BUILDING UP A MODULAR TRAM SIMULATOR

Jan Grippenkoven
Agenda

1) Introduction DLR

2) Research Questions / Usability Engineering

3) The Simulator

4) The Virtual Environment
DLR

7400 employees across 32 institutes and facilities at 16 sites.

Institute of Transportation Systems

Residence: Braunschweig, Berlin
Since: 2001
Director: Prof. Dr.-Ing. Karsten Lemmer
Employees: About 150 employees from various scientific disciplines
Fields of Research: Automotive
Railway Systems
Traffic Management
Range of Tasks: Basic research
Creating concepts and strategies
Prototype development
Quality: DIN EN ISO 9001
VDA 6.2
ISO 17025 (RailSiTe®)
Institute of Transportation Systems
The objectives of building up a Tram Simulator

Key requirements

1. The simulator has to serve **scientific research** in the field of traffic psychology and usability engineering.

2. The simulator with all components has to be designed in a way, that allows different partners to **implement and evaluate** their specific **control panels** and assistance systems.

3. The simulator has to be **modular** in a way, that enables usability research on different constellations of control- and displaymedia.
Research Questions
Risk factors

- Pedestrians
- Perceptual load of the driver
- Lane change
- Bad sight
- Crossing vehicles
- Distraction by passengers
Example 1: Car crosses rails

- Crossing error, inattentive crossing of cars coming out of a street branch
- Mistakes while turning left / illegal U-turning
- Full-break by tram driver necessary

→ Research on trajectory based warning system?
→ Haptic Feedback via an active sidestick?
Example 2: Heavy perceptual load

- High traffic density during rush hour
- Parallel fashion of tasks:
  monitoring road traffic, pedestrians, schedule, stops.
- Noisy passengers
  → Research on effects of automation. How much automation is beneficial?
  → Can visual resources be relieved by making use of acoustic and haptic feedback?
Usability Engineering
Usability Engineering

- **ISO 9241** defines usability as
  "The extent to which a product can be used by specified users to achieve specified goals with **effectiveness**, **efficiency**, and **satisfaction** in a specified context of use."

**Typical considerations:**
- Who is the user? What are his characteristics?
- How might we support the user in accomplishing his goals…
  …fast.
  …with as few errors as possible.
- Which aspects of the working environment are more / less complex?
- How do systems have to be designed in order to meet the requirements of the users?
What determines the usability of systems in a tram?
The Simulator
<table>
<thead>
<tr>
<th></th>
<th>Distance</th>
<th>Speed</th>
<th>Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Longitudinal Y</strong></td>
<td>±1,5 m</td>
<td>± 2 m/s</td>
<td>±10 m/s²</td>
</tr>
<tr>
<td><strong>Lateral X</strong></td>
<td>±1,5 m</td>
<td>± 2 m/s</td>
<td>±10 m/s²</td>
</tr>
<tr>
<td><strong>Vertical Z</strong></td>
<td>±1,3 m</td>
<td>±1 m/s</td>
<td>±10 m/s²</td>
</tr>
<tr>
<td><strong>Roll</strong></td>
<td>-20 ° / +21 °</td>
<td>±50 °/s</td>
<td>±250 °/s²</td>
</tr>
<tr>
<td><strong>Pitch</strong></td>
<td>±21 °</td>
<td>±50 °/s</td>
<td>±250 °/s²</td>
</tr>
<tr>
<td><strong>Yaw</strong></td>
<td>±21 °</td>
<td>±50 °/s</td>
<td>±250 °/s²</td>
</tr>
</tbody>
</table>
Why are LEGO bricks the greatest toys in the world?
They are modular!
Virtual Environment
Defining a modular driving environment – The „tile - solution“
The Road Designer

- puzzling together the tiles
Part of the innercity crossing tile
Oncoming Traffic: Low - Floor Tram NGT8D (Braunschweig)
Cross Section – WeisenhaUSDamm / Braunschweig
Cross Section – Gliesmaroder Straße / Braunschweig
Next Steps

- Defining the last tiles for the virtual environment
- Manufacturing the Mockup and the Skin
- Finalizing the Interior design
- Motion Cueing
Thanks to the BVG simulator team!

Quelle: BVG
Thank you for your attention!

Jan Gripenkoven
jan.gripenkoven@dlr.de
Tel: +49 531 295 3507

DLR e.V.
Institut für Verkehrssystemtechnik
Lilienthalplatz 7
38108 Braunschweig
Backup Slides
Da die Höhe des Simulators ca. 30% kleiner ist, als bei einer „echten“ Straßenbahn, ist es ganz besonders wichtig, die reale Breite und die Erscheinung so schmal wie möglich zu gestalten, damit die Proportionen elegant wirken. Deshalb würde ich auch in der Draufsicht von einer kreisbogen förmigen Front absehen und statt dessen an den „Backen“ Volumen wegnehmen, um den Kopf zu verjüngen.
große Verteilung Funktionselemente und Anzeigen

Bahnsteuerung
- Geschwindigkeitsanzeige
- Blinker Recht-Links Schalter
- Warnblinklicht Schalter
- Scheibenwischer Schalter
- Scheibenheizung Steuerung
- Licht Schalter
- Warnton Taster
- Außenspiegel Steuerung
- Mikrofon

Anzeige
- Haltestellen
- Streckenplan
- Haltewunsch

Hauptschalter
- Einschalt Schlüsselschalter
- Werkstattfahrt
- Kuppelfahrt
- Hilferuf
- Klimaanlage Steuerung
- Licht Innenraum Steuerung

Geschwindigkeitsteuerung
- Beschleunigungen
- Bremsen
- Vollbremsung?

Passagierbezogene Funktionen
- Türautomatik Schalter
- Türe Auf/Zu vorn hinten
- Boden senken/heben
- Sanden Schalter
- Not-Aus Schalter

Überwachungskamera innen
Tramway traffic
Characteristics of tramway traffic, compared to trains

- Driving by range of sight, not determined by pre- and main-signals.
- Slower than trains.
- Higher frequency of stops.

- Variable driving paths
  Independent tracks
  Shared trafficspace with other participants

- Higher level of attention required.

- More accidents with damage to persons
- Broader variety of control concepts
Accident Statistics

Comparison of the absolute number of accidents with damage to persons between train (red) and tram (blue), 2007 – 2010.

(Source: Statistisches Bundesamt)