Electronic Train Management System and Safety
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March 9, 2007
Derailment Prevention

Technical Research & Development

- Small Team of Technical People (15)
- Derailment Investigation / Training
- Technical Consulting
- Simulation - Stopping Distance Analysis
- Safety Analysis
Derailment Prevention

Web Based Training

Technical Research & Development

Derailment Info:

INVESTIGATION ASSIST:
  An on-line derailment investigation manual, including a listing of the cause codes.
- Playbook
- List of items to take to a derailment
  Assistance in investigation procedures.
- Measurements:
  See procedures on how to take mechanical (equipment), engineering (track), and operating (transportation) measurements, and see what tools to use to take the measurements.
- Detectors:
  Mech. Detector Map & Data
  Eng. Detector Map & Data
  Ops. Detector Map & Data
  N/C. Detector Map & Data

DERAILMENT STATISTICS:
How is your area doing in reducing derails? See latest stats, 5 year trends, Derailment Map, etc.

CLASSES:
- Derailment Workshop
  See the schedule, and register to attend.

CONTACT LISTS:
- TR&D Contacts
- Transportation Contacts
- Engineering Contacts
- Mechanical Contacts (N/A)

FORMS:
Derailment Prevention

Risk Analysis

Average $ in Derailments By Cause Group

- Main Track Authority
- Flag / Signal
- Environmental
- Rail / Joint Bar Defects
- Axle / Journal
- Wheel Defects
- Track Geometry
- Other Way
- General Switching Rules
- Loading Proc.
- Misc. Other
- Train Handling / Make-Up
- Unusual Ops
- Hwy-Xing

Avg. Derailment Frequency in 5 Years

0 10 20 30 40 50 60 70 80 90 100
ETMS and Safety

ETMS Basics

- Electronic Train Management System
  - Primary purpose is to keep trains from colliding
  - Another important feature is to prevent trains from entering work zones without permission
  - Also prevents trains from over-speeding

- Video
ETMS and Safety

ETMS Background

- Previous Efforts – BNSF Involvement
  - ARES – Advanced Railroad Electronic System
  - PTS – Positive Train Separation
  - NAJPTC – North American Joint Positive Train Control
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FRA Approval Process

• Federal Regulation Developed using RSAC
  49 CFR Parts 209, 234, and 236 subpart H

  ➢ First step is to develop an Railroad Safety Program Plan - RSPP
  ➢ Product Safety Plan - PSP
  ➢ System Description and Operation Plans
  ➢ Training / Maintenance Plans
  ➢ Safety Analysis
RSPP

• Railroad Safety Program Plan
  ➢ Design Specification Document for All Processor Based Signal and Train Control Systems
  ➢ Describes Railroad Safety Concepts and Philosophy
    ➢ What Standards Were Used
  ➢ Describes Railroad’s Safety Critical Development Plans
    ➢ RSPP Lays Out the Architecture of the PSP
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RSPP

Severity
I. Catastrophic
II. Critical
III. Marginal
IV. Negligible

Probability
A. Frequent
B. Probable
C. Occasional
D. Remote
E. Improbable
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PSP

• Product Safety Plan
  ➢ Detailed Description of the Proposed System
  ➢ Description of Railroad Operations using this System
  ➢ Description of Sub-systems
  ➢ Description of the Safety Aspects of System
  ➢ System Architecture
  ➢ Hazard Log
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PSP

• Product Safety Plan (cont.)
  ➢ Comparison of Risk – Existing to Proposed MTTHE
  ➢ Description of Methodologies Used for Safety Analysis
    ➢ Preliminary Hazard Analysis – PHA
    ➢ Functional Fault Tree - FFT
    ➢ Sub-System Hazard Analysis – SSHA
  ➢ Verification / Validation Processes
  ➢ Human Factors Analysis
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PSP

• Product Safety Plan (cont.)
  ➢ Training of Operators and Maintainers
  ➢ System Operations and Maintenance Manual
  ➢ Test Procedures
  ➢ Post Implementation Monitoring
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ETMS Onboard Screenshot - ConOps

MILEPOST: 17.4
STOPPING DIST: 4210 ft
WARNING DIST: 1.4 mi
MAX SPEED 60 mph

WARRANT
MP 19.8 to 27.1
NEXT TARGET: MON SWITCH
DIST TO: 4589 ft
## ETMS and Safety

### ETMS Safety Analysis - PHA

<table>
<thead>
<tr>
<th>ID</th>
<th>Function</th>
<th>Hazard/Failure Modes</th>
<th>Consequence</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETMS01.01</td>
<td>Warn Train Approaching Unacknowledged Work Zone</td>
<td>Failure to Warn of Impending Unacknowledged Work Zone</td>
<td>None (Crew Controls Train) Enforcement w/o Warning * Collision w/ Work Gang **</td>
<td>None Negligible Catastrophic</td>
</tr>
<tr>
<td>ETMS01.02</td>
<td>Warn Train Approaching Unacknowledged Work Zone</td>
<td>Early Warning of Unacknowledged Work Zone (&gt;75 sec)</td>
<td>Increased Work Load</td>
<td>Negligible</td>
</tr>
<tr>
<td>ETMS01.03</td>
<td>Warn Train Approaching Unacknowledged Work Zone</td>
<td>Late Warning of Unacknowledged Work Zone (&lt;75 sec)</td>
<td>None (Crew Controls Train) Crew unable to properly set-up train Collision w/ Work Gang **</td>
<td>None Negligible Catastrophic</td>
</tr>
<tr>
<td>ETMS01.04</td>
<td>Warn Train Approaching Unacknowledged Work Zone</td>
<td>Visual Warning of Unacknowledged Work Zone without Audible Warning</td>
<td>None (Crew Controls Train) Crew misses warning - Enforcement w/o Warning Collision w/ Work Gang **</td>
<td>None Negligible Catastrophic</td>
</tr>
<tr>
<td>ETMS01.05</td>
<td>Warn Train Approaching Unacknowledged Work Zone</td>
<td>Audible Warning of Unacknowledged Work Zone without Visual Warning</td>
<td>Increases Work Load – Reason for Warning unknown to Crew</td>
<td>Negligible</td>
</tr>
</tbody>
</table>
## ETMS and Safety

### ETMS Safety Analysis - PHA

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
<th>Failure Rate (failures/hr)</th>
<th>Yearly Occurrence</th>
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</thead>
<tbody>
<tr>
<td>BROKEN_RAIL</td>
<td>Broken Rail Occurs</td>
<td>7.4E-4</td>
<td>6000</td>
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<tr>
<td>DISPATCH01</td>
<td>Dispatch misreads Authority Data to Crew</td>
<td>3.73E-4</td>
<td>30</td>
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<tr>
<td>DISPATCH02</td>
<td>Dispatch Supplies Erroneous Form B Data to Crew</td>
<td>6.22E-7</td>
<td>5</td>
</tr>
<tr>
<td>DISPATCH03</td>
<td>Dispatch misreads Speed Restriction Data to Crew - ETMS Data Correct-</td>
<td>1.24E-5</td>
<td>100</td>
</tr>
<tr>
<td>HF001</td>
<td>Crew Fails to Adhere to Existing Operating Rules</td>
<td>1.24E-3</td>
<td>10000</td>
</tr>
<tr>
<td>HF002</td>
<td>Crew Incapacitated or Inattentive</td>
<td>1.24E-4</td>
<td>1000</td>
</tr>
</tbody>
</table>
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ETMS Safety Analysis – Functional Fault Tree
ETMS and Safety

ETMS Safety Analysis – Functional Fault Tree

- Train to Train Collision
  - XTRAIN2TRAIN: 2.20E-04

- Train Exceeds its Authority
  - XRR045: 1.56E-05
    - Page 3

- Misaligned Switch
  - Page 16
  - XRR054: 9.93E-07

- Train passes over an Unsafe, Unmonitored Switch
  - XRR100: 7.47E-07

- Train passes over an Unsafe, Monitored Switch
  - XRR101: 2.46E-07
## ETMS and Safety

### ETMS Safety Analysis - Comparison

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Analysis</th>
<th>Failure Rate (failures/hr)</th>
<th>Events Per Year</th>
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</thead>
<tbody>
<tr>
<td>Collision Train Exceeds Authority</td>
<td>Existing</td>
<td>1.56E-5</td>
<td>125</td>
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<td></td>
<td>ETMS</td>
<td>4.39E-8</td>
<td>.353</td>
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<td>Collision Passes over Unsafe, Monitored Switch</td>
<td>Existing</td>
<td>2.46E-7</td>
<td>2</td>
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<tr>
<td></td>
<td>ETMS</td>
<td>2.69E-11</td>
<td>0.0002</td>
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<tr>
<td>Collision Passes over Unsafe, Unmonitored Switch</td>
<td>Existing</td>
<td>7.47E-7</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>ETMS</td>
<td>2.69E-11</td>
<td>0.0002</td>
</tr>
<tr>
<td>Collision Train Enters Work Zone w/o Permission</td>
<td>Existing</td>
<td>1.24E-5</td>
<td>100</td>
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<td></td>
<td>ETMS</td>
<td>5.70E-8</td>
<td>.458</td>
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</table>
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ETMS Safety Analysis - Reliance

1. Improper Use of ETMS Information
2. Improper Use of ETMS Functions
   - Training of Operators
   - Operations Testing
   - Post Implementation Monitoring
ETMS and Safety

Derailment Prevention Through Technology

ETMS Improves Safety

- Prevents Train-to-Train Collisions
- Prevents Work Zone Incursions
- Prevents Overspeed Derailments
- Provides Platform for Future Development