The Impact of Railway Automation on Train Driver Tasks and Skills

Niels Brandenburger, Dr. Anja Naumann
German Aerospace Center (DLR)
Rail Human Factors
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Trends in the railway domain

- Digitalization
- Automation
- Centralization
- Shift from direct and active operations to supervisory activities

Human/Organisation/System Design
Railway Automation

- General framework provided by Grades of Automation (GoA) [1]
  + Railway specific
  - Proposed for closed metro systems

- At DLR, we study the role of the train driver at each grade up to GoA4 in mainline operation
  - Task analyses
  - Simulator studies

- Today’s focus is on tasks and skills at GoA2

<table>
<thead>
<tr>
<th>Grade of Automation</th>
<th>Type of train operation</th>
<th>Setting the train in motion</th>
<th>Stopping train</th>
<th>Door closure</th>
<th>Operation in event of Disruption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade of Automation 1</td>
<td>ATP with driver</td>
<td>Driver</td>
<td>Driver</td>
<td>Driver</td>
<td>Driver</td>
</tr>
<tr>
<td>Grade of Automation 2</td>
<td>ATP + ATO with driver</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Driver</td>
<td>Driver</td>
</tr>
<tr>
<td>Grade of Automation 3</td>
<td>Driverless</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Train attendant</td>
<td>Train attendant</td>
</tr>
<tr>
<td>Grade of Automation 4</td>
<td>Unattended train operation (UTO)</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Automatic</td>
</tr>
</tbody>
</table>


Source: DLR e.V.
Train Driver Tasks in GoA2 \cite{2}

- Characteristic changes in task environment
  - Quite infrequent manual speed control
  - Proportionally more visual monitoring tasks (displays and outside)
  - Infrequent but critical diagnosis and intervention

Typical intermediate level of automation
Train Driver Skills in GoA2 [2]

- Extracted job requirements for GoA2 train drivers (F-JAS[3]: n=21)
- Key changes in skills:
  + Interactive/ social skills
  + Perceptual (mainly visual) skills
  + Cognitive skills
  + Psycho-motoric skills
  - Physical and basic technical skills

<table>
<thead>
<tr>
<th>Item</th>
<th>Domain</th>
<th>Mean Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependability</td>
<td>Interactive/social</td>
<td>6.43</td>
</tr>
<tr>
<td>Perseverance</td>
<td>Interactive/social</td>
<td>5.86</td>
</tr>
<tr>
<td>Far vision</td>
<td>Sensory/ perceptual</td>
<td>5.81</td>
</tr>
<tr>
<td>Night vision</td>
<td>Sensory/ perceptual</td>
<td>5.76</td>
</tr>
<tr>
<td>Reaction time</td>
<td>Psycho-motoric</td>
<td>5.57</td>
</tr>
<tr>
<td>Control precision</td>
<td>Psycho-motoric</td>
<td>5.57</td>
</tr>
<tr>
<td>Selective attention</td>
<td>Cognitive</td>
<td>5.48</td>
</tr>
<tr>
<td>Problem sensitivity</td>
<td>Cognitive</td>
<td>5.43</td>
</tr>
<tr>
<td>Speech clarity</td>
<td>Interactive/social</td>
<td>4.86</td>
</tr>
<tr>
<td>Near vision</td>
<td>Sensory/ perceptual</td>
<td>4.67</td>
</tr>
</tbody>
</table>

Source: DLR e.V.

Effects of GoA2 tasks on train drivers in the simulator

- In comparison to GoA1:
  - **Task-induced fatigue** remains critical issue [4]
    - Monotony and sustained attention…
    - How do we alleviate the continuous visual monitoring strain?
  - **Response times** to unexpected critical stimuli increase [5]
    - Out-of-the-loop/situation awareness (SA)…
    - How can we highlight critical situations/train for better anticipation of those?
  - **Workload** in routine task drops to suboptimal level [6]
    - Low task-load/complacency/task disengagement…
    - Can we preserve the meaningful/holistic nature of train driving?

![Diagram of Grade of Automation and Type of train operation]

- [Source: International Association of public Transport, 2012]
- [Source: DLR e.V.]
Skill retention in GoA2 – On-the-job measures

- **Mandatory manual driving periods** (counter fatigue/low workload)
  - Perceptual skills
    - Routine information acquisition
    - Feeling of traction
  - Cognitive skills:
    - Problem sensitivity
    - Selective attention

- **Enhance standardized communication with track side** (counter fatigue/low workload)
  - Interactive/social skills
    - Dependability
    - Speech and information clarity
    - Safety culture (team attitude)

- **Intensify check of technical display during station stops** (heighten SA)
Skill retention in GoA2 – Training to enhance SA

- **Frequent simulator training** (manual driving and disruptions)
  - Perceptual skills
    - Routine information acquisition
  - Cognitive skills:
    - Selective attention
    - Problem sensitivity
    - Mental models of disruption processes

- **Joint regular disruption debriefings** (e.g. analyse anonymous videos or logs)
  - Cognitive skills:
    - Problem sensitivity
    - Mental models of disruption processes
  - Technical skills
    - Diagnosis capability

Source: DLR e.V.
Train Operator (TO) Workplace – GoA3
Potential development of the train driver’s role in the context of automation

• **Approach** [7], [8]:
  - Occasional request of the (autonomously driving) train for the TO in critical operational situations (e.g., animals on the track -> driving on sight)
  - TO takes over the train via remote control (e.g., in a control room)
  - TO hands train back to automation when situation is solved
  - Train is driving autonomously again, TO documents his intervention

References

**Automation Effects, Tasks, and Skills**


**Train Operator**


Call for Contributions

Special issue for Cognition Technology & Work journal:
The role of human factors for sustainable and resilient rail systems

Keywords: railway, guided transport, design, operation, maintenance, supervisory, driving, infrastructure, human support system, safety, reliability, security, energy consumption, human factors, sustainability, resilience, dissonance, autonomous driving, accidentology, degree of automation, impact of automation, human-machine cooperation

Organizers: Frédéric VANDERHAEGEN (Univ. Valenciennes, France), Jean-Marie BURKHARDT (IFSTTAR, France), Weining FANG (Beijing Jiaotong Univ., China), Anja NAUMANN (DLR, Germany), Grigore M. HAVĂRNEANU (UIC, France)

Contact:
F. Vanderhaegen, University of Valenciennes, LAMIH UMR CNRS 8201, France, Frederic.vanderhaegen@univ-valenciennes.fr
J.-M. Burkhardt, IFSTTAR, France, jean-marie.burkhardt@ifsttar.fr
W. Fang, Beijing Jiaotong University, China, wnfang@bjtu.edu.cn
A. Naumann, DLR, Germany, Anja.Naumann@dlr.de
G. M. Havărneanu, UIC, France, havarneanu@uic.org

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Thank you very much for your interest!

Dr. Anja Naumann
Anja.Naumann@dlr.de

Niels Brandenburger M.Sc.
Niels.Brandenburger@dlr.de

Institute of Transportation Systems, Human Factors Department
www.DLR.de