy use of geographic location information and GPS locating devices came with track geometry vehicles that continuously access track condition for immediate and long term remedial
maintenance. Initially, when BN and Santa Fe merged in 1995 there were two rail-bound track geometry cars to monitor the condition of the track structure. During normal testing operations when a high priority exception (Red Tag) is located, cars used a paint spray system to mark the location of the exception for local section gangs to verify and correct. The paint system however had a major flaw, marks could not be placed directly on the exception because of vehicle movement and the time it took to determine the exception. Hence, marks were 300 feet beyond the actual exception location and the field had to know the test direction to determine the location and then add weather conditions and varying temperature conditions to keep the paint system operational. The operating cost of a paint system on a single vehicle was well over $50,000 not including the cost of labor to keep it supplied and working.

So in 2005 BNSF installed GPS devices onboard the rail-bound track geometry cars. The GPS receivers are high-end units with the ability to utilize a commercial differential service for accuracy levels to a sub-meter at normal testing speed. The GPS receiver is directly integrated into the geometry collection and analysis computer system where it can tag all exceptions with a longitude and latitude. BNSF went to great lengths to ensure longitude and latitude matched the actual location of the exception. Initially, longitude and latitude was printed on a roadmaster exception report and a roadmaster had to enter the numbers into a handheld device by hand. Today the roadmaster only needs to plug the GPS device directly into the geometry computer system and the exceptions with longitude and latitude transfers to the device as waypoints. This allows the general “Go To” function of the handheld device to assist guidance to the exception location, eliminating the complexities that go with paint spray systems and the related maintenance cost. Cultural change usually takes time but BNSF field forces have embraced the technology as a better way to locate the correct location the first time.

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Beyond the use of handheld GPS devices to assist in locating track exceptions, BNSF also assists field MOW personnel with BNSF track lines and milepost files for the GPS device. This provides a more accurate representation of BNSF track with commonly known features over the commercial information. An important secondary benefit is the capability to obtain driving directions which is a great help to employees new to an area or new to the industry. Getting to a location around a railway company is often a great challenge that can now be more easily addressed.

**Crew Van Locations**

Crew vans play a critical role transporting train crews to and from trains. That can be challenge enough in major metropolitan areas and even more daunting in vast rural areas where access points are sparse. In a perfect world the crew vans deliver fresh crews and pickup expired crews with efficient travel and wait time. For this to happen the crew manager needs to understand where the location of crew van resources and a given train’s tie-up location for the crew swap.

To accomplish this goal the crew van needs a GPS device for location tracking and a communication device that allows location data delivery to BNSF for the real-time tracking of the crew van. Second a system of locating the locomotive power of a train, which can be established through a GPS installed device or established points for crew change (station, sidings, etc.). This is available to crew management for assisting in dispatching crew vans to pick up train crews and
deliver the fresh train crews to the trains. Picking up a train crew and transporting the crew to their home terminal is one thing but the ability to track the mileage of the crew van plus information about the time involved provides validation for billing from the crew van operating firm. Just the awareness of the driver knowing there was a system monitoring the route and time of travel helps ensure a more efficient process of providing crews to trains is used.

![Figure 10 – Crew Van Location Web Application](image)

**MOW Vehicles**

Relatively inexpensive consumer-grade GPS devices also enable MOW vehicles or personnel to determine a route and the time it took to get there. Engineering creates track feature data files that can be loaded into consumer GPS handheld devices: features include tracks (main, yard, industry), milepost signs, station signs, turnouts, road crossings and signals. Engineering maintains a self-service web site to support updates for Garmin, Delorme and Magellan handheld devices.
**Figure 11 – Portable/Handheld GPS Device**

**GIS Maintenance**

Beyond the improvements to process, finding where to go, and where you have been, is the challenge of keeping geographic information up-to-date. Maintenance is key to all GIS systems. The world changes and the railway system changes with it. To efficiently keep up with track changes, GIS includes the use of contract firms employed to conduct various testing and maintenance operations. Contractors that operate rail defect testing vehicles on BNSF tracks (mainline, siding, yards, etc.) collect geographic (longitude/latitude) data every time the rail flaw tests are done. The geographic location data is used to check existing geographic information on the correct location of terminal, industrial or mainline track. This is not a trivial aspect of GIS and electronic mapping systems; in fact, it is one of the most important functions of GIS; keeping track data up-to-date. It is less about building the GIS application and data and more about maintaining its currency.

**Figure 12 – Detector Car GPS data overlay with current Track Lines**

**CONCLUSION**

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GIS and electronic mapping is a relatively new technology to the railway industry but it has a proven track record of delivering more meaningful results to business, simplified directions to difficult locations and provides a verifying means to track the performance of external contractor operations. This is just touching the surface of current applications within BNSF where electronic mapping technology is proving many benefits. And that does not begin to touch the special analytical possibilities to not only improve the efficiency of how BNSF maintains and manages its network’s ability to serve its customers but to expand the business itself.
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The benefits of applying Geographical Information Systems (GIS) and electronic mapping technology to railroad business applications

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Agenda

- BNSF System Facts
- GIS Technology
- Engineering Business Benefits
  - Efficiency & Productivity
  - Expanding the Audience
  - Bring in the outside World
  - Finding the Way and Keeping Track of It
- Conclusion
BNSF System Facts

- 32,000 miles of track
- 28 states & 2 Canadian provinces
- Land area 2.2 million square miles
- 3 regions
- 14 operating divisions
- Approximately 250 subdivisions
GIS Technology

Geographic Information Systems (GIS)

- Originated in late 1950
- Commercial software in late 1970’s
  - Environmental Systems Research Institute (ESRI)
- Business emergence in 1990’s
  - Personal computers
  - Global Positioning System (GPS)
- Consumer explosion
  - Internet
  - Map content providers; Map Quest/Google
What magic does GIS Provide?

Location – Shape – Dimension (Spatial)
- Universal Geographic Location
  - Longitude, Latitude, Elevation & Temporal
- Geographic Shape
  - Point – Station, Signal, Turnout……
  - Line – Track, Roads……
  - Polygon – Territory, Political, Boundaries…….
- Feature dimensions – length, area, distance……

Ability to analyze Spatially
- Companies within 20 miles of terminal
- Track within a flood plain
The GIS Location Key

- All railroad information is not Geographically referenced!
- Railroad location akin postal address
  - Territory/Line Segment = State
  - Track Designation = Street
  - Milepost = Street Number
- Connecting to Geographic Location
  - Geo-coding/Geo-referencing
  - Requires GIS Track base map
Productivity & Efficiency
How GIS improves existing processes

Map Generation
Track Chart Automation
Maps and the Railroad

- Original Government Land Surveys (1800’s)
- Public availability with Rand-McNally (1870’s)
- Electronic form - Computer Aided Design (CAD)
Corporate Maps

System

Territories

Train Operation

Supervisor
CAD Map Update Process

- Manual creation & management
  - Computer Aided Design (CAD) software
- Regeneration when changes
  - Territory & Supervisory boundary
  - New, Retired, Sale of track
  - Yearly Info; capital projects, etc
- Single change update many files
GIS Map Update Process

- Map data resides in GIS
- Regeneration automation
  - Manual changes map feature
  - Process regenerates all maps

**Benefits**
- Increase in Production
- No increase in resources
Self-Service Maps

- Provides user with ability to create custom maps
- Maps on Demand
  - Data layers
  - Map Size
  - System or Territory
  - Save Configuration
- Increase Access
- Relieve Map Resource
Track Chart Automation
Track Chart Background

- Track Schematic cover 5 miles per page
  - Over 20 types of track information
  - Designations, Features & Maintenance
- Assembled by Subdivision Territory
  - 32,000 miles with 275 Subdivisions
  - Represents 6400 pages
- Computer age managed by CAD software
  - Drafting skills required
- High effort to keep up to date
  - Up to four years between updates
Track Chart Information

- Track
- Milepost
- Speed
- Operation
- Curve Info
- Grade/Elevation
- Feature & Info
- Station
- Rail Type/Date
- Tie Replacement
- Surfacing Date
Update Process with GIS

1. CAD Files
2. CAD Track Charts
3. Corporate Databases

→ Extractor

XML Document

→ Merge

Track Chart
Track Charts from GIS

Results
- Weekly Updates
- Automatic

Benefit
- Single Data Maintenance point
- Up to Date Charts
- No resource increase
Expand the Audience
What your neighbor needs to know
Production Gang Reporting
Weekly Gang Activity Map
Daily Production Gang

- Interface Styles
  - Tabular
  - Map
  - Pie Chart

- Increase visibility across System
- Increase visibility across Disciplines
- Support different Roles
Drill Down production

BNSF Features with Google

Production Start to End
Bring in the Outside World
When data comes together

Stream Gage
Wireless Signal Strength
Combine Data Sources

Universal Geographic Location
- Enables the ability to easily merge data sets

External Data Sources Explosion
- Public agencies – census, boundary, water, pipeline
- Private – survey, aerial images, utilities

Enhances safety and business decisions
Stream Gage Status

Dashboard
color coding
Flood Categories
Google Map
BNSF Features
USGS Stream Gage Data

Gage locations

Flood Categories
- Major Flood Stage
- Moderate Flood Stage
- Flood Stage
- Action Stage
- All Gauges

Stream Gage Status
This application displays stream gages that are currently in Action Stage or higher.

To use:
With your mouse, click on a stream gage to return more information. A link is also provided to the National Weather Service stream gage web site for each gage. Use the navigation tool in the left corner to zoom in or out. Use your mouse to 'Pan' or slide the map to an area of interest.

Note:
Gage stages are updated every hour.

About Stream Gages use this link:
Stream Gage Drill-Down

Stream level related to BNSF Track Line Segment & Milepost

Streams & flow directions

Stream gage information is used to calculate if water level exceeds top-of-rail.
Wireless Signal Strength

Help field operation select best Wireless Provider

BNSF features to Provider
Provider merges with signal strength and service type
Available on Provider’s Web

BNSF Track, Stations, Subdivision

Color = Service Type; 3G, 4G
Finding the Way and Tracking It

Crew Van Exception Location Directions
Crew Van Location

Provide visibility of Locomotive & Crew Van

Popup details
Google Map
BNSF Features
Crew Van Location

Visualize route of Crew Van to Train

Drill-down to van location in yard with aerial image and BNSF track feature
Marking Track Exception

All exceptions marked with geographic location (Longitude & Latitude)
  - GPS - Differential correction & dead reckoning
  - Roadmaster download to GPS device
  - USB connection onboard geometry car
  - GPS device used to “GoTo” exception

Benefits
  - Increased level of confidence in locating
  - Elimination of paint spray marking systems
  - High yearly cost & maintenance
Track Exception Marking

Geometry
Car
Computer
System

Exceptions

Engineering
Central
Information
Systems

Exceptions as Waypoints

Navigate to Track Location

Exceptions

Track Features

Earthmate GPS PN-20
Waypoints
1266_CAR088 20100505
1368_CAR088 20100505
1428_CAR088 20100505
1430_CAR088 20100505
1439_CAR088 20100505

DeLORME

Navigate to Track Location
Helping the MOW employee get to where they need to be!

- Consumer device
- Import railway feature
- Route to Railway locations

Benefits

- System employ new employees
- Employees to new territory
GIS Data Maintenance

Check accuracy of what’s there and add what’s new
Only as Good as Data

New industrial track
Survey with Rail Detector

- Rail Detector vehicles with Differential GPS
- Record complete on-track test
- Utilize Detector vehicle test as GPS survey
- Overlay with current track survey lines
  - New or missing track
  - Changes in alignment
  - Replace less accurate data
- Extend the value of existing required process
Validate Quality of Data

Detector Car GPS survey points

Original Survey Track line
Find New or Missed Data

Dotted lines indicate new tracks.
Conclusion

- Do more with the same resources
- Expand your audience
- Bring in outside world to make more informed decisions
- Manage the way and track the way there
- Getting there quicker
- Maintain the data

Small slice of the benefits
  - Marketing, Mechanical, Operations, etc.
Thank You
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