Data Collection and Management: How We Collect and Manage Data in the Field, Transmit Data, and Create Information

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You likely often wonder…

- Why do we generate data?
- What types of systems collect data?
- What kinds of data are collected?
- How is data managed at the point of collection?
- Where does data go and how is it transmitted?
- How is data used to CREATE INFORMATION?
- How are data and information shared?

So, Why DO We Data?

- Generating data is driven by our need to monitor and learn more about the conditions of our assets and infrastructure
- We generate data so that we can CREATE INFORMATION
- INFORMATION drives our decision making process– e.g., maintaining versus replacing assets, changing our processes, implementing improvements
- INFORMATION gets us closer and closer to the truth– the HOW and the WHY

Mobile-Based Data Collection, Inspection and Assessment Systems

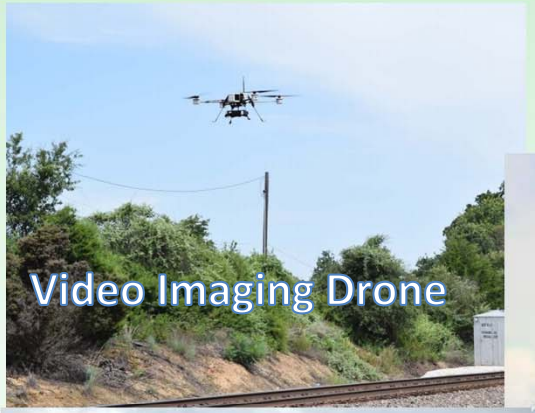
What Do Mobile Systems Do?

- Mobile systems are traditionally used to gather data about structural assets and components:
  - Track
  - Rail
  - Wayside
  - Structures/In-Track Assets
- They are typically mounted to dedicated rail bound platforms, hi-rail vehicles, revenue cars, or even aerial vessels (drones, etc).

Mobile Systems

Ultrasonic Platforms

Vehicle Based Systems



Commonly Used Vehicle-Based Systems

- Track Geometry Systems
- Joint Bar Integrity Vision System
- Ballast Integrity Vision System
- Gage Restraint Assessment
- Subgrade Monitoring (GPR)
- Rail Profile Measurement
- Rail Flaw Detection
- Vehicle/Track Interaction Monitoring
- Rail Surface Condition Assessment
- Coefficient of Friction Monitoring
- Track Component Visual Assessment (fasteners, ties, tie plates, etc)
- Clearance Measurement
- Aerial Survey and Imaging
- Right-of-Way Visual Inspection
- Lubrication System Monitoring
- Ballast/Subgrade Movement Detector

What Types of Data Are Produced?

- Raw signal/sensor data: accelerations, vibrations, images, applied signal responsivity (acoustic/ultrasonic, laser/light, LIDAR, x-ray, etc.)…
- Filtered/processed signal data
- Combined/integrated data from multiple sensors and modalities
- Exception/anomaly data

How Big is Big

- **Class 1 Railway: "Generating 100 Gb of Data Per day just from one on-board measurement program (9-systems)"**
- **100Gb per day ≈ 25 Tb per year per vehicle**
- **Facebook photos uploaded per day ≈ 350 million**
- **Railroad with 10 vehicles ≈ 350 million pictures**
  (4 cameras @ 30 frames per second)
- **Now add other technologies, measurements, & information.**

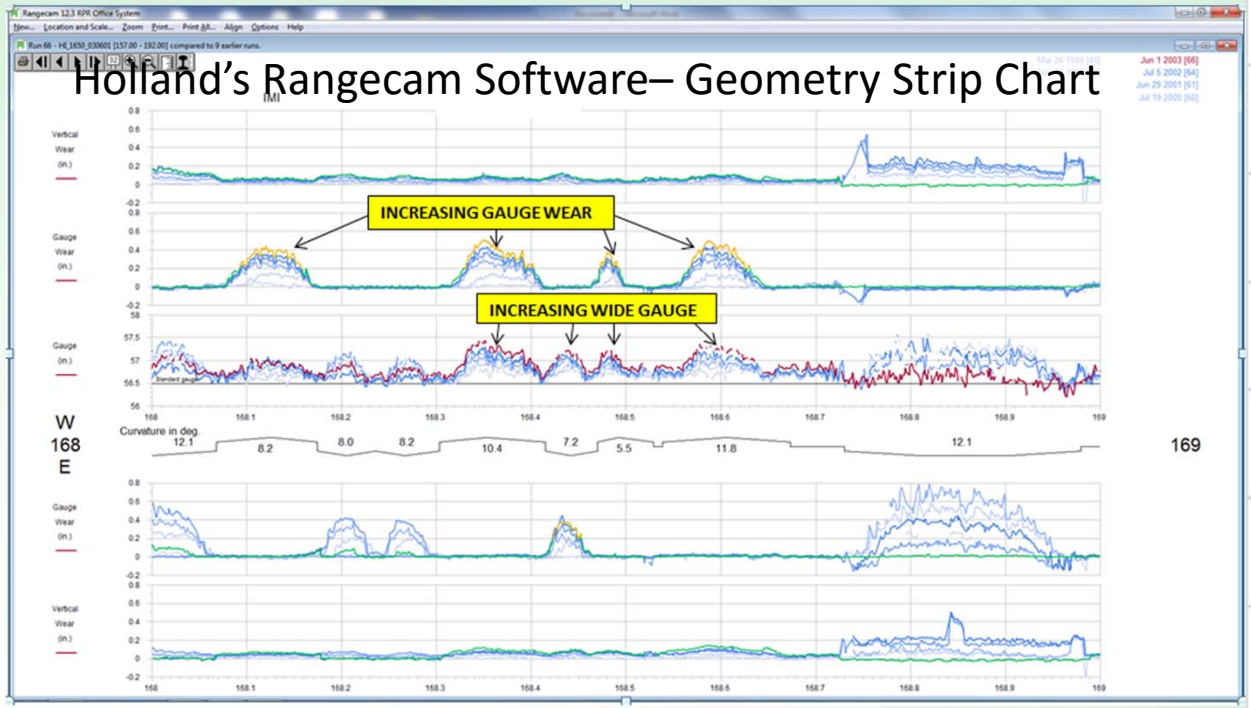
Deriving Informative Data from Raw Data

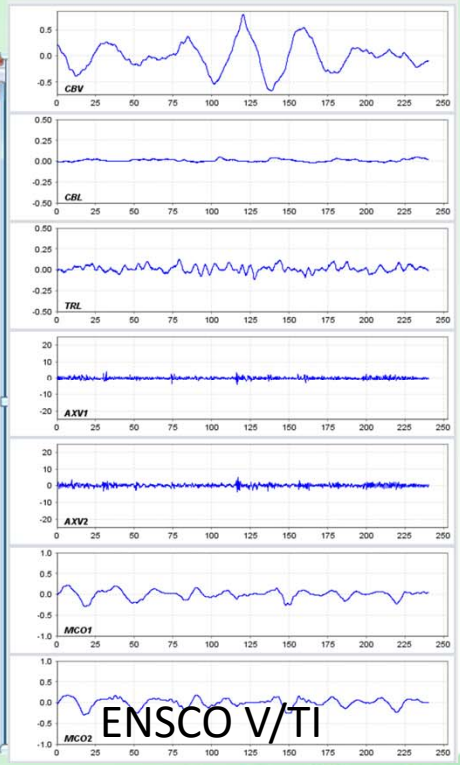
- Sensor data is typically filtered or processed to tease out the relevant signal
- Once the noise is filtered, that signal may be:
  - Analyzed to identify signatures representative of an issue, exception, or anomaly
  - Fed into additional processing layers and/or combined with filtered/processed data from other sensors

Deriving Informative Data from Data

- This process continues until an informative level of data is achieved (i.e., geometry foot-by-foot data processed for EXCEPTIONS)
- We can also “chain” or combine data streams and first-order exceptions to create new types of exceptions

What Does Data Look Like?





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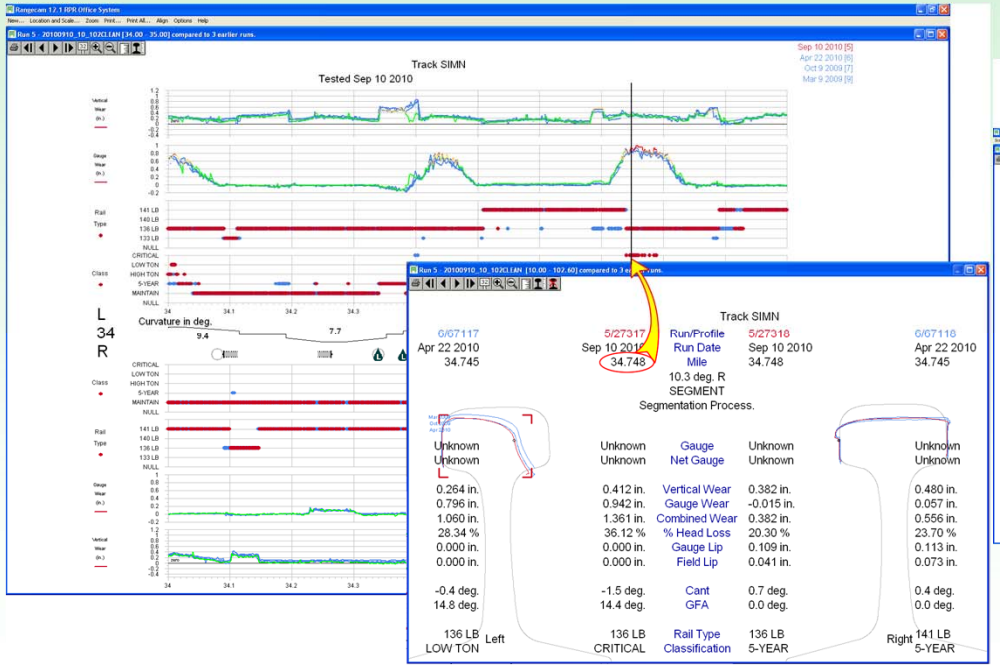
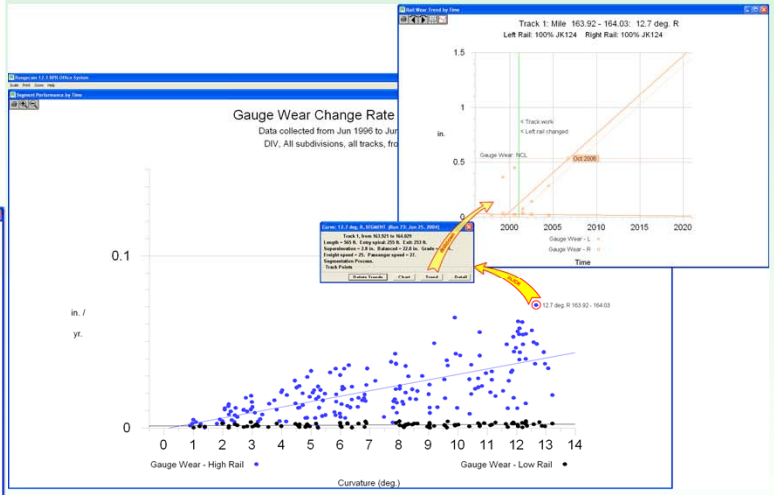




Holland's Rangecam Software with Rail Profile and Wear Analysis

On-Board Data Handling and Storage

- Data is typically stored on-board mobile platforms on high-capacity servers
- Different systems store varying degrees of “raw” data: sensor, filtered, processed, exceptions, etc.
- Data can be stored in a variety of formats: flat files, rudimentary to sophisticated databases, video/images and associated metadata or file reference to database, etc.

On-Board Data Handling and Storage

- Many testing platforms host systems from multiple vendors.
- Often, vendors will collaborate to synchronize their data streams and populate a common database.

On-Board Data Handling and Storage

- Some systems do not store data locally at all
- Unattended, Unmanned, Autonomous systems transmit data in real time directly from the field to a central location:
  - Some store data locally until such data is purged
  - Some store data locally temporarily, until wireless transmission is confirmed

Liability?

What happens when we experience data loss/ overload?

Railroad Shutdown?

What if we have the information but we haven't reviewed and/or acted on it?

Are we liable?

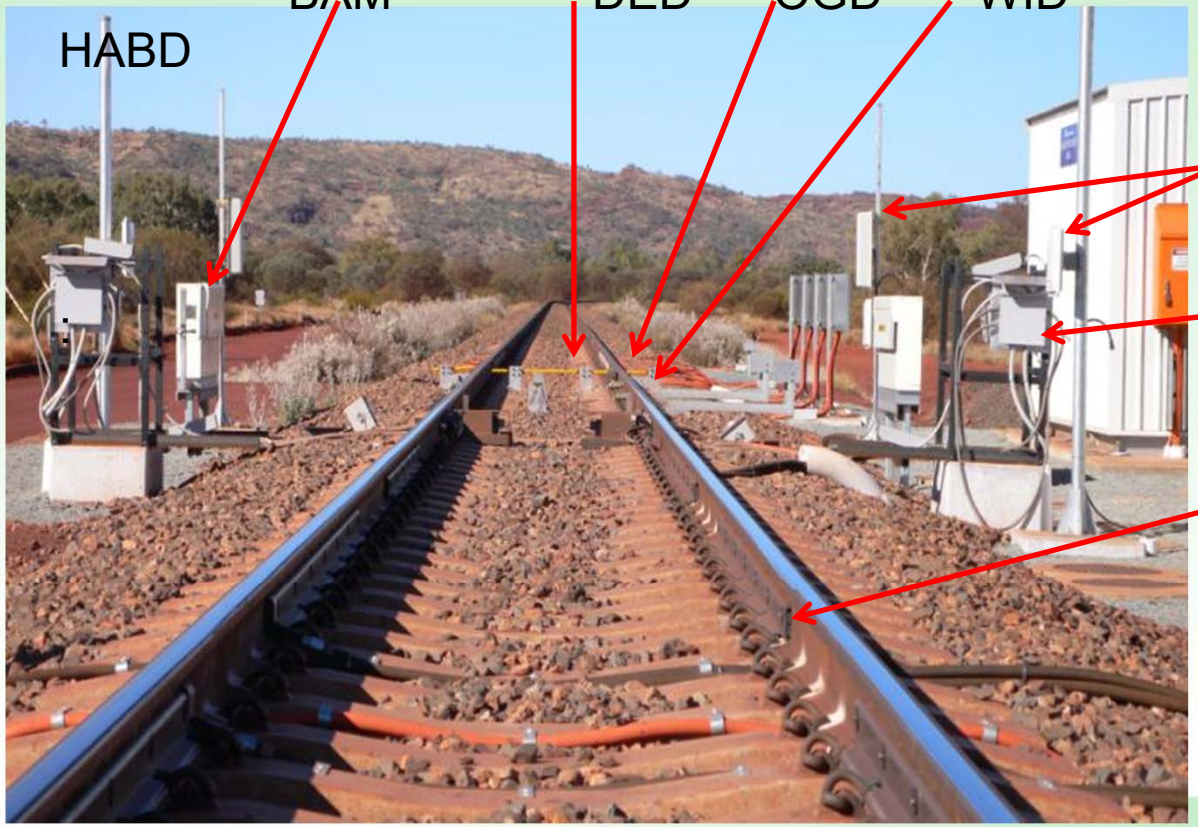
Unwritten/ Unspoken understandings?

Will those agreements change?

How Do We Reference Data from any Given Platform?

- Systems gather information about vehicle and wayside assets
- We need a way of knowing exactly WHAT/WHERE the data is describing
- We also need a way to reference multiple data streams to each other

Integrated Sites



How Do We Reference Data from a Mobile Platform?

- Systems residing on the same host vehicle can be time-referenced to each other, although processing delays can contribute to errors
- On-board systems typically rely on GPS and/or track-based referencing techniques to synchronize and report data
- Location information can be embedded at one or multiple points along the processing chain

Decoding the Decentralized Nature of Data Collection

- With thousands of vehicles collecting data all over their networks, railroads are faced with the issue of how to integrate or associate all of these disparate data streams
- This typically happens at a centralized location– “The Office”
- Requires data streams to have:
  - A common method of referencing the data (GPS, track location or asset, etc)
  - A known or anticipated margin of error for the accuracy of the location reference

What Happens to Data (Part 1)?

- Some data is immediately actionable
  - Ex.: Rail flaw detectors routinely stop and hand verify detected exceptions
- Some data is near-immediately actionable
  - Ex.: Geo cars radio back exceptions, hand off printed exception reports/strip charts to field personnel– during or at the end of a test

What Happens to Data (Part 2)?

- Generally, most data is transmitted back to a central repository for further action and storage after collection
- Data transmission happens in a variety of ways:
  - Physical– disk transfers via snail mail from vehicle to office
  - Electronic– email, upload to server/FTP

What Happens to Data (Part 2)?

- The central repositories are architected to host all different types of data sources, and accessibility provisions must be made
- High level users access data for follow up, audits, more detailed evaluation
- Most data management systems include provisions for “close the loop”

What Happens to Data (Part 2)?

- Because many modalities of data are hosted in these repositories, we start talking BIG DATA
- When combined with data from and about other assets, we move well beyond “find and fix” to predictive modeling and planning

The First Degree of Data

- A single survey yields data that is **immediately actionable**:
  - Rail Profile → Grinding
  - Rail Flaw → flaw removal
  - Imaging → Replace broken joint bars, bad ties, missing fasteners, etc.

The Second Degree of Data

- A second survey yields **HISTORY**, upon which a **FORECAST** can be built:
  - Rail Profile → Rail replacement planning
  - Rail Flaw → Internal defect growth
  - Imaging → tie replacement planning

The Third Degree of Data

- Multiple modalities of data at the same location yield **PREDICTIVE ANALYTICS** and provide the **WHY**:
  - Rail Profile + Rail Flaw + Rail Stress → predicting rail break
  - Rail Profile + Geometry → wide gage due to rail wear
  - Impact Monitoring + Visual Inspection → predicting rapid deterioration of joints

The Fourth Degree of Data

Lots of data about a specific Location or Asset

+

Lots of data about Vehicle/Mobile asset data

=

WHAT IF

The Fourth Degree of Data

- Using sophisticated modeling techniques and softwares, we can SIMULATE the **behavior of our track** as it responds to **different loading conditions**
- And vice versa– we can SIMULATE the **response of a particular vehicle/load** to a **specific track condition**

The Fourth Degree of Data…

- **Predicting responses** of our track and vehicles to each other based on ACTUAL or anticipated conditions means:
  - More effective maintenance standards and practices
  - More informed decisions about condemning limits
  - More efficient operational practices

…And Beyond

- The first four degrees of data optimize our operations
- By integrating our track and vehicle data with ERM/ERP's, we can optimize our BUSINESSES

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