PIARC – International Seminar
Intelligent Transport Systems (ITS) in Road Network Operations

Electronic Toll Collection
Approaches, technologies, experiences

Univ.-Prof. Dr.-Ing. Fritz Busch / Dr.-Ing. Andreas Rau
Chair of Traffic Engineering and Control
Technische Universität München

14 to 16 August 2006
Contents

- Objectives and Technologies
- Applications and Experiences
- Resume and Perspectives
Objectives of Road Pricing

Road Pricing and Toll Collecting…

- shall increase market driven processes in transportation to balance demand and supply
- offer – when used with flexible fees – opportunities to
  - control the spatial distribution of traffic volumes within the network
  - influence the timely distribution of traffic volumes
  - support the shift of demand to other transportation modes
- may contribute to financing and maintaining the transportation infrastructure
- offers a market for added-value services via the installed ITS-technologies
Principles of Tolling

Principle 1:
The fees are approach- or entrance-oriented
Payments are needed when the vehicles enter the priced section or network part; fees are independent of intensity of usage

Examples:
Vignette (CH, since 1985), 'Pickerl' (A, since 1997)

Principle 2:
The fees are usage-oriented
i.e. depend on time and/or length of usage of priced road-network
Technologies

Currently, the following technologies are in use / discussion:

- **Toll Collection**:
  - manual collecting
  - DSRC = Dedicated Short Range Communication
  - Video, ANPR (automatic number plate recognition), LPR (License Plate Recognition)
  - Tag / Transponder / RFiD – Recognition (electronic license-plate)
  - GNSS (Global Navigation Satellite System)
  - W-LAN / W-MAX

- **Vehicle Classification**:
  - Inductive loops
  - Laser scanner
  - Weigh-in-Motion
  - Video
  - Tags / RFiD
Applications and Experiences (some examples)

DSRC – Applications
- Hong Kong: (First DSRC application)
- Singapore: Electronic Road Pricing
- Stockholm: Congestion Charging

GNSS – Applications
- Truck Toll Germany (TollCollect)
DSRC - Dedicated Short Range Communication

Communication between vehicle OBU (on-board unit) and infrastructure (gantry with DSRC-beacon) via microwave (5.8 GHz) or infrared.

- Gantry transmits the OBU-data to central system, together with timestamp.
- OBU sends data to gantry.
- Wake-up signal from gantry to OBU.
- Vehicle with OBU approaches toll gantry.

Electronic Toll Collection
F. BUSCH, A. RAU – August 2006
First application in Hong Kong

- 21-month trial 1983-1986: first application ever of Electronic Road Pricing
  - more than 2500 vehicles (mostly government-owned) with electronic identifier at the vehicle's bottom
  - technically the experiment was successful
  - permanent operation was not possible due to strong public resistance

OECD, 1988
Singapore: Electronic Road Pricing

- since 1975 Singapore Area Licensing Scheme
- in the beginning only morning peak
- since 1989 extended to the evening peak
- since 1998 DSRC
- fees are time-dependant
  (long-term view, also traffic-dependant)
Singapore: Electronic Road Pricing

- Today: some expressways, trunk roads and 3 priced zones in central area of the city

[Diagram showing ERP Gantry and restricted zones]

Source: www.onemotoring.com
Singapore: Electronic Road Pricing (ERP)

- (quarterly) adjustment of fees

Source: Singapore Land Transport Authority
Effects:
- Reduction of volumes during tolling-period
- Average speed increased by 22%
- Less vehicles with just 1 person
- Shift of volumes away from peak-hours

Source: Land Transport Authority, Singapore
Stockholm Congestion Charging

- 22 August 2005: extended public transport
- 3 January 2006 - 31 July 2006: trial implementation of congestion charging
- Summer 2006: impact evaluation
- 17 September 2006: referendum on the permanent implementation

1 SEK = 0.51 MYR

Tax [SEK]

Time

6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00

1 SEK = 0.51 MYR
Stockholm Congestion Charging

Technology:

DSRC and
Car Number Plate Recognition

Source: Swedish Road Administration
Stockholm Congestion Charging

- Traffic reduction
  April 2006 compared to April 2005

Source: Swedish Road Administration
Stockholm Congestion Charging

- Traffic reduction spring 2005 compared with spring 2006

Source: Stockholmsforsoket: Facts and results from the Stockholm Trials; First version – June 2006 P. 26
Stockholm Congestion Charging

Are objectives being met?

- Objective: 10 -15 % less traffic to/ from inner city
  - Result: 20-25%

- Objective: Increased accessibility
  - Result: Queue times down 30-50%, except Essingeleden

- Objective: Decreased emissions
  - Result: 14% less in inner city; 2,5% in total county

- Objective: Inhabitants should perceive an improved urban environment
  - Result: Unclear—difficult to define and measure
**GNSS: Truck Toll Germany (TollCollect)**

**Toll road network**
- approx. 12,000 km on federal motorways
- approx. 2,500 junctions
- approx. 250 motorway interchanges

**Trucks required to pay the road toll**
- 1.2 - 1.4 million trucks ≥ 12t
- Including approx. 400,000 - 500,000 registered outside of Germany

**Toll road usage**
- 22.7 billion vehicle kilometres per year
- 35% accounted for by vehicles registered outside of Germany
GNSS: Truck Toll Germany (TollCollect)
GNSS: Truck Toll Germany (TollCollect)

Technology:

1. Install On-Board Unit
2. Enter vehicle data
3. Position detected via GPS
4. On-Board Unit detects toll road
5. Enforcement (stationary/mobile)
6. On-Board Unit calculates toll charges
7. Toll is sent via mobile radio (GSM) to the toll collection center
8. Toll collection center charges toll fees to the transport company’s account
GNSS: Truck Toll Germany (TollCollect)

**Automatic System - Technology**

- System based on **GPS** (Global Positioning System), **GSM** (mobile communications), and other components
- Booking via On-Board Unit in vehicle (OBU)
- On-Board Unit with DSRC module:
  - Communication with enforcement system (infrared)
  - Technical prerequisite for interoperability with other toll collection systems (microwave)
- (Gantries: only for enforcement)
Objectives:

- Transport infrastructure funding
- ‘User pays’ principle
- Efficient use of transport system
- Emission reduction
- Fairer competition between road transport and the railways
GNSS: Truck Toll Germany (TollCollect)

First Results:

- Toll revenue 2005: € 2.86 billion (gross)
- Empty runs: 15% reduction
- 7% increase of containers carried by rail

Chances

- Change in travel patterns
- Public transport improvements
- Traffic flow improvements
- Congestion Reduction
- Better environment
- Revenue Generation
- Increased Safety
Equity Aspects

- Some People can not change travel patterns
- Lower-income people can be more affected

Impacts depend on how revenues are used

Earmarking of Revenues!
Conclusions

- From a technological viewpoint, road pricing has proven its value in different system concepts; consolidation of technology has begun in detail.
- The positive effects of pricing clearly show up, the negative effects are much less than expected.
- If the conception of the pricing-application is well balanced and openly communicated, barriers and opposition in public as well as special lobbies are diminishing over time.
- ETC-applications with directly traffic-related fees are not yet in regular operation on a wider scale.
- A holistic view on the pricing solution is needed with respect to traffic effects, financial charge and use of fee-incomes.
Conclusions

(Electronic) Toll Collection may become an increasingly important instrument within the big bundle of measures for regional demand and traffic management.

Thank you for your attention.

Contact:
Univ.-Prof. Dr.-Ing Fritz Busch, fritz.busch@vtbv.tum.de
Dr.-Ing. Andreas Rau, andreas.rau@vtbv.tum.de
Dipl.-Ing. Friedrich Maier, friedrich.maier@vtbv.tum.de
Further information: www.vtbv.tum.de