Electronic Toll Collection Technologies for Road Pricing

World class Intelligent Transport Systems for
Road User Charging and Traffic Surveillance

Q–FREE
LEADING THE WAY
IN ROAD USER CHARGING AND TRAFFIC SURVEILLANCE

TCL workshop - Asilomar – 27. – 29. June 2011

Furnes, Per Jarle, Q-Free ASA
Ruja, Sascha, Q-Free ASA
Voss, Stefan, University of Hamburg

Congestion Charging on Roads

- Congestion Charging is not new

  Dupuit (Fr, 1849), Pigou (1920), Knight (1924), Walters (1961), Vickery (1969)

- Recent road pricing surveys

  Newbery (1990), Lindsey & Verhoef (2001), Lawphongpanich et al. (2006), Small & Verhoef (2007), Tsekeris & Voß (2009)

- Charging schemes are not the same
  - Policy objectives
  - Applications
  - Economic arguments
  - Technology choices

Conceptual Approaches to Managing Congestion

- Maximize Flows: (can lead to inherent instability and heighten the risk of unpredictable congestion)

- Optimize flows taking into account the balance between supply and demand for road space and what people are ready to pay in order to use the road [and for better performance]

- Technical vs. economical optimization – need new hybrid approaches

Methods of Congestion Pricing

Types of Congestion Charging

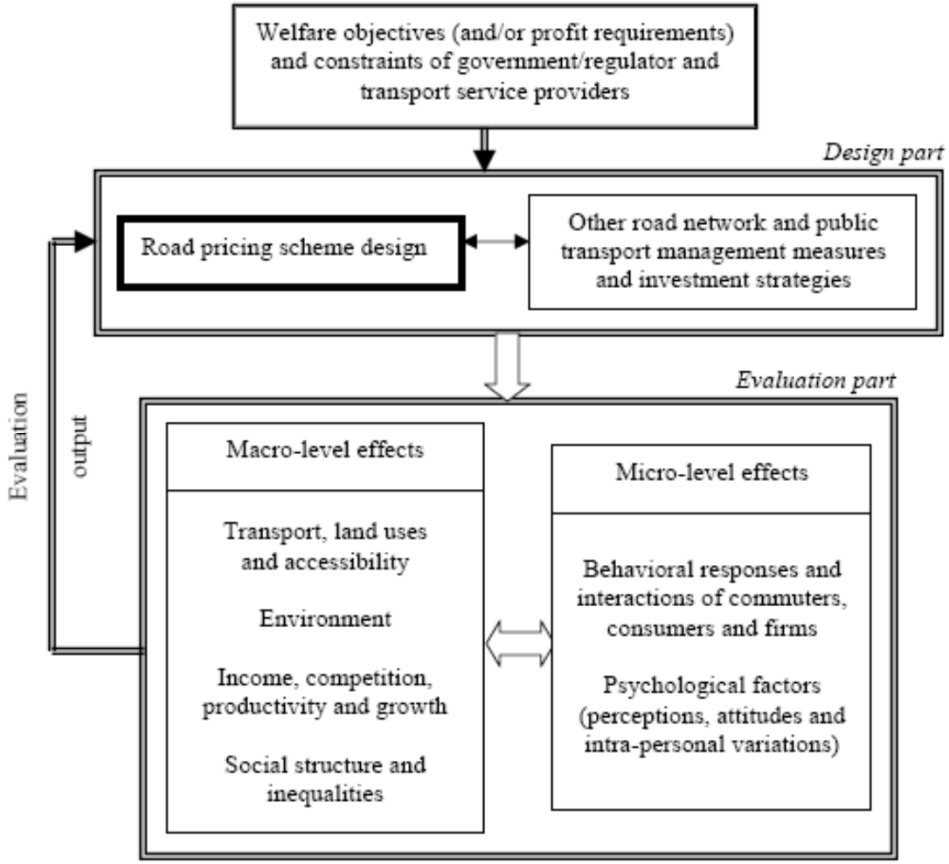
- Facility-based
  - Roads, tunnels, bridges, HOT
  - Single or multiple points
- Area pricing
- (Multi)Cordon based
- Distance-based based
- [TDP based]

Static vs Dynamic Charging

- Static
  - (flat toll) Determined a priori, constant over given time horizon
  - (scheduled) Determined a priori, vary over time, most common peak vs off peak
- Dynamic
  - (Responsive) vary in real time as a function of prevailing traffic conditions
  - (predictive)

De Palma and Lindsey (2009)

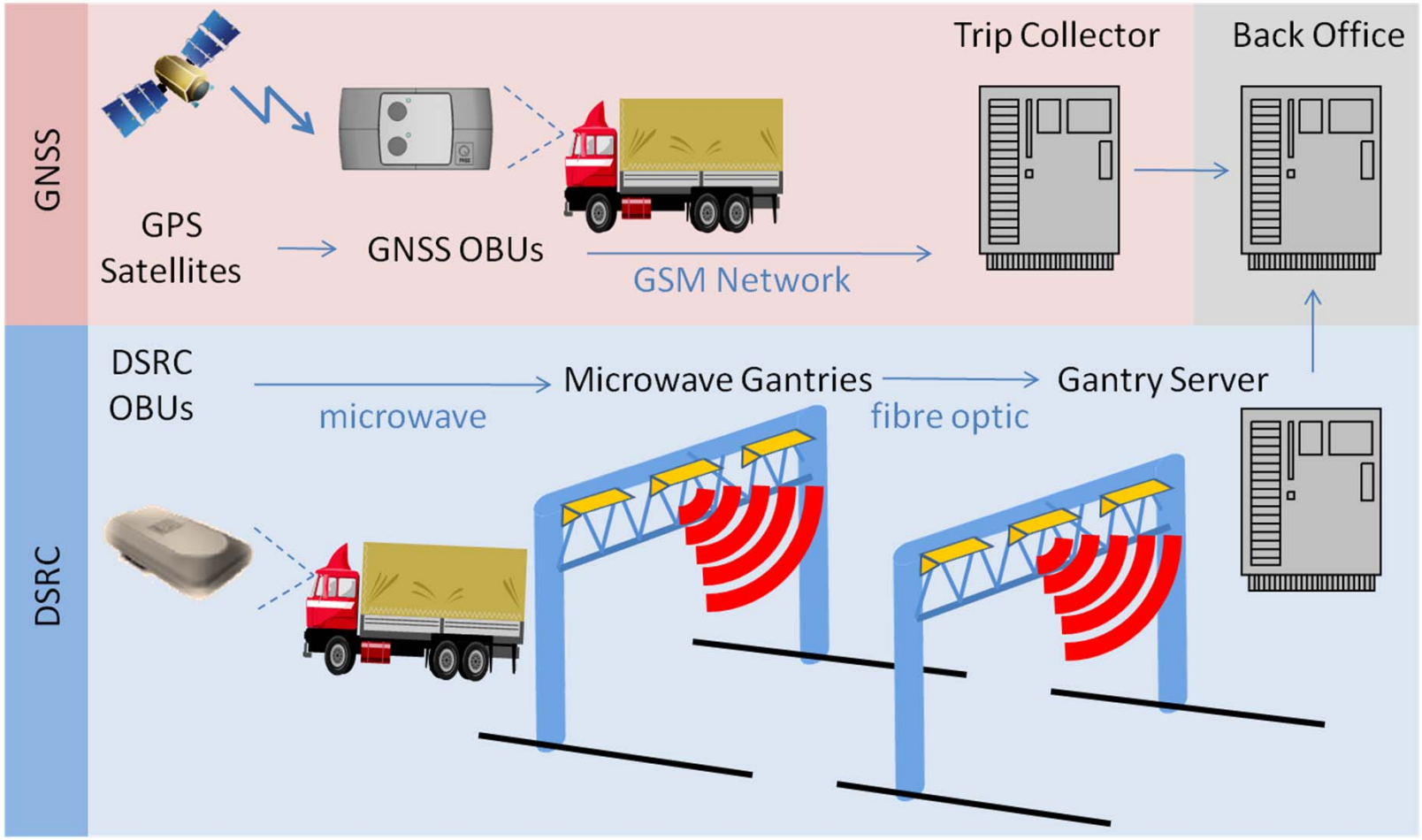
Integrated framework for the evaluation of road pricing schemes



Choosing technology as a function of system design

Theodore Tsekeris & Stefan Voß (2009)

Technology alternatives - GNSS/DSRC and VIDEO



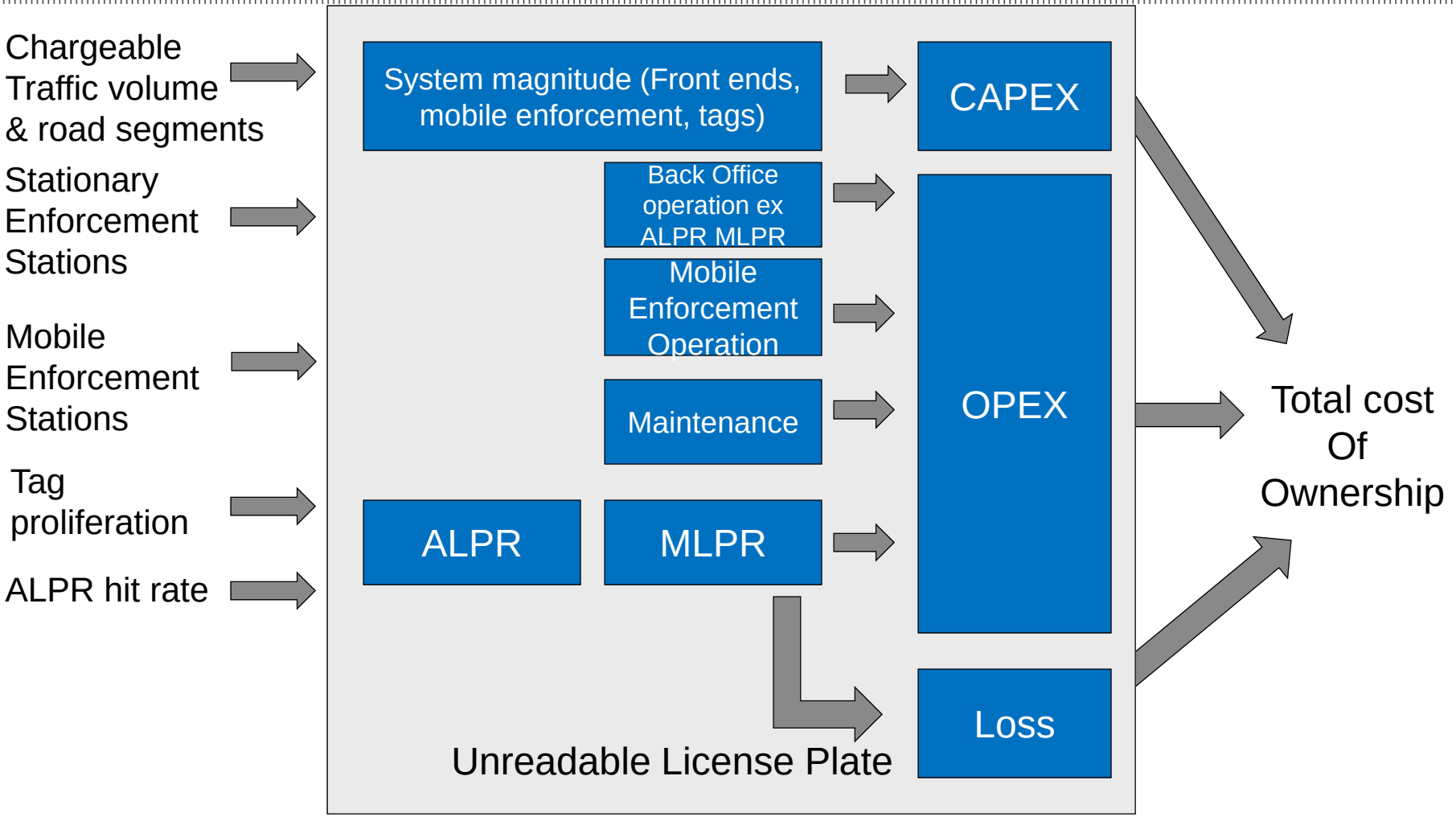
Technology Alternatives

Tech-nology	OBU	Investment Costs	Operational Costs	Physical Gantry	Additional Enforce.	Vehicle Speed	Weather	Updated Vehicle Reg.
GNSS	Yes	High	Medium-High	No	Yes	No limit	Not sensitive	No
DSRC	Yes	High	Low-Medium	Yes	Yes	High	Not sensitive	No
Video	No	Medium	Medium	Yes	No	High	Sensitive	Yes
RFID	Yes	High	Low	Yes	Yes	Low-Medium	Sensitive	No
Manual	No	Medium	High	Yes	No	Stop	Not sensitive	No

Key questions related to Total Cost of Ownership Modelling

- Can TCO modeling explain customers' technology preferences ?
- Can TCO figures be accurately quantified to advise on a certain technology ?
- Can TCO calculations predict certain strategies?
- And last but not least
- Does TCO really matter for our customers investment phase ?

Total Cost of Ownership Model



Total cost of Ownership validation based on empirical data

- Empirical data
  - Amdal & Welde (2004)
    - Sensitivity analysis on Norway's toll collection projects
    - Findings: OPEX ranging from 7-25% relative to income, tag proliferation sensitivity, system magnitude sensitivity
  - Oslo: OPEX :8% relative to income in 2006 (75% hit rate, 85% tags)
  - Stockholm: OPEX 25% relative to income in 2008 (>95% hit rate, 0% tags)
  - London: OPEX 67% relative to income in 2003 [Levinson and Odlyzko 2008]

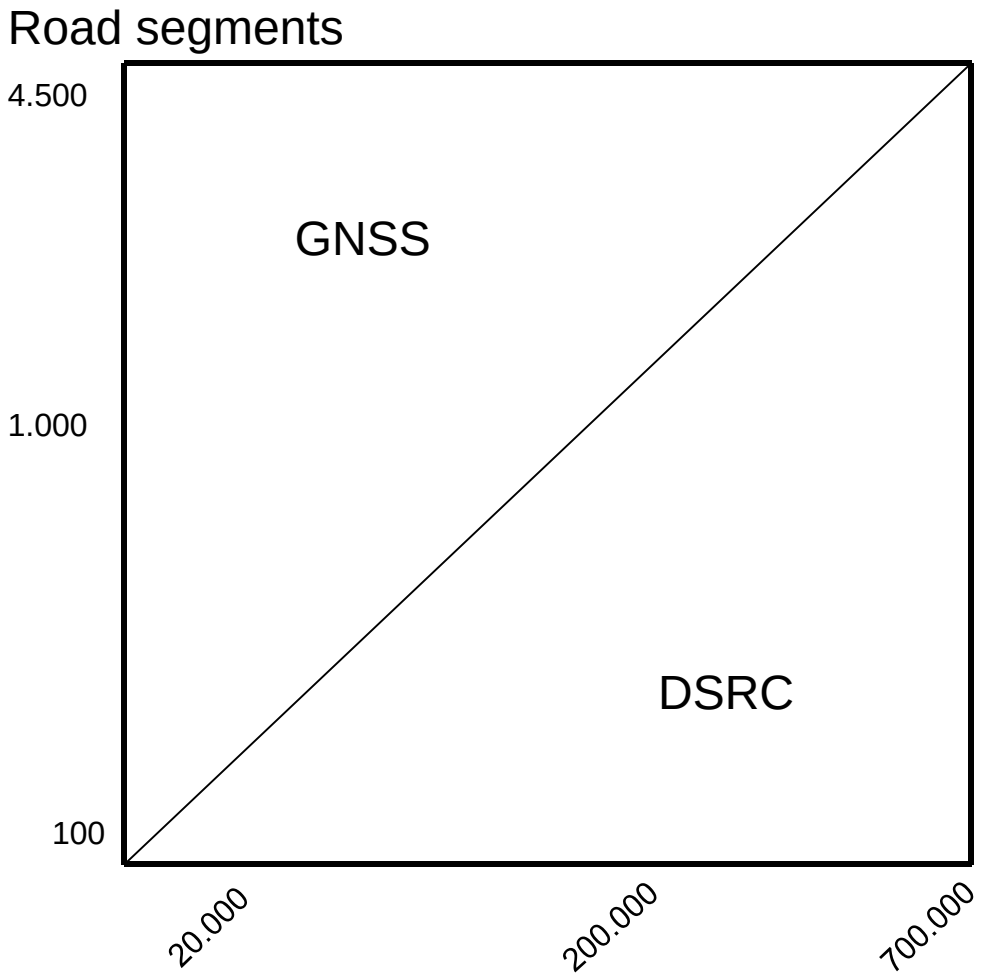
- Validation of Model
  - Identified same effects as (Amdahl & Welde 2004) when using Norwegian manual labor costs
  - Identified same OPEX levels as in Oslo, Stockholm and London when same ALPR hit rates and tag proliferation levels were used.

- Major model limitations (same for both ALPR, DSRC, GNSS)
  - Maintenance is linear to the system magnitude, 15%
  - Translating scheme rules and enforcement procedures into a unified model for back office operating costs is highly challenging

Technology Choice – Crossing Point GNSS/DSRC

Number of roads to cover gives an indication on how many physical charging points must be installed.

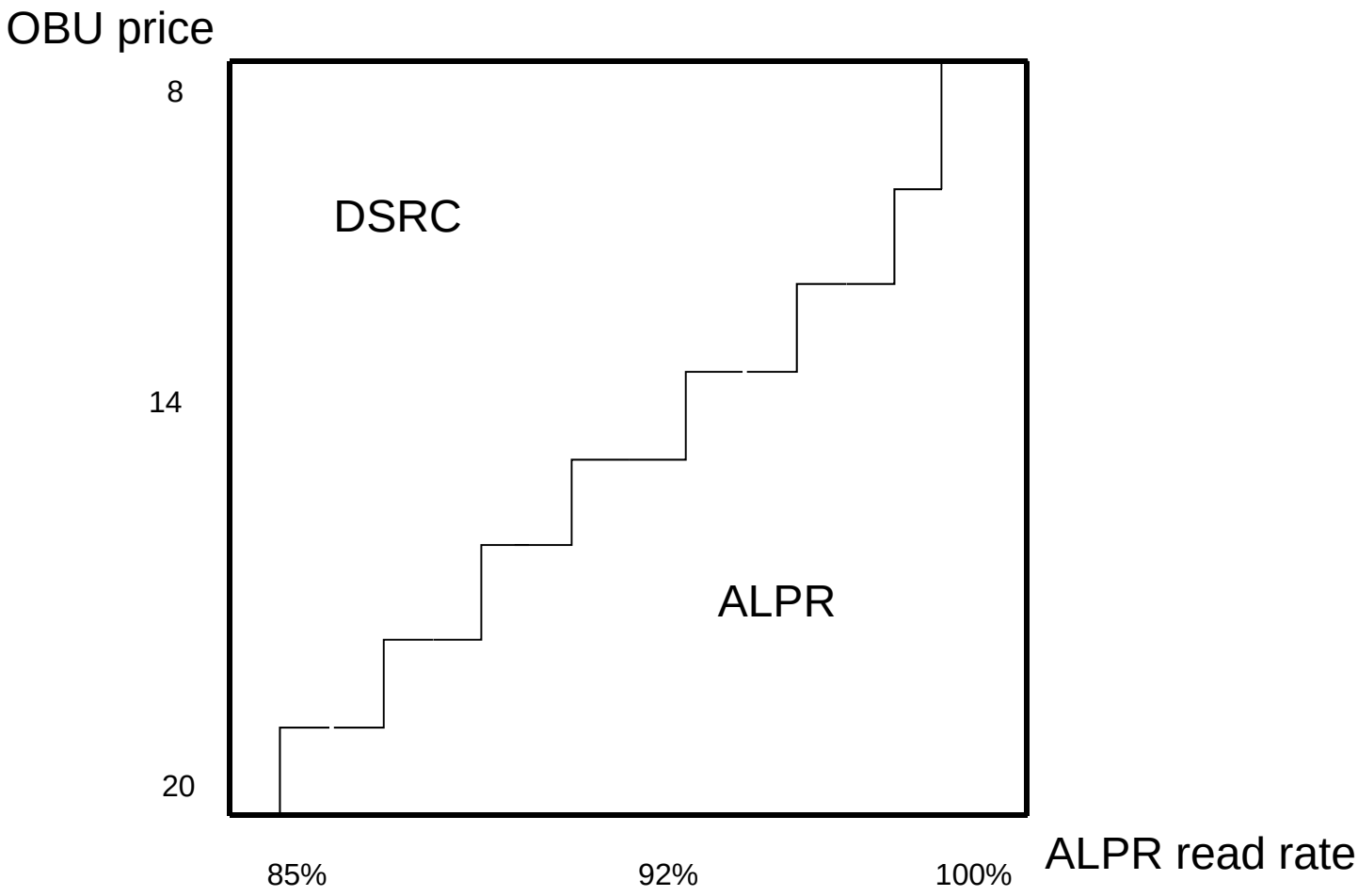
As for Road User Charging systems it is more common having a high number of cars for a small number of roads in a city.



— : equal

Graph:
Crossing point where GNSS or DSRC is the most favorable technology, based on number of road segments and number of vehicles applicable for tolls

Modeling results: DSRC versus ALPR



Scenario Investigations and Details

Scenario / Parameters	City Zone Congestion Charging	Motorway Open Road Tolling	Heavy Goods Vehicle Charging
Charging principle	Point	Distance	Continuous
Vehicles to charged (pr day)	400000	800000	850000
Road Infrastructure Size (km)	100	2500	12500
Chargeable Road Segment Length (km)	5	5	5
Usage frequency pr day	0.7	2	8
Enforcement operation	Stationary Offline	Stationary Offline	Mixed (stationary and mobile)
Proof verification	Mandatory	Mandatory	Spot
Payment Mode	Mixed	Mixed	Mixed
Charging Fee pr km	0.07	0.03	0.07

Technology Parameter Settings

Strategy / Parameter	Video	DSRC	GNSS
OBU proliferation	0%	90% (unequipped through Video)	90%
OBU acquisition and distribution cost €	0	15	350
OBU transaction unit €	0	0	0.03
Read Rate/Error rate	97%	99%	99%
Unequipped passage detection coverage (ratio of chargeable segments)	100%	100%	20%
Mobile Enforcement (ratio of chargeable segments)	0%	0%	10%
Back office stationary cost pr year €	500000	500000	500000
Back Office fee pr transaction €	0.2	0.2	0.2

Modelling Results

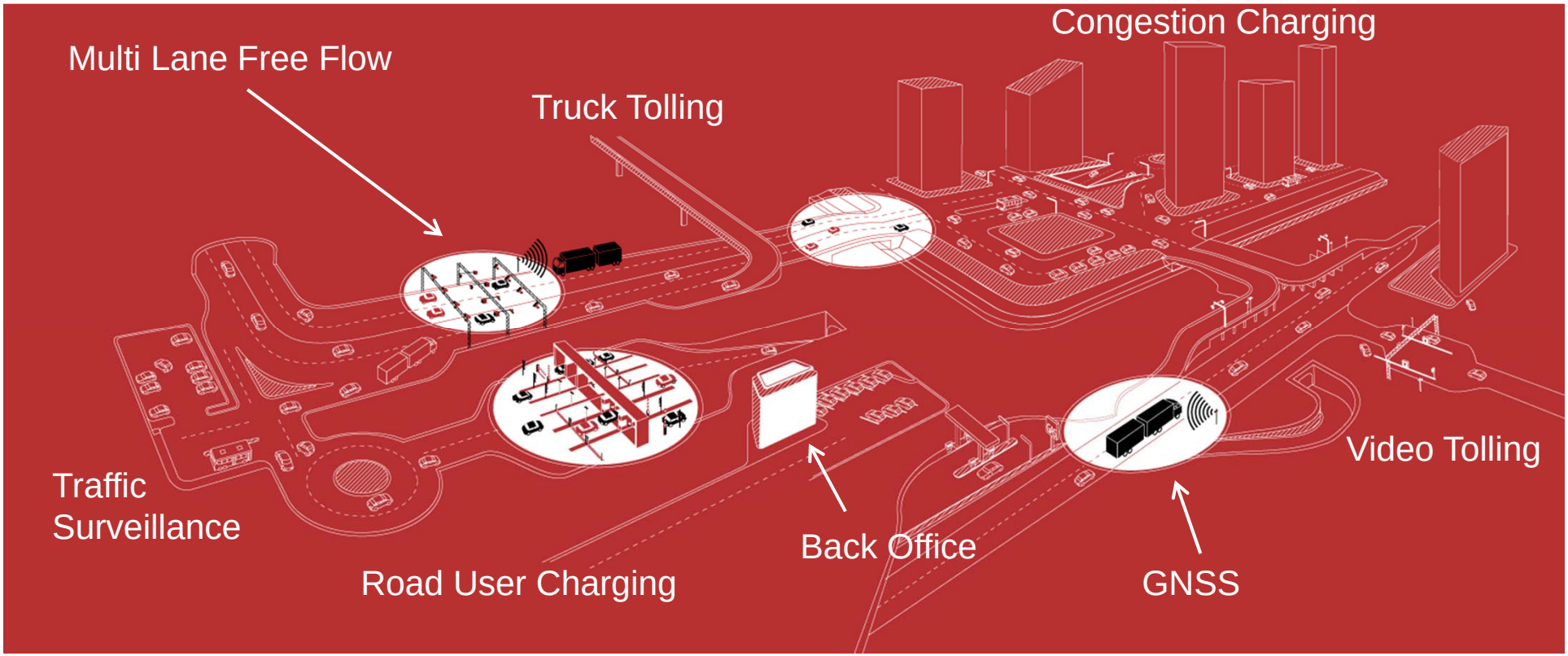
Technology grid based on the ratio between TCO and revenues. The latter is given in percentages. Cell values are highlighted in green and red to indicate a relatively low and high figure, respectively

	Video	DSRC	GNSS
City Zone Congestion Charging	9,50	7,30	17,30
Motorway Financing	9,80	9,40	12,40
Truck Tolling	378,00	39,90	38,50

Modelling Results

Technology / Scenario	Video	DSRC	GNSS
City Zone Congestion Charging	Automated billing through accurate video and ALPR	Low cost OBU	High OBU CAPEX and OPEX.
Motorway Open Road tolling	Vulnerable to large amount of unregistered users and manual handling costs	Best fit as OBU costs are low for a high number of users.	High OBU CAPEX and OPEX. Enforcement frequency increasing with number of users
Heavy Good Vehicle Charging	High front end infrastructure costs and operation costs (and loss from foreign users)	High front end infrastructure costs when there are few users and large road network	Best fit with many segments and few users but which are frequently being charged

Thank you!


Congestion Charging
Multi Lane Free Flow
Truck Tolling
Video Tolling
Traffic
Surveillance
Back Office
Road User Charging
GNSS