Contents

Author’s preface xix
Biographies of the authors and editor xxxiii

1 Introduction to road pricing 1
   John Walker and Andrew Pickford
   1.1 Introduction to the book 1
   1.2 Terminology 1
   1.3 Context: congestion, pollution, taxation 2
   1.4 What are not the solutions to congestion and pollution 3
      1.4.1 Improvements in public transport 5
      1.4.2 Car-sharing 5
      1.4.3 Park-and-ride schemes 5
      1.4.4 Autonomous vehicles 6
      1.4.5 Workplace Parking Levy 6
      1.4.6 Smarter travel 6
   1.5 Equity 6
   1.6 Public acceptability of road pricing 7
   1.7 Low emission zones 8
   1.8 Taxes or charges? 8
   1.9 An outline of the book 9
   References 14

2 The Smeed Report at 50: will road pricing always be 10 years away? 17
   Stephen Glaister
   2.1 Introduction 17
      2.1.1 The economists versus the rest 17
      2.1.2 Unintended consequences of under-pricing 19
   2.2 What’s new? 20
      2.2.1 Forecasts of road congestion 20
      2.2.2 The shortage of capital and the national debt 20
      2.2.3 Decarbonising and tax yields 21
      2.2.4 Air quality 22
      2.2.5 Cost of technology 22
2.3 Misunderstandings
  2.3.1 Privatisation
  2.3.2 Fuel duty is a better mechanism?
  2.3.3 Road tolls ‘do not work’ in England
  2.3.4 Road charging is only about congestion or only about raising money

2.4 Reactions to past UK proposals
  2.4.1 The Smeed report
  2.4.2 The London congestion charge
  2.4.3 The 2004 road pricing feasibility study
  2.4.4 The 2006 Eddington Transport review
  2.4.5 The 2010 coalition government roads policy review

2.5 Charges to replace existing taxes

2.6 Fairness
  2.6.1 Equity and revenue-neutral, fully efficient pricing
  2.6.2 Road pricing and household income

2.7 Governance is the key
  2.7.1 A ring fenced fund

2.8 Conclusions
  2.8.1 One problem or five?
  2.8.2 Lessons from experience
  2.8.3 What next in England?

References

3 Types of road pricing, and measuring scheme cost and performance
John Walker and Andrew Pickford

3.1 Introduction

3.2 Policy context
  3.2.1 Policy options
  3.2.2 Major scheme design issues
  3.2.3 Major scheme design issues: other charging options
  3.2.4 Practical considerations in defining charging schemes
  3.2.5 Security, privacy and fraud
  3.2.6 Enforcement

3.3 Functional requirements
  3.3.1 Principal functions
  3.3.2 Security
  3.3.3 Enforceability and enforcement
  3.3.4 Privacy
  3.3.5 Environmental issues
  3.3.6 Back-office processing – the central system

3.4 Technology options
  3.4.1 Option 1: DSRC
  3.4.2 Option 2: GNSS/CN
4 We can’t get there from here: ecofiscal policies to address traffic congestion in Canadian cities

*Nancy Olewiler*

4.1 Introduction: congestion costs—an economic and social loss 89
4.2 The economic rationale for congestion pricing 90
4.3 Pricing congestion: a basket of ecofiscal policies 91
4.4 Designing congestion-pricing policy: evaluation of trade-offs 96
4.5 Principles for implementation 99
4.6 Options for congestion pricing in Canada’s four largest cities 101
   4.6.1 Metro Vancouver 102
   4.6.2 Calgary 105
   4.6.3 Greater Toronto Area 107
   4.6.4 Greater Montreal 110
   4.6.5 Congestion pricing could benefit other Canadian cities 113
4.7 Summary 114
4.8 Recommendations 115
References 118

5 The public acceptability of road pricing—a US case study

*Lee Munnich, Frank Douma, and Joe Loveland*

5.1 Public acceptance and road pricing 126
   5.1.1 Singapore 126
   5.1.2 London and Stockholm lead the way 126
   5.1.3 Setbacks with Manchester and Edinburgh referenda 127
   5.1.4 The US experience with HOT/managed lanes 129
5.2 The Minnesota experience 130
5.3 The challenges 130
5.4 The turning point 132
5.5 The results 133
5.6 Lessons learned 134
   5.6.1 Seeing is believing 134
   5.6.2 Task force is an in-depth education tool 137
   5.6.3 Public outreach improves project design 137
   5.6.4 Grasstops support is first priority 138
   5.6.5 Top-level champions are keys 138
8 Case studies of communication and consultation strategies for road pricing schemes
Andrew Pickford and John Walker

8.1 Introduction 195
8.2 Policy context, themes and consultation variables 196
  8.2.1 Policy, legal and regulatory contexts 196
8.3 Stakeholder consultation and communications processes 198
  8.3.1 Perceptions and attitudes 198
  8.3.2 Types of consultation, levels of engagement and setting expectations 199
  8.3.3 The shape of a consultation programme, themes and phasing 199
  8.3.4 Communications, media management and measurement of stakeholder attitudes 202
8.4 Case studies 203
  8.4.1 London 203
  8.4.2 Edinburgh and Manchester 205
  8.4.3 New York 206
  8.4.4 Singapore 207
  8.4.5 Hong Kong SAR 209
  8.4.6 The Netherlands 210
  8.4.7 Milan 212
  8.4.8 Berlin 213
  8.4.9 Summary 214
8.5 Recommended approaches 215
8.6 Conclusions 216
Acknowledgement 217
References 217
Further reading 219

9 Road pricing standardisation
Jan Kersten and Jasja Tijink

9.1 Introduction and scope 221
9.2 History and status of standardisation 222
  9.2.1 Why standards in road pricing? 222
  9.2.2 Early initiatives in standardisation in road pricing 223
  9.2.3 Standardisation organisations currently active in road pricing standards 225
9.3 Paving the path towards interoperability 227
  9.3.1 DSRC-based ETC systems 227
  9.3.2 Autonomous systems based on CN and GNSS 229
9.4 Existing framework of road pricing standards 230
  9.4.1 Overview 230
  9.4.2 EFC architecture, role model and interoperable interfaces 231
### 9.4.3 Application interface specification for autonomous systems

Page 235

### 9.4.4 Interoperability application profile for DSRC-based systems

Page 239

### 9.4.5 Application interface definition for EFC-DSRC systems

Page 239

### 9.4.6 Standards for compliance check communication in autonomous EFC systems

Page 240

### 9.4.7 Standards for secure monitoring in autonomous EFC systems

Page 241

### 9.4.8 Location augmentation communication in autonomous EFC systems

Page 242

### 9.4.9 Back-office data exchange between Toll Chargers and Service Providers

Page 243

### 9.4.10 Interoperable application profile for the back-office data exchange between Toll Chargers and Service Providers

Page 244

### 9.4.11 EFC security framework

Page 245

### 9.4.12 Additional EFC standards

Page 245

### 9.5 Outlook for future work in standards for road pricing

Page 246

### References

Page 246

---

### 10 The European Electronic Toll Service – EETS – and the REETS project


datei

Mike Hayward and Hubert Resch

#### 10.1 Introduction – the EETS vision for interoperable Electronic Toll Collection (ETC) services

Page 251

#### 10.2 The need – business and political drivers for interoperability of electronic toll collection systems in Europe

Page 252

#### 10.3 Background – the ETC landscape and the beginnings of ETC interoperability in Europe

Page 253

- 10.3.1 ETC for motorway tolls in Europe

Page 254

- 10.3.2 ETC for national heavy vehicle charging

Page 255

#### 10.4 The route to EETS via REETS – the service provider concept and the emergence of regional interoperability services

Page 256

- 10.4.1 The service provider concept

Page 256

- 10.4.2 The service provision model in France

Page 257

- 10.4.3 The service provision model in Ireland

Page 258

- 10.4.4 ETC interoperability and service provision in Spain and Portugal

Page 259

- 10.4.5 ETC interoperability and service provision in Italy

Page 260

- 10.4.6 Interoperability of ETC services in Scandinavia – EasyGo

Page 260

- 10.4.7 Overall European interoperability architecture

Page 260

#### 10.5 EETS is more than interoperability – advantages and disadvantages

Page 261

#### 10.6 Legal background/framework

Page 262

#### 10.7 European co-operation – European Commission projects, standards, activities, committees, etc.

Page 262

#### 10.8 Getting EETS off the ground: the REETS project

Page 264
10.9 REETS project organisation 268
   10.9.1 Overall rationale and approach 268
   10.9.2 Project scope and objectives 268
   10.9.3 Project organisation 269
   10.9.4 Analysis phase activities 269
   10.9.5 Information platform 270
10.10 Implementation of EETS – compliant services and REETS pilot 270
   10.10.1 Conditions for the pilot and roles of the actors 270
   10.10.2 Roadmap actions project coordination 271
   10.10.3 Coordination with REETS TEN toll chargers 271
   10.10.4 Coordination with service providers 272
   10.10.5 Transparency of the process between the partners 273
   10.10.6 Status at the end of the REETS pilot 273
   10.10.7 Continuation under an EETS facilitation platform 275
10.11 EETS facilitation platform 275
10.12 Conclusions 277
10.13 Necessary changes in legislation 278
10.14 Outstanding high-level issues 279
   10.14.1 Continuing development of interoperability management 279
   10.14.2 Consistency of registration procedures 279
   10.14.3 Back office interfaces 279
   10.14.4 Notified bodies 279
   10.14.5 Toll context data format 280
   10.14.6 Cross-border enforcement 280
   10.14.7 Conciliation procedures 280
10.15 Other trends – light vehicle charging, smartphone apps, etc. 281
   10.15.1 Smartphones 281
   10.15.2 RFID and light vehicles 282
10.16 Summary, conclusions and further work 282
References 283
Further reading 284

11 Standardisation and implementation of ANPR – a practical guide 285
   Peter Vermaat

11.1 Introduction to ANPR 285
   11.1.1 Short history of ANPR 285
   11.1.2 How ANPR works – a short technical description 286
   11.1.3 ANPR cameras 288
   11.1.4 Effect of plate design on ANPR 293
   11.1.5 Expected performance of ANPR systems 295
11.2 The use of ANPR in road pricing 298
   11.2.1 Primary charging using ANPR 298
11.3 Implementation of ANPR 306
   11.3.1 General points 306
   11.3.2 Case study: London congestion charge zone 307
11.4 Standards relevant to the implementation of ANPR
11.4.1 Interface standards
11.4.2 Performance and deployment standards
11.5 Summary and conclusions

References

12 Engineering interoperability in the US: video tolling and multiprotocol tags and readers

James J. (JJ) Eden

12.1 Introduction
12.2 Interoperability when cash was king
12.3 Electronic toll collection (ETC)—the early days
12.4 The start: formation of E-ZPass
12.4.1 The building blocks of interoperability
12.5 A small greenfield project that changes everything: North Carolina
12.6 Multiprotocol tags and readers
12.6.1 A new tag and protocol—ISO-18000-6C
12.6.2 National interoperability
12.6.3 Governance of interoperability
12.7 The future of tolling in North America
12.8 Lessons for other countries

References

13 London Congestion Charging – a personal account

Nick Patchett and Jeremy Evans

13.1 Introduction to the project
13.1.1 Our roles and the team
13.1.2 Making it real
13.1.3 Our leadership
13.2 Why congestion charging
13.2.1 So why did London need congestion charging?
13.2.2 What was the history?
13.2.3 Where does the scheme operate?
13.2.4 What problem were we solving?
13.2.5 What was the public’s reaction?
13.3 How does it work?
13.3.1 Customer channels and payment of a charge
13.3.2 Vehicle detection and camera images
13.3.3 When things go wrong
13.4 Complementary measures
13.5 Implementation
13.6 Expansion, other schemes and the opportunity for a ‘shared service’
<table>
<thead>
<tr>
<th>13.7</th>
<th>What about national road pricing?</th>
<th>360</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.7.1</td>
<td>What are the arguments?</td>
<td>360</td>
</tr>
<tr>
<td>13.7.2</td>
<td>Is it feasible?</td>
<td>361</td>
</tr>
<tr>
<td>13.8</td>
<td>Conclusions</td>
<td>361</td>
</tr>
<tr>
<td>References</td>
<td>362</td>
<td></td>
</tr>
<tr>
<td>Further reading</td>
<td>362</td>
<td></td>
</tr>
</tbody>
</table>

14 **The Swedish congestion charges – lessons learnt** 363  
*Ida Kristoffersson and Maria Börjesson*

14.1 Introduction 363  
14.2 System designs 364  
14.3 Traffic effects 367  
14.3.1 Traffic volume across the cordon 367  
14.3.2 Traffic volume in the inner city 369  
14.3.3 Traffic volume on roads bypassing the inner city 370  
14.3.4 Travel times 370  
14.3.5 Long-term effects and effects of increased charging levels 372  
14.4 Adaptation strategies 373  
14.5 Revenues and system costs 375  
14.6 Model predictions 376  
14.7 Cost–benefit analysis, equity effects and company cars 377  
14.8 Public support 378  
14.9 Political support 380  
14.10 Lessons learnt and recommendations for other cities 382  
References 384

15 **Moving from conventional tolling installations to open road tolling** 387  
*Bjarne Olav Tveit*

15.1 Introduction – new challenges 387  
15.2 Unobtrusive toll plazas 388  
15.3 Vehicle detection 389  
15.4 Vehicle classification 390  
15.4.1 Direct measurement classification methods 390  
15.4.2 Declared class classification methods 392  
15.4.3 Summary 392  
15.5 Vehicle/vehicle owner identification 392  
15.6 Enforcement 395  
15.7 Legal issues 396  
15.8 Changes in payment process and payment products 396  
15.9 Impact on system design 397  
15.9.1 Introduction 397  
15.9.2 Asynchronous reception of passage and payment data – individual accounts 399
15.9.3 Data storage capacity 399
15.9.4 Monitoring of system performance 399

15.10 Changes to the operational organisation 400
15.10.1 Customer support 400
15.10.2 Transaction control 400
15.10.3 Money management 400
15.10.4 Summary 401

15.11 Road works/civil works 401

15.12 Conclusion 402

16 GNSS-based tolling: standards and implementations 403
Norbert Schindler and Erich Erker

16.1 Overview of major GNSS tolling projects in Europe and worldwide 403
16.1.1 Introduction 403
16.1.2 The Swiss distance-based ‘LSVA’ system 403
16.1.3 German ‘Toll Collect’ system 405
16.1.4 The planned lorry road user charge in the United Kingdom 406
16.1.5 The planned tolling scheme of the Netherlands for all vehicles on all roads 408
16.1.6 Slovakia’s innovative ‘Myto’ system 409
16.1.7 The French écotaxe system 412
16.1.8 Hungary’s ‘HU-GO’ system 414
16.1.9 Russia’s ‘PLATON’ system 416
16.1.10 The Belgium ‘Viapass’ system 417
16.1.11 Common themes in all GNSS-based tolling systems 419
16.1.12 Summary of failed projects 422

16.2 Technical challenges of GNSS in tolling 423
16.2.1 Introduction 423
16.2.2 Challenges of GNSS technology 424
16.2.3 Issues with the communication link 428
16.2.4 Issues with power supply 428
16.2.5 Issues with maps 429
16.2.6 Key performance indicators (KPIs) and service-level agreements (SLAs) 430

16.3 Commercial and political obstacles in implementing tolling systems 431
16.3.1 Long lead times 432
16.3.2 Privacy concerns 432
16.3.3 Increase in transportation costs 432
16.3.4 Fear of failure and over-specification 433
16.3.5 Lack of a sound business case 433
16.4 Trade-offs in the definition of tolling systems
16.4.1 Number of vehicles vs. size of the road network
16.4.2 Flexibility vs. complexity
16.4.3 Cost of implementation vs. cost of operation
16.4.4 Thin vs. fat client

16.5 Trends in GNSS-based tolling systems
16.5.1 Integration into cooperative intelligent transportation systems (C-ITS)
16.5.2 Multi-constellation GNSS
16.5.3 Fusion of GNSS signals with inertial sensors and vehicle data (CAN bus)
16.5.4 Separation of Toll Service Providers and Toll Chargers
16.5.5 Interoperability and EETS
16.5.6 Use of smartphones in electronic tolling

16.6 Using GNSS-based tolling systems for other purposes
16.6.1 Missing trader fraud
16.6.2 A Multipurpose GNSS-based OBU – with data privacy

16.7 Lessons learned from existing GNSS-based tolling systems

17 HU-GO: the Hungarian distance-based electronic toll system

Zoltán Varga

17.1 The Hungarian tolling and RUC (road user charging) environment
17.1.1 History of tolling and RUC in Hungary
17.1.2 The need for implementation
17.1.3 Hungary—the home of innovations

17.2 The innovative approach
17.2.1 Prevailing circumstances of implementation
17.2.2 The unified open operational platform
17.2.3 The toll declaration methodology

17.3 Modules of the HU-GO system
17.3.1 The central system
17.3.2 The sales module
17.3.3 The enforcement module [1]

17.4 Implementation and operational challenges
17.4.1 The time frame
17.4.2 Internal and international communication
17.4.3 Major stakeholders—the involved organizations
17.4.4 EETS compatibility

17.5 New opportunities for utilization of the toll system
17.5.1 The National Mobile Payment services [2]
17.5.2 The National Electronic Ticketing Platform (NETP) [3]
17.5.3 The Electronic Public Road Trade Control System (EPRTCS) [4] 463
17.5.4 Weigh in Motion 464
17.6 Facts and figures 464
17.7 Summary and conclusions 464
References 465

18 West Coast distance charge programs: an open market as the gateway to implementation in the United States 467
James M. Whitty

18.1 Introduction 467
18.2 Context for distance charge activities in the United States 468
18.3 Legislative direction of distance charge policy development and technical research and development 471
18.3.1 Oregon 472
18.3.2 California 473
18.3.3 Washington State 474
18.4 Pacific Coast distance charge programs 475
18.4.1 Oregon’s road usage charge program 475
18.4.2 California’s road charge pilot program 477
18.4.3 Washington State’s road usage charge pilot program 478
18.5 Commonalities and differences among the Oregon, California and Washington distance charge programs 478
18.5.1 An open market 479
18.5.2 Distance traveled reporting methods 480
18.6 Other Western States’ distance charge pilots and authorities 483
18.6.1 Colorado road usage charge pilot program 483
18.6.2 Hawai‘i road usage charge pilot program 484
18.6.3 Utah 484
18.7 Key issues for distance charge programs in the United States 485
18.7.1 Issues essentially resolved or substantially calmed 485
18.7.2 Issue requiring continual management 488
18.7.3 Issues for later resolution 488
18.7.4 Issues determined by legislatures 489
18.8 Impact of the US Federal STSFA grant program on distance charging 491
18.9 Awards for predevelopment of new pilots 492
18.9.1 Minnesota 492
18.9.2 Missouri 493
18.9.3 Western Road Usage charge consortium (RUC West) 493
18.9.4 I-95 Corridor Coalition 493
18.10 Planning for mandatory road usage charging in the United States 494
18.11 Strategic engagement and political acceptance 495
18.12 Conclusion 497
References 497
19 Four years of Milan’s road charge: effectiveness, acceptability and impacts 501
Paolo Beria, Luca Tosi, and Davide Nuccio

19.1 Introduction 501
19.2 Milan’s road pricing 501
19.3 Four years of Area C: consolidated effects 505
   19.3.1 Traffic reduction 506
   19.3.2 Vehicle mix 508
   19.3.3 Hourly trends 510
   19.3.4 Emissions 511
   19.3.5 Revenues and reinvestment 511
   19.3.6 Housing market 512
19.4 Technological and organisational architecture 513
   19.4.1 The technological infrastructure 513
   19.4.2 The informative architecture 513
   19.4.3 Payment systems 514
19.5 Acceptability 514
   19.5.1 The acceptability of pricing policies in the literature 515
   19.5.2 The results of the 2011 referendum 515
   19.5.3 Monetary impact on user groups 517
19.6 Conclusions and lessons learned 518
   19.6.1 Summary of results 518
   19.6.2 What can be taken from Milan’s experience? 518
   19.6.3 What cannot be taken from Milan experience? 519
References 520

20 Optimising use – using incentives to address traffic congestion 523
Rob Mours, Jorrit Nijhuis, and Colin Black

20.1 Introduction 523
20.2 Development of peak-hour avoidance initiatives 524
20.3 Launch of the initiative 526
   20.3.1 Programme paying differently for mobility 526
   20.3.2 Improving the value of existing road infra (Programme Spoedaanpak & Beter Benutten) 527
20.4 A guide to implementing ‘Spitsmijden’ 530
   20.4.1 Recruiting participants 530
   20.4.2 Types of rewards 531
   20.4.3 Available technology 531
   20.4.4 Fraud prevention 533
20.5 The results 533
   20.5.1 Effects in rush-hour avoidances 533
   20.5.2 Effects: behavioural change of participants 535
   20.5.3 Effects: congestion reduction on the road network 536
   20.5.4 Effects: long-term contribution of rush-hour avoidance projects to congestion reduction 538
   20.5.5 Costs–benefits 540