Rail IT – from Automation to Optimization of Railway Operations

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- State of the art – Rail Automation
- Tomorrow’s needs – Rail Optimization
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In the beginning – Rail Safety
Rail Operations Safety

Objectives

- Avoidance of human error
- Increase of operational safety
- Reduction of the number of operator actions
- Improvement of quality, i.e. enhanced reliability and punctuality

Approach

- Trackside equipment (signals, switches)
- Operational rules (based on “block concept”)
- Technology support for “block concept” (interlocking system)
- Centralized supervision (signal adherence control, distance/speed control)
- First train protection systems with enforced braking (Indusi based)
- Systematic Quality Assurance (models, assessments, approvals)
What makes railway operations safe?

- **Safe distance supervision:**
  - Traditional: Each section (block) must not be occupied by more than one train
  - Modern: Safe braking distance

- **Signalling and Control of admissible speed**
  - Traditional: By signals and train control
  - Modern: By cab signalling

- **Protection against flank, head and tail collisions**

- **Locking of movable wayside elements**

- **Well trained personnel**
Significance of Safety

- Safety is a clear competitive advantage of railways, in particular in comparison with individual transport modes.
- The achieved safety level is very high and only comparable to civil aviation.
- Safety is a core competency of the railway industry.
- Insufficient level of safety is a KO criterion for railway products.
- Suicide candidates, careless grade crossing people and track trespassers cause accidents that no system can prevent.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fatality Risk (EU-15 2003) Per 100 mio passenger kilometer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road (Total)</td>
<td>0.95</td>
</tr>
<tr>
<td>Motorcycle/moped</td>
<td>13.8</td>
</tr>
<tr>
<td>Foot</td>
<td>6.4</td>
</tr>
<tr>
<td>Cycle</td>
<td>5.4</td>
</tr>
<tr>
<td>Car</td>
<td>0.7</td>
</tr>
<tr>
<td>Bus and coach</td>
<td>0.07</td>
</tr>
<tr>
<td>Ferry</td>
<td>0.25</td>
</tr>
<tr>
<td>Air (civil aviation)</td>
<td>0.035</td>
</tr>
<tr>
<td>Rail</td>
<td>0.035</td>
</tr>
</tbody>
</table>
Casuality distribution of rail operations

Figure 6 – Fatalities per victim category (2008–2010)

61%
28%
4%
4%
3%

Source: European Railway Agency – 2012 Railway safety performance in the European Union
From manual work to computer interaction

Rotary switches

Operating levers

Signalman’s workplace in Braunschweig (1965)

Workplace in Hannover (1965)

Workplace in Helmstedt (1979)

Push button plane

Workplace in Murnau (1988)
State of the art – Rail Automation
Automation of Rail Operations – From operations control to dispatch management

Objectives
- Further improvement of safety, e.g. by automated train control
- Further improvement of reliability and punctuality
- Increase in line capacity through shorter headways
- Sharing of trains and infrastructure across country borders
- Further reduction of routine activities

Approach
- More sophisticated automated train control (ATP, ATO, ATR)
- Standardization of technology and operation rules (ETCS)
- Increased usage of radio communication (GSM-R, WLAN)
- Introduction of driverless trains (airport people movers, subways)
- Complex operation control centers
ETCS Level 1
Intermittent automatic train control via Eurobalises

- operational rules based on fixed blocks
- „supervision“ of train and driver behavior at „check points“
- automated train protection in case of driver mistake

LEU: lineside electronic unit
TVDI: track vacancy detection indication

LEU: lineside electronic unit
TVDI: track vacancy detection indication

Signal aspect
Eurobalise (transparent)
Eurobalise (fixed) e.g. line parameters
Vacancy detection section boundary

Interlocking

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Operations Control and Dispatching – From computer workstations to computer control centers

Operator console in Hungary (1997)


Future Web-based solutions (prototype status)
Tomorrow’s needs – Rail Optimization
How can I improve the Business?
By overall Optimization of Rail Operations

Objectives
- Maximum utilization of available resources, reducing „total costs of ownership“
- Creating timetables by optimizing assets (trains, infrastructure), people (crews) and other operating costs (energy, maintenance)
- Online correction/re-action in case of failures
- Continuous information to all stakeholders (passenger, staff, management)
- Fulfilling business targets (incl. the possibility of performance contracts)
- Easy to use, easy to use, easy to use, …

Approach
- IT infrastructure as enabler (wireless communication, server farms, cloud, …)
- Decision support systems for operators and dispatchers
- Software for optimization and re-planning (Operations Research algorithms)
- Predictive supervision and maintenance of equipment
- System / UI integration based on usability studies
Example Operational Train Control -
Energy-efficient automated train operation (E-ATO)

Test Installation of „Falko Advice“ in 2004
Driver receives advice on PDA (start, stop, speed up/down)
Example Operational Train Control - Energy-efficient automated train operation (E-ATO)

Energy consumption

![Bar chart showing energy consumption for different scenarios: Reference, Falko Advice, existing ATO, and manual drive. The chart displays energy used in kWh, with values of 108.7, 91.5, 96.4, and 96.5 respectively.](image-url)
Example Operational Train Control - Energy-efficient automated train operation (E-ATO)

Delays

Delays per trip

<table>
<thead>
<tr>
<th></th>
<th>Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>144</td>
</tr>
<tr>
<td>Falko Advice</td>
<td>3</td>
</tr>
<tr>
<td>existing ATO</td>
<td>40</td>
</tr>
<tr>
<td>manual drive</td>
<td>24</td>
</tr>
</tbody>
</table>

Example Operational Train Control - Energy-efficient automated train operation (E-ATO)
Example Dispatching in Operations Control - Timetable execution activities

- **Elimination of structural conflicts**

  - **Time table construction**
    - Off-line
  
  - **Time table execution**
    - Online
  
  - **Time table reporting**
    - Off-line
  
  - **Time table analysis**
    - Off-line

- **Continuously in real-time**
  - Train tracking & performance analysis (detect time table deviations)
  - Route setting & route release (automatic, semi automatic, manual)
  - Conflict detection (+ rule based conflict resolving)

- **Prognosis, once per x seconds** = Advanced conflict management
  - Conflict prediction; (semi) automatic or manual conflict resolution
  - Speed profile calculation for driver guidance
  - Adapt the production time table >> Inform customers

- **Administration work**
  - Register reasons for deviations & conflicts
Possible methods for timetable modifications

Search for possible solutions

- **Change only times**
  - speed up or slow down trips
  - longer or shorter (if possible) scheduled dwell-times
  - new departure times
  - decision of keeping or breaking connections

- **Change order of trips**
  - includes crossing or passing
  - implicitly combined with changes of times

- **Change of trip routes**
  - trains use other routes within bottleneck areas
Automatic conflict resolution is NP-hard

Possible heuristics and simplifications in the railway domain:

- time interval selection
- limited look-ahead for prediction and calculation
- reduced routing possibilities
- fixed speed profiles
- fixed train order
- fixed headways
- pre-calculated solutions
- geographical decomposition (e.g. macro-, meso- and micro topology)
- multi-level approach
- combinations of different strategies

Difficulty – Someone has to make decisions!
Requirements on the Implementation of future Rail-IT systems

- **Scalable architecture** that supports individual usage (personal workplace) as well as “super-centralized” infrastructures (cloud concepts)

- **Conceptual merge of different user interfaces** including cross-role operative and dispatching tasks

- **Event-based operator guidance** to further relieve operators of routine tasks

- **Modern devices for portable usage** like tablets, PDAs, smart phones

- **Suitable application of new interaction technologies** for implementation of flexible working systems

- **Reduction of equipment** and elimination of functional redundancies at workplaces

- **Concentration of IT infrastructure**, for example in a „private cloud“
UI Integration Concepts:
Only systems that are “easy to use” will be accepted

"Consistency is assumed to enhance the user's possibility for transfer of skill from one system to another.

Note: prototypes status
Innovative Interaction Concepts: Multi-touch table for efficient team collaboration

Note: prototypes status
Adoption of Standard Tools: Possible Mobile Devices for Service Teams

Note: prototypes status
Our Vision: Pioneer in Rail Efficiency
Thank you very much for your attention

Rail Automation from Siemens: Bringing Complete Mobility to Life