Portable Ride Quality Meters for Detecting Vehicle and Track Safety and Maintenance Issues

Presented By:
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Agenda

- Ride Quality
- Ride Quality Meters (RQMs)
- Detect Track Issues with RQMs
- Detect Vehicle Issues with RQMs
- rMetrix: Portable RQM
- Leveraging Portable RQM Technology
- Future of Portable RQMs
Ride Quality and Ride Comfort

- Ride Quality: How a Vehicle’s Vibration Correlates to the Vehicle/Track Interaction Forces to Detect Issues on the Track or of the Vehicle

- Ride Comfort: How a Vehicle’s Vibration Affects the Ride for its Passengers or Crew
Ride Quality Importance

Train Accidents Primary Causes
(United States 2013)

- Human Factors: 38%
- Track Defects: 31%
- Equipment Defects: 12%
- Signal Defects: 3%
- Miscellaneous: 16%

*FRA Office of Safety Analysis Website
Ride Quality Standards

- 49CFR213.333 (United States)
- UIC 518 (International Union of Railways)
- EN 14363 (Europe)
- Individual Rail Companies
  - Amtrak
  - Indian Railway
  - Queensland Rail
  - SNCF
  - Union Pacific
  - CSX
## FRA 49CFR213.333
### V/TI Safety Limits

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Passenger Cars</th>
<th>Power Cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbody Vertical Transient</td>
<td>1.0g Peak-Peak</td>
<td>1.25g Peak-Peak</td>
</tr>
<tr>
<td>Carbody Vertical Sustained Oscillatory</td>
<td>0.25g RMS LTR</td>
<td>0.25g RMS LTR</td>
</tr>
<tr>
<td>Carbody Lateral Transient</td>
<td>0.65g Peak-Peak</td>
<td>0.75g Peak-Peak</td>
</tr>
<tr>
<td>Carbody Lateral Sustained Oscillatory</td>
<td>0.10g RMS LTR</td>
<td>0.12g RMS LTR</td>
</tr>
<tr>
<td>Truck Lateral Sustained Oscillatory</td>
<td>0.30g RMS LTR</td>
<td>0.30g RMS LTR</td>
</tr>
</tbody>
</table>

LP 10 Hz, 100 Hz Sample Rate (Minimum)
# Maintenance Limits (Option)

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Passenger Cars</th>
<th>Power Cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbody Vertical Transient</td>
<td>0.40g Peak-Peak</td>
<td>0.80g Peak-Peak</td>
</tr>
<tr>
<td>Carbody Vertical Sustained Oscillatory</td>
<td>0.22g RMS LTR</td>
<td>0.22g RMS LTR</td>
</tr>
<tr>
<td>Carbody Lateral Transient</td>
<td>0.25g Peak-Peak</td>
<td>0.50g Peak-Peak</td>
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<tr>
<td>Carbody Lateral Sustained Oscillatory</td>
<td>0.08g RMS LTR</td>
<td>0.08g RMS LTR</td>
</tr>
<tr>
<td>Truck Lateral Sustained Oscillatory</td>
<td>0.27g RMS LTR</td>
<td>0.27g RMS LTR</td>
</tr>
</tbody>
</table>

LP 10 Hz, 100 Hz Sample Rate (Minimum)
Ride Quality Meter

- Records Acceleration At:
  - Carbody
  - Truck
  - Axle

- Compares Computed Acceleration Measurements Against:
  - Safety Thresholds
  - Maintenance Thresholds

- Reports
  - Excessive Acceleration Events
  - Correlated Location
Ride Quality Meter History

http://www.youtube.com/watch?v=vybOobUK1FE
Illustrations from "The Railway Book for Boys", 1930
Detect Track Issues with RQMs

- Lateral Track Geometry Issues
  - Alignment Deviations
  - Gage Deviations

- Vertical Track Geometry Issues
  - Profile Deviations
  - Cross Level Deviations
Real-World Example 1

- Excessive Carbody Vertical Acceleration

Profile Condition:
- Mud Spot
- Pumping Tie
Detect Track Issues with RQMs

- Track Structure
  - Mud Spots
  - Fouled Ballast
  - Pumping Joints
  - Loose Ties
  - Crushed Heads
  - Low/Joints/Joint Batter

- Broken Heel Blocks
- Broken Switch Points
- Engine Burn
- Corrugation
Real-World Example 2

- Excessive Carbody Vertical Acceleration

- Findings:
  - Engine Burn
  - Pumping Tie
Detect Vehicle Issues with RQMs

- Primary and Secondary Suspension Components
  - Springs
  - Dampers
- Worn Wheels
Differentiating Track and Vehicle Issues

- Use Multiple Systems (Fleet Deployment)
- Track Root Cause
  - Multiple Vehicles Exhibit Same Exception at Same Location
- Vehicle Root Cause
  - One Vehicle Exhibits Acceleration Responses Inconsistent with Other Vehicles
Portable RQM History

2006: FRA Solicited Proposals for ULTRA-PORTABLE Ride Quality Meters

- Existing Commercial Systems:
  - Not “Portable”
  - Lacked GPS Integration
  - High Maintenance
  - Too Expensive

- Subjective Measurements
  - Rough Ride Locations Manually Noted
  - Rough Ride Conditions Varied Between Inspectors

Ideal Time to Revisit Ride Quality Meters

- Components are Increasingly Cost-Effective
- Components are Increasingly Smaller and Portable
Portable RQM Objectives

- Quantify Ride Quality Exceptions
- Real-Time Display of Data Channels
  - GPS
  - Acceleration
- Powered by Inspector’s Laptop
- Ultra-Portable
- Low-Cost
## Quantify Ride Quality Exceptions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter</td>
<td>Low Pass (Different Frequency Ranges)</td>
</tr>
<tr>
<td></td>
<td>Band Pass (Different Frequency Ranges)</td>
</tr>
<tr>
<td>Window</td>
<td>Milliseconds</td>
</tr>
<tr>
<td>Measurement Type</td>
<td>Peak to Peak</td>
</tr>
<tr>
<td></td>
<td>Zero to Peak</td>
</tr>
<tr>
<td></td>
<td>RMS</td>
</tr>
<tr>
<td></td>
<td>RMS Mean Removed</td>
</tr>
<tr>
<td></td>
<td>RMS Linear Trend Removed</td>
</tr>
<tr>
<td>Exclude Duration</td>
<td>Milliseconds</td>
</tr>
<tr>
<td>Level 1 Threshold</td>
<td>g (Alarm Condition)</td>
</tr>
<tr>
<td>Level 2 Threshold</td>
<td>g (Alert Condition)</td>
</tr>
</tbody>
</table>
Real-Time Display of Data

GPS Data Window

Accelerometer Data Window

Exception Data Window
Powered by Laptop

- GPS Receiver (USB/Bluetooth)
- Tri-Axial Accelerometers (USB)
- Ride Quality Software Installed on Inspector’s Laptop
Portable
Field Use
rMetrix History

2007-2008
- System Prototype (SBIR Phase I)
- Commercial System (SBIR Phase II)

2010-2011
- Version 1.3: Time and Frequency Analysis
- Version 1.4: Email Exceptions Data with Google Map Information

2012-2013
- Version 1.5: ISO 2631 Ride Comfort/Health
- Version 1.6: Upload Exceptions to Online Portal

2014
- Version 1.7: Overlay Geometry Defect Data
- Autonomous System
Autonomous Portable RQM

- Hardware
- Ride Quality
- Software Engine
- Real-Time Online Visualization
- Reporting
Impact of Low-Cost Portable RQMs

- Variety of Track Inspection Technologies
- Augments These Technologies More Comprehensively and Cost-Effectively
- Increased Situational Awareness of Track and/or Vehicles
  - Safety Standards
  - Proactive Maintenance Activities
Leveraging Portable RQM Technology

- Vehicle Qualification
- Suspension Systems
- Jerk Analysis
- Window Limits
- Speed Profile
- Time and Frequency Based Analyses
- Steady State Acceleration Measurements

Frequency-weighted acceleration levels can be correlated to:
- Crew and Passenger Comfort
- Crew and Passenger Health
Future of Portable RQMs

- **Economies of Scale**
  - More Coverage
  - Smaller, Cost-Effective Sensors
  - Data Storage Capacity

- **Track Defect Identification**
  - Rail Fractures
  - Chipped Rails
  - Broken Concrete Foundations

- **Carbody Acceleration to Detect Long-Wavelength Track Geometry Defects**
Contact Us

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- www.rMetrix.com