Workshop on Electric Roads

Technical Review of eHighway (ENUBA)

Dipl.-Ing. Rainer Lehmann
Federal Highway Research Institute (BASt), Germany

Federal Highway Research Institute (BASt)
Responsible to the Federal Ministry of Transport and Digital Infratructure (BMVI)

- Founded in 1951
- Since 1983 near Cologne
- Office, Laboratories
- 10 Halls for Testing

- Research
- Advice
- Tests, Certification
- Standards

- 400 Employees

ENUBA - Electrification of Freight Transport

Technical Review of eHighway by BASt

Aim: Technical basis for realistic cost estimation for economic evaluation

Subjects: infrastructure, vehicle safety, electrical safety, maintenance and operation, rescue after accidents

Solutions for 20 objects of investigations were reviewed

ENUBA – Participants and Roles

Project

Technical development and securing of functionality

- Siemens: Developer
- TU Dresden: Support in research / testing procedures for electrical traffic systems and road traffic
- EDAG: Automotive consultant for assessment of truck specifics

Economic reports

- Siemens / TU Dresden

Ecological reports

- Siemens / TU Dresden

ENUBA

Experts / Validation

Technical validation of the system and integration in existing road infrastucture (highway)

- **Bundesanstalt für Straßenwesen (BASt)**

Economic advice and validation

- **„Deutsches Zentrum für Luft- und Raumfahrt (DLR)“**
- **„Ludwig-Bölkow-Systemtechnik (LBST)“**
- **Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie (NOW)**

Ecological advice and validation

- **Institut für Entsorgung und Umwelttechnik (IFEU)**
- **Umweltbundesamt (UBA)**
- **NOW**
- **LBST**

Role of BASt in the ENUBA-project

Quelle: Siemens AG

- effects on infrastructure
- effects on traffic safety, traffic flow and operation
- interdependency between ENUBA and other technical systems
- technical review of solution

Technical Aspects

vehicle safety

infrastructure

maintenance and operation

rescue/repair after accidents

Assignment of the investigated topic areas to the main groups

TB 1 – Structural infrastructure

- TB 11 Clearance height under structures, derivation of the standard height and special constructions
- TB 12 Oversized transports up to 4.5 m
- TB 13 Statics of catenary poles taking into account the lateral clearances
- TB 14 Statics of bridge structures, assessment of the feasibility of electrification
- TB 15 Requirements for guard rail system
- TB 16 Crash test to verify the recommended guard rail system
- TB 17 Visibility of road signs

TB 2 – Electrical infrastructure

- TB 21 Integrated electrical protection concept including technical vehicle systems
- TB 22 Integrated EMC concept, including requirements for the technical vehicle systems
- TB 23 Emergency shutdown of the overhead contact line system

TB 3 - Construction, operation, maintenance

- TB 31 Construction concept
- TB 32 Maintenance concept
- TB 33 Technical monitoring and user authorization
- TB 34 Incident management / rescue concept
- TB 35 Hazards caused by ice on the overhead contact lines

TB 4 – Technical vehicle systems

- TB 41 Evasive maneuvers and changes in the vehicle dynamics
- TB 42 Changes in crash behavior of eHighway trucks
- TB 43 Changes in the fire behavior of eHighway trucks
- TB 44 Restrictions regarding the transport of hazardous goods
- TB 45 Length increase for semi-trailer truck to 17.0 m

ENUBA Vehicle: Assessment of Technical Aspects

Two main topics:

1. Driving dynamics
2. Crash behaviour and crash compatibility

Further advice and general information regarding electric vehicles

Driving Dynamics

Assessment of the assumptions and calculations regarding:

- breaking
- tilt test
- (steady-state) circular test
- lane change
- sinus test
- ramp steer input

Crash Behaviour and Crash Compatibility

Advices and evaluation of crash relevant topics:

- frontal collision
- lateral collision
- rear-end collision
- single vehicle accident

Further Advice and General Information for ENUBA

- Considering general safety aspects
- Effects of emergency shutdown
- Conditions of fire load
- Importance of energy storage system for vehicle approval
- Consideration of Electromagnetic Compatibility (EMC)

Recognition and Visibility of Traffic Signs

During daylight

.. with illumination by truck lights at night

Recognition and Visibility of Traffic Signs

- According to german traffic rules and guidelines three positions for traffic signs are defined:
  - sign beside the roadway
  - sign above the roadway on a cantilever
  - sign above the roadway on a gantry
- Generally all signs are located 5 metres above the road surface (exception: 4,7 metres)

Recognition and Visibility of Traffic Signs

The following masking effects and interdependencies of the catenary are possible:

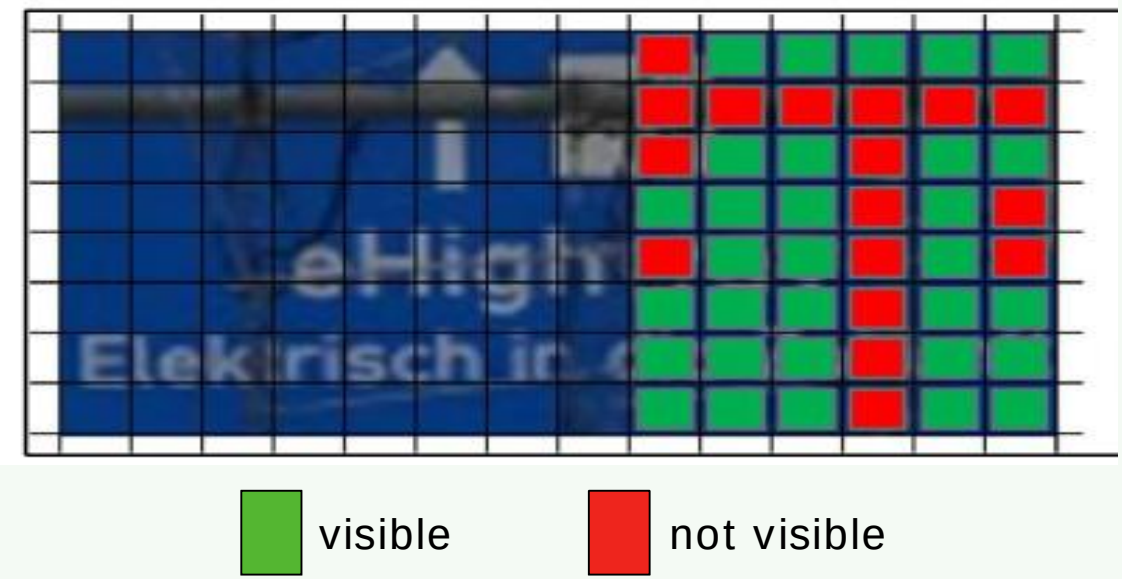
- on signs placed above the road surface
  - by the contact and messenger wires of the catenary
  - by rigid parts (e. g. cantilevers, steady-arms) of the catenary
  - by the pantographs of trucks running ahead

- on signs placed beside the roadway
  - by poles on the roadside („visual wall“)

New Rating Scheme for Visibility of Traffic Signs

different types of vehicles, vehicle orders, lighting and drivers perspectives are checked

Based on these positions and ranges of visibility a methodology was created to assess the visibility and legibility



Tests in Driving Simulator

Additional studies were done in a driving simulator differentiated

- between truck and car drivers
- by lighting conditions (day/night)
- by traffic conditions (low traffic/rush hour)
- by surrounding (with/without catenary)

Eye tracking was applied during the simulation

Simulator test drivers had to fill in a questionaire

Results and Consequences

- relevant masking effects were identified
- solutions were recommended for the positioning of poles and the complete catenary to minimize their masking effects on traffic signs
- no influence on the driving behaviour was observed during the driving simulation

Results and Consequences

Based on these findings the positions of the components of the catenary were modified.

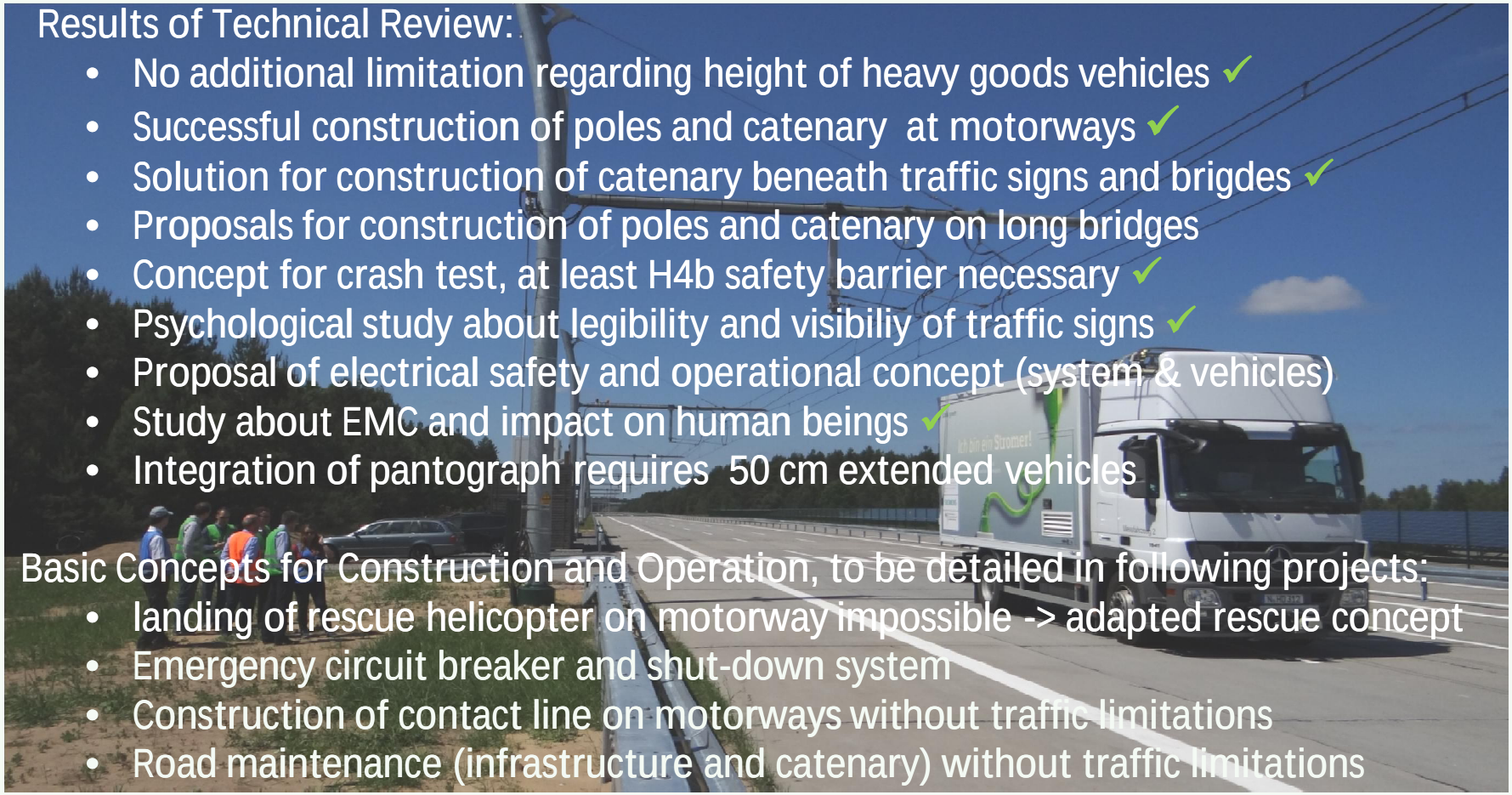
Saftety Barriers and Crash Tests

Aims: - driver/passenger safety
- prevention of risks for others

Adaptation of crash test design:
- combination of barriers and poles
- 38 t semi-trailer, H2-barrier

Result of crash test:
at least H4b barriers necessary for german motorways!

Results of Technical Review for German Motorways



Results of Technical Review:

- No additional limitation regarding height of heavy goods vehicles ✓
- Successful construction of poles and catenary at motorways ✓
- Solution for construction of catenary beneath traffic signs and brigdes ✓
- Proposals for construction of poles and catenary on long bridges
- Concept for crash test, at least H4b safety barrier necessary ✓
- Psychological study about legibility and visibiliy of traffic signs ✓
- Proposal of electrical safety and operational concept (system & vehicles)
- Study about EMC and impact on human beings ✓
- Integration of pantograph requires 50 cm extended vehicles

Basic Concepts for Construction and Operation, to be detailed in following projects:

- landing of rescue helicopter on motorway impossible -> adapted rescue concept
- Emergency circuit breaker and shut-down system
- Construction of contact line on motorways without traffic limitations
- Road maintenance (infrastructure and catenary) without traffic limitations

Thank you for your attention !

Bundesanstalt fuer Strassenwesen
Bruederstraße 53
D - 51427 Bergisch Gladbach – Bensberg
Telefon +49 (0)2204 43-0
info@bast.de
www.bast.de