Automatic Incident Detection
Content

Motivation

Frame conditions at the Elbtunnel

Field Test - Involved Systems

Field Test - Results

Actual Project Status
Motivation
One Requirement of the RABT 2006 for the safety upgrade of the Elbtunnel was to equip the four Tubes with a Traffic Monitoring System for a quick and reliable Incident Detection every 300 m ...
But which system??

RABT gives no specifications or detailed requirements

To do:
⇒ Market Analysis
⇒ System Analysis
⇒ Field Tests
Frame conditions at the „Elbtunnel“
4 tubes in operation

- Surveillance 24 hours / 7 days
- Technical staff, Police and Fire Brigade
- Manual incident detection by video monitoring with 72 Monitors
Geometrical conditions

Old tubes 1\textsuperscript{st} to 3\textsuperscript{rd}
- Length ca. 2,800 m
- Clear height 4.5 m
- Lane width 3.50 m
- Bright walls out of white ceramic tiles

Newer 4\textsuperscript{th} Tube
- Length ca. 3,100 m
- Clear height 4.85 m
- Lane width 3.75 m
- Hard shoulder width 2.00 m
- Grey walls out of facing concrete
Traffic Volumes (during tests in the first tube 2007)

Weekly Time Variation Curve with a peak of 48,000 veh./day on 2 lanes – Thursday
What traffic incidents should be detected?

- Traffic disturbance or congestion
- Stopped vehicles
- Standstill traffic as an indicator for an accident

And nice to have

- Short-term prediction of congestion to react proactive
Field Test
Involved Systems
(in 2007)
After an inquiry on the market two system suppliers were willing to support a field test

- **Video technology system:**
  Traficon VIP/SYS System with VIP-T Modules (Belgium)

- **Induction loop technology system**
  Aachener Verkehrswirtschaft GmbH with the product MAVE®-tun
Traficon VIP/SYS System with VIP-T

Edge-based picture analytics with promised detection of:

Traffic events
- Stopped vehicle
- Speed drop
- Levels of service
- Wrong-way drivers
- Traffic congestion
- Under speed

Non-traffic events
- Smoke in tunnel
- Pedestrian
- Fallen object

Technical alarms
- Camera tampering
- Image quality
The inductive Loops create detuning curves of each passing over vehicle.
With correlation analyses the single vehicle can be identified at the next detection module with its own characteristic detuning curve.

Advantage according to normal loops is the possibility of section analyses not only local analyses on a cross section.
Dynamic Fundamental-Diagrams
Analysing the level of service (LOS) and the disturbance in the traffic flow on a section

Continuously monitoring the traffic status (every 5 to 15 seconds) with analysing the trend of

- Traffic Volume
- Traffic Density
- Speed

Traffic quality areas of FD
- Free flow
- Bounded traffic
- Synchronized flow
- Slow moving traffic
- Congestion
- Standstill

Fundamentaldiagramm M1, 31.03.2007, 8:31 – 8:35 Uhr
MAVE®-tun Induction Loop Technology

Used modules
- Traffic data,
- Traffic flow analysis,
- Incident detection

Promised detection of traffic events:
- Local traffic data at the loop
  - Over- / under speed vehicles
  - Wrong-way drivers
- Section traffic flow by analyses of traffic volumes and driving time
  - Level of service / traffic quality
  - Speed drop / congestion
  - Disturbance in traffic flow
  - Break-down / stopped vehicle
  - Traffic at a standstill
Test Track

- East tube in north direction with one-way traffic on two lanes
- Inclining section (3.5%)
- Section with frequent congestion

Messpunkte im Feldversuch
Monitored Sections (distance 200-300m)

Four Inductive Loop cross sections

Loop 1.7 was not considered cause of bad values (reason: adverse position of reinforcement)

<table>
<thead>
<tr>
<th>Detektion</th>
<th>Streckenkilometer BAB A7</th>
<th>Abstand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induktionsschleife 1.6</td>
<td>157.433.250</td>
<td>0</td>
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<tr>
<td>Induktionsschleife 1.7</td>
<td>157.091.000</td>
<td>342.250</td>
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<td>Induktionsschleife 1.8</td>
<td>156.878.900</td>
<td>212.100</td>
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<tr>
<td>Induktionsschleife 1.9</td>
<td>156.563.580</td>
<td>315.320</td>
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<tr>
<th>Detektion</th>
<th>Streckenkilometer BAB A7</th>
<th>Abstand</th>
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</thead>
<tbody>
<tr>
<td>Kamera 07</td>
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<tr>
<td>Kamera 08</td>
<td>157.437.950</td>
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<tr>
<td>Kamera 09</td>
<td>157.133.500</td>
<td>304.450</td>
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<tr>
<td>Kamera 10</td>
<td>156.837.200</td>
<td>296.300</td>
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<tr>
<td>Kamera 11</td>
<td>156.616.700</td>
<td>220.500</td>
</tr>
</tbody>
</table>

Süden | Norden

157.740 | 157.740
302m   | 304m
157.438 | 157.134
304m   | 296m
157.134 | 156.837
296m   | 221m
156.837 | 156.617
221m   | 221m
156.617 | 156.617

VDRS 01.10.2015
Video Installation

• Device to convert analogue to digital Signals / Camera Height 4.5m
Problems with Video Installation

Hidden Object Areas (occlusion of trucks)

Soiled Lens in the near of the front portals
Problems with Loop Installation

• Adverse position of reinforcement
• Pavement deck with steel girder to fix the joints

=> Pre-Measurements to find the best installation place had to be done
Field Test - Results
## Summery (2007)

<table>
<thead>
<tr>
<th></th>
<th>Automatic Detection with Video Technology (System VIP-T &quot;Traficon&quot;)</th>
<th>Automatic Detection with Inductive Loops and Correlation Analysis (System Mave-TUN von &quot;ave&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment Costs</td>
<td>1.950.000 €</td>
<td>1.800.000 €</td>
</tr>
<tr>
<td>Maintenance Costs</td>
<td>Costs for maintenance, cleaning and energy</td>
<td>Costs for maintenance, cleaning and energy</td>
</tr>
<tr>
<td>Traffic Flow Analysis with Trend Forecast</td>
<td>- Installation height causes hided areas</td>
<td>Detailed traffic flow analyses with dynamic fundamental diagrams</td>
</tr>
<tr>
<td>Stopped Vehicle</td>
<td>Quick reliable detection except in hidden areas</td>
<td>light delayed reliable detection, trend analysis possible</td>
</tr>
<tr>
<td>Wrong Driver</td>
<td>Quick reliable detection</td>
<td>Quick reliable detection</td>
</tr>
<tr>
<td>Fallen Objects</td>
<td>Objects have to be bigger than 50cm</td>
<td>Only if traffic flow reacts clearly</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>Quick reliable detection except in hidden areas</td>
<td>Only if traffic flow reacts clearly</td>
</tr>
<tr>
<td>Smoke</td>
<td>Quick reliable detection</td>
<td>Only if traffic flow reacts clearly</td>
</tr>
<tr>
<td>Truck on overtaking Lane</td>
<td>Not reliable detection of vehicle type</td>
<td>reliable detection of vehicle type</td>
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<tr>
<td>Slow Driving</td>
<td>Imprecise detection of speed</td>
<td>Precise detection of speed</td>
</tr>
<tr>
<td>Too fast driving car</td>
<td>Imprecise detection of speed</td>
<td>Precise detection of speed</td>
</tr>
<tr>
<td>Fire load density</td>
<td>No Detection in smoked area</td>
<td>Traffic detection is possible in fire area</td>
</tr>
<tr>
<td>Number of Persons in Smoke area</td>
<td>No Detection in smoked area</td>
<td>Traffic detection is possible in fire area</td>
</tr>
</tbody>
</table>
Current Project Status
Elbtunnel System Requirements

• Important Interfaces to:
  - Traffic Control System
  - Operation Control System
  - Video Control System
  - Traffic Management System
  - Statistic Database Application

• The Algorithms have to consider:
  - Traffic Operational Status (One-Way or Contraflow Traffic)
  - Regulations as Speed Limits, No Passing allowed
  - Closed Lanes, End of Closed Lanes,
  - Emergency Stops and Height Control
  - Detected Fires, Maintenance situations, ...

• Traffic Flow Analysis should be able to detect trends for proactive Traffic Control Measurements to avoid potential Accident Situations
Automatic Incident Detection

A7, Elbtunnel – Tunnel operation and traffic telematics

Incident Window

Monitoring of System and Interface status

Current Graphic User Interface under Construction

Filling Level Indication, Driving Direction Arrows with Number of Cars / HGV
Traffic quality based on dynamic Fundamental Diagrams
Incident (Local / Section)
Legend of the Graphic User Interface (GUI)

Filling Level Indication and LOS
- Congestion
- Slow Traffic
- Bounded
- Free Traffic
- No Traffic

Incident in the Section
- Slow Driving Car
- Too Fast Driving Car
- Congestion
- Disturbance in Traffic Flow
- Predicted Congestion
- Congestion back into tunnel
- Blockade / Accident red
- Stopped Vehicle red

Incident Local at inductive loop
- Ghost Driver
- Truck is overtaking
- Driver on closed Lanes

Traffic Volumes
- Total Vehicles
- No. of Trucks

Colour of Incident Status
- No Incident
- Recently Inc.
- Actual Inc.
- Quitted Inc.
- Critical Inc.

Operational Status and Technical Faults
- Operating active
- Non Operating passive
- Disturbed
- No traffic
- Others
Dynamic Fundamental-Diagrams to detect the traffic quality (LOS)

Thresholds have to be calibrated
At the moment we are working on

- the implementation of the interfaces to the video monitoring system and to the tunnel control system
- optimizing the Graphic User Interface (GUI)
- optimizing of the detection parameters

So next year we will be able to present more ...
Automatic Incident Detection

A7, Elbtunnel – Tunnel operation and traffic telematics

Thank you for attention