A SURVEY OF FUTURE RAILROAD OPERATIONS AND THE ROLE OF AUTOMATION

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Imagination at work.
Survey Overview

Goals:

• Elicit view of future automation in rail industry: Generate discussion!
  – Features, success metrics, new operational configurations, adoption
  – Automation concerns

Methodology:

• Delphi Survey Method (Helmer, 1967)
  – Round 1: open-ended questions
  – Round 2: ranking of prior responses + research team options
  • Modified to reduce time to complete
Survey Participants & Topics

7 in first round (3 GE, 4 RR), 8 in second round (3 GE, 5 RR)

Current Roles: senior controls/systems engineers (GE), directors of operations, locomotive productivity, operating technology, and safety (Class 1 RRs)

<table>
<thead>
<tr>
<th>Experience as Crew Member</th>
<th>Mean</th>
<th>Range</th>
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</thead>
<tbody>
<tr>
<td>Engineer</td>
<td>12.8 years</td>
<td>0 – 25 years</td>
</tr>
<tr>
<td>Conductor</td>
<td>13.8 years</td>
<td>0 – 31 years</td>
</tr>
<tr>
<td>Dispatcher</td>
<td>0 years</td>
<td>0 years</td>
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<tr>
<td>Foreman</td>
<td>8 years</td>
<td>0 – 18 years</td>
</tr>
</tbody>
</table>
Results Summary

Desired Future Automation Features:

- Proper interaction with disturbances (slow orders, work zones, current conditions, etc.)
- Automatic pacing of trains to avoid restricted signals when possible and meet schedule
- Display paperwork, switching information, routing, etc. electronically in the cab

Measures of Success of Automation Systems:

- Train Safety
- Minimize authority violations
- Ease of Use
- Compatibility with other automation and technology adoption rate
- Train efficiency (e.g., fuel consumed)

Solutions to Improve Operator Training:

- Provide operators with additional simulator time with the automation system
- In current classroom training environment, provide examples of designed strategies of the automation system
- In current classroom training environment, present example failures due to human over-reliance on automation and technology adoption rate
- Incorporate an element of malfunctions into simulations

Solutions to Reduce Operator Deskillling:

- Improved design of transitions from automatic to manual modes to ensure operator situation awareness
- Require operators to maintain and document ongoing manual operation in a simulator
- Introduce technology to monitor crew alertness and revert to a more manual mode of operation if the operator appears to be unengaged in the operation of the train
- Have the automation systems periodically require the operator to take manual control of the system (with and without advanced warnings)

Highlights:

- Desired: additional automation, longer/heavier trains, more information in cab
- Key success metrics: Ease of use and compatibility
- Need to provide more comprehensive training
- Work to improve operator situation awareness after automatic/manual transitions
Desired Features, Success Metrics
Importance of Desired Future Loco Automation Features

- Proper interaction with disturbances (slow orders, work zones, current conditions, etc.).
- Automatic pacing of trains to avoid restricted signals when possible and meet schedule.
- Display paperwork, switching information, routing, etc. electronically in the cab.
- Allow for safe operation of longer and/or heavier trains.
- Monitor and communicate track health.
- Ability to automatically detect exceptions (track failure, object on right or way, etc.).
- Monitor and communicate individual freight car health.
- Monitor and communicate locomotive health to service shop.
- Monitor and communicate locomotive fuel levels to fueling station.
- On-board crew feedback during manual operation (speed compliance, train handling, etc.).
- Remotely perform train inspections.
- Individual freight car control (braking and/or monitoring) to improve train handling or velocity.
- Reduce wear or impact to equipment and infrastructure.
- Capability for engineers to report work done (set-offs, switching, etc.) electronically from the cab.

Rating Average
Importance of Measures of Success of Automation

- Train Safety
- Minimize authority violations
- Ease of Use
- Compatibility with other automation and...
- Train efficiency (e.g., fuel consumed)
- Technology adoption rate
- Schedule adherence
- Rail network efficiency (e.g., average velocity)
- Labor efficiency (e.g., higher proportion of time...)
- Minimize human intervention

Details of ideas about how to measure each in full paper (DOI: 10.3141/2608-02)
Alternate Operating Configurations
New Operating Configurations

Question motivated by recent proposals for single-person crews with roving “conductors”

<table>
<thead>
<tr>
<th>Tasks Performed by Remote Crew</th>
<th>Tasks Retained by Local Crew</th>
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</thead>
<tbody>
<tr>
<td>Handle train movements through territory.</td>
<td>Exceptions requiring manual interventions (i.e., automatic switch failure, other mechanical failures).</td>
</tr>
<tr>
<td>Train inspections.</td>
<td>Switching activities, coupling, and uncoupling.</td>
</tr>
<tr>
<td>Track inspections.</td>
<td>Assembly/disassembly of trains.</td>
</tr>
<tr>
<td>Remotely operating train on main line with no en-route switching, operating more than one train.</td>
<td>Guidance over unprotected public crossings.</td>
</tr>
<tr>
<td>Pull back of tracks in yard switching.</td>
<td>Horn and bell operation.</td>
</tr>
<tr>
<td>Monitor signals.</td>
<td>Monitoring environment for emergency situations.</td>
</tr>
<tr>
<td>Air brake application.</td>
<td>Air brake application.</td>
</tr>
<tr>
<td>Speed control.</td>
<td>Monitoring gauges.</td>
</tr>
<tr>
<td>Alert button application.</td>
<td>Checking that siding is clear.</td>
</tr>
<tr>
<td>Monitor train location.</td>
<td></td>
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</table>

Consensus: technically feasible (though some current gaps), unsure of public/regulatory feasibility
Automation Benefits by Task

- Maintain awareness of and respond to maximum safe speed.
- Maintain awareness of and incorporate new information received en-route.
- Maintain awareness of and respond to current track conditions.
- Maintain awareness of and respond to track topology (curvature, grade, grade crossings, signal locations, etc.).
- Maintain awareness of and respond to nearby traffic.
- Maintain awareness of and comply with rules and regulations.
- Maintain awareness of and respond to train state (speed, coupler forces, etc.).
- Maintain awareness of and respond to tactical intermediate plan (plan for next 5-7 miles).
- Maintain awareness of and respond to automation system limitations.
- Maintain system integrity (vigilance toward proper operation of wayside equipment, track encroachment, following authority, etc.).
- Maintain awareness of and respond to crew capacity (time of work, alertness, etc.).
- Maintain awareness of and respond to long-term plan.

All average ratings are positive – industry sees net benefit of increased automation
Automation Concerns
Operator Deskilling

“users of the technology…feel they are being sidelined….made redundant”

Feasibility of possible solutions:

**Solutions to reduce operator deskilling and its effects.**

- Improved design of transitions from automatic to manual modes to improve operator situation awareness.
- Require that operators have significant and ongoing manual operation in a simulator.
- Introduce technology to monitor crew alertness and revert to a more manual mode of operation if the operator appears to be unengaged in the operation of the train.
- Have the automation systems periodically require the operator to take manual control of the system (with and without advanced warning).
Operator Training

Need “continuous training with respect to updates”

“PowerPoint [not effective]….having simulator capability….in classroom”

“if crew understands why system does what it does…they will accept the system more readily”

Feasibility of possible solutions:

- Provide operators with additional simulator time with the automation system
- In current classroom training environment, provide examples of designed strategies of the automation system...
- In current classroom training environment, present example failures due to human over-reliance on automation and...
- Incorporate an on-the-job training mode into automation solutions
- Additions to automation system interface explaining behavior to operator (i.e., allow the operator to have...
“designers are too far removed from the train crews’ environment…start thinking like a locomotive engineer”

“products tend to be sold before developed…[have to wait] for production…

“[results in] systems that do things we didn’t need and won’t use…counter productive…complications”

Feasibility of possible solutions:

- Have railroad personnel participate in early concept design reviews.
- Railroad to provide opportunities for design engineers to have operational field experiences.
- Encourage developers to employ former railroaders for design, testing, and evaluation.
- Move to an interactive, iterative development and field test model rather than waiting for a finished product.
- Have railroad-provided test engineers operate new systems on a simulator before operational testing.
- Have railroads create technology fund for initial development of automation, then receive discounts on resulting products.
Takeaways

Rail industry sees net benefit of increasing automation and wants to explore alternate operating configurations

Opportunities to improve training effectiveness, design process

Questions? brooksja@ge.com
Related Publications


