



Enhanced transport quality and tramway energy efficiency by multi-modal traffic management systems

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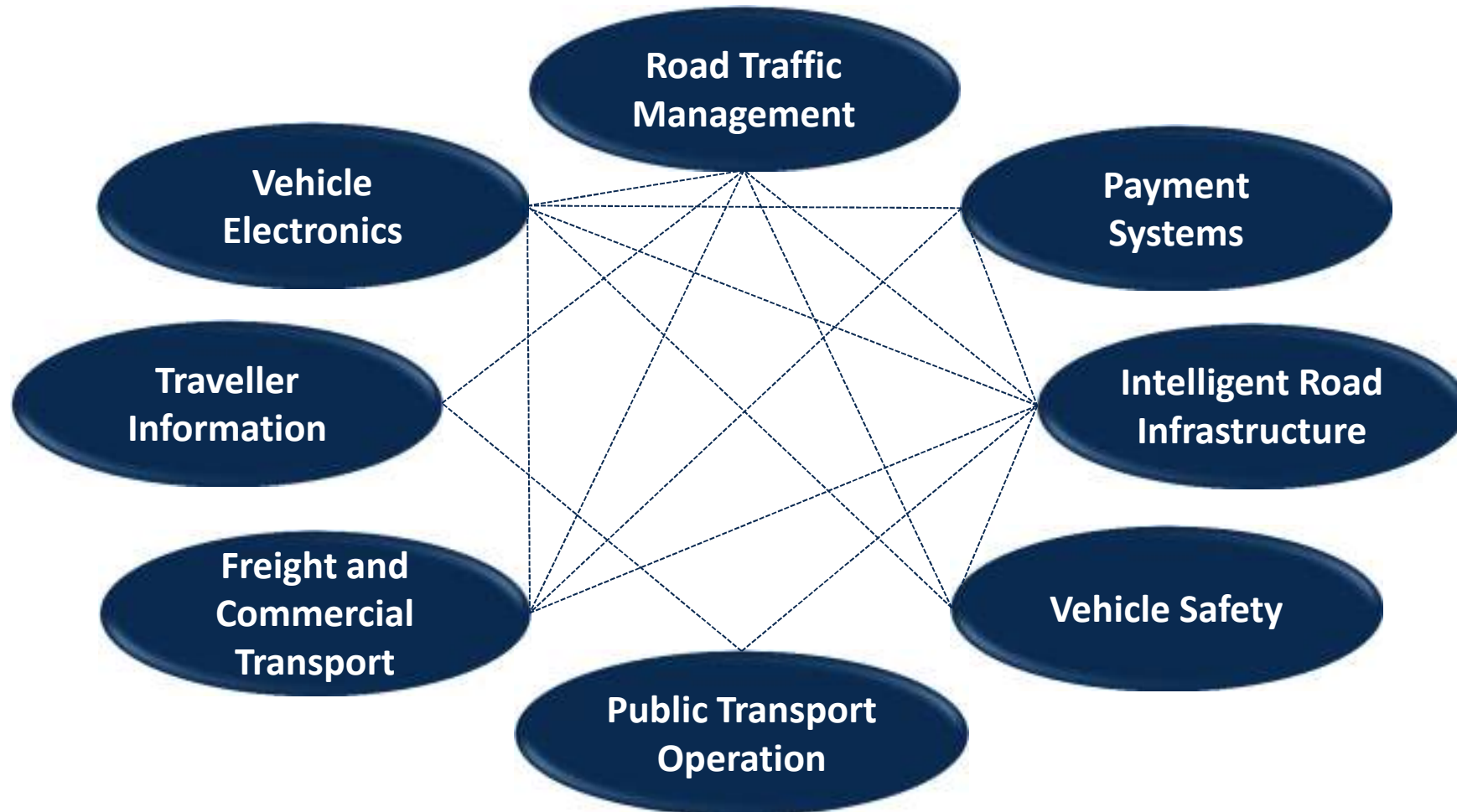


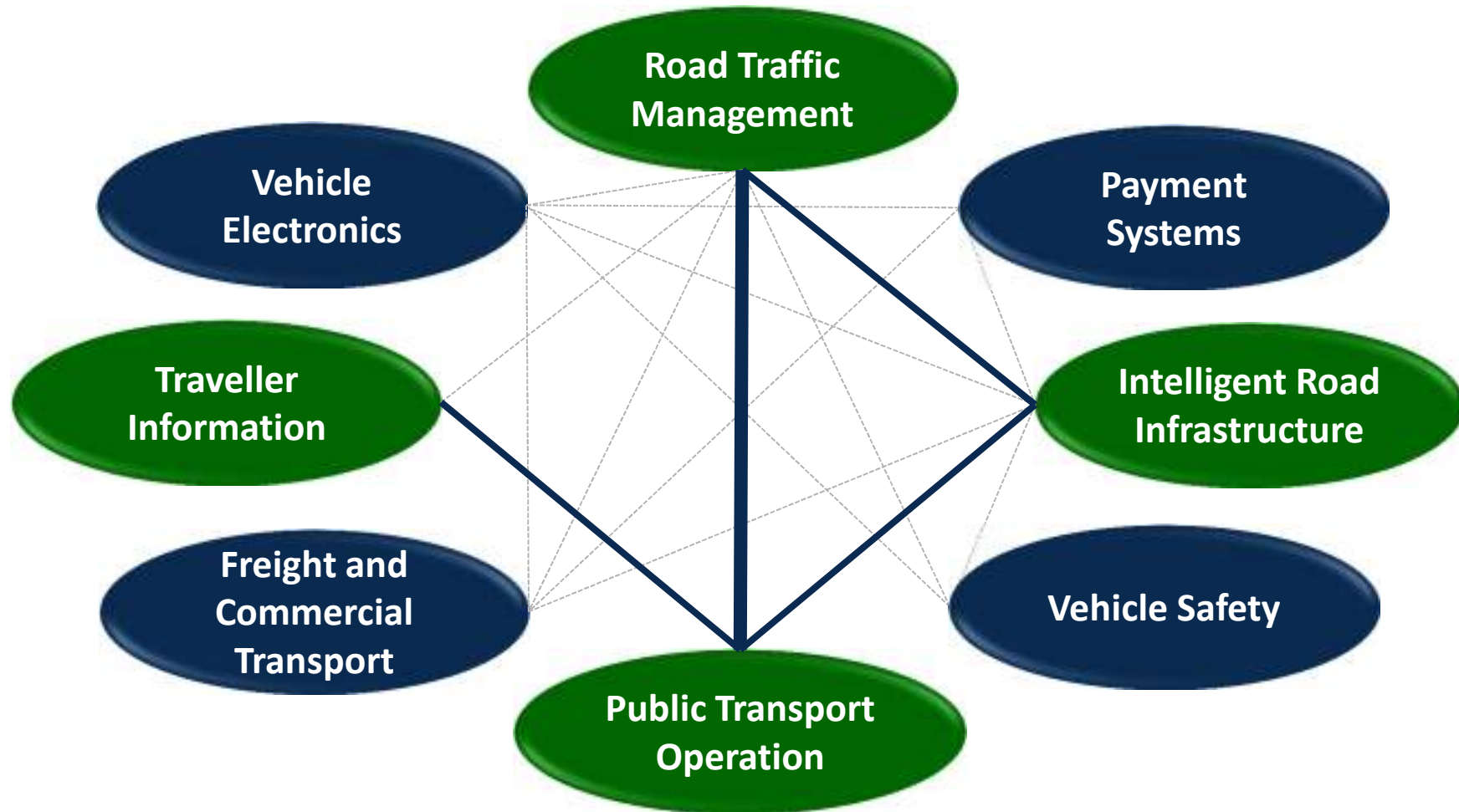
► Background

- Brisk demand for Intelligent Transport Systems (ITS) within the last years

“ Intelligent Transport Systems can significantly contribute to a cleaner, safer and more efficient transport system” [European Commission Mobility and Transport]

- Broad support for ITS by European Commission, member states and local authorities
 - ICT Work Programmes
 - ITS Action Plan COM(2008)886 and Directive 2010/40/EU
 - National Research Programmes
 - ...





ITCS and TCC Systems – both used to save high transport quality

ITCS

(Intermodal Transport Control System)

- Locate and dispatch vehicle fleet
- Passenger Information Services



TCC

(Traffic Control Centre)

- Road traffic condition monitoring
- Derive measures to improve traffic flow



Intermodal Transport Control System

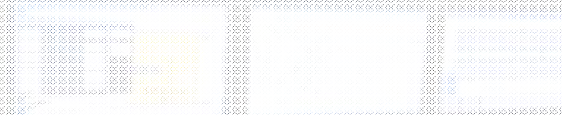
ITCS (Intermodal Transport Control System)

- Locate and dispatch vehicle fleet
- Passenger Information Services



TCC (Traffic Control Centre)

- Real-time traffic conditions monitoring
- Dynamic intermodal routing to improve traffic flow



Intermodal Transport Control System

ITCS

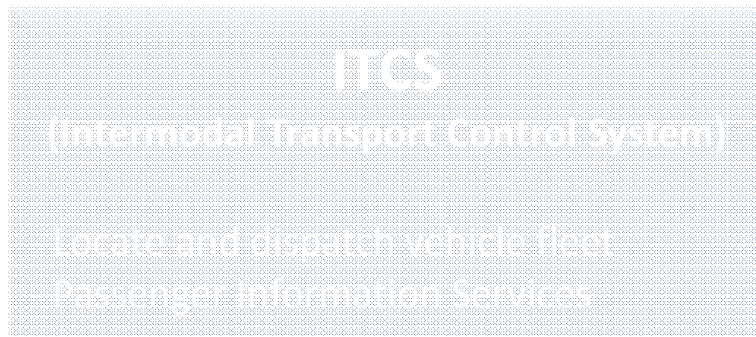
(Intermodal Transport Control System)

- Locate and dispatch vehicle fleet
- Passenger Information Services



Dresden ITCS System:

- Monitoring of 12 tramway routes and 28 bus routes



Traffic Control Centre



Dresden TCC System

- **traffic flow detection**
single- and multi-induction loops, infra-red and video detection, taxi FCD (about 1200 sensors)
- **Traffic control & information**
changable traffic signs, parking information,...

Traffic Control Centre

TCC (Traffic Control Centre)

- Road traffic condition monitoring
- Derive measures to improve traffic flow



→TCC with poor knowledge of Public Transport issues

ITCS

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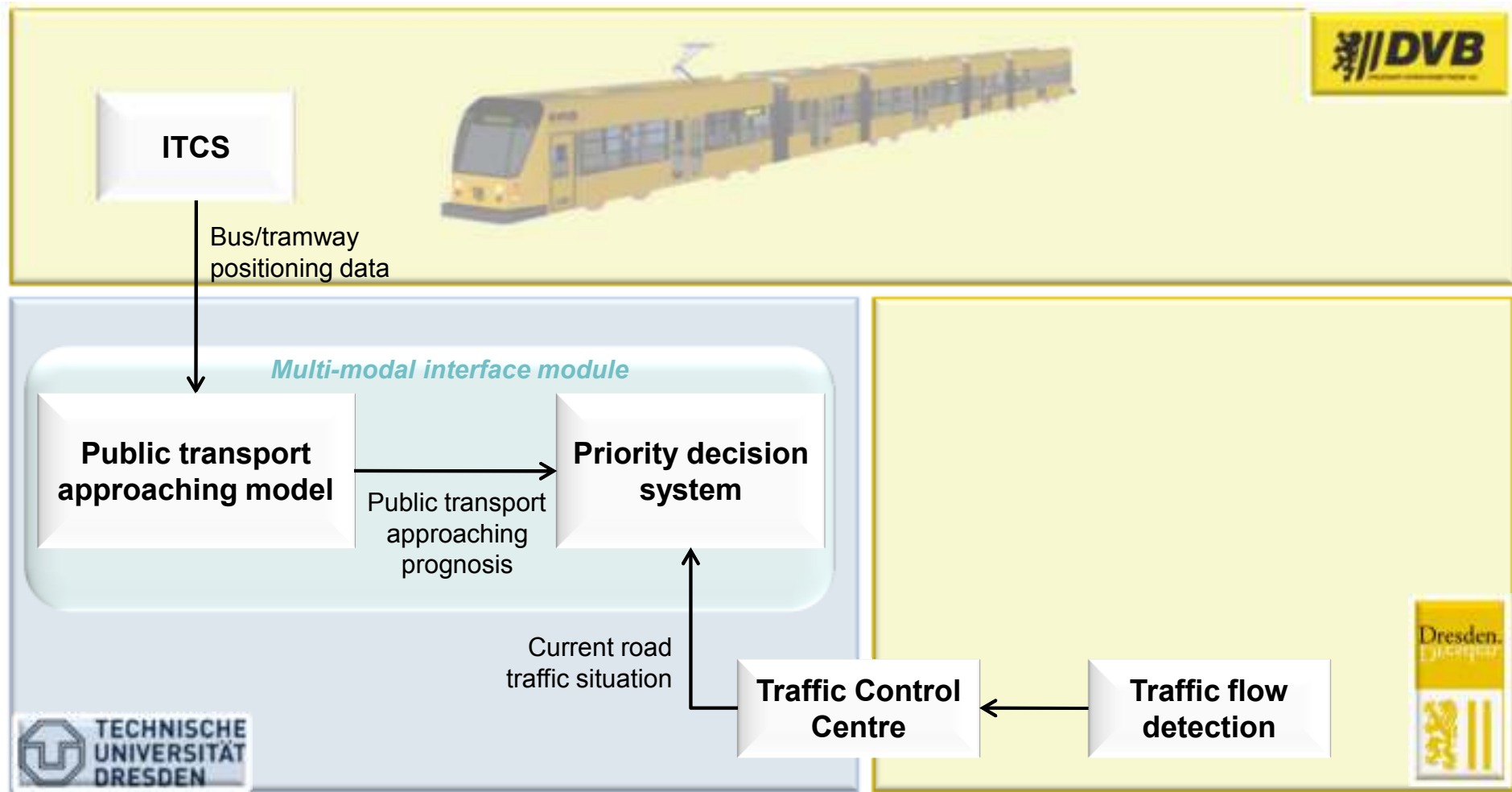
Project approach:

Improve traffic quality by differentiated priorities at traffic lights depending on

- Private transport conditions
- Punctuality of Public Transport
- Dynamic connection services

and reduce energy consumption of trams

Multimodal System Architecture



Priority Decision System

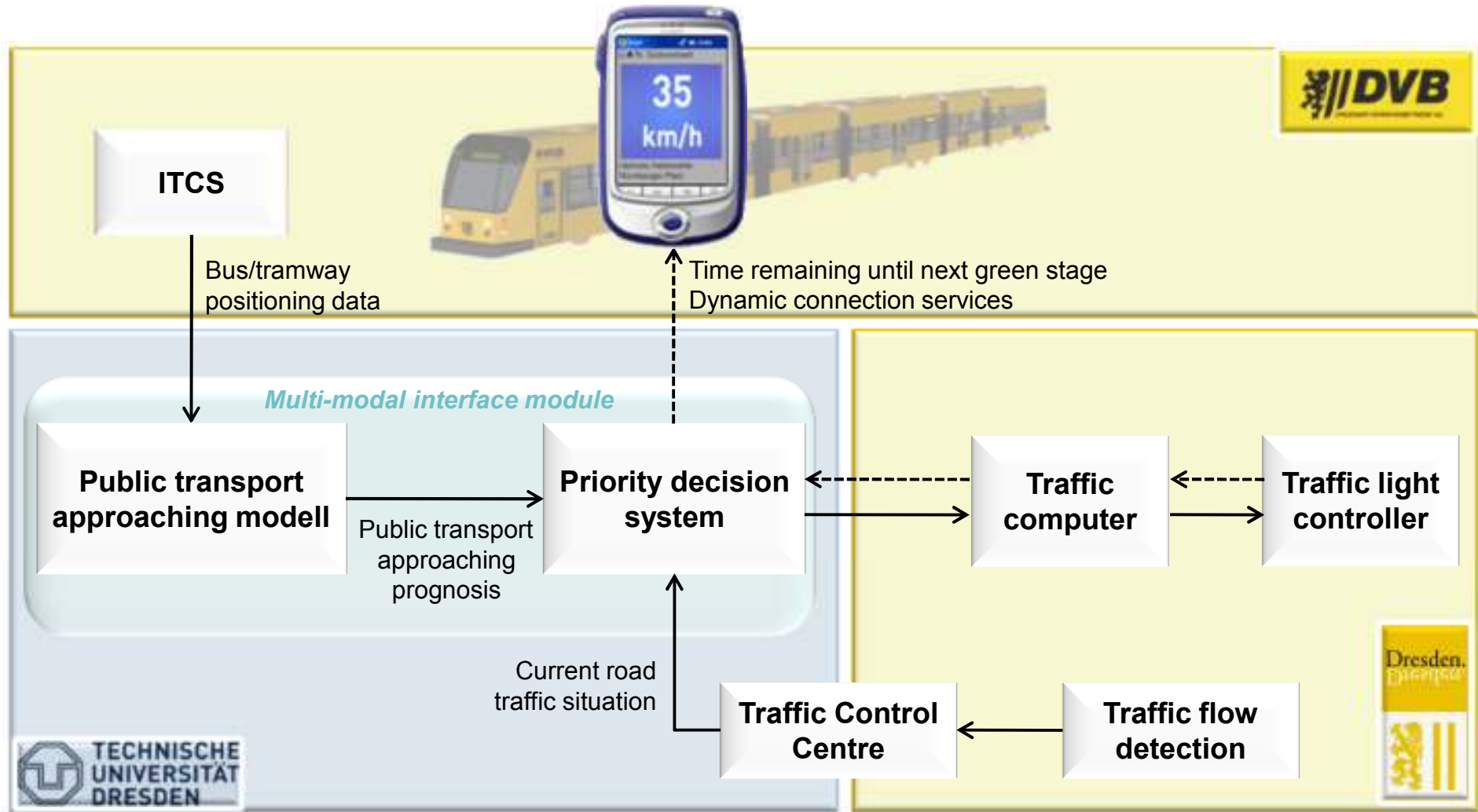
- 7-stage-priority system for each public transport vehicle approaching an intersection

<ul style="list-style-type: none">• Punctuality• Headway regularity• Connection services	ITCS
<ul style="list-style-type: none">• Private transport conditions (LOS A...F)	TCC

Simplified example:

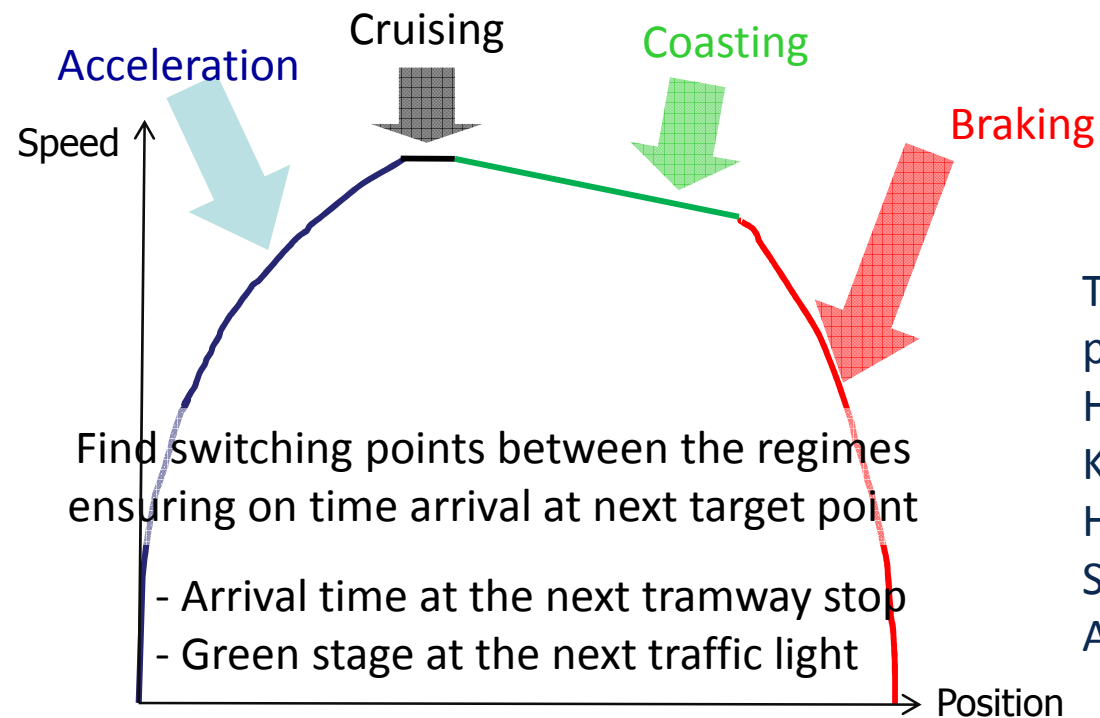
- Tram delayed and LOS A/B for road traffic: High priority for tram
 - Tram before schedule: Low tram priority
- Commutation into realizable modifications of the ordinary signal timing plan
 - Modification options given by Urban Road Department
 - Modifications coded in traffic light login-telegrams and interpreted by traffic light controllers

► Multimodal System Architecture



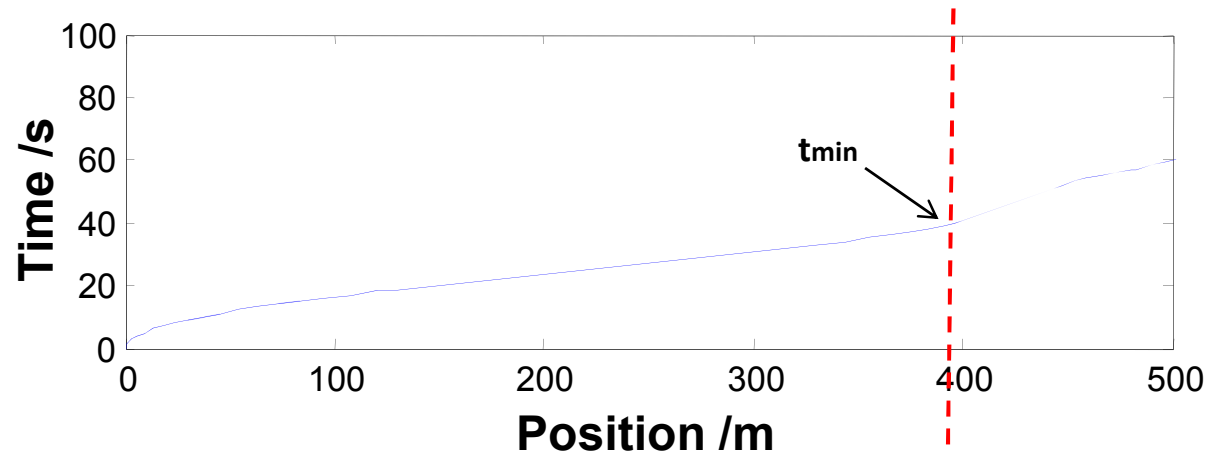
3. Energy-Efficient Light-Rail Control

- Driver Advisory Systems already used in railways and metro systems (savings: 5-10%)
- Maximum Principle of Pontryagin useful for Light-Rail / Tramway environment

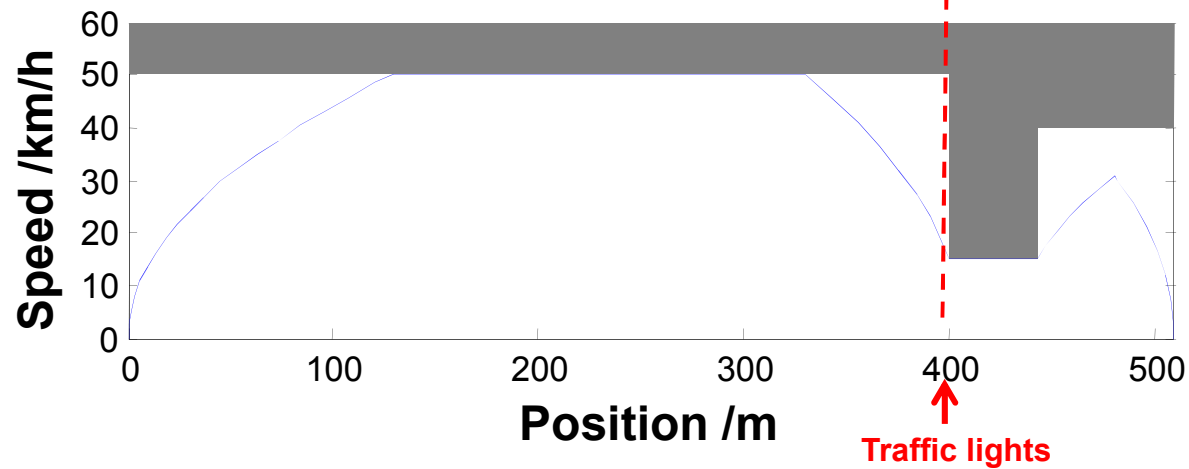


Theoretically and practically proved:
Horn/Strobel (1974);
Kraft/Schnieder (1981);
Howlett (1994);
Sanftleben (2002);
Albrecht (2006)

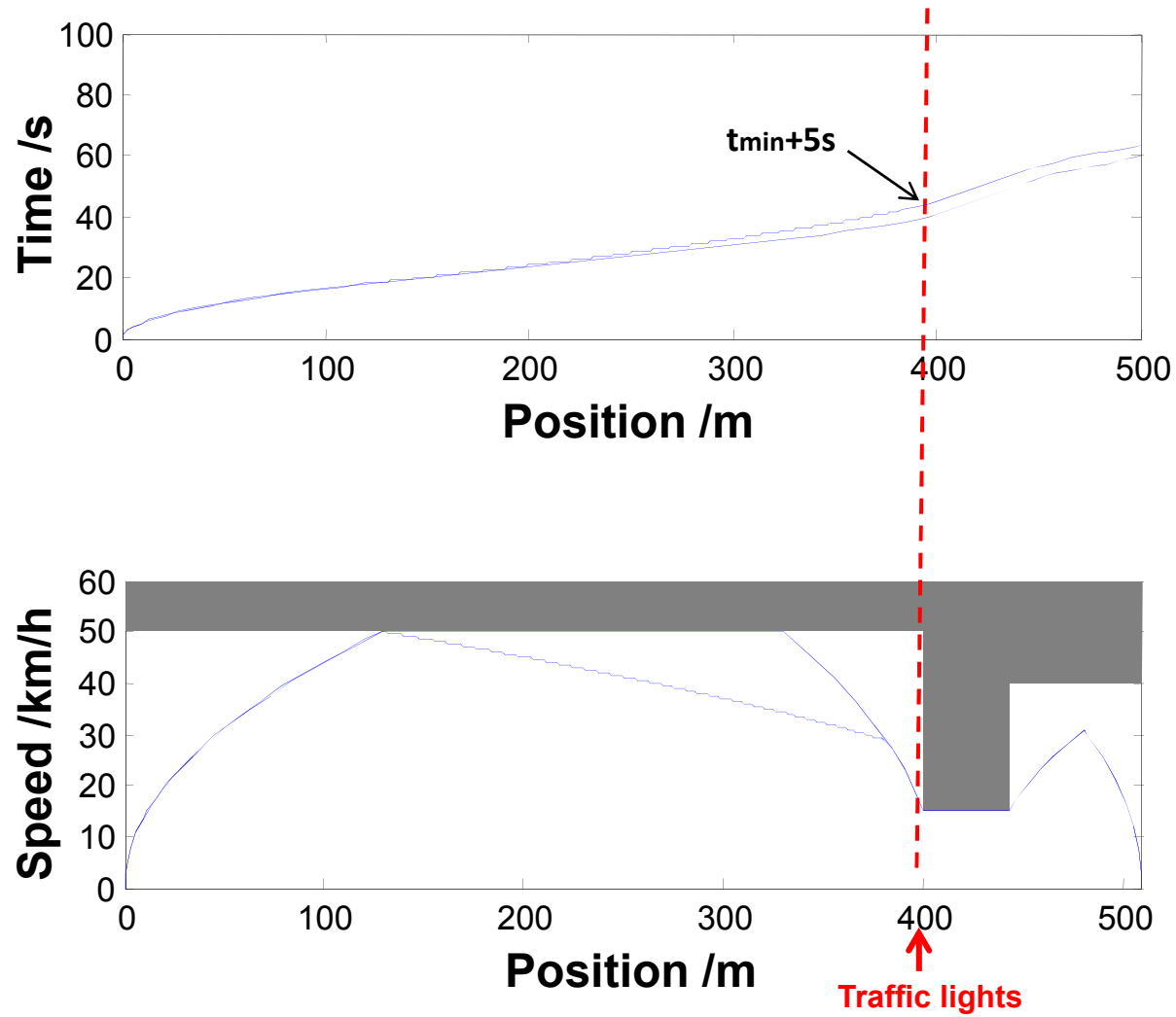
► Energy-Efficient Light-Rail Control



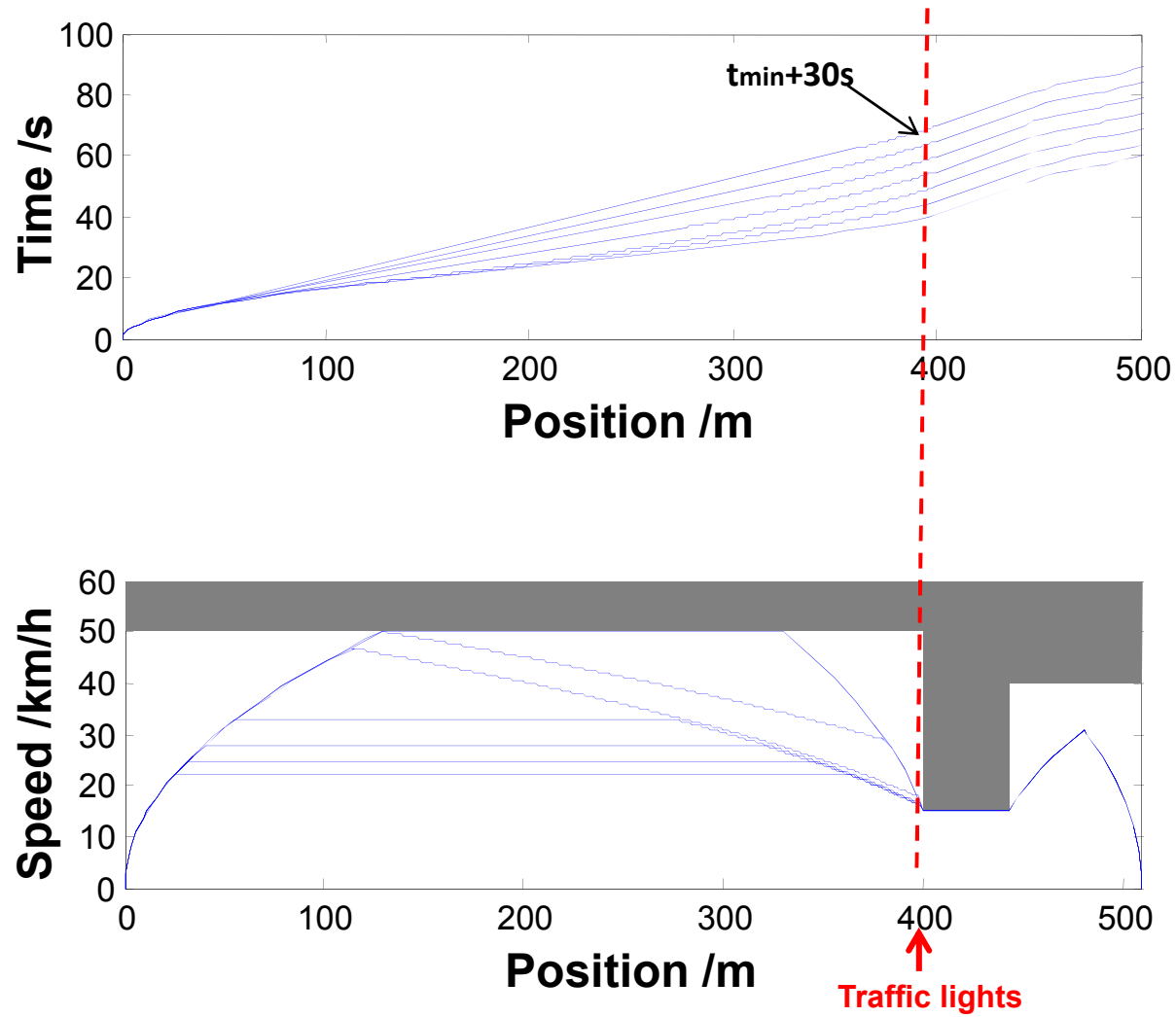
Minimum constraint for the
solution space: minimum
running time



► Energy-Efficient Light-Rail Control



► Energy-Efficient Light-Rail Control

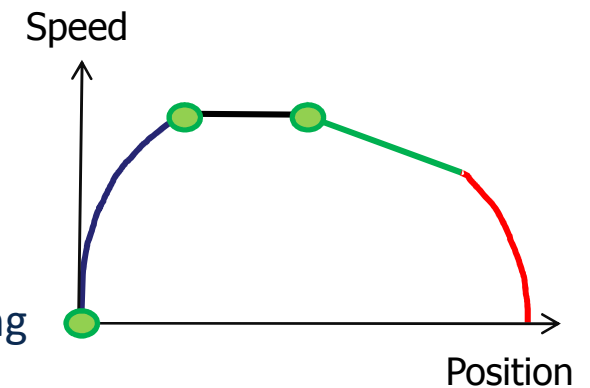


Human Engineering Aspects



Dynamic signalling
scenarios

- High distraction risk when giving a large variety of information
- Advice: departure, cruising (only below maximum speed), coasting
- $v_{cr,min} > 0,5 * v_{max}$!



► Case Study Nürnberger Platz

4. Case Study Nürnberger Platz



4. Case Study Nürnberger Platz



- ADT major road: 28000 vehicles
- ADT minor road: 10000 vehicles
- 3 PT lines (3, 8, 61)
- Connection service (8 > 61)
- Traffic Control: Vehicle actuated, partly restricted

Driving Behaviour Analysis

- Data collection by Dresden Measuring Tram (in ordinary operation)

5-year data collection:

- Lateral, longitudinal and vertical acceleration
- Longitudinal position
- Speed
- Voltage at pantograph
- Total vehicle current
- Braking power
- Status track brake
- GPS-signal

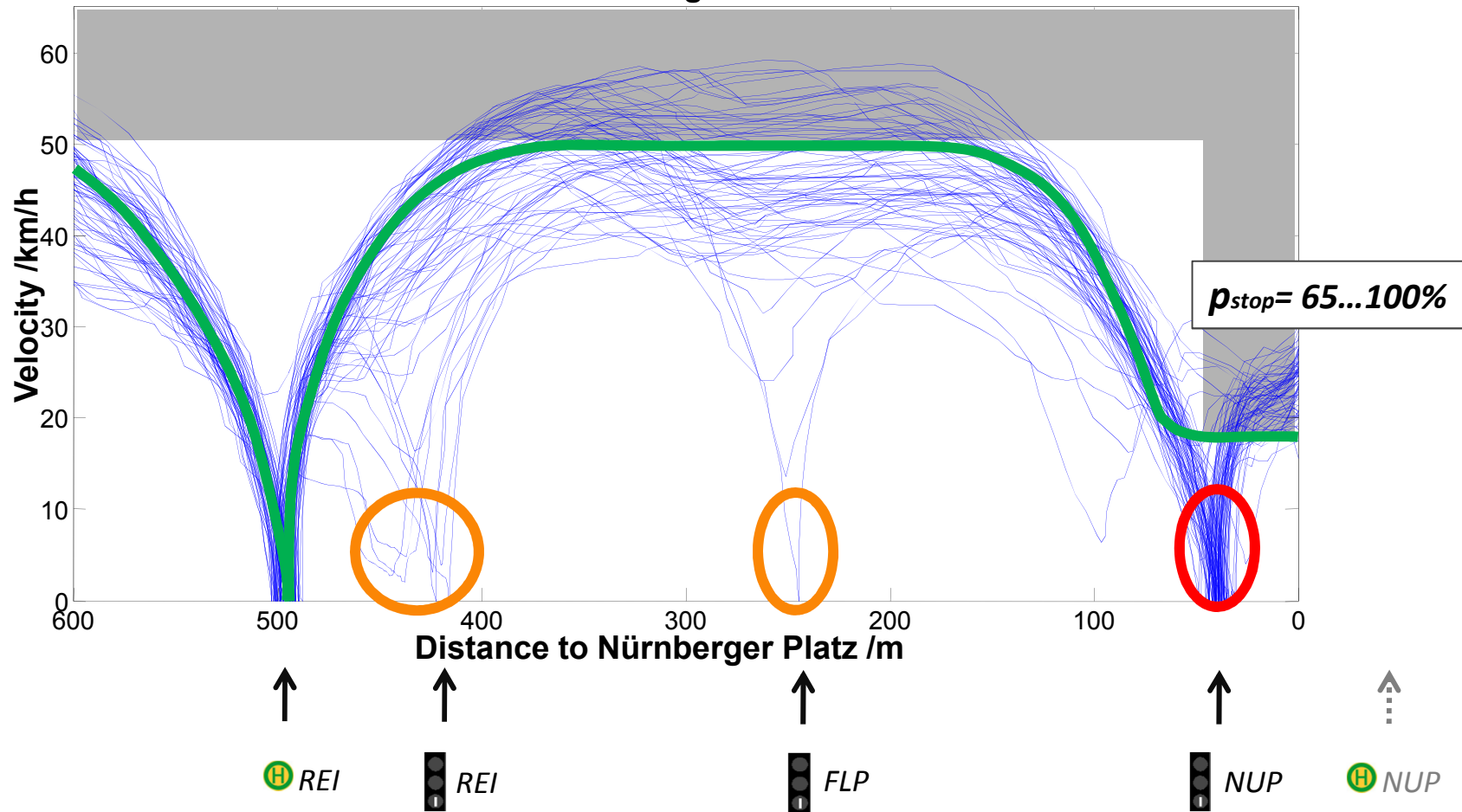
...



Source: DVB AG(2009)

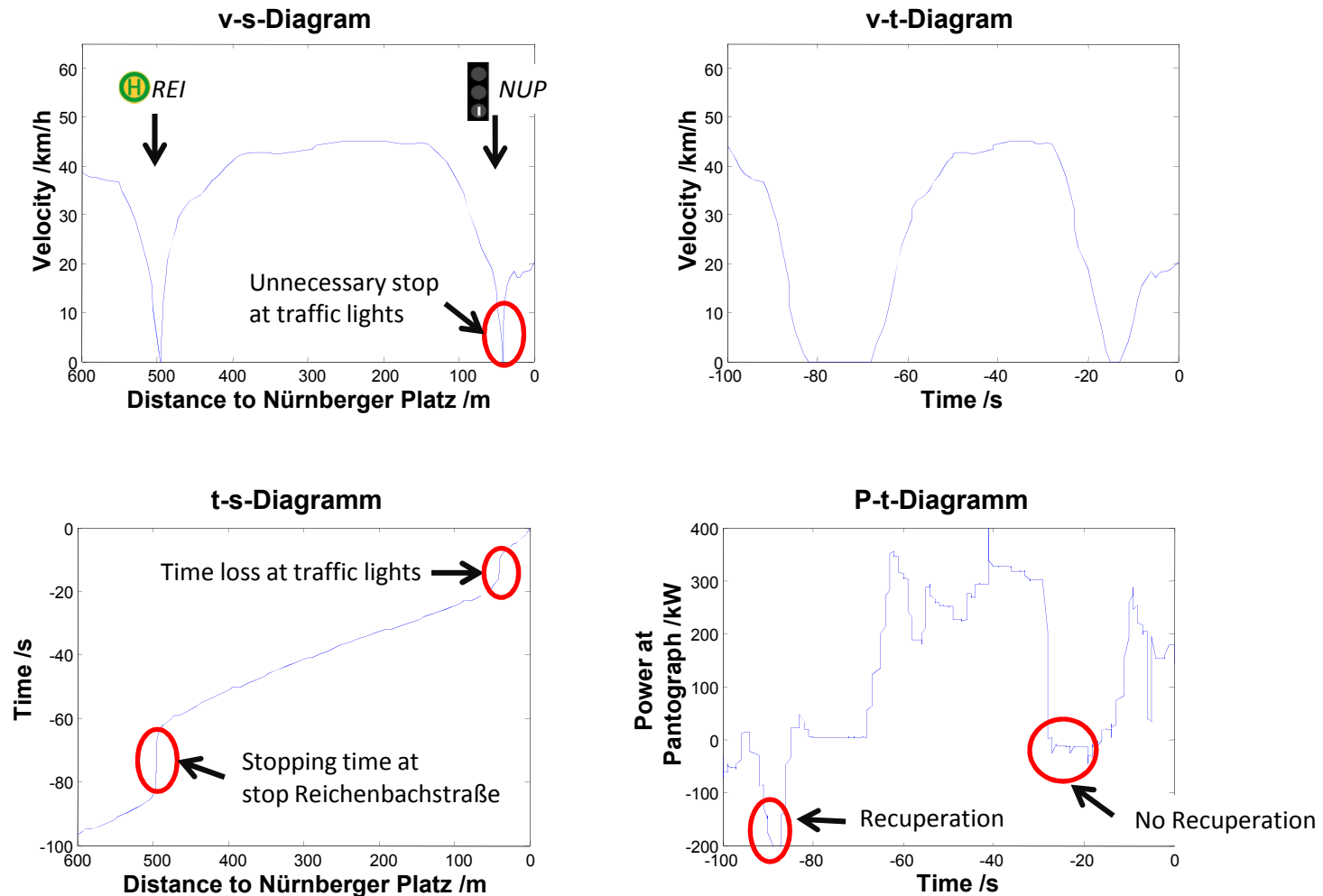
Line 8 Direction Südvorstadt

v-s-Diagramm



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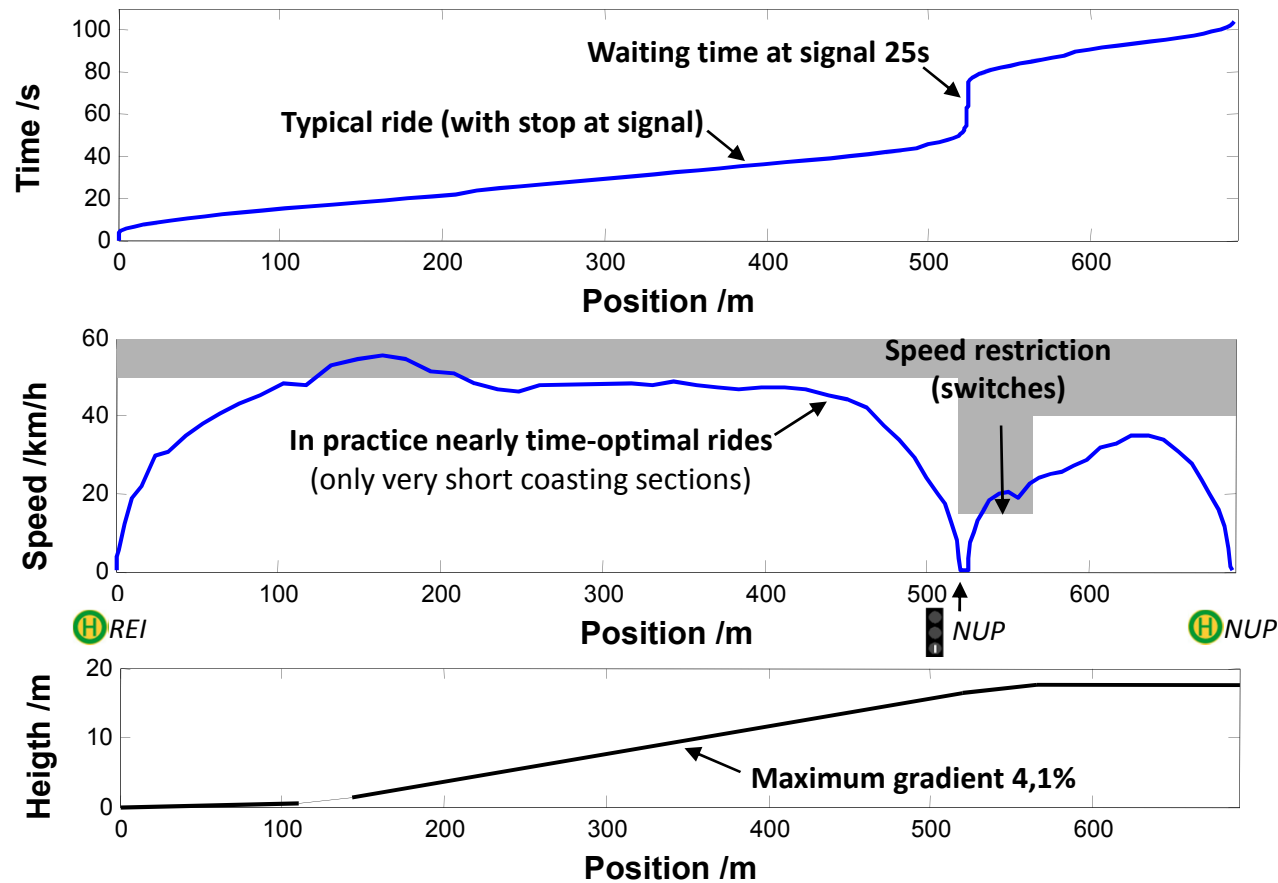
Measurement Tram Data Analysis



► Case Study Nürnberger Platz

Example:

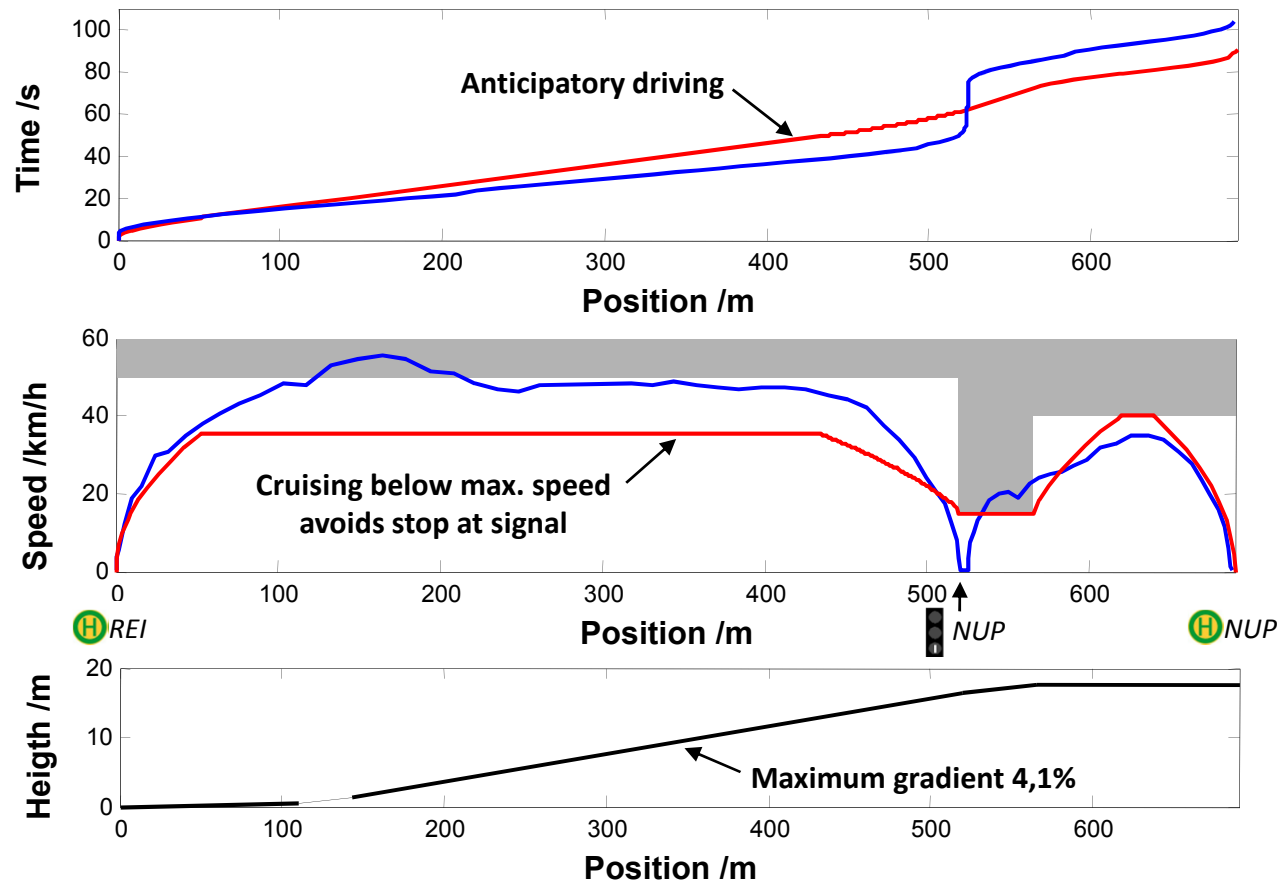
- Begin green phase at signal: 61 seconds after doors have been closed at previous stop



► Case Study Nürnberger Platz

Example:

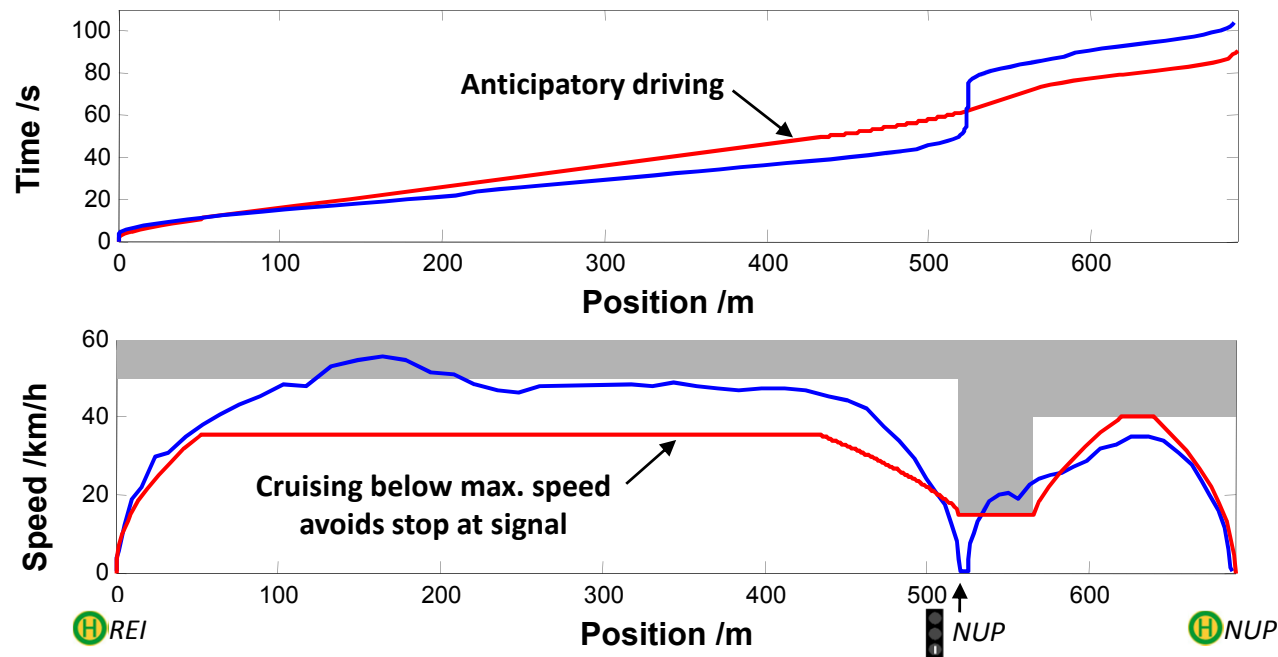
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► Case Study Nürnberger Platz

Example:

- Begin green phase at signal: 61 seconds after doors have been closed at previous stop



Energy savings by combination of cruising and coasting: 11%

► Case Study Nürnberger Platz



- Bus line 61 receives message to save connection service to tram line 8
- extended green phase for private transport (line 61)
- High priority for line 8
- Signal timing plan modification - second green phase for tramway
- COSEL speed advice for line 8
- Information about dynamic connection service
- Passenger interchange

Conclusions and Future Work

- First cooperative traffic signs considering full Multi-Modal Transport issues and energy efficient driving
- Multimodal system in full operation from winter 2010/2011
- Extension to the whole North-South-Corridor in Dresden

