Intelligent Right of Way Safety & Inspection Systems

Dallas Texas - January 25, 2020
The FRA has Identified 6 Key Areas of Focus in 2020

1. **Safety**
2. **PTC (Positive Train Control)**
3. **Regulatory Form**
4. **Crossing & Trespasser Accidents**
5. **Amtrak**
6. **Technology**

**Key Technology Points from the FRA**

1. Developing Opportunities to promote safe methods to support growth.
2. Applying Prescriptive Regulations will do more harm for safe growth.
3. Augmenting performance & Prescriptive-based rule making

**Culture change with Technology**

“The Federal Railroad Administration cannot issue regulations fast enough to keep up with technology advancements within the railroad industry”

“White Papers and interaction with vendors and railroads will help support advancement that is favorable with FRA “

Ronald Batory – FRA Administrator, March 26, 2019
Today’s World..

Both Passenger and Freight Transportation teams need the latest state-of-the-art technologies to **modernize, optimize** and **improve** the rail car inspection process, which result in:

- Improved Safety
- Reduced Online Failures
- Greater Productivity
- Improved Yard & Network Fluidity
- Increased System Velocity

…most importantly, make it a more **reliable** and **safer** railroad.
Potential Rail Applications

FREIGHT

- rip® Railcar Inspection Portals
- vue® Vehicle Undercarriage Examiner
- tvue™ Thermal Vehicle Undercarriage Examiner

TRANSIT

- apis® Automated Pantograph Inspection System
- trackaware™ Track Intrusion Detection System
- centraco® Inspection Workflow Software Platform
Automated Rail Inspection Portal
The future of rail mechanical inspections

- High speed, high resolution cameras
- High-intensity LED lighting
- AEI reader and car cutting subsystem
- PTZ security cameras
- Laser motion sensing system
- Vehicle Undercarriage Examiner
vue® Vehicle Undercarriage Examiner

- Ultra-high definition \texttt{xtd}\textsuperscript{TM} images
- Precision linear speed sensor
- Undercarriage images of rail cars
- Supports reduced inspection times
vue® Vehicle Undercarriage Examiner cont’d
vue® Vehicle Undercarriage Examiner cont’d
Prevent the Accident Before it Becomes an Accident

- Defective Truck Spring
- Missing Cut-Lever
- Dragging Hand brake Chain
- Defective HB Wheel
- Defective Truck Spring
- Missing Bolt
- Low Hanging Air Hose
- Stuck / Applied Brake
- Hand Brake Applied
t-vue® Thermal Vehicle Undercarriage Examiner

- Thermal imaging displays thermal signatures
- Identifies component’s thermal signatures
- Components monitored include traction motors, motor bearings, gear drives, brakes, wheels, bearings, and power cables
t-vue®  Thermal Vehicle Undercarriage Examiner

Locomotive Image
apis® - 3d Automatic Pantograph Inspection System
apis® - 3d Automatic Pantograph Inspection System

- Dedicated apis® team
- Continuous R&D
- Accelerated Algorithm development for defects
Sample OCR Container Detection
Industrial Rail Car Inspection System
Industrial Rail Car Inspection System
Command and Control Inspection Workflow Software Platform with a user friendly interface
trackAware™ Intelligent Right of Way Safety System
trackAware™ Intelligent Right of Way Safety System

- Virtual fence, multiple zones
- Object classification
- Object tracking
- Directional movement
- Object counting per class
- Defect identification
trackAware™ Intelligent Right of Way Safety System

Lexington Ave at 59th Street
trackAware™ Intelligent Right of Way Safety System

- **100%** accurate human detection with proper pixels on target
- Distinguish/Identify specific markings (hardhat, safety vest etc.)
- People Counting
Track Aware Intrusion Detection – NYC Transit
When the signaling system activates the gate arms to stop traffic, the system will automatically engage the distinct alarm zone. Whenever a pedestrian, bicyclist, object or motor vehicle infringes upon or is within the zone, the following will occur immediately:

- Automated Zone Obstruction Radio Message transmitted via the railroad AAR radio channel to the oncoming train to take action using proper train handling
- An alarm will be transmitted visually and audibly to the OCC
- Real-time video will be automatically streamed to the OCC
- Potential to use cell notification within zone
- Locally, in addition to the existing bells from the gate arms, our system will begin to flash high intensity strobe lights and locally annunciate a warning message in multiple languages.

**trackAware™ Intelligent Right of Way Safety System**

<table>
<thead>
<tr>
<th>Distance from a Highway-Rail Grade Crossing (ft)</th>
<th>Casualties Nationwide</th>
<th>Casualties in Top 10 Counties</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 to 700</td>
<td>2,798 66 %</td>
<td>21 67 %</td>
</tr>
<tr>
<td>700 to 800</td>
<td>2,945 69 %</td>
<td>16 70 %</td>
</tr>
<tr>
<td>800 to 900</td>
<td>3,049 72 %</td>
<td>10 72 %</td>
</tr>
<tr>
<td>900 to 1,000</td>
<td>3,142 74 %</td>
<td>12 74 %</td>
</tr>
<tr>
<td>1,000 to 1,250</td>
<td>3,328 78 %</td>
<td>25 79 %</td>
</tr>
<tr>
<td>1,250 to 1,500</td>
<td>3,477 82 %</td>
<td>21 82 %</td>
</tr>
<tr>
<td>1,500 to 2,000</td>
<td>3,711 87 %</td>
<td>30 88 %</td>
</tr>
<tr>
<td>2,000 to 3,000</td>
<td>3,959 93 %</td>
<td>21 92 %</td>
</tr>
<tr>
<td>3,000 to 5,000</td>
<td>4,107 97 %</td>
<td>24 96 %</td>
</tr>
<tr>
<td>5,000 to 10,000</td>
<td>4,185 99 %</td>
<td>12 98 %</td>
</tr>
<tr>
<td>More than 10,000</td>
<td>4,242 100 %</td>
<td>11 100 %</td>
</tr>
<tr>
<td><strong>Total Casualties</strong></td>
<td><strong>4,242</strong></td>
<td><strong>559</strong></td>
</tr>
</tbody>
</table>

Source: FRA analysis.
trackAware™ Intelligent Right of Way Safety System
trackAware™ Intelligent Right of Way Safety System
trackAware™ Intelligent Right of Way Safety System

The Platform - Hardware

- It is an appliance,
  - **no cloud access is needed**
- Training can happen directly on the unit
- Inference on GPU and CPU
- Supports wide variety of hardware
  - **From single board to server class**
The Development of Algorithm Mapping
The Development of Algorithm Mapping

- Improving the Confidence level with FRA 49CFR Rules
- Performance Statistics
- Low False Positive Rate
- Consensus Data
- Document Progression and Development from Start to Finish
The Development of 49CFR - Algorithm Mapping

Model Validation Checklist

NS AIP – Model Validation Checklist

<table>
<thead>
<tr>
<th>Item</th>
<th>Question</th>
<th>Rationale</th>
<th>Ranking (1-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>To what extent was the appropriateness and the completeness of assumptions checked?</td>
<td>Consensus data will be analyzed in a cloud staging environment prior to being sent to a staging environment where the images will be further validated</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>To what extent was it checked that all variables employed have been clearly defined and listed?</td>
<td>Variables will be defined per FRA requirements and the reference points will be adjusted as changes are made to these requirements. As the requirements are updated the new metrics will be fed into the system and the models will be re-trained to ensure the new guidelines are followed</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>To what extent have the causal relationships between variables been included?</td>
<td>To address the risk of causal relationships, the models will receive feedback on a gated process from application creation to model output</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>To what extent has input data been assessed in terms of reasonableness, validity and understanding?</td>
<td>Model input data will be validated by comparing car-associated metadata information across different portal locations. The data being used is captured in a consistent format across the network</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>To what extent has a comparison of model outputs against actual realizations been performed?</td>
<td>Outputs will be validated by comparing car-associated billings to the list of defects found by the portals</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>To what extent are all results repeatable?</td>
<td>Repeatable results will be validated by having different trainers train each model to mitigate the bias that may be held by a single trainer</td>
<td>6</td>
</tr>
</tbody>
</table>

Note: The purpose of this checklist is to provide high-level guidance as to the types of items that should be verified when validating mechanical inspection workflows, including all applications. This checklist is based on requirements to ensure models meet the same standards and have passed a gating process before being released into production. Please answer the below questions ranked from: 1-No Evidence | 2-Due Consideration Lacking | 3-Some Consideration | 4-Fully Evident.
The Platform – Chaining

- Freightcar Classification (99%)
- Open Boxcar Door (99%)
- ISO 646: Intermodal IDs ID (94%)
- Intermodal ID OCR (97%)
- Brake Piston (100%)
- Cushion Device (100%)
- Brake Connecting Rod (99%)
- HopperDumpGate (99%)
- Side-a
- Top
- Side-b
- trids
- trids 2
- Freighthopper (99%)

[Diagram showing various elements related to rail inspection and analysis]
Case Study – Hazmat Placards

• 99% accuracy of localization and 100% accuracy on OCR
What are the end results?
Inspection Solutions Offer Immediate Value

The future of rail mechanical inspections

1. Safety – Reduction in Derailments & Employee Injuries
2. Dwell Impact – Significant Reduction in Cars Sitting Idle
3. Capacity – Creates Virtual Capacity
4. Velocity – Significant Increase
5. Productivity – teams become “Fixers” Instead of ”Finders”
6. Expense – Reduction in Labor Expenses
7. Train Accuracy – Eliminate Ghost Containers/Cars/Assets
8. Value – Significant Impact on Operating Ratios
9. ROI – Immediate Return of Investment
Inspection solutions can offer immediate value

Application of automated hub inspection process on current class 1 operation yields immediate value

### Automated Car Inspection Portals – Benefits

<table>
<thead>
<tr>
<th>Benefits Drivers</th>
<th>Estimated Annual Benefits (in M$)</th>
<th>Estimated Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roll-By Elimination Moving carmen off roll-by inspection</td>
<td>$0.7</td>
<td>Q2 ’19</td>
</tr>
<tr>
<td>Wheels Defect Cost avoidance of derailments due to wheel failures</td>
<td>$0.7</td>
<td>Q2 ’19</td>
</tr>
<tr>
<td>Derailments Prevention Cost avoidance of derailments with mechanical causes</td>
<td>$0.4</td>
<td>Q3 ’19</td>
</tr>
<tr>
<td>Dwell/Yard Delays Reduction Reduction in costs related to in yard delays</td>
<td>$1.8</td>
<td>Q3 ’19</td>
</tr>
<tr>
<td>Border Wait Time Reduction Reduction in border delays to due to mismatch with Manifest</td>
<td>$0.3</td>
<td>Q2 ’19</td>
</tr>
<tr>
<td>R&amp;D Tax Benefits</td>
<td>$0.2</td>
<td>Q2 ’19</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$4.1</strong></td>
<td></td>
</tr>
</tbody>
</table>
Thank You – Q&A