Road user charging for heavy goods vehicles –
Implementation aspects

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Abstract

Several factors have influenced the recent development in charging of heavy goods vehicles in Europe. European legislation is changed and the political will is strong in many countries. The public awareness and acceptance is large for the need to put a price and a cost on the use of infrastructure. Environmental concerns are also actuating change in this direction. Systems are being introduced to support and enhance principles of marginal cost, fair pricing, inclusion of emission factors and to support modal shift. This has laid the foundation for a payment will for good technical solutions in the field of road user charging.

This licentiate thesis aims at analysing and identifying the most important factors and areas to focus on for reaching a successful implementation of a system for charging heavy goods vehicles based on distance and marginal cost. These are:

- Public acceptance and use of opportunities and public opinion
- The political process and most important decision points
- The legal framework before and during introduction as well as for operation of a system
- The institutional framework
- Responsibility assignment
- System procurement and implementation, including procurement strategy, technology choices, testing and demonstration and interoperability

Another important contribution is the implementation process model for an introduction of a distance based system for heavy goods vehicles in a country. The model comprises of the most important aspects to consider which has been made through the study and analysis of both implemented and cancelled systems as well as planned introductions, where the Swedish work in this direction has formed the major part of the analysis. The implementation process model with its main actors, decision points and information flow between actor groups are cornerstones of the model, which can serve as a tool for future implementers to follow.
Acknowledgements

I dedicate this work to my mother in law Anna, who passed away in April 2008. Thanks for all your support. I miss you greatly.

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Kuala Lumpur, May 2008

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1. Introduction

Since the turn of the millennium, the European development has been fast in the field of distance based road user charging for heavy goods vehicles (HGVs). A paradigm shift has occurred, from flat fee charging for road use towards pricing principles based on internalisation of external effects. This policy is now the guiding principle across Europe. Several countries have introduced or are planning to introduce road user charges which are based primarily on the distance driven by the vehicle. Other factors affecting the marginal cost, such as pollution and wear and tear, are also discussed to be included in more correctly priced road user charging. The policy work in this field is carried out on EU level and by the member states. Several groupings and networks, both formal and informal, have been formed to find good, sustainable solutions to the future European road user charging system.

The countries having introduced road user charging for HGVs have chosen different technologies and different scope for their charging system, thereby complication interoperability between systems. For Sweden this has raised many questions on how to approach the task of introducing distance based road user charges for heavy goods vehicles in Sweden. It is a big step going from using the Eurovignette system with a flat fee for all heavy goods vehicles operating in Sweden and change to a system based on marginal cost. This has to be done with care taken not only to the domestic and foreign users, but also operators and authorities inside and outside Sweden. Which is the best path to follow to achieve a fair and efficient marginal cost based system for heavy goods vehicles?

1.1. The European transport policy

“Transport is crucial for our economic competitiveness and commercial, economic and cultural exchange. Transport also helps to bring Europe’s citizens closer together and the Common Transport Policy is one of the cornerstones of the building of Europe.” These are the first lines in Europe’s transport policy Time to Decide (COM (2001) 370) and it continues by pointing out the future challenges for Europe, if the building of Europe shall be successful. Congestion, accidents and the underfinanced road network are identified as threats to this goal. The transport policy points out measures to be taken, and in the last years several directives and decisions have been taken to achieve the goals of the transport policy, where road user charges are considered to be one helpful tool in tackling some of these problems (COM (2003) 132 Final). Tolling as a way of financing the building of new infrastructure is
also pointed out as a way of solving the financial crisis in the underfinanced road network (COM (2003) 448). Congestion charging as a way of managing demand in larger cities is also treated favourably as a way forward to a sustainable Europe. The main thought through all this is that all fees introduced should reflect a socio-economic marginal cost principle.

As half the time span for the transport policy has now passed, the European Commission has produced a review of the policy (COM (2006) 314 final). This states that “The overall objectives of the European transport policy remain the same: a competitive, secure, safe, and environmentally friendly mobility, fully in line with the revised Lisbon agenda\(^1\) for jobs and growth and with the revised Sustainable Development Strategy. The transport policy toolbox needs to evolve to take into account the experience gained and to reflect the evolving industrial, political and international environment. Stronger international competition, but also weaker than predicted economic growth have made the task of ensuring sustainable mobility even more challenging…

...A European sustainable mobility policy therefore needs to build on a broader range of policy tools achieving shifts to more environmentally friendly modes where appropriate, especially on long distance, in urban areas and on congested corridors. At the same time each transport mode must be optimised. All modes must become more environmentally friendly, safe and energy efficient.”

To summarise, EU points out that a broad and holistic approach should be used to meet the goals set up for the Union in the future. EU works more intensely than before to reach its policy goals, utilising a wide range of incentives for goal fulfilment. Innovations for efficiency and sustainability are needed, co-modality and environmental protection as well as international connections beyond EU. The measures include new types of financing as well as user charges for the use of infrastructure. These are seen as they should contribute more than

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\(^1\) During the meeting of the European Council in Lisbon (March 2000), the Heads of State or Government launched a "Lisbon Strategy" aimed at making the European Union (EU) the most competitive economy in the world and achieving full employment by 2010 (http://europa.eu/scadplus/glossary/lisbon_strategy_en.htm.) This strategy, developed at subsequent meetings of the European Council, rests on three pillars:

- An economic pillar preparing the ground for the transition to a competitive, dynamic, knowledge-based economy. Emphasis is placed on the need to adapt constantly to changes in the information society and to boost research and development.

- A social pillar designed to modernise the European social model by investing in human resources and combating social exclusion. The member states are expected to invest in education and training, and to conduct an active policy for employment, making it easier to move to a knowledge economy.

- An environmental pillar, which was added at the Göteborg European Council meeting in June 2001, draws attention to the fact that economic growth must be decoupled from the use of natural resources.
today to the financing of the most commercially viable parts of the transport networks in Europe. Distance based road user charging for heavy goods vehicles are considered as the starting point for this development as the heavy goods vehicles fleet is limited in numbers, compared to the private vehicle fleet.

1.2. Road user charging

The concept of direct road user charging is not new. It has been considered as a tool for managing congestion and raising revenues for a long time. Pigou proposed the economic theory on which the principle of road use charging is based in his report Wealth and Welfare in 1920 (Pigou 1920). During the 1960’s several economists adopted the principle of marginal cost pricing for the transport sector, where the fixed taxes should be replaced with fees based on actual wear and tear, thus internalising the external factors. In UK, the thoughts were brought forward through the Smeed report in 1964 and several economists around the world followed suit in pursuing these principles. During the 1980’s the theories gained more attention, and by mid-1990’s the general public had embraced the principles of marginal cost pricing (Suter et al 2001), which were then included in the transport policy for the EU, first through its Green paper (COM (1995)691, and then through its White paper (COM (2001) 370) which was adopted and followed by its member states.

The reason for why variable road user charges are more equitable than fixed taxation or charges relates to the principle of vehicle user’s responsibility for costs that arise from their use of roads. The element of cost that arises with congestion (disproportionately) is the delay for fellow road users. As the delay, pollution, noise and other harmful effects rise much more than the fuel consumption these costs are thus not covered by the fuel tax. The road user charges are also fairer as the pay is for the actual, geographical use of a specific road segment. This removes the unfairness of different fuel prices in different countries, where some haulers fill up fuel in a country with cheap fuel and then perform work in a country with higher fuel prices, thus causing unfair competition and lack of funding for maintenance for the road operator subject to the use.

There are essentially three types of scheme design for road user charging systems (Pickford and Blythe 2006):

- The charging of use of an area, through cordon or zonal charge e.g. London, Singapore, Oslo, Rome and Stockholm.
- The charging of a fixed length link e.g. the M6 Toll in UK, Melbourne, Santiago, French Autoroutes, Toronto and San Diego.
- A distance based charge e.g. Switzerland, Austria and Germany.

1.3. **Scope of work - research goal**

This thesis aims at summarising the state of the art within the area of distance based road user charging for HGVs and analysing and identifying the most important factors and areas to focus on for reaching a successful implementation of a marginal cost based system for charging of HGVs.

1.4. **Main Contributions**

This licentiate thesis has analysed and identified the most important factors and areas to focus on for reaching a successful implementation of a system for charging heavy goods vehicles based on distance and marginal cost. These are:

- Public acceptance and use of opportunities and public opinion
- The political process and most important decision points
- The legal framework before and during introduction as well as for operation of a system
- The institutional framework
- Responsibility assignment
- System procurement and implementation, including procurement strategy, technology choices, testing and demonstration and interoperability

Another important contribution is the implementation process model for an introduction of a distance based system for heavy goods vehicles in a country. The model comprises the most important aspects to consider when planning for this. This has been made through the study and analysis of both implemented and cancelled systems as well as planned introductions, where the Swedish work in this direction has been thoroughly studied and analysed. The implementation process model with its main actors, decision points and information flow between actor groups are cornerstones of the model, which can serve as a tool for future implementers to follow.
1.5. Methodology

Several methods have been used for data collection, analysis and for generation of models and conclusions.

1. A literature review and study has been performed. This was done to examine what other scholars have written on the subject of road user charging in general and for heavy goods vehicles in particular. The literature search also addressed issues around implementation aspects, acceptance and legal issues of road user charging. Further on, literature on complex systems, knowledge production in the era of globalisation and innovation system theory was also studied, all in order to find relevant descriptions and a theoretical framework for my research, my analysis and my modelling.

2. Seminars, conferences and workshops have served as valuable sources of information, identification of potential persons to interview, discussion on ideas and solutions and as a general source for the tacit knowledge in the field of road user charging.

3. I have also participated in a couple of study tours to Germany, Switzerland and Berlin, which were useful for validating the information gained through literature and earlier conference presentations.

4. For this thesis I have deep interviewed over 20 experts in the field of road user charging.

5. A large portion of my research have been focused on the case studies on implemented and not implemented systems for distance based road user charging systems for heavy goods vehicles.

6. The case studies have been used as input data when designing the model showing the implementation process for a country, both for verification and for finding success factors and hurdles for implementation.

7. For the analysis of the Swedish implementation process the factors commonly related and studied in Economics of Technology for analysing innovation systems have been used (Granstrand 1994). As the study is mainly focusing on national and international issues it has been chosen to use the macro factors as described by Granstrand (ibid), and especially the technology related factors.

The thesis is limited to experiences from the European transport market and is focusing on solutions for heavy good vehicles and distance based charging. Knowledge and experiences
from adjacent fields in the transport sector\(^2\) have however also been used for reaching and validating the conclusions and recommendations for the thesis. The scope of research has been focused on for validation purposes.

1.6. **Outline**

This report is divided into six chapters. Below is a brief outline of the content of each chapter.

The introduction chapter gives the background and context for the research followed by a brief summary of the contributions of the research. The methodology used for carrying out this research is presented.

Chapter two contains a more extensive presentation of the research environment and scientific perspective this research has been performed within. It also presents the innovation system I have been a part of, with contributing actors from the academy, the industry and authorities, and how I see this type of research environments as very fruitful.

The third chapter contains most of the empirical data found during the research as well as a first analysis of important factors influencing successful implementations of complex technical systems. The empirical data comprise an account of the European development, based on conference presentations and proceedings, study tours and discussions with experts as well as more official documentation such as the European transport policy directives and other public documentation. This is followed by discussion around successful implementation factors, ending with a table summarising the most interesting experiences and recommendations surfaced during the interviews with experts in the road user charging field. The chapter ends with case studies comprising countries that have already implemented distance based road user charging systems as well as countries identified as interesting examples based on their either ongoing or halted implementation processes.

Chapter four, like chapter three contains empirical data, but focuses solely on the Swedish development in the researched field. The chapter starts off by describing the Swedish policy development that forms the foundation for a future implementation of road user charging based on marginal costs. It then continues with a description of the Swedish development

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\(^2\) Mainly congestion charging and public transports, where I argue that many conclusions are valid for the more limited sector of distance based road user charging for heavy goods vehicles.
towards a system for distance based road user charging has been and is carried out. This is
analysed from an innovation system perspective showing how the Swedish innovation system
on road user charging for heavy goods vehicles has developed and formed. Much of the work
done in the ARENA project is included in chapter four.

Chapter five summarises the major findings into an implementation process model, which is
an important contribution from this research. The chapter also contains discussions and
conclusions on institutional aspects, procurement concerns and responsibility in different
stages of implementing a road user charging system for heavy goods vehicles. The importance
of acceptance and technological considerations are also pointed out as necessary aspects in a
successful implementation. The chapter ends with recommendations to future implementers.

The last chapter of the thesis identifies questions that have not been answered yet and that
may be part of future research.
2. Research Environment

This licentiate thesis is based on data from many sources, gained both as consultant at TFK\(^3\) and SWECO\(^4\) (1996-2006) and as PhD student at Linköping University, Department of Infra Informatics (2006-onwards).

I have been a part of the research and discussion community concerning distance based road user charges in Sweden and Europe for the larger part of the 21\(^{\text{th}}\) century. During my career I have written several papers and consultancy reports on the subject of road user charges for heavy goods vehicles. As a consultant I have done work for the Swedish Road Administration (SRA) and Vinnova\(^5\) as well as regional authorities in southern Sweden. During these assignments I have studied a possible implementation of a road user charging system for heavy goods vehicles from several angles and perspectives.

I was an active part of the team working towards the implementation of the Swedish ARENA project, and have later as a PhD student received financial support for this research and thesis in front of you. I can thus not state myself as the objective observer performing objective research and my analysis, conclusions and recommendations in this thesis are of course influenced by my ARENA involvement.

My background as an engineer from Chalmers\(^6\) has given me a set of tools which employs a systematic approach for problem solving with a system perspective in focus. During my career I have, however, been aware of that this classical system approach to problem solving is not always enough, as large parts of successful innovation processes depend more on how different actors interact rather than to how big or how many they are, as Brulin states (2003).

This has further been emphasised from my experience from TFK and the inter-disciplinary project work style that was employed there. TFK’s member organisation engage

\(^3\) In 1996 I joined Transport Research Institute (www.tfk.se), which has a strong research profile in the transportation and logistics field. TFK is a network organisation with members from the industry, authorities and academic institutions. These are organised in theme-based committees co-operating with the TFK researchers, all meeting at a neutral arena for discussions on common issues and possibly finding solutions to problems.

\(^4\) In 2001 I changed employer from TFK to SWECO (www.swecogroup.com), the major engineering consulting firm in the Nordic region.

\(^5\) The Swedish Governmental Agency for Innovation Systems

\(^6\) I graduated from Chalmers University of Technology with Master of Science Degree in Mechanical Engineering in 1991.
representatives from authorities, the industry and the academy which were all included in problem definition, problem solving and innovation. This modus operandi taught me how fruitful and useful this is for gaining sustainable solutions to identified problems. It was a true application of the system concept of national innovation systems (NSI), long before the term was widely used.

The concept of NSI emerged in the mid-80s and was first used by Freeman (Sharif 2005) and was later adopted by Lundvall as a reference to the producer-user-cooperation between academy and industry (Lundvall 2007). The term is now widely adopted and used to describe a framework for the relationships between the academia and the industry in an innovation policy context. Being part of the TFK environment taught me the strong network belief I have carried with me since, where there are always several actors and their needs to consider in a development of or a solution to a problem.

As a consultant at SWECO I have mainly been working with large projects, involving partners from the universities, the industry and other institutions, plus sub-contractors, often from all over Europe. These complex projects, often with un-clear goal settings, has taught me that a large share of the project work is about communication and understanding each other, and the organisation and leadership have been important ingredients to ensure successful project outcome.

Throughout my career as a consultant and a PhD student I have therefore applied both a classical system perspective and a perspective inspired by the school of thought around knowledge production, describing this as context-driven, problem-focused and usually interdisciplinary (Gibbons et al 1994). The theories around complex systems have also been applied to this research (Cilliers 1998). According to him, complex systems are open systems consisting of a large number of elements, where dynamic interaction is present, usually in a non-linear mode. Most of the interaction comes from immediate neighbours and there is a constant flow of energy in the system. I have applied this view on my research and the model of system change of charging principles from one based on flat fees to a system based on marginal cost principles. I have viewed this not only as a stepwise implementation process of

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7 Mainly for the Swedish Road Administration, the European Commission, City of Stockholm and Region Blekinge.
a system, but also as a paradigm shift which requires a change in thinking and organising involved actors and stakeholders as well as implementing a new institutional framework.

2.1. **Starting point for the research**

The starting point for this licentiate work is the TANGO project, executed 2003-2004, where I was leading expert on road user charging and part of the core project team. TANGO was a feasibility study for providing basic data for decision-making on a Swedish system for electronic fee collection for heavy goods vehicles. The main recipients were SRA and regional authorities in southern Sweden who saw the conditions change due to the planned German introduction of its toll system for heavy goods vehicles. The TANGO project produced several reports, of which the report Tango Collect – Differentiated kilometre charges as a driving force for implementing telematics for heavy goods vehicles summarises the main findings of the project (Gustafsson and Schelin 2004). The TANGO work was well perceived by the authorities and was continued in the report Implementations aspects and Implementation plan (Gustafsson and Schelin 2005), made for SRA.

During the work 2004-2005 on implementations aspects and implementation plan for Sweden regarding distance based road user charges, the critical factors for a successful implementation were identified (ibid). These are summarised in the figure below, and have since then been used as basis for data collection during seminars, interviews, the literature review and case studies. These factors have later been further elaborated on for the conclusions from this research.

![Figure 1 showing the critical factors for successful implementation identified by Gustafsson and Schelin 2005.](image-url)
A useful input to the work on implementation aspects and implementations plan took place in February 2005, where I acted as brainstorming session facilitator for the international road user charging research workshop around marketing RUC\(^8\) to users, which was jointly hosted by the UK Department for Transport (UK DfT) and Newcastle University. All major experts in UK and Europe (around 65 persons) gathered for discussions on how to introduce distance based road user charges in Europe in accordance with the EFC directive that had been published the year before (European Parliament and the Council 2004/52/EC). During this workshop the question of a viable business case for road user charging systems was heavily discussed as well as possible technical solutions.

My long-term cooperation with Professor Phil Blythe at University of Newcastle upon Tyne in UK has opened many doors to colleagues on the European field and given me access to situated knowledge used for many of the case studies. Several papers have been written in cooperation with Professor Blythe and another colleague in the field, Inger Gustafsson. The papers have mainly concerned the European development within the field of road user charging for HGVs and are part of the foundation for this thesis:

- Kilometre charges for heavy goods vehicles: The Swedish Approach (Gustafsson and Schelin 2004)
- European Road User Charging for Heavy goods vehicles – an overview (Schelin, Blythe and Gustafsson 2005)
- An analysis of road use charging trends in Europe (Gustafsson, Schelin and Blythe 2006)

2.2. Methodological considerations

As part of the road user charging field for the last decade, I have participated in numerous seminars, conferences and workshops, more often than not as a speaker. A yearly conference where I participate is the ITS World Congress, where most experts in the field gather. During the 2004, 2005 and 2006 conferences I have held presentations on the subject of distance based road user charges and have also listened to numerous presentations on the subject. The conferences have thus been useful sources for oral and written information.

I have also been invited to speak on several seminars and conferences around Europe, covering different aspects of distance based road user charges. Among these are the yearly

\(^8\) Road user charging
IEE Seminar held in UK on the road user charging topic (Schelin 2004, Schelin 2005) and the Inter-urban road tolling conference (Schelin 2004). For the Transport research arena (TRA) I have participated with 2 papers (Schelin et al 2006, Gustafsson et al 2007 (to be published)). The major Swedish conference in the transport research sector Transportforum has also covered the road user charging subject during later years, and I have participated and presented papers on several occasions, as I have in the national conference on ITS held every year in September in Stockholm.

In June 2006 I was acting as evaluation expert on behalf of the European Commission in Brussels, evaluating the TEN-T Non-MIP applications from the member states. This was a useful exercise as it clearly showed the close connection between the European transport policy (COM (2001) 370) and the member states and their implementation of this policy. The transport policy has clear bearings towards the field of road user charging as important guideline.

In February 2007 I participated in a workshop held in Sweden where some 80 of the leading experts in the road charging field in Europe met for discussions around the Swedish concept for road user charging for heavy goods vehicles, arranged by the ARENA project. This was a major milestone in the Swedish innovation process and several of the statements and conclusions from this workshop are used in this thesis.

In May 2007 another workshop was held in Stockholm within the ARENA framework, where some 60 international experts debated the enforcement system of a future Swedish system. The discussions were held in a very open style, and notable is that the discussions made the Swedish enforcement concept totally change paradigm. From applying a principle of compliance controlling for nearly 100% of the vehicles the new approach applies a totally reversed concept of 1) utilising the business systems of companies for monitoring and verification of compliance 2) utilisation of other authorities monitoring and control systems for the heavy goods vehicles sector, like the Swedish customs and the yearly vehicle control for verification 3) differentiating between “good” or “bad” users and treating them differently, thus applying more frequent checks on the “bad” users. This is typical for how the production of knowledge is applied in the Swedish innovation process for road user charging, often in larger, inter-disciplinary groups and an open and innovative atmosphere.
During the spring of 2007 my scientific paper was accepted by the World conference on transport research (WCTR), held every 3rd year (see below). This paper summarised my research on the current developments of distance based road user charging for HGVs. The paper comprises an account and analysis on the European situation in this field, identifying the most critical success factors in implemented and cancelled systems. The Swedish development work in this field is described and an analysis is carried out on how the Swedish implementation project (ARENA) is handling the identified critical factors as well as how the ARENA is approaching compliance with both national and European demands and legislation. The paper title is:


In May 2007 a study tour was performed within the East-West project, conducted in Switzerland and Germany and studying their respective systems for distance based road user charging for heavy goods vehicles.

Figure 2 shows the BAG mobile control unit in action in Berlin. © Eva Schelin

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9 See www.east-west.com
I participated in the study tour and was able to interview representatives for both authorities and consultants involved in the implementation of the systems and thus gain much knowledge used in the case studies and analysis. I participated in a meeting in Berlin in June 2007 with Toll Collect, Satellic and BAG, where much data and hands-on experience was gained, as the system was shown in real operation. This meeting was very valuable for its input on the German system and the German actors’ views on the European development for road user charging.

To the knowledge base I have gained as a consultant in the field during many years I have added some 20 deep interviews as well as accounts from presentations and discussions during seminars and conferences where I have participated. I chose to add the interviews to my research to try to catch some of the more tacit knowledge around why projects are successful or not successful. Softer aspects of political and technical implementations such as the importance of dedicated persons capable of driving the process, rivalry and personal ambitions were also discussed. My earlier role as a colleague to the respondents helped to achieve this type of information. Most of the interviews were carried out during the ITS World Congress in London 2006. The respondents usually gave new tips on people to interview as well as literature to consult, which has been very useful.

2.3. Insider - Outsider

In my role as a consultant I have been an active partner in the national and international innovation system connected to road user charging for heavy goods vehicles. Within this framework I have had access to an extensive network of experts all over Europe, to whom I have had direct access for information and discussions, not in the role as researcher but rather in my role as fellow expert. Therefore I can not distinguish myself as the outside bystander who objectively records what she sees, but rather one who takes an active part in the development of the events.

From being an insider I have become more of an outsider during the last 2 years, as I have been living in Malaysia and not participated in the conceptual and development work on a daily basis. Instead I have followed it as a PhD student at Infra Informatics at University of Linköping and combining this with the studies of several PhD courses at University of Malaya (UM) in Kuala Lumpur. The courses have given me gave a thorough foundation on development of science and technology into modern society, emphasizing the paradigm shift
from religion to science as value base in developed countries, and how innovation and technology should be managed for a country to be successful. During these courses contemporary theories about knowledge economy, innovation, techno-economic paradigms and technology governance were introduced. Freeman, Lundvall, Perez and Nelson and their schools of thought are now part of my frame of reference and form a theoretical framework for my research that I have found very useful. These scholars have had large influence on the European Union’s strategies for development as well as the Lisbon agenda.

During the latter two years, when I have been a PhD student, my role has been more of observing, reflective and analysing nature from an outsider perspective. To colleagues in the field I have, however, still been regarded as an insider which has given me situated knowledge about the current processes and development. I have also had many opportunities to ask questions and have been given direct access to information in a way I would not have had without my previous role as an insider (Elovaara 2004).

2.4. Knowledge production – borderless, open, global

Knowledge is a term that is not easily defined. United Nations have tried to define the term in a way I subscribe to, describing knowledge as two parts of an ice-berg. In their report Understanding Knowledge Societies (UN 2005) knowledge is defined as having two forms:

1. Explicit knowledge (information) refers to justified true belief that is codified in formal, systematic language. It can be combined, stored, retrieved, and transmitted with relative ease and through various means, including modern information and communication technology (ICT). This is the visual part of the ice-berg.

2. Tacit knowledge is a fluid mix of framed experience, values, contextual information and expert insights that provides an individual with a framework for evaluating and incorporating new experiences and information. Tacit knowledge is information combined with experience, context, interpretation and judgement...It is intangible, without boundaries and dynamic. It is highly personal and hard to formalize, making it difficult to communicate with others. Subjective insights, intuitions and hunches all fall into the category of tacit knowledge. This is the part of the ice-berg under the surface.

For an innovation process to be successful both explicit and tacit knowledge have to be captured and included into system concept and design. To do this the knowledge production
should be context-driven, problem-focused and inter-disciplinary (Gibbons et al 1994). Gibbons and his fellow scholars also discuss the complexity of knowledge production. In the book Rethinking Science (Nowotny et al 2001) they state that knowledge production in the “mode-2” society can be interpreted in two contexts. The first is that it has become increasingly difficult to establish a clear demarcation and differentiation between science and society. The fundamental categories of modern society – state, society, economy, culture and science - have become porous and even problematical. They no longer represent readily distinguishable domains. The second is that both science and society are subject to the same driving forces; 1) the overall growth of uncertainty; 2) the growing influence of new forms of economic rationality; 3) the transformation of time into the extended present; 4) the flexibilisation of space and 5) an increasing capacity for self-organisation in both scientific and social arenas.

Lundvall and his fellow colleagues Freeman, Edquist and Nelson have been advocating the theories of innovation systems since the 80s (Lundvall 1992, Sharif 2005). These theories have been gaining much attention during recent years, and is now one of the fundamental theories forming the Lisbon Agenda. The innovation systems theory mark an alternative perspective on national economy and competition, where the perspective of more conservative economical theories advocate low wages as the biggest competitive edge. The innovation system theories criticise classical economical theories for not acknowledging innovation or actors capable of learning. The most important part of the theory of innovation system focuses on the interaction between the micro cooperation between producers and users and applies a system perspective for this. It also acknowledges the actor and structure perspective and how the actors are important for creating and destroying institutions, relations and communication channels. Hereby innovation systems are created that affect the actors deeds (Lundvall 2007).

Brulin et al. (2003), stresses that innovative development of products always contains a great deal of networking and experimentation under rather chaotic circumstances. The authors also provide an overview of new perception of innovation processes and knowledge formation in the era of globalization, where they focus on successful innovation processes as relationship-building and networking between reflexive human beings, both individuals and collectives. New products and business ideas are seen as the result of many complicated patterns of cooperation and interaction with external actors, sub-contractors, customers, researchers etc.
Successful innovation processes are thus depending more on how different actors interact rather than to how big or how many they are.

To conclude it is really like navigating in an ocean filled with unidentifiable icebergs as well as vessels which require thorough knowledge, both explicit and tacit, to reach the goal of successful implementation of systems in today’s complex society.

Friedman describes how several shifts around the turn of the millennium created a global, web-enabled platform for multiple forms of sharing knowledge and work, irrespective of time, distance, geography and language (Friedman 2006). Like the industrial revolution, Friedman argues, the globalization of the world economy is re-structuring the ways that people work, where the work is being done, and how people relate to one another. Newsweek has also covered the knowledge revolution in a special issue (2006). This describes how the knowledge society is developing in a digital, borderless world, where everyone is connected. Internet also enables researchers to co-work all over the world.

My main conclusion from these modern schools of thought is that the world has become borderless and that explicit knowledge is available to the majority in a totally different way than before. Complexity in systems is increasing and chaotic circumstances for work are rather the rule than the exception. Systems are self-organizing and usually the result of complex patterns of interaction. This generates a new society and new methods for doing work, research and science as well as new methods for how knowledge is produced. All this demands strong leadership and strong executers, capable of acting without knowing all parameters for their work beforehand.
3. Description and analysis of the European development

This is the chapter containing most of the empirical data found during the research as well as an analysis of important factors influencing successful implementations of complex technical systems. The chapter starts with an account of the European development, based on conference presentations and proceedings, study tours and discussions with experts as well as more official documentation such as the European transport policy directives and other public documentation. This is followed by a section on successful implementation factors. A table summarising the most interesting experiences and recommendations that have surfaced during the interviews with experts in the road user charging field follows after this, and the chapter ends with case studies comprising countries that have already implemented distance based road user charging systems as well as countries identified as interesting examples based on their either ongoing or halted implementation processes.

3.1. European development and movements

Road user charging systems have been introduced in several countries in Europe during recent years, much due to the liberalisation in EU legislation described earlier. Switzerland introduced a distance-based road charging system for heavy goods vehicles in 2001, based on the tachograph technology. Germany procured a sophisticated system for distance based road user charging on its motorways, based on GNSS/CN\textsuperscript{10} technology, which was introduced in 2005, while Austria introduced a road user charging system for heavy goods vehicles on its motorways that was based on DSRC\textsuperscript{11} technology. The Austrian system started its operation in 2004. Several other European countries have been active investigating the possibilities to introduce electronic fee collection systems as ways of financing the use of infrastructure, as the problems of the underfinanced infrastructure network are clearly becoming a threat to the development of the member states and the European Union and its economy. UK and the Czech Republic are among these, but while UK cancelled its procurement of an LRUC\textsuperscript{12} system at a late stage the Czech Republic went through and introduced a system very similar to the Austrian one in 2007. All countries that have introduced a system for road user charging have chosen a system solution based on which system best suits the specific

\textsuperscript{10} GNSS - Global Navigation Satellite System; CN – Cellular Networks
\textsuperscript{11} DSRC – Dedicated Short Range Communication
\textsuperscript{12} LRUC- Lorry Road User Charging system planned for UK. Procurement process was halted midway through in 2006.
country’s characteristics and needs. This development has however caused that several of these systems are not interoperable with each other.

### 3.1.1. The European Commission takes action

The rapid development taking place in Europe during the early years of the 21st century, where non-interoperable road user charging systems for heavy goods vehicles have been introduced in several countries, is seen upon by the European Commission as a threat to the principles of free movement of people and goods as is stated in the European transport policy *Time to decide* (COM (2001)370). A proposal for directive was therefore proposed by the Commission (COM (2003) 132), and in April 2004 the EFC directive (Directive 2004/52/EC) was accepted by the European Parliament, forming the principles of “one device, one contract” for Europe. The goal of this directive is to create a European electronic toll service\(^\text{13}\) for heavy goods vehicles that should be interoperable on a contractual and procedural level using one or several of the following technologies:

1. GNSS
2. DSRC
3. Mobile communication.

The directive lays down the conditions necessary to ensure a European electronic toll service that is interoperable at the technical, contractual and procedural level. The aim is to have a single contract between the users and all operators and a set of technical standards that allow the industry to provide the required equipment on a competitive market. The directive describes the essential principles of the system and a committee (Comité Télépéage) consisting of experts from all member countries are involved in the definition of EETS.

Several European projects have been working on reaching the goals outlined in the directive, among other the CESARE III project, in cooperation between ASECAP\(^\text{14}\) and the Stockholm Group\(^\text{15}\). The latter is an informal association of European road authorities whose objective is to find ways to achieve interoperability of systems and services for electronic fee collection and road user charging for heavy goods vehicles.

It is intended that EETS will be phased in according to vehicle category, initially with trucks and long distance coaches by 1-July 2009 followed by passenger vehicles 2-3 years later.

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\(^{13}\) EETS – European electronic toll service

\(^{14}\) The European Association with tolled bridges, motorways and tunnels, www.asecap.com

\(^{15}\) See [www.its-sweden.com](http://www.its-sweden.com) for more information about the Stockholm Group
EETS overlays any existing toll or road user charging scheme but requires scheme operators (referred to as ‘Toll Checkers’ in the draft decision) to support EETS subscription on request at no additional charge to road users. The draft decision will be further revised and incorporated into local legislation within 2 years of final publication. The draft decision already sets expectations for these future logistical, operational and contractual obligations on all charging scheme operators in the EU, except those that have local charging schemes where the cost of compliance is greater than the benefit afforded by EETS to road users.

The most important tools for reaching to solutions on how the EETS shall work have been the expert groups and the two projects CESARE III and RCI (Interview Hamet 2006).

- The expert groups have been acting as task forces investigating a multitude of aspects on the European electronic toll service on behalf of the European Commission.
- The RCI\textsuperscript{16} project (www.ertico.com) aims at contributing to the development of a standard for the electronic collection of road tolls. The RCI project goal is to produce an open integrated framework that will enable road charging interoperability. Prototype onboard equipment will be developed that will demonstrate how such a system would work. The framework and equipment will be implemented and tested in six countries: Austria, France, Germany, Italy, Spain and Switzerland.
- The CESARE III project has been co-funded by the Commission DG TREN\textsuperscript{17} and the member states. The main goal for CESARE III has been to look into several aspects of interoperability and technical characteristics of both the roadside and the on-board equipment (CESARE III 2006)

To conclude the projects and expert groups working on these issues cover a wide spectrum of topics, e.g. technology, interoperability and enforcement. It will be hard to reach a solution that is optimal for all Europe, as a system fitting one country doesn’t automatically fit another country, due to the diverse characteristics of the European countries, which was thoroughly discussed during an expert seminar in Malmö (ARENA 2007).

\textsuperscript{16} RCI - Road Charging Interoperability
\textsuperscript{17} The Directorate General for Transport and Energy of the European Commission
3.1.2. The Universal On-Board Unit project

The Universal On-Board Unit (UOBU) project, conceived by DG TREN in 2004, aimed at considering the scope for consolidation of several on-board applications, particularly those aimed at delivering European transport policies. The idea of the project was to consolidate the immense work that has been put into the arena and identify the need for a platform providing common services, such as location, time, identification and communication, to multiple applications. In one of the reports presenting the outcome of the project (Woodward et al 2006) it is stated that the UOBU is technically feasible and, in principle, could be implemented in the European vehicle park in a manner that fosters the on-board telematics market place. The paper further identifies a positive business case for the UOBU, at least from the preliminary analysis viewpoint, although this shows several sensitivities, where the largest is that the preliminary business case depends on a relatively high uptake of key applications. Other critics have stated the same concerns, meaning that eCall\textsuperscript{18} is supposed to carry most of the costs for the system implementation. Thus the business case will need further analysis to be justified, also according to the UOBU project team.

3.1.3. NORITS – The Nordic interoperability initiative

The Nordic countries have worked with the questions and problems arising from the interoperability subject for several years, lately in the NORITS project. This is a regional interoperability initiative comprising toll operators from Norway, Denmark and Sweden. The goal for the NORITS joint venture is to reach interoperability between all toll collecting services in the Nordic countries, on a contractual level (NORITS 2004). The NORITS cooperation has been open and fruitful and reached solutions acceptable for all partners taking part.

Notable for the actual outcome of this cooperation is that SRA is not operating any toll collection services, while the other parties take the role of toll charging. On the Swedish side of Svinesund (the border bridge between western Sweden and Norway) a Norwegian toll charger is operating the toll service on behalf of SRA.

\textsuperscript{18} eCall is intended to bring rapid assistance to motorists involved in a collision anywhere in the European Union. The service aims to employ a hardware black box installed in vehicles that will wirelessly send airbag deployment and impact sensor information, as well as GPS coordinates to local emergency agencies.
The NORITS project consortium recognises that the ongoing process of developing an EETS will cause adjustments to the contractual joint venture agreement. The main implication is probably, that the EETS according to the directive must be offered to all users in EFC systems that the directive concern and that therefore a regulatory and organisational framework open for all parties on equal terms will be developed to administer this EETS. It is also recognised that not all parties involved in EETS may be able to sign this type of arrangement.

3.1.4. Less sophisticated systems for kilometre tax charging

The sophisticated systems advocated by the EU Commission and several countries implementing road user charging for heavy goods vehicles (and their house consultants) have met critique, mainly due to the long time frame foreseen before implementation and also because of the high costs associated with it.

McKinnon writes about the planned and abandoned LRUC system for UK that was originally planned for 2008 (McKinnon 2005). He has many criticisms against the proposed system, especially that it would take so long to implement and that it would not be compatible with EETS. McKinnon’s proposal is instead to wait until road user charging for heavy goods vehicles can be part of a nationwide British road user charging system for all vehicles, and meanwhile implement a less sophisticated system, mainly for the purpose of fulfilling three goals:

1. Establishing tax parity with foreign operators
2. Decoupling taxation of lorries from that of other classes of vehicle
3. Relating the vehicle taxes more closely to environmental and track costs on a distance travelled basis

The proposed interim system should according to McKinnon have three key elements:

1. A kilometre-based charging matrix
2. A method of recording the distance travelled by lorries on UK roads
3. A fuel duty rebate scheme.

The latter element would require a reading of meters every time the lorry leaves the country. This opposes the EU principles of free flow of people and goods. It would also leave Northern Ireland outside the system as the free flow border crossing to Eire would not function if
lorries were to stop for meter reading every time they crossed the border. This makes the proposal questionable.

Kågesson has in his report for SIKA\(^1\) Simplified form of a Swedish road tax (Kågesson 2007) argued for a simplified form of kilometre tax system for Sweden, in line with what McKinnon proposes for UK, with yearly reading of distance driven by the trucks and charging accordingly. For distance driven abroad a reading at the border or some electronic device for reading would be used, according to Kågesson. Among the advantages of an implementation of a kilometre tax Kågesson states:

- A faster renewal of the vehicle park and increased use of emission reduction technology at older vehicles
- Possibility to increase the tax for lighter vehicles
- Lower road wear and tear due to increased use of lower axle pressure
- Lower part of transports executed by trucks, as higher laden factors, modal shift, and shorter distances will increase due to km tax implementation.
- Fairer competition between national and foreign trucks

### 3.1.5. New technologies enable new schools of thought for road user charging

Blythe and Pickford cover in their book Road user charging and electronic toll collection (Blythe and Pickford 2006) the future developments in ITS in general and road user charging in specific. According to them, the new communication and location based technologies will change the whole area of road user charging. The authors write that in the longer term there is a school of thought evolving that is suggesting that advances in communication and wireless mobile networking technologies may actually cause a radical rethinking of how vehicle-to-vehicle and vehicle-to-infrastructure communications may evolve. Blythe and Pickford base their argumentation on a foresight study made by the Office of science and technology foresight firectorate in UK (Foresight IIS, 2006) exploring how science and technology can bring intelligence into infrastructure over the next 50 years to meet demanding objectives. The study found that intelligent infrastructure could help in many ways, such as enabling delivery of services in real time, control of people and goods, integration of systems including all transport modes, integrated logistics and goods chains, provision of viable and sustainable alternatives to moving goods and people. All this would of course affect the road user

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\(^1\) Swedish Institute for Transport and Communications Analysis, www.sika-institute.se
charging field in terms of policies that should be implemented and the technologies used for this. Arvidsson et al (2006) writes about the paradigm shift foreseen in insurance pricing. Modern technology will make it possible in the future to more rightly allocate insurance premiums according to driver behaviour, for instance speed and time of day. Pickford and Blythe (2006) also write about these new forms of systems which are enabled by new technology, such as pay-as-you go schemes. As technology develops, new systems, but also new concepts for business models are enabled.

3.2. Implementation of complex systems

My research focuses on the area of distance based road user charging for heavy goods vehicles (HGVs) and aims at analysing and identifying the most important factors for reaching a successful implementation of a marginal cost based system for charging of HGVs. This requires a system change from charging flat fees based on quite rough and simple calculation to a more sophisticated system incorporating factors and fulfilling the transport policy goals. This can be viewed as a paradigm shift and a shift towards implementing a complex system, not merely a fee adjustment.

For gaining a better understanding to such systems and the present and future development of the road user charging innovation system theories around complex systems have been applied to this research (Cillier 1998). Cillier describes complex systems as open, dynamic structures with a large number of elements, with much interaction present, where most of the interaction comes from immediate neighbours. He further uses the notion of a constant flow of energy in the system and a common history, on which the system is behaving and organising itself.

Other scholars discuss how policy is connected to functional requirements (Pickford and Blythe 2006). They discuss in their book how technology availability and capability helps influence policies, and vice versa, and policy development guides future direction of technology evolution, which then further sparks technological development and progress.

More tacit knowledge about implementation processes for road user charging system, as described in the UN report Understanding Knowledge Societies (UN 2005) has been harder to find in the literature. Some writers have however addressed the kind of aspects that success factors and failure factors represent. Balmer writes in the report for OECD on the Swiss introduction of RUC how hurdles were overcome and how converging changes were used to
reach success (OECD 2004). Suter and Walter also describe these converging factors in their paper (Suter and Walter 2001) about how the acceptance of the LSVA\(^\text{20}\) was mainly due to a political window of opportunity, which created a win-win situation for all actors involved.

- The LSVA was perceived as an instrument for ‘‘getting the prices right’’, i.e. making the users and polluters pay for the costs they cause. The user- and polluter-pays-principle is well accepted by the public and in environmental politics in Switzerland.
- The LSVA allowed the increase in the weight limit with limited environmental impact, which was a prerequisite for the land transport agreement with the EU and the whole package of agreements with the EU. This was of course favoured by the hauliers.

The LSVA provides a significant part of the funding for the new alpine rail tunnels, which is necessary for achieving a modal shift from road to rail. The introduction of LSVA in Switzerland was the first time that the principle of internalisation was embodied on legal grounds.

3.2.1. User acceptance

User acceptance is the key to successful implementations. This has been stated by several of the people interviewed for this research (interviews 2006 with Höök, Rode, Blythe, Tatchell, 2007 with Pickford) and several of the papers and presentations held by experts confirm this (presentations For 2006, Gillan 2007). This is especially true for charging schemes affecting the public, and most acceptance evaluations have been done in this sector. However many of the conclusions are valid also for the commercial sector and heavy goods vehicles.

William Gillan of TRL\(^\text{21}\) held a presentation about tolling and charging acceptance (ARENA 2007). According to him tolling and charging are engineering systems designed to raise revenue and change behaviour. The key issues to success are according to Gillan to:

- Generate acceptance
- Ensure that users comply
- Minimise operating costs
- Efficient start up and operation

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\(^{20}\) LSVA - Leistungsabhängigen Schwerverkehrsabgabe; the term used for the Swiss heavy vehicle taxation system.

\(^{21}\) TRL – Transport Research Laboratory, see www.trl.co.uk
Gillan states that compliance and acceptance are functions of:

- cost or difficulty of equipping vehicles to pay (s)
- the charge rates (ca)
- the ease of payment (s+ca)
- probability of evasion being detected (s)
- penalty for evasion (ca)
- system reliability and robustness (s)
- culture and trust (s+ca)

The system determines s and ca is determined by the charging authority. When a system parameter comparison is done there will be some parameters that have a value to them and others that can only be evaluated as more or less important. Based on this comparison decisions have to be taken on how the system should work.

There are ways to influence behaviour and culture, according to Gillan. The understanding of concerns is an important start to this. Other ways to influence behaviour and attitude include:

- Clarification of benefits – show people who behave in the desired way how they benefit.
- Financial rewards for “good” behaviour
- Publicity campaigns to illustrate losses due to compliance failure – related to individual situations.

Fair play is a term coming back from commercial operators when discussions around acceptance for road user charging occur. Evaluations show that commercial operators are content with charging, provided it is fair and equal for competitors (Gustafsson and Schelin 2004, OECD 2004). Other factors affecting acceptance are (Gustafsson & Schelin 2004) how easy the system is to use, how transparent it is and if it is safe and protects the integrity of the users. The charging means must also be designed to address the needs of both low-tech and high-tech users to be acceptable.

The EU-financed project Progress measured acceptance for road charging during its trials in 2002-2004. The findings indicate that road pricing is justified by the users if the revenues are allocated back to the transport system and used for the areas of public transport and the environment (Loncar-Lucassi et al 2004). Other important aspects for gaining acceptance...
during introduction are to (http://www.transport-pricing.net/confppts/):

1. Present facts
2. Develop an appropriate scheme (evaluate several schemes)
3. Undertake an extensive dialogue with users
4. Fine-tune design and technique before introduction
5. Constantly adapt to current conditions

Another aspect affecting acceptance is if the road pricing charge is a tax. Then the revenues go straight into the federal budget and cannot be earmarked for a specific use. A way around this is that the authorities increase the budget allocation to these sectors in accordance with the revenue stream.

Acceptance is closely connected to the effects of a road charge. From a macroeconomic perspective, the positive effects of improved infrastructure (regional competitiveness and employment) can be assumed to balance negative impact (cost increases). However, at the microeconomic level, small transport companies will face serious difficulties and may, to a certain degree, even vanish from the market (Doll & Schaffer 2007). Existing research indicate that changes in modal split and route choice are limited as a consequence of kilometre taxation, and that greater utilisation of the vehicle capacity have been noticed (Doll and Schaffer 2006). It is expected that the impacts of kilometre taxation will decrease closer to the end-consumer.

Other reports show that the consumer prices have not increased significantly in Germany, Switzerland or Austria as a consequence of kilometre taxation (Liechti and Renshaw 2007). This is also confirmed by the Swedish investigation (Östblom and Hammar 2007). It is also expected that the influence of an introduction of kilometre taxation will be higher when the transport cost is large in relation to the overall value of the goods (Liechti and Renshaw 2007).

Researchers at the Swedish national institute of economic research\textsuperscript{22}, have shown that an introduction of a Swedish kilometre tax for heavy goods vehicles will give small effects on GDP, while change in the industry structure will be noticeable (mostly for steel, chemical and

\textsuperscript{22} See further information at www.konj.se
Ramstedt et al (2007) have made an attempt to categorise the Swedish hauler market, based on the segmentation made by Gustafsson and Schelin (2004). The categorisation has been used in a study on how Swedish haulers will be influenced by an introduction of a kilometre tax for heavy goods vehicles. Ramstedt’s investigation presents the hauler views concerning the implementation of the kilometre taxation:

- The purpose of the tax is important to state very clearly
- The system has to be fair, e.g., cheaters should be stopped directly
- There should be few exempted vehicle groups in the system
- Equal tax levels for everybody
- There has to be European interoperability
- The collected tax should pay road maintenance and investment

The above statements confirm the Swiss experiences.

Several researchers have written about acceptance, however mostly focusing on congestion charging and tolling for cities (Nazer et al 2007, Ison 2000, Thorpe et al 2000). I argue that some of the conclusions from this research are applicable to acceptance for kilometre charging as well. Nazer et al argue that the implementation of a charging regime depends on securing and maintaining a critical mass of public support – independently of any national scheme foreseen for in the future. Delivering benefits prior to the introduction of road user charges is helpful to develop public support. The local, direct and visible use of revenues collected has been shown to increase acceptance. Evidence from Bergen (Norway) suggests that infrastructure improvements, where used sparingly, can further develop acceptance. Delivering benefits also appears to depend on making them visible and understandable. Both in London and Stockholm the authorities have shown the results from the operation of the systems, which have also increased acceptance over time. The experiences from the Stockholm congestion charging trial in 2006 show that massive information activities can indeed increase acceptance significantly (interview Höök 2006). Revenue allocation into transport related services increases acceptance and success (Farrell and Saleh 2005).
To conclude, acceptance is affected by fairness, ease of use, transparency and revenue allocation to an understandable and acceptable field.

3.2.2. Successful implementations

The conclusions drawn out of the Swiss case for a successful implementation of road tolling projects can be considered as being of general value. They are summarised by Balmer below (OECD 2004 and presentation by Balmer 2007):

1. A clear objective embedded in a national strategy based on a firm political commitment
2. Clear charging principles – driving more means paying more and the same cost rate applies regardless of where you drive
3. The system is perceived as fair
4. The authorities took the lead in defining and implementing a system which meets the objectives
5. The acceptance of a road-pricing project can be increased decisively if the revenue is earmarked for transport matters. The use should, of course, also be in line with the policy developed.
6. Basic information is declared to the central systems, which does the consistency checks and calculates the tax to be paid.
7. It is decisive to start with the technical solution in time and it is an advantage to begin with a simple design and to shift to more sophisticated solutions later on.
8. The best project will fail, if it is launched in an unsuitable political environment. So seize the window of opportunity and good luck.
9. Easy access for non-equipped users

The countries differ in their approach to implementation, based on several factors such as authorities’ power, belief in commercial forces making right choices and cultural differences. The British attempt at outsourcing the responsibility for implementation of the LRUC system to commercial actors was probably based on UKs tradition of allowing private actors into classical authorities’ fields. In Holland the process is more politically influenced and driven, which was also the case for the German implementation, however fiscal and fairness principles were also converging in the same direction as the political will. It is important to realise that several perspectives will have to interact during implementation in order to create a successful implementation.
### 3.3. Interviews

The interviews with the experts have given a lot of information on system implementation and their success factors, enabling forces and hurdles to success, on which many of the conclusions later in this thesis have been based. Table 1 below is an account of the most interesting views of experts and some presentations at conferences. Note that this is the interpretation I have done based on the interviews. The experts have however been able to check and confirm my interpretation. The questionnaire used as discussion base is found in the appendix of this report.

<table>
<thead>
<tr>
<th>Name and affiliation</th>
<th>Most important aspects influencing successful implementation, according to the expert</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Philippe Hamet</strong></td>
<td>The legal process is ongoing, now the stakeholders have to work together to find a solution. Interoperability is important for the European demand of free flow of people and goods. There is a political and an operational level to an implementation. PH finds two major difficulties: 1. Ministry stays above, concessionaires do the work 2. Member states don’t want to commit themselves to satellite tolling, too risky. The EC don’t want to wait for 10-15 years.</td>
</tr>
<tr>
<td><strong>Birger Höök</strong></td>
<td>User acceptance and a dialogue with stakeholders important System should be easy to understand and have a clear motive, followed by a well functioning system. Clear division of work between involved parties enables success. Politics and legal aspects must not be forgotten.</td>
</tr>
</tbody>
</table>
| **Jan Larsson**  
Ministry of Finance, Sweden (2007) | The government must protect the integrity of the individuals. When the charge is a tax it must rest on a democratic base, as a tax is not so clearly connected to visible benefits.  
Several Ministries are cooperating on the issue of implementing a km-based tax. Ministry of Communication and Ministry of Environment views it as a tool for implementing the transport policy, while the Ministry of Finance is more focused on the hurdles that must be overcome if an implementation should be successful.  
A km-tax implementation demands high-level support (the Minister or Secretary just below) that will support and drive the process. |
| **Hans Rode**  
Swedish Road Administration (2006)  
Responsible for implementing new services in SRA | If division of work is unclear, this will affect the system negatively. The technology must be solved before the legal framework can be settled.  
Focus on the benefits for the users. |
| **Bernard Oehry**  
RappTrans, Switzerland (2006)  
Involved in most projects regarding road user charging for heavy goods vehicles in Europe, including CESARE | The directive makes the stakeholders in Europe act in a unified way, towards unified European solution. CESARE, RCI and VERA projects work towards this goal. |
| **Brian Stoneman, William Gillan and Dave Tindall**  
TRL, UK (2006)  
Experience from many trials for tolling and road user charging (UK, Holland, Germany) | The importance of testing equipment and systems should not be underestimated. Actual performance is not always the same as the supplier says. Be aware of version changes. Important to use “the intelligent tester” as they find deviations. Political will is important for success. |
| **Eric Sampson**  
Department for Transport, UK (2006)  
Long term experience from tolling in UK. Large network within the road user charging world. | Political changes can affect the development both positively and negatively. Important to get the message through to people on which benefits should be delivered.  
Government should be leading in an implementation. The power of running the process; the procurer or the consultants? Division in three lots during the LRUC project caused unclear responsibilities. Financing and public opinion important for success. |
| --- | --- |
| **Phil Blythe**  
University of Newcastle upon Tyne (2007)  
Long term expert in the field of road user charging. Organiser of several seminars and workshops in Europe. Broad network in the RUC field. | Policy first, technology and systems later.  
Any toll system must link to traffic management.  
Many legal issues to solve and test: collection of payments, enforcement powers. The EETS interpretation is still unclear and legally not tested. Mandating an OBU is almost impossible.  
The payment scheme concept must be simple, flexible and allow flexible payment options.  
Occasional user schemes/enforcement schemes should have a cost/benefit test.  
Make system procurement easy and transparent.  
Get public and political support from the start. |
| **Jonas Sundberg**  
SWECO VBB, Sweden (2006, 2007)  
Long-term expert. Project Manager for developing the conceptual design for the Swedish kilometre-tax within the ARENA project. | System operation will change along the way, often due to legal constrains. In Stockholm a system was procured based on a technical specification including a DSRC-OBU for payment and enforcement purposes. The system now operating only uses ANPR for enforcement. The Svinesund bridge between Sweden and Norway could not be charged for during the first year of operation due to unclear legal framework. |
| **Inger Gustafsson**  
BMT-ts and Blekinge Institute of Technology, Sweden (2006, 2007)  
Project manager for the ARENA project in Sweden. | Implementation objectives should be reflected in the design of the scheme. These are closely connected to objectives and driving forces in the implementing countries. Involve stakeholders early in the process. |
|---|---|
| **Karl Heinz Stappert**  
TÜV, Germany (2006)  
German expert involved i.a. in specification, procurement, implementation and operation monitoring of the heavy vehicle tolling systems in Germany and Austria and the M50 free-flow tolling scheme in Dublin/Ireland. | The German unification was base for tolling, as financing was needed for the Eastern road network. Political commitment pushed the process. Time constraints and rush caused problems in development work. Eurovignette was cancelled too early, 1 year’s revenue lost. Legal framework could be finished only when technology was decided. |
| **Jack Opiola**  
Booz Allen Hamilton, UK (2006)  
Long term engagement in the tolling business around the world. | The directive 2004/52/EC anchor itself in existing technologies, reinforcing what we are currently doing and knowing. What we do today does not scale to national charging. The EC gives the concessionaires a very powerful position – too powerful. It is important to look at other commercial drivers, such as the digital tachograph, alco-lock, safety systems, and ADAS\textsuperscript{23} systems. Involve banks in a system implementation and look into what others are doing (Japan, USA). |
| **Michael Leyendecker**  
Vitronic, former Toll collect Germany (2006)  
Involved in the German implementation of Toll Collect. | All projects differ, why comparison between them is hard. The timeline set by politicians is usually unrealistic. The preparatory legislation important so the procurement is positioned right. |

\textsuperscript{23} Advanced Driver Assisting Systems
| **Bob Tatchell and Grant Klein**  
Road Pricing Framework Division,  
Department for Transport, UK (2006)  
Experience from the studies performed  
by DfT in UK during several decades. | Most important factors are:  
1. Cost aspects  
2. Procurement aspects  
3. Detailed design issues  
4. Legislation  
5. Policy  
6. How to engage with local authorities  
7. Important to make benefits visible for public acceptance |
| --- | --- |
| **Ueli Balmer**  
Deputy Head, Transport Policy Section,  
Federal Office for Spatial Development, Switzerland (2007) | Successful implementation: Well functioning project group with clear separation of tasks, pragmatic approach focusing on goals. Use opportunities that converge to carry implementation through (rising of allowed truck size, funding for rail tunnels, polluter pays principle) |
| **Mirka Ticivici and Uwe Leinberger**  
Satellic, Germany (2007) | The stage has been set for intelligent traffic management systems.  
Most problems are not technical; they are legal, organisational or contractual. Legal constraints will demand a legally valid digital map.  
Current movements in Europe: Haulers are flagging out, environmental aspects more in focus – there will be a demand for drastic reduction of CO2 emissions. Good opportunity now to act upon climate and CO2 issues e.g. taxing of non-transferable goods.  
Large innovation potential in sophisticated vehicle charging systems. |
<table>
<thead>
<tr>
<th>Name</th>
<th>Position/Background</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Michael Blum</strong></td>
<td>Dornier Consulting, Germany (2007)</td>
<td>Political risks: new administration to change targets or stop realization process. Tender risks: complex bid evaluation procedures are vulnerable to legal actions (e.g. Germany, UK, Czech Republic, Taiwan).</td>
</tr>
<tr>
<td><strong>Christer Ryd mell</strong></td>
<td>Swedish Road Administration, Sweden (2007)</td>
<td>More active push from the European Commission for changing views and approach, demanding more from the market, e.g. certification of the future TSP (Toll Service Providers). The Commission works more actively, using incentives to reach objectives.</td>
</tr>
<tr>
<td><strong>Andrew Pickford</strong></td>
<td>Transport Technology Consultants, UK (2007)</td>
<td>Acceptance comes when benefits are shown. It is strategically wise to start deliver benefits beforehand, as Bergen, London &amp; Stockholm. Acceptance depends on understanding the scheme. Public operators show their performance in public, which is good for acceptance.</td>
</tr>
<tr>
<td><strong>Lars Källström</strong></td>
<td>BMT-ts (2007)</td>
<td>The European Commission is acknowledging its responsibility for reaching success and is taking a firmer grip on road user charging, as well as other transport related sectors, such as the logistics sector. They pose more long-reaching demands on the sectors to converge towards policies and directives. Certification is also an area where the Commission is taking a more active part.</td>
</tr>
<tr>
<td><strong>Paul For</strong></td>
<td>Siemens, Austria</td>
<td>Learn from what works, let demand be the driver for technical development and stick to a user centric approach.</td>
</tr>
</tbody>
</table>
The most important is who is in charge of the work. It should start with the Ministry which sets off a political process. When enough studies are done a policy should be made, and a law supporting this. After this it should go over to the financial ministry, as it has become a financial issue. As long as the issue remains with the Transport Ministry there will only be studies performed. When transferred to Financial Ministry the money will rule and this will drive the implementation process. A correctly designed legal framework should support a good concept and any technology.

Inge Vierth
VTI, Sweden (2007)
Inge is expert on Internalisation of external effects.

In the middle of the 90ies society was ready to embrace and implement the actual use of the marginal cost principles. The White Paper from the EU Commission supported it and the Swedish governmental proposition “Kom Kom” in 1997 strongly supported its principles, which have since then guided the Swedish transport policy. The marginal cost principle is now being challenged as guiding principle by the implementation of emission rights trade, which is used primarily in the aviation and shipping sector.

Table 1 describes the main findings from the interviews with experts in the road user charging field.

To summarise what the interviewed experts state, it is clear that acceptance, legal aspects and framework, responsibility and political issues are important questions to deal with in an implementation process of a road user charging system, even before technology choices and organisational issues are dealt with. This is important to be aware of before applying a strict engineering perspective and approach to an implementation process. These factors will be further elaborated on later in this report.


3.4. Case studies

The European development has been fast in the field of road user charging for heavy goods vehicles. There is a growing acceptance by the authorities and the public that the heavy goods vehicles should pay for the costs they incur in terms of congestion, environmental damage and wear and tear (Blythe and Pickford 2006, Suter and Walter 2001). This is viewed as one of the most important reasons for implementing distance based road user charging systems in the transit countries of Europe, where the vehicle owners were not contributing to the cost of the road network. In many cases they filled up the vehicles with cheaper fuel, and the country where the vehicle was driving did not get any coverage to road maintenance from the fuel duty.

Due to changes in the European legislation in 2003, the member states are more free to charge traffic for the use of infrastructure (COM (2003)448). Several countries have therefore introduced or are planning to introduce road user charges, based primarily on the distance driven by the vehicle, but also emission class, number of axels and other factors, all in line with Time to Decide, the European Commission’s White paper on transport policy for 2010 (COM (2001) 370). The countries having implemented a distance based road user charging systems for heavy goods vehicles are Switzerland (2001), Austria (2004), Germany (2005) and The Czech Republic (2007). UK had far-reaching plans for introducing a lorry road user charging scheme (LRUC), when the procurement process was halted and cancelled in 2005. Several countries are currently doing feasibility studies aiming at introducing a system in the future. Among these are Sweden, The Netherlands, UK, Slovenia, Hungary and Belgium.

The case studies in this report are each an account of the countries’ driving forces for system implementation as well as an account of the system layout and most significant characteristics. In order to sort and analyse data I have used the implementations in Switzerland, Austria and Germany for case studies, as well as the British project, which was cancelled half way through. I believe much information can be found in non-successful systems and implementations. After the chapter covering case studies the Swedish implementation process so far is included. I have been heavily involved in this work both as an insider and as an outsider. The case studies have then been used as input data when designing the model showing the implementation process for a country, both for verification and for finding success factors and hurdles for implementation.
<table>
<thead>
<tr>
<th></th>
<th>Switzerland</th>
<th>Austria</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subject to fee</strong></td>
<td>Vehicle above 3,5 tons total weight</td>
<td>Vehicle above 3,5 tons total weight</td>
<td>Goods vehicle of 12 tonnes or more total weight</td>
</tr>
<tr>
<td><strong>Geographical limit</strong></td>
<td>Public land tax, i.e. on all roads</td>
<td>Public road fee, i.e. on motor- and expressways only. 20% VAT included</td>
<td>Public road fee, i.e. on highways only</td>
</tr>
<tr>
<td><strong>Tariff per km, €</strong></td>
<td>0,60 for a 40t truck (EuroI) (average)</td>
<td>0,27 for a 40t truck</td>
<td>0,124 for a 40t truck</td>
</tr>
<tr>
<td>2005</td>
<td>Increased to 0,65 €/km (average price) in 2008</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Foundation of costs</strong></td>
<td>Distance, Weight</td>
<td>Distance, no of axles</td>
<td>Distance, Number of axles</td>
</tr>
<tr>
<td></td>
<td>Number of axles</td>
<td></td>
<td>Pollution class</td>
</tr>
<tr>
<td></td>
<td>Pollution class</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>OBU</strong></td>
<td>Until 2004 free of charge</td>
<td>5 Euro</td>
<td>Free, but vehicle owner has to pay for installation</td>
</tr>
<tr>
<td></td>
<td>Unit cost = 800 €, new generation around 350 €</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Based on the Tachograph for calculation of fee.</td>
<td>DSRC</td>
<td>GPS and Digital map</td>
</tr>
<tr>
<td></td>
<td>GPS part for enforcement purposes</td>
<td></td>
<td>GSM for communication</td>
</tr>
<tr>
<td></td>
<td>DSRC part for calibration</td>
<td></td>
<td>Infra-red for enforcement purposes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Price list location</strong></td>
<td>OBU</td>
<td>Server</td>
<td>OBU and server for booking system</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Financing of infrastructure</td>
<td>Financing of road infrastructure</td>
<td>Financing of infrastructure. User related costs/payment system</td>
</tr>
<tr>
<td></td>
<td>Reduce external costs</td>
<td></td>
<td>Increase competition between modes</td>
</tr>
<tr>
<td></td>
<td>Improving railway network</td>
<td></td>
<td>Leadership road pricing systems</td>
</tr>
<tr>
<td></td>
<td>Shift transport form road to rail</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Operation cost</strong></td>
<td>8,2%&lt;sup&gt;25&lt;/sup&gt;</td>
<td>12,5%</td>
<td>18%&lt;sup&gt;26&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Occasional user</strong></td>
<td>Manual recording</td>
<td>OBU mandatory</td>
<td>Journey booking (internet or road-side terminals)</td>
</tr>
</tbody>
</table>

Table 2. Overview of implemented and planned road user charges for heavy goods vehicles in Europe.

<sup>24</sup> ECMT Conference Proceedings 2006, presentation by Bernhard Oehry
<sup>25</sup> According to Ueli Balmer (2008) operation costs are summarised to 8.2%. This figure includes all costs, including depreciation of investments and operation costs of Swiss customs. In 2010, when investments will be paid back entirely, operational costs will be reduced to 5-6%.
<sup>26</sup> Everything except the staff of BAG including the financial guarantees (presentation Cieslac 2007)
The implementing countries all have different background for why they implement a system, which has been reflected in their choice of system. A summary of the major characteristics for each implemented system is shown in table 2 above.

3.4.1. Switzerland

In Switzerland there was a growing concern about the rapid increase of transit truck traffic during the 90ies. Authorities and the public were starting to consider the social costs for traffic and the concern about having transit traffic polluting and causing accidents grew in Switzerland. A research study carried out on behalf of the WHO (Suter and Walter 2001) showed that the health costs due to air pollution (from all sources) amount to about 1.1% up to 5.5% of GDP in the three countries Switzerland, Austria and France. For Switzerland, the costs were about 6.7 Billion CHF (3,94 Billion €) per year, and about 50% was attributable to road traffic. Another base for the introduction of distance based heavy goods vehicle charging was the lack of funding for increasing the capacity of the transalpine rail connections.

Following a public debate and a referendum, Switzerland introduced their road user charges for heavy goods vehicles (LSVA) above 3,5 tonnes in 2001, at the same time increasing the allowed weight limit for trucks on the Swiss road net from 28 to 34 tonnes. This weight limit was further increased in 2005 to 40 tonnes. Initially the average charge for a 40 ton truck was 40 €-cent/tonne km. In 2005 the fee was increased to 0,60 € and in 2008 to 0,65 €.

The OBU\textsuperscript{27} is free of charge for the users. The installation costs 200 € is paid by the vehicle owner and includes a connection to the tachograph. When a truck is sold, the OBU follows the truck. The new owner is registered at the same time as he or she is entered into the vehicle register. The DSRC-interface makes the Swiss OBU interoperable with the Austrian system, however plans are to make it interoperable with the French and Spanish systems in the future.

During the time period of 2001-2003, heavy goods traffic fell, coinciding with a downturn in the economy. Analyses show that the economic downturn played only a minor role (14%-33%) in the reduction of traffic volume on Swiss roads (presentation Balmer 2004). The main influencing factor was the new transport policy. This has also influenced the traffic behaviour and the procurement behaviour, as cleaner trucks were purchased to a larger extent.

\textsuperscript{27} On-board unit
The success of the Swiss road user charging system for heavy goods vehicles is due to that several enabling factors converged and made the implementation possible. Environmental considerations (to avoid lorry transit) were combined with transport and regional considerations (to assure the financing for the new alpine rail tunnels) as well as economical and political arguments (to avoid opposition against the agreements between Switzerland and EU), all enabling the decision and implementation. Last but not least, the success is also due to the fact that lorry taxation and the problem of the external costs of transport have been on the agenda for a long time and people have become familiar with it (Suter and Walter 2001).

3.4.2. Swiss system characteristics and enforcement

The Swiss charge is considered as a tax and the system is operated by the Swiss customs on behalf of the Ministry of Finance. The distance driven is automatically registered by the OBU or based on manually registration of entry and exit made by the driver. The registrations are considered as a tax declaration and are submitted on a smart card to the tax authorities. The data can also be downloaded in the office and e-mailed to the authorities. The system is based on the tachograph, but uses the GPS (positioning system based on satellites) for control functions. The charges are based on both distance and emission factors. The user sends in his smart card containing trajectories of driven distance on a regular basis to the customs authorities, which are responsible for the collection of charges (Interview Oehry 2006, presentation Balmer 2007). The software of the OBU can be updated via smart cards distributed by the authorities. The OBU is mandatory in all vehicles (>3.5 tonnes) registered in Switzerland. 55 000 vehicles are equipped with an OBU and 500 000 vehicles annually use the manual declaration at the border points. The main characteristics for the Swiss system is summarised below (presentations Oehry, Balmer 2007, Källström 2007)

- The whole road network is subject to the charges, and the fees are set in order to reach a modal shift from heavy goods vehicles to rail.
- 3/4 of the revenues (total of revenues in 2005: 910 M€) come from Swiss vehicles
- The operation of the system costs 8% of the revenues (however the charges are high compared to European standards)
- 2/3 of the profit (net revenue) goes to the public transport fund which is used to finance rail. Investments are mainly two tunnels, one of which was opened in 2007.
- Introducing a higher cost per vehicle km in combination with an increase of the maximum permissible gross weight to 40 tonnes have resulted in a 23% reduction of the vehicle km driven had the old system been maintained. In plain figures, the reduction was about 6% (comment Balmer 2008)
- 15-20% increase of the load factor (better utilisation of the vehicles)
- Cleaner vehicles
- Little impact on modal split

It is perceived important that fair competition requires that everybody should pay, i.e. fraud should be difficult. The Swiss OBU reads data from the tachograph and makes it possible to compare the registered distances with GPS position recordings. The OBU also has a sensor which can detect different types of vibrations. Such readings are also registered and the combination with the tachograph and the GPS readings makes non-detected tampering with the OBU very difficult. The tax authority decides the amount to be paid based on the tachograph recording, provided the tachograph seems to be working properly. A maximum of 2% deviation from the GPS-calculated values is accepted. The OBU has a series of lights that makes it easy to see from the outside if the OBU is working properly. Occasional/foreign users receive a smart card coupled to the vehicle identity on entry into Switzerland. At the same time the tachograph reading is registered and (if this is the first entry) the customs officer registers also the necessary vehicle data in the central system (Euro-class and gross total weight). On exit the driver registers his tachograph standing at the border and pays, usually with a credit card. The police have a special tool for rapid and correct capturing of the tachograph standing. 23 gantries on the major routes are used for OCR of number plates and as a reminder of that “Big brother is watching you. Don’t forget to pay.” (Oehry 2003).

### 3.4.3. Austria

Austria was the second country in the world to introduce distance based heavy goods vehicle charging, which was successfully implemented in 2004. The decision mainly had a financial background. During the 90ies the traffic increased significantly in Austria. This, in combination with un-sufficient public funds for realisation of expensive infrastructure projects enabled the decision to finance the infrastructure projects on credit base, but with state guarantees. This required the establishment of tolling companies. In 1996 the Austrian

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28 This is possible as Switzerland is not part of EU. Had it been, it must have adhered to the principles of free flow of people and goods, which makes stopping at borders impossible.

29 Optical Character Recognition
parliament agreed on relevant legal adaptations for the introduction of an electronic distance related toll system on all motorways and express roads (existing and new network). In 1997 ASFINAG, a company owned to 100% by the Austrian state was re-defined and received all the responsibility for Austria’s motorways and express roads (Hofstetter 2006):

- Design, construction, maintenance, operation & funding
- Ownership of the existing toll companies
- Transfer of the debts for motorways (5660 M€) (thus enabling Austria to meet the convergence criteria set up for entering EU)
- Right to collect tolls for the entire network
- Responsibility to prepare and introduce an electronic fee collection system

All motorways of Austria are subject to the fees and the technology used is DSRC. The implementation process from discussions took approximately 36 months, with a construction period of only 18 months including testing. The system is straight-forward, built by off the shelf technology. Even though the project and construction time was short, the system could start on time, mainly through the use of well-known technology and the limited scope - only motorways (presentation For 2006). All vehicles above 12 tonnes driving on Austrian roads are required to have a DSRC transponder (OBU). As the cost for this is quite low, the Austrian authorities were allowed by the EU Commission to mandate this also for occasional users.

### 3.4.4. Go-Box characteristics, enforcement and interoperability

The main characteristics with the Austrian system are:

- The OBU is mandatory. This was agreed to by EU because of its low cost (5€)
- Installation is done by driver, equipment is available via internet order or points of sale
- Personalised to registration number & basic vehicle class
- Three vehicle classes, depending on number of axels
- 2 modes of payment; pre pay (15%) or post pay (85%)
- About 600 000 Go-Boxes distributed, 3000 user contracts with the Swiss Tripon-Go-Box
- High performance rate (99.7%)
- 1,8 Million toll transactions per day
- Less than 1,5% violators
- High user acceptance, mainly due to user-friendliness
There are 100 permanent enforcement gantries installed on the Austrian network, supported by 20 portable equipments, 30 dedicated vehicles and 100 toll officers. The 12 traffic control sites in Austria can also be used for enforcing toll payment, along with weight, technical and driving conditions, hazardous goods etc.

Interoperability is achieved with the Swiss system, as a Swiss equipped user can use his or her OBU in Austria, through the Tripon – Go-Box. The Austrian Go-Box is not interoperable with the Swiss system, however. Several projects are working towards reaching interoperability with Austria’s neighbouring countries.

3.4.5. Germany

Germany introduced its sophisticated system for heavy goods vehicles charging in 2005, after several severe delays. The idea of tolling heavy goods vehicles started in the 90ies, after the unification, when the East German road network was in very bad condition and in need of serious maintenance and rebuilding. Driven by the scarcity of public funds, a decision to introduce road tolling for heavy goods vehicles was made in 1998. The German government set up a government commission (the Paellmann Commission) for the financing of transport infrastructure in 2000. This commission’s final report in September 2000 recommended a replacement of the tax-based financing of the federal road system with a toll-based system. The effective price for road haulage was recommended to be 12.5 euro-cent/km for all HGV:s on motorways, including those which did not pay a fuel tax in Germany. The federal government followed the main recommendations of the Paellmann Commission and decided in August 2001 to introduce an electronic toll collection system on German motorways, with a launch of the system scheduled for August 2003. The Paellmann Commission was clear on technology for this; it explicitly stated that GPS and GSM should be utilised and that the system should be prepared for introducing value added services on this sophisticated platform. The goal was also to shift freight transport from road to rail and inland waterways and to strengthen German industry.

In 2002 the Toll Collect Consortium consisting of partners from DaimlerChrysler, Deutsche Telekom and Cofiroute was appointed to design, implement and operate the system. The system chosen was really a pioneering one in terms of technology use - satellite positioning with a specific location recognition function based on GPS-coordinates, a map-matching
function, and mobile communication in the OBU. The system also contains an infra-red device for control purposes. The sophisticated system meant that there was little need to do construction work on the motorways, as what only was needed was the gantries for enforcement. The rest of the system was located inside the OBU or in the central system.

After several delays the system was finally introduced in January 2005. The problems were mainly of technical and design nature, but also due to installation difficulties. The whole German motorway network is (with few exceptions) subject to charges for all goods vehicles and vehicle combinations of 12 tonnes or more. The vehicles are also charged in accordance with axles and emission category. The occasional user can use self-service terminals for declaration of expected transport route. Internet can also be used for this purpose.

The main purpose with introducing the charging was due to fairness – Germany wanted the users of its motorway net to pay for its use. As the situation was before, several users filled up their trucks on cheaper diesel in other countries, thus avoiding the German diesel tax that should cover wear and tear, and so used the road network for free. The increased outflagging of vehicles was also a contributing factor to the decision. But as Jochen Cieslak at Bundesministerium für Verkehr, Bau und Stadtentwicklung says “the only thing you can not transfer is the infrastructure, and therefore you have to charge for it, hence Toll Collect. (Presentation Cieslack 2007). The introduction of Toll Collect is the largest PPP project in Germany so far.

According to a government study the detouring of trucks appears to cause traffic safety problems and annoyance for inhabitants in a few specific spots on the toll-free federal road network. To address this problem, the German states have received legislative power to close affected roads for HGV transit traffic (presentation Menge 2007). A new traffic sign has been created for this purpose. In addition to this, the federal states have applied for three sections of the federal road network to be included in the Toll Collect system. During a study tour in Germany and Switzerland in May 2007 a presentation was held by Jürgen Menge at the regional Ministry in Mainz. Menge said that enough knowledge about the impacts of the Toll Collect system was gained through working closely with the stakeholders. Such a co-

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30 PPP – Public Private Partnership describes a government service or private business venture which is funded and operated through a partnership of government and one or more private sector companies (Wikipedia).

31 Detouring is when vehicles are driven on roads free from charges in order to avoid these.
operation also facilitated the finding of acceptable solutions to the problems of traffic
deviation from pay-roads to secondary roads. As a general remark the introduction of the
maut\textsuperscript{32} has resulted in a public focus on the heavy goods traffic and consequently triggered a
demand for a more systematic approach from the Ministry in dealing with the management of
such traffic. The complex design of the German maut system enables it to easily incorporate
new road network links (even non-motorways) into the scheme. Legally it has proven harder
to make these changes, as not only the federal government in Berlin, but also the EU has to
accept the change because of the risk for discrimination of foreign vehicles.

3.4.6. System characteristics, enforcement and interoperability

The main characteristics with the German system are (Bolte 2003, Kossak 2004):

- Fairness - User pays principle
- Strengthening of market mechanisms
- Funding for the German infrastructure
- Promotion of modal split, currently 50% road, 38% rail, 12% waterways (presentation
  Cieslac 2007)
- Promotion of innovative technologies
- 12 000 km road network are subject to tolling
- Revenues are 3 Billion € annually, traffic increase of 30% since 2005 gives more
  revenues (but also more wear and tear)
- Revenues can only be used for traffic purposes, construction work
- Compliance with European legislation
- 571 000 OBUs installed. Germany, Netherlands, Poland largest uptake
- 180 000 vehicles have both German OBU and GO-Box
- Empty long distance trips have fallen by from 10,1\% to 9\%
- Empty trip-km have fallen by 7\%

The authority BAG - Bundesamt für Guterverkehr is responsible for the enforcement of Toll
collect. The system has several pieces working together. There are 300 enforcement gantries,
of which 150 are equipped with radio transmitter for communication with the 250 BAG
mobile units. 5\% of the traffic is controlled, and on average every 10\textsuperscript{th} journey is checked. 10
million vehicles are checked per year. The OBU can be switched off remotely by Toll Collect

\textsuperscript{32} The maut is the daily term used for the Toll Collect system.
in case of missing creditworthiness of the user. The DSRC/IR\textsuperscript{33} part of the OBU can be read during movement for control purposes, to check if the OBU is working and the charging has taken place. During controls basic information is transmitted to the central system to check compliance and accuracy with information stated. There is also a staff of 80 people doing desktop analyses to find possible violators. The number of offending vehicles is below 2%, reaching far below the goal which was less than 5% (presentation Klar 2007). The fines for violation can be up to 20 000 €.

The German Toll collect system is alone on the market in terms of its degree of sophistication. It is not interoperable with any other systems, but plans are to make the DSRC part in accordance with European standard requirements. The German authorities are prone to let the Toll collect system converge towards the specifications emerging from the work around the EETS, but have not yet reached there, as the EETS specification is not yet ready. German representatives participate in the European work towards interoperability, e.g. CESARE.

### 3.4.7. United Kingdom

UK has been looking into the possibilities of introducing a distance based road user charge system for heavy goods vehicles. The Department for transport (DfT) has been researching different aspects of road user charging since 1994. The HM Treasury\textsuperscript{34} published in November 2001 a consultation paper on distance-based charging for all heavy goods vehicles, British and foreign alike, to ensure fair competition in haulage and to shift to an efficient direct charging regime at the point of use. The Chancellor (i.e. UK Finance Minister) confirmed plans for distance-based HGV charging, named the LRUC\textsuperscript{35} programme, in his April 2002 budget and had the backing of the FTA\textsuperscript{36} and of the CBI\textsuperscript{37}. The launch of the procurement phase was made in May 2004 with the timetable then suggesting that the HGV charging should be introduced in the UK in 2008.

The changes in the tax policy for the haulage industry that a distance based road user charging system would entail were influenced by came about as a result on the UK fuel protests in September 2000. Concerns over the government's fuel price escalator policy was the primary

\textsuperscript{33} Dedicated Short Range Communication / Infra Red
\textsuperscript{34} The Ministry of Finance in UK
\textsuperscript{35} Lorry Road User Charging
\textsuperscript{36} Freight Transport Association
\textsuperscript{37} Confederation of British Industry
cause behind the protests, as three-quarters of the cost of petrol in the UK was tax (in the form of fuel duty or value added tax), somewhat higher than the European average, and dramatically higher than other developed countries such as the United States and Australia. The fuel protesters said that this disparity was making it increasingly difficult for the British haulage industry to remain competitive with their European rivals, especially since the introduction of the European free market on 31 December 1992.

With the year on year increase in traffic growth and the more frequent use of vehicles for longer journeys in the UK, policy has recently changed to grasp the opportunities offered by road user charging. The 2000 transport act enshrined the possibility for local authorities to introduce some form of demand restraint such as congestion charging and to retain the revenue through hypothecation for re-investment in local transport. Only two cities have introduced this (Durham and London), however many cities have expressed an interest in exploring some form of demand restraint.

In July 2005 the Secretary of State made a major policy announcement in which he outlined the intention to investigate the potential for a national scheme after 2014 (earlier if the technology could be delivered) – this also led to the cancellation of the LRUC procurement programme.

Commentators suggest that this was not a bad thing (except for the industry involved) as the management and programme costs had escalated and industry was being pushed to deliver to an unrealistic timescale. The LRUC programme was run by HM customs and excise and surprisingly had very little interaction with the UK DfT and their national road user charging programme – which meant that LRUC could have been implemented as a non-interoperable system with other charging initiatives in the UK initiated by DfT.

Several comments (interviews Sampson (2006), Blum (2007), Tindall (2006)) on this cancellation indicate that the 3-parted procurement strategy made the project tremendously hard to manage and expensive. Some of the questions that have been raised are “Where did one supplier’s responsibility end and the other one’s start? Who was responsible for integration?” Other critics mean that the fact that the procurement was the responsibility of the customs and excise authority put a whole new player into the game, where DfT had a lot
of knowledge, which was not being utilised. It was also hard to come across to the public about what was so great about the introduction of a lorry user charge system.

UK now envisages a national road-pricing scheme in the medium to long-term run, which will incorporate both heavy goods vehicles and private cars (Pickford and Blythe 2006). However no decision has yet been taken. A PIN notice38 was published in July 2006 to request proposals for demonstrations of distance based charging in the UK39. The UK Government also plans to spend £2 billion over a 10 year period to fund local authorities to introduce innovations in demand management led road pricing as a way to learn from any such schemes, be it user attitudes, traffic impacts or technical solutions.

### 3.4.8. The Czech Republic

The Czech Republic has recently procured a DSRC-based system, which will initially be covering the Czech highways and major roads, but later will also cover the smaller roads. The system was taken into use during 2007. The first phase is covering motorways and main roads, around 1000 km, while phase 2 (2008 and 2009) will include the smaller roads, in total covering 2100 km. Heavy goods trucks from 12 tonnes are subject to fees, but an extension to lighter vehicles is foreseen (Liechtl 2007). There are also plans for implementing a system like the German in the Czech Republic, utilizing sophisticated technology for distance measuring and communication.

### 3.4.9. The Netherlands

The Netherlands have had many attempts to design and implement different schemes for road user charging, mainly with the purpose of fighting congestion. However most of them have been cancelled due to feasibility complications, technical or political reasons. Now there is a new initiative, however. In November 2007 the Dutch cabinet decided to implement a system of road pricing on all Dutch roads as of 2012. The pay-by-drive program will be cheaper for environmentally friendly vehicles, and will include a congestion price at rush hour locations. Current taxes will be reduced at the same time. The envisaged system will use satellite navigation and will be introduced in phases, starting with heavy goods vehicles in 2011. Until 2011 pilots will be installed to improve the flow of Dutch traffic.

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38 The Prior Information Notice (PIN) is an advertisement in the Official Journal of the European Union, advising the contracting community of future procurement plans. PINs are intended to ensure that interested parties have as much time as possible to prepare for participation.

39 [http://www.dft.gov.uk](http://www.dft.gov.uk)
3.4.10. Future implementations of systems

In eastern Europe, the new member states of the European Union are facing a tremendous growth in traffic. The transit traffic has also grown bigger as many of the East European countries border to those that have already introduced charges, which has made the traffic diverge to the still free road network of eastern Europe. Facing the facts of increased traffic and an under-developed road network, these countries need to:

2. Get a tool with which traffic demand can be controlled.
3. Utilising incentives for promoting the use of cleaner vehicles

The eastern countries are moving forward at a fast pace in the areas of road user charging, quickly adopting technologies and strategies from western Europe.

- Slovakia is expected to procure a road user charge system in the near future.
- Slovenia is following its neighbours in the Alpine region and is currently adopting an action plan issued by the government and Ministry of Transport. It considers three steps and foresees a free flow tolling system by 2008 for commercial and by 2011 for all vehicles. Technical solution is not yet specified.
- Hungary is also planning road user charges implementation.

Going through the eastern European plans, one can see that the strategy seems to be to start with less sophisticated systems and then migrate to GNSS/CN/GSM systems.

Several of the older member states are also looking into introducing distance based road user charging. France and Belgium are getting more involved, and the Dutch system will be developed in cooperation with these states.
4. Description and analysis of the Swedish development

This chapter starts with a description on the Swedish policy development forming the foundation for a future implementation of road user charging based on marginal costs. The chapter continues with a description on how the Swedish innovation system on road user charging for heavy goods vehicles has developed and formed.

4.1. Policy development

Since 1972, internalisation of external costs has been a key element of Swedish transport policy. When a governmental commission in 2002 was commissioned to make a review of the entire road and vehicle taxation system, an important aspect to consider was the task to analyse the possibilities to implement a kilometre-based road charging system for heavy goods vehicles in Sweden. In May 2004 the commission presented its conclusions (Ministry of Finance 2004), recommending that a distance based road taxation system should be introduced around 2009 that should:

1. Encompass the whole Swedish public road network
2. Be applicable for heavy goods vehicles above 3.5 tonnes
3. Reflect the marginal cost principle

This recommendation was based on the assumptions that a kilometre tax is possible to differentiate and can facilitate to cover the external costs on a more detailed level. Following additional investigations and a national hearing process, the Swedish Government made a proposition for the new transport policy of Sweden Modern Transports (Ministry of Industry, Employment and Communications 2006), where the principles of a sustainable and socio-economically viable transport system prevail. The proposition pointed at road user charges for heavy goods vehicles as a tool for fulfilling this ambition. Before a firm decision could be taken it was required by the Swedish Parliament that an investigation should be done, determining if certain regions (e.g., northern Sweden) or industry sectors (e.g., the forest industry) would be affected by such a system. This study was performed by SIKA during 2006 and 2007. The result from the study is positive to a kilometre tax and concludes that the marginal cost based tax levels - proposed by the institute - would have limited impact on production and employment (SIKA 2007). SIKA however raises the question whether a kilometre tax system is socio-economically viable or not. The general recommendations from SIKA are that a kilometre tax should be phased in towards the marginal cost level and be
differentiated in terms of vehicle characteristics and urban/rural areas. Several experts question SIKA’s analysis as they only perform an analysis assessing socio-economic factors, but are neglecting to assess the structural change in the transport system a kilometre tax would impose and the benefits this bring to society. Further investigation and a cost-benefit analysis are to be performed by SIKA in the near future (2007-2008).

The Swedish Government established the Climate committee, which conducted a review of the Swedish policy on climate change. Its main task has been to prepare a foundation to the government bill on climate policy planned to be presented in fall 2008. All parties represented in the Swedish parliament took part in the committee, which presented its conclusions and recommendations in the spring of 2008 (Miljödepartementet SOU 2008:24). This also included measures to be taken within the transport sector, with its growing emissions of CO2. The Climate committee recommends a kilometre tax to be implemented by 2010 in Sweden.

### 4.2. Earlier work towards a road user charging system

Within the Tango framework\(^{40}\) an examination was made of the possibilities of introducing a distance based road user charging system for heavy goods vehicles in Sweden. The feasibility study was carried out during 2003 and 2004. One of the reasons for this was the development in Germany, where the rapid development in the field of distance based road user charges for heavy goods vehicles had taken Swedish authorities with surprise and a bit off guard. If Germany was to introduce a satellite based positioning and GSM based charging system on all its highways, what should Sweden do then?

Six reports were produced within the Tango Collect project, and the major findings were summarised in the final report *Tango Collect – Differentiated kilometre charges as a driving force for implementing telematics for heavy goods vehicles* (Gustafsson and Schelin 2004). This report focused on providing decision support for a future implementation of distance based road charges in Sweden, then foreseen in 2008. During the project a national stakeholder network with a composition of relevant stakeholders was established to form the basis for further work. The project was performed with the philosophy of not viewing a future distance based road taxing system as an isolated phenomenon, but instead taking a wider view and focus both on the innovation potential and the consequences and possibilities related to a full-scale implementation, respecting that the stakeholders have different needs and

\(^{40}\) Tango was a regional project carried out in southern Sweden during 2003-2004.
requirements. The conclusions from the project include the views and needs of the
stakeholders (the transport sector, the authorities and the system and service providers) and
are summarised below:

- Give us technology that supports us – not control us. This was the message brought
  forward by the transport industry. They also identified that a mandatory road charging
  application can enable a platform to which other service applications can be added,
  thus speeding up the use of telematics in the transport sector. The transport industry
  brought forward strong requirements for how a road charging system should function:
  it must be easy to use, transparent and safe and protect the integrity of the users. The
  charging means must also be designed to address the needs of both low-tech and high-
  tech users. The hauler business is very disparate, from a large group of one-man
  companies usually performing the same tasks for the same clients in the same
  geographical area to large international hauler companies with very complex
  operations and technology use.

- Service providers and system suppliers identified an innovation potential provided the
  value chain is attractive to the relevant stakeholders and a business case can be built.
  Important input from these stakeholders is the requirement for open interfaces and a
  functional system specification, delivered as soon as possible. The system
  specification should be based on well defined interfaces to enable connections with
  other applications as well as charging systems in other countries.

- The Swedish road network is large but not heavily used, and few roads are of
  motorway standard. The road operators identify the increased possibility to direct the
  heavy goods traffic to the main network, which is designed and built for carrying
  heavy traffic. A telematics platform in the vehicles would provide possibilities to the
  authorities with regard to traffic management as well as other areas, such as improved
  traffic safety, tracking of hazardous goods, environmental aspects and capacity
  utilization.

All stakeholders further emphasised the importance of involvement of all relevant
stakeholders in the work as the way to reach a well-functioning system design as well as a
successful implementation.

The Tango Collect project was well received by authorities and people working in the field,
and was followed by a project financed by the Swedish road administration. The major focus
of this study was to find answers to “How do we get from the analysis phase into a successful implementation of a distance based road taxation system?” The main findings from this project were published in the report Distance based road user charges; Implementations aspects and Implementation plan (Gustafsson and Schelin 2005). The report focused on the following aspects:

- Provision of an overview of the work carried out so far.
- Discussion of possibilities on how to establish a long term solution for the future work in this field – aiming at a national arena comprising these tasks.
- Provision of an overview of topics that needs to be addressed and solved before a full-scale implementation. This work took the work into consideration of the governmental commission on road tax charges.

When the Tango Collect work had been carried out and the Implementations aspects study (described above) had been performed the European development in the field was up to great speed. This included ongoing implementations in Austria and Germany, planned implementations in the Czech Republic, a cancelled procurement process in UK and several other countries performing feasibility studies. In Sweden it was decided that the Swedish work should continue in the form that had been proposed in the implementations aspects and implementation plan project. This ARENA project started in February 2006 and has since then coordinated many of the Swedish activities in the field of road user charging for heavy goods vehicles.

4.3. Formation of the ARENA

As can be read in the chapters above, several activities have taken place in Sweden and the surrounding world during recent years within the field of road user charging for heavy goods vehicles. The work is performed by many parties and legal entities. The time table set by the European Commission for the introduction of the EETS is quite tight. This calls for a coordinated and integrated action from the Swedish side, to ensure that the activities within the field of road user charges and electronic fee collection are dealt with in an efficient way, both fulfilling Swedish and international requirements.
The Swedish approach is to gather all national expertise under an umbrella project, named ARENA\textsuperscript{41}, which started in February 2006. The ARENA is financed by Swedish Road Administration and Vinnova.

The basis of the ARENA is the distance based road charging application, which is the driving force for innovation as well as regional and national development and growth. The ARENA is run as a joint effort between the academia, the industry and authorities. It brings together existing competences from different sectors. Through joint actions knowledge and competence are built up to enhance the possibility for Sweden to implement a distance based road charging system in Sweden after 2010. The ARENA aims at opening up possibilities for all actors and stakeholders involved and to facilitate the implementation of new innovations, based on knowledge and demand, all in order to create a fruitful innovation system as Lundvall states (Lundvall 2007). The ARENA also plans for a test- and demonstration site open for all stakeholders, private as well as public. The project has a strong political support from SRA, Vinnova and the regional authorities in Southern Sweden.

The ARENA goals have been:

- To develop a conceptual design for a Swedish distance based road user charge service for heavy goods vehicles
- To ensure that this is done in accordance with the Swedish transport policy, where internalisation of external effects is an important part
- Through an adequate concept design ensure that Swedish characteristics and requirements are taken into account of which the most important are:
  a. The road network is large and not so densely used
  b. There are few roads of motorway standard
  c. There are several remotely placed border crossings
  d. There is not so much transit traffic, even though this is increasing
  e. There is a very large forest road network, often privately owned
- Ensure that the concept design fits to the European legislation and the European EETS development
- To support an increased use of telematics within the transport sector, which was one of the recommendations from the Tango Collect project

\textsuperscript{41} www.arena-ruc.com
• To create opportunities for innovative Swedish solutions to find a larger market
• To facilitate increased knowledge exchange on a European level
• To prepare for innovative demonstrations for the 2009 ITS World Congress in the area of e-payments

Thanks to the pragmatic approach from financing bodies (SRA and Vinnova) and involved stakeholders, the ARENA could form for a sustainable concept building with participants from authorities, social scientists, researchers, consultants and system and technology providers, thus ensuring a good base for forming a good system for road user charging for heavy goods vehicles.

4.4. **Expert seminars leading the way to European solutions**

The ARENA system concept was presented and discussed during the expert seminar held in Sweden in February 2007, where some 80 European experts from authorities, industry and the academia gathered to discuss the Swedish approach to road user charging for heavy goods vehicles (ARENA 2007). The most important questions for further research / examination were summarised (ibid):

1. Policy first, technology and systems later
2. Is the Swedish concept really a tax or a fee?
3. Thin vs. thick client\(^{42}\) needs much more analysis
4. How to link a public payment scheme to a private one
5. There is a need to test legal issues – collection of payments, enforcement powers etc.
6. Any toll system must link to traffic management
7. EETS interpretation is still unclear and legally not tested
8. Mandating an OBU is almost impossible
9. The payment scheme concept must be simple, flexible and allow flexible payment options
10. Occasional user schemes/enforcement schemes should have a cost/benefit test
11. Make system procurement easy and transparent
12. Get public and political support from the start

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\(^{42}\) The concepts of a thin versus a thick client for the EETS service has been much debated. The thick client refers to an OBU capable of making all calculations, map matching and communication, while the thin concept refers to an on-board client equipped with basic trajectory measurement, but where the main fee calculation is done in a central unit, off board.
The discussions have then been ongoing and the approach has been scrutinized and discussed in the European network of experts during spring 2007. A new seminar, following up on the weak points identified in the concept during the seminar in February 2007 (ARENA 2007) was held with some 60 experts in May 2007. The main issue for discussion was the enforcement system, which had earlier been identified as being too particular and thus expensive. After discussion during the workshop it was decided to change approach towards enforcement and concentrate on the users’ internal processes as well as cooperation with other authorities, i.e. the Swedish customs. Some spot checks and fixed enforcement points would support such a system.

The open environment of the ARENA workshops have attracted many of the leading experts in Europe to these seminars, which have served as a platform for identifying hurdles, outstanding tasks to solve and future research needed. The discussions have much summarised outstanding issues for many European countries in the process of finding ways to implement road user charging systems feasible both for the individual country and in accordance with the requirements from EU perspective.

4.5. The ARENA – an innovation system

The Swedish work in the ARENA has been analysed in accordance with the technology factors / variables and phenomena that Granstrand holds as important in the Economics of technology discussion (Granstrand 1994) for creating innovations.

![Image of Technology factors / variables / phenomena](image_url)

Figure 3. Important factors for economy of technology analysis (Granstrand 1994).

The analysis shows that the system of innovation is very strong in this research field. The ARENA is run as a joint effort between the academia, the industry and authorities, strengthening its credibility. Actors from several sectors, both Swedish and international, work together with the development of a robust concept for distance based road user charging.
Through this cooperation knowledge and competence is built up to a larger sphere of actors, enhancing the possibility for Sweden to implement a robust and viable system for distance based road charging around 2010. These joint actions increase the innovation efficiency and facilitate co-ordination of information and communication. The inclusion of science and technology institutions is relatively high, as several universities participate to a high extent in the research and development of the concept (Blekinge Institute of Technology, Linköping University and Lund University). Representatives for Newcastle University have also participated in concept discussions and development.

In general, it can be concluded for this innovation system, that most of the knowledge about road user charging is present among experts outside the academic world, usually active as consulting engineers, authorities and among the system and service providers. The cooperation among the expert network from all over Europe ensures that the Swedish concept development is done in the right way. It gives valuable input in the design process. The open work-style of the Swedish implementation process enhances the European knowledge, as the European experts meet at this ARENA and can exchange views and knowledge with each other.

From the start of the ARENA project two of the industry partners were included in the project steering committee. This was questioned by several other industry actors referring to a future procurement process. Consequently, shortly after the project started the industry partners were removed from the core of the project and become members of the industry forum, which suited all involved partners and financiers well. This example showed however how complicated PPP (public private partnerships) are in different stages of concept, development and procurement process. “Real partnerships do not (yet?) fit in with the institutional rules, roles and habits based on a public-private division at the beginning of the 21st century” (Klijn and Teisman 2005). Institutional frameworks in general and procurement policy in particular have a barrier effect to the successful formation and implementation of public private partnerships. An analysis around the PPP work of the ARENA has been done (Gustafsson, Hultén and Schelin 2007), where the main conclusions are that institutional frameworks in general and procurement policy in particular have a barrier effect to the successful formation and implementation of PPPs, The ARENA model of creating close co-operation with industry through other models than project membership, e.g.: industry forum, bilateral meetings and
workshops has however enabled an open and fruitful co-operation between parties that in other situations have shown scepticism towards each other.

One of the ARENA goals is to open up possibilities for all actors and stakeholders and facilitate the implementation of new innovations based on knowledge and demand. So far the ARENA has not applied for any patents. The ARENA also plans for a test- and demonstration site open for all stakeholders, private as well as public. This will mainly serve the purpose of demonstrating to actors and decision makers about the concepts and thought formed within the ARENA. To be able to show this in reality is seen as a good possibility for inclusion and explanation, thus enabling fruitful discussions.

The project has a strong political support from SRA and Vinnova and the regional authorities in Southern Sweden. The R&D system as set up using the ARENA as a facilitator seem to be a very fortunate model for innovation and implementation. The structured work and organisation of the project serves as a good base for efficient R&D work and policy implementation.

4.6. Final remarks on the Swedish development

The Swedish approach of forming the ARENA has shown to be very fruitful in many aspects. Acting in a large innovation system provides a good base for innovative solutions. The financing partners of SRA and Vinnova ensure a strong support from authorities, which will help future implementation. The large inclusion of internal and external actors and stakeholders is a very rich foundation for ensuring that the research process and innovativeness is going in the right direction, towards a fully functional and accepted technology system. The openness, with which the European work in the field is being done, is also a positive factor for ensuring good outcome.
5. Results and recommendations

This chapter summarises the major findings from this research and outlines an implementation model for how the implementation process of road user charging is done. The implementation model is not complete, but can serve as a tool for an implementing country. The seven actor groups in such an innovation system have been identified, including their most important roles in the system as well as the most important tasks to deal with during an implementation process.

5.1. An implementation process model

In Sweden a paradigm shift in transport policy was initiated in the 1960’s, when the school of thought advocating the marginal cost principle for internalisation of external effects started gaining support. In Sweden this process was started by social scientists and economists active in the transport research field.

Consultants and engineers developed the idea further in the 90’s and combined it with technology emerging first at labs and later entering the commercial market, such as positioning and communication technologies and cheap memory and computing power. Meanwhile the social scientists fine-tuned their models and theories and advocated the inclusion of them in the Swedish transport policy.


The political body was informed about the development by several actors in the innovation system, mainly by their authorities and by scientists active in the field. Especially the latter category was supported by the consulting engineers’ practical and technical knowledge in their information task.

When the marginal cost principle for externalisation of internal effects was accepted as the main principle for price mechanisms in the transport sector and also practically possible as shown by the consulting engineers’ feasibility studies, these theoretical pillars were included
as guiding principles in the transport policy. In Sweden this occurred in 1997 with the governmental proposition Transport policy for a sustainable development (Regeringens proposition 1997/98:56).

To fully understand the successive development in this innovation system it is important to realise that a policy statement is only brought forward when a technical realisation for this is present and possible (interview Vierth 2007). From emerging theories to inclusion in policy the development carried forward by technically oriented actors is therefore important.

Can the implementation process for a road user charging system be modelled into a few pictures? Certainly not, as all aspects of such a complex system and process can not be summarised in a few words or a few lines in a figure, since a complex system is dynamic in its nature (Cilliers 1998), but the model sketched below is an attempt to visualise the process of implementing a road user charging system in a country. It shows the innovation system of road user charging, and includes identification of the most important actors, decision points and information flows.

The analysis before designing this model is mainly based on the Swedish process towards implementation. The case studies from Switzerland, Germany, Austria and the UK including London Congestion Charging have also been used as valuable input for forming the model, as well as validating the conclusions around it. Experiences from the Stockholm Congestion charging project also influence the conclusions and recommendations, as these are generic and useful for the case of heavy goods charging.

5.1.1. Model outline and most important actors

The outline of the figure is time-based. Seven groups of actors have been identified and placed in the figure based on their internal relationship as well as the credibility in terms of societal “good” the actor group possess. The increasing credibility is shown through the vertical arrow in Figure 4 below, and each actor group is described:

1. On top of the figure is the public. The public represents the citizens affected by a road user charging system. They require it to be as fair and efficient as possible, with few negative societal impacts. The public assign the task to the political body of implementing a road user charging system, which is done through general elections. A democratic
process is required for ensuring acceptance, especially if the charge is a tax, as money goes straight to the state budget, and can not be ear-marked for a specific purpose. The public also represent the end users of an actual road user charging system, as commercial haulers, drivers or other individuals affected by the system.

2. The next actor group is the political body, usually in the form of the Parliament, but it can also be a local government. The political body makes the decisions on implementation of a system for road user charging, and decides on the legal framework for this. The decision making is based on the transport policy earlier decided (both on EU and national level). The political body, through a Ministry, assigns responsibility for procurement and implementation to one of its authorities. A high risk is present for this actor if the political majority change or politically correctness winds blow elsewhere. This can cause high costs for tenderers whose bid may not even be evaluated, like in UK when the procurement process was cancelled during the evaluation of the tenders from system suppliers.

Figure 4 shows the seven identified groups of actors, placed in the model based on their societal good.

3. The authorities execute the political body’s decisions. They have a thorough knowledge on the issue, based on their own expertise and close cooperation with the social scientists, the consulting engineers and the business oriented actors (system and technology providers). This way the knowledge is filtered through the authorities before reaching the
political body. Both the implementer and later the operator of a road user charging system are usually found among the authorities. With increased use of PPP models the operator can also come from a private concessionaire.

4. The social scientists provide knowledge and models to the actors both above and below them (the authorities and the consulting engineers). This actor is the starter of the paradigm shift and they are the pioneers in providing new schools of thought. At later stages they are usually not so involved in the actual development process of a system, but they tend to come back into the loop for evaluation purposes. This actor is usually found at universities and research institutes.

5. The consulting engineers are interacting at many levels of this innovation system. They do consulting work for many actors and stakeholders, usually the ones found above them in the figure. During interaction with the social scientists the consulting engineers acquire new economical theories and ideas, which they develop into feasible system solutions. This is done through combining theory with emerging technologies from the technology providers. The consulting engineers are very important in this innovation system for spreading the knowledge to larger groups of actors and stakeholders as well as developing technical solutions for how they can be realised. They act as information brokers and technological gatekeepers, bringing in scientific and technical information to the actors of the innovation system (Brown 2005). The consulting engineers drive parts of the process without a formal mandate to do it.

6. The system providers use technology combined with system integration for implementing a functioning system. The system provider is often the counterpart delivering the system to the authority responsible for implementing and operating a road user charging system, often with the technology provider as subcontractor.

7. The technology providers have developed technology suitable for realising parts of a system for road user charging. They are often part of other innovation systems, as their technology can be used for many purposes. Consequently they are not always aware of the business opportunities within the road user charging sector, and sometimes they have to be found and addressed by other actors within this innovation system.
5.1.2. Important decision points

Figure 5 shows the important decision points along the way towards an introduction of a road user charging system. The dotted line indicates the firm political decision to implement a system.

The implementation process starts with the new theories as presented by social scientists. These theories are continuously combined with enabling technologies. This is often shown in trial and demonstration projects, which however rarely are capable of showing all possible features in real-time. Their strong advantage is that they can provide good, live demonstrations on how a system could work to many stakeholders and actors.

The decisions along the way to a firm political decision on implementation are made by the political body. A constant increase of knowledge is taking place before each step of decision making. This is done in a constant process of information and knowledge exchange with the other actors in the innovation system. The later in the process they are made, the more specific the decisions are in terms of time, place and assigned responsibility. The most important decisions and decision processes along the way to firm implementation and later contract award are shown in Figure 5.
5.1.3. Activities along the implementation process

When the political body is convinced that a system implementation is a feasible idea the firm political decision is made by the parliament. Here a strict responsibility to a procuring authority as well as an operating authority is also decided. The firm political decision on implementation is very precise on when, where, how and by whom an implementation will be executed, while the earlier decisions by the political body have been more of describing nature on what would be wanted if shown feasible. This is e.g. expressed as policy statements, triggering more feasibility studies and trials. The activities along the implementation process are illustrated by green arrows in Figure 6 below.

Figure 6 shows the activities taking place along the way towards introduction, both for preparation before decisions and development after decisions are taken.

A policy decision is usually followed by an expression of political will, when an authority is assigned to further evaluate and prepare for a future decision on implementation. This usually triggers the actual system development to start, which is when system and technology providers get involved in the innovation process. This is illustrated in the bottom of Figure 6 above.

When enough knowledge is gathered and the political situation ripe, a firm political decision on implementation is made, usually in the form of a governmental proposition.
the responsibility for procurement and implementation is given to a suitable authority, which
then makes necessary decisions on request for quotation and after evaluation, contract award.

5.1.4. Concept developers and information brokers

The continuous development in the innovation system is very much facilitated by the
consulting engineers, an actor that is also acting as the main information broker. The
development is carried forward based on theories, emerging technologies and necessary
decisions along the way. The consulting engineers use their close cooperation with the
scientific field for this (sometimes they even become the experts/researchers) and they are
active on several arenas, advising the political body, the authorities and the scientists. It is
usually the consulting engineers that finds the technology providers and introduces them to
the specific needs and demands in this innovation system. The information flows are
illustrated in the expanded model in Figure 7 below, where knowledge is transferred between
the different actor levels by information brokers, thus enabling further decision making.

![Figure 7](image_url)

**Figure 7** shows the interaction between different levels in the model. The information and communication
flow cover one or two actor group levels, rarely three.

At later stages in the innovation process the consulting engineers combine their knowledge
with system and technology providers, for developing viable systems for road user charging.
This is illustrated by the green rectangle on top of the system development bar, where the
information flow (blue arrows) transfer knowledge between actor groups. In this innovation system the consulting engineers become an important actor as technological gatekeeper (Brown 2005). This illustrates the importance of providing enough possibilities and funding to perform trials and demonstration projects, and to create possibilities for meetings and information brokerage. As Gibbons et al state (1994), for an innovation process to be successful both explicit and tacit knowledge have to be captured and included into system concept and design. To do this the knowledge production should be context-driven, problem-focused and inter-disciplinary, which requires possibilities to build and exchange knowledge. This way conferences and seminars that gather actors from many groups serve an important purpose in this dynamic innovation and implementation process.

This research shows that the information and communication flow between actors usually cover one or two levels, but rarely three, just in line with Cilliers description on complex systems where interactions and information is passed between immediate actors (Cilliers 1998). The actors involved in this innovation system should be aware of this, as it shows that information sharing and influencing other actor groups is a stepwise process. The higher in the model the stakeholder group is placed, it has a higher credibility in terms of societal good. The research shows however, that communication between the lowest and the highest stakeholder group usually does not work well. A more successful approach would be for the business oriented actors (system and technology providers) to approach the actors close above them, as these will carry the information and solution approaches to higher levels, supported by their higher societal good credibility. That way information and knowledge successfully disperses through the system and reaches its address.

A conclusion of the analysis above is that to ensure a long-term sustainable development and knowledge production in this field, with its sometimes quite slow development, it is important to support both basic research and development and demonstration projects. It is also important to acknowledge the needs of all actors in this innovation system, for ensuring a solid development based on thorough knowledge, all for the public good. The communication, knowledge sharing and actions all provide for a good innovation system (Lundvall 2007). Another conclusion is that this innovation system functions very much as is described in the mode 2 theories presented by Nowotny et al, where it is hard to find a clear demarcation and difference between science and society, as these areas are inter-twined with each other and no longer represent readily distinguishable domains (Nowotny et al 2001).
5.2. **Implementation aspects**

The European legal framework for implementing distance based road user charging systems is in place to a large extent, allowing the member states to implement systems for charging the use of infrastructure. The threat to the basic European principles of free movement of people and goods is met through the EFC-directive (COM 2004/52/EC) where it should be made possible to use one device and one contract in the whole of Europe for heavy goods vehicles. European legislation requires all directives to be included in the national legislation of the member states. However the EETS service is not yet specified, but the work is going on concurrently to the Swedish development work.

The European Commission is watching the process towards EETS, but has expressed doubts about the pace and the commitment from the member states and their authorities (interview Hamet 2006). Lately it has been noticed that the Commission is taking a firmer grip on the market forces, demanding them to converge towards the EFC directive. The Commission is also working more actively not only with directives but does also implement incitements to reach its goals (interview Rydmell 2007).

5.3. **Legal concerns**

Even if the legislation is there, will it ensure a system according to it? Not always, as was shown in Stockholm congestion charging system. The system procured did not meet all necessary requirements for a legal enforcement process, why in the end the system now identifies and charges vehicles based on ANPR\(^{43}\), instead of the originally procured DSRC based system (interview Sundberg 2007). When the Svinesund Bridge between Sweden and Norway was opened in June 2005 the legislation framework for this was not complete, which made it illegal to charge the traffic for using the bridge for almost a year (ibid). The Swedish experiences from Stockholm and Svinesund show the need for a consistent and robust legal framework, that suits the needs within the electronic fee collection area.

Another problem is caused by the legal actions taken during the tender process. These have shown to be a high risk as has been identified by both Blum (2007) and Gustafsson et al (2007), which can hinder a close and fruitful cooperation between system suppliers and the authorities during the system development phase. This may at later stages judge the

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\(^{43}\) Automatic Number Plate Recognition
authorities as biased towards the system supplier and thus cause the exclusion of the system supplier as tenderer. In the long term this is a hindering factor to a sustainable system development, where all actors are involved and active partners.

The timing of the legal framework is debated by experts in the field. A robust preparatory legal framework is important to ensure a viable procurement process (interview Leyendecker 2006). Hamilton (2007) supports this and states that the legal framework should be written before any technological choices are done. The procurement requirements should be functional, only prescribing output parameters. This opens up for service providers to choose their preferred technical solution. Other experts state that a legal framework can only be decided when a technical system has been decided (interviews Rode 2006, Stappert 2006, Larsson 2007). A too firm legal framework can become a hurdle to extension of a system, as has been shown in Germany (Källström 2007). This shows the importance of a suitable legal framework to support procurement, implementation and operation of a system.

Each country differ in their approach to implementation, based on several factors such as authorities’ power, belief in commercial forces making right choices and cultural differences. The British attempt at outsourcing the responsibility for implementation of the LRUC system to commercial actors was probably based on UK:s tradition of allowing private actors into classical authorities’ fields. In Holland the process is more politically influenced and driven, which was also the case for the German implementation, however fiscal and fairness principles were also converging in the same direction as the political will. It is important to realise that several perspectives will have to interact to reach a successful implementation of such complex systems.

5.4. Procurement strategy

The procurement strategy requires a well thought through process. The British example of allotting three lots for different system suppliers and the integration complications this brought forward shows the importance of a well thought through procurement strategy, both before and during the procurement phase, testing phase and implementation phase. Several experts have also stressed the lesson learnt that no matter how much responsibility is transferred to the suppliers, the authority will still stand the responsibility for failure in the public opinion, as has been shown both in Germany and UK. This leads to the
recommendation that the authority given responsibility for implementation should take this and pursue it.

5.4.1. Technology choices

If a legal framework is already written for the procurement of a road user charging system, will it anchor to existing technology or enable new? Several applications within the transport sector have emerged during the last ten years, utilizing new technology in new ways. Examples of this are the insurance systems based on the principle of pay as you drive, ADAS systems supporting the driver’s task, guidance systems based on positioning and digital map technologies and vehicle to vehicle systems, where vehicles communicate with each other for improved road and traffic update (Pickford and Blythe 2006, Sundberg 2007). All these systems and concepts provide possibilities to new actors and new business models, where a road user charging system may also be a part. Several interviewed and cited experts demand thorough look into neighbouring concepts and systems such as the digital tachograph, alcolock, the customs tasks and capabilities and to apply a more open approach towards possible solutions for a future road user charging system (interviews Opiola 2006, Gustafsson 2007, Rydmell 2007 and Hamilton 2007).

5.4.2. Trials and demonstrations

Recent research at TRL (interviews Stoneman, Gillan & Tindall 2006) and the experiences of the Stockholm congestion charging trial (interview Höök 2006) has led to the conclusion that it is important for successful implementations to have a demonstrator where the basic principles of the systems can be demonstrated for different groups of stakeholders. This is also supported by German, Swiss and Czech experiences (interviews Oehry 2007, Stappert 2007). Such a demonstration site can also enable tests of different functionalities of suggested solutions and can at a later stage be developed into a validation and certification unit. As different stakeholders have different views on feasible solutions a demonstrator can facilitate and illustrate discussions around different design concepts for fruitful discussions towards the ultimate solution. However, according to Stappert (interview 2008) real systems come out of real procurement. At the time being, there is not so much to be demonstrated with regard to the Swedish, Dutch and UK planned schemes requirements. Almost all of the currently available technical solutions can be shown and observed in the Swiss, Austrian, German and London schemes. Testing of the final technical solution (after procurement and during implementation) is of course very, very important.
5.4.3. Interoperability

The interoperability issue is a complicated one that still requires a viable solution. The legal framework is already in place on European level (Directive 2004/52/EC). Several aspects have to be taken into account. The biggest concern is cost; shall all vehicles have an OBU that is interoperable all over Europe and that probably is quite expensive, or shall the respective country go for several solutions, with a low-cost model for national users and a high-cost model for the international users? CESARE, VERA and RCI are EU supported projects that have been working towards interoperability and have come to some results, however the OBU solution brought forward by the RCI project is more or less a device comprising all technical solutions present in Europe, thus making the device interoperable. This can not be viewed as very cost efficient for the European transport users. Neither CESARE nor VERA have solved all issues with regard to interoperability or legal aspects. Another complex issue is how to handle the occasional user. The NORITS cooperation and the solutions found for interoperability in this project should be used as a guide towards how these critical issues can be solved.

5.5. Acceptance necessary for success

The message is very clear among respondents and in scientific literature: To reach a successful implementation it is utterly important to gain acceptance. As several papers have revealed and interviewees have stated: make benefits visible, communicate with stakeholders, show how users benefit and deliver benefits before the system starts.

This research shows that it is clear that acceptance requires a road user charging system to have a clear motive embedded, which should reflect the national policy. Clear charging principles should be used, which can be easily communicated and understood by involved stakeholders and actors. A successful system should also be guided by principles perceived by the users as fair. A democratic implementation process is important for public acceptance. If the charge is a tax the revenues should be allocated back to the transport system. An authority should operate the system – thus ensuring reliability and efficient operation. The system should also be robust and easy to use for non-equipped users.

A firm political commitment is important, and a successful implementation requires high political support. In countries where a champion has been present and visible the implementation has been running fast and efficiently. London congestion charging project is
the classical example, where “Red Ken” (Livingstone) went to election to become London’s Mayor on the promise to implement congestion charging and do something about congestion. He was elected and the process ran very smoothly and successfully, even if a technology was chosen that almost “burned money” in its high costs for operations. One can conclude that a champion clearly supporting the idea and in hold of the necessary networks for implementation is an important success factor when it comes to implementation. The higher up in the innovation system the champion is present, the easier to carry through the implementation. Several of the interviewees in the road user charging innovation system have verified this and pointed to the need of a high-level champion, preferably Minister or 2nd secretary level in the political body. Also without a champion the implementation can be successful, as the Swiss example shows. The Transport Minister was responsible for the implementation, and the Swiss customs was assigned the responsibility for the actual implementation. This organisation was very pragmatic and functioned well also without a very strong leader (interview Balmer 2007). The Stockholm congestion charging trial in 2006 show a similar experience, with increasing acceptance during the life of the trial (9 months), and without a strong leader. Here, the large information efforts are given the credit for this positive development, as well as the actual traffic development during the trial (where traffic during peak hours decreased with around 20%).

Another success factor for ensuring acceptance is shown in the Swiss case of implementing their LSVA system in 2001. Several effects converged (Suter and Walter 2001), where environmental considerations (to avoid lorry transit) were combined with transport and regional considerations (to assure financing for the rail sector) and economical and political arguments (to avoid opposition against the agreements between Switzerland and EU). Lorry taxation and the problem of the external costs of transport have been on the agenda for a long time and the public have become familiar with it.

Nazer et al (2007) states that delivering benefits prior to the start of the system is a strong factor to increase acceptance. This shows the importance of making several factors work concurrently towards acceptance among the public and the users and to grab opportunities when they present themselves.
5.6. **Concluding remarks and recommendations**

Several factors have influenced the recent development in charging of heavy goods vehicles in Europe. European legislation is changed, making it possible for countries to charge for the use of motorways and other infrastructure (COM (2003) 448). The political will is strong in many countries, as well as public awareness and acceptance for the need to put a price and a cost on the use of infrastructure. Environmental concerns are also actuating change in this direction. National systems are being introduced to support and enhance principles of marginal cost, fair pricing, inclusion of emission factors and to support modal shift. This has laid the foundation for a payment will for good technical solutions in the field of road user charging, encouraging suppliers to develop systems fulfilling these demands. It is important for public acceptance however, that the money gained from the charges is used in the transport system.

Since several countries have already implemented distance based road user charges, their neighbouring countries are affected by this, as traffic is diverted into new, not yet charged routes. Therefore it is quite natural that the countries in Eastern Europe are following the footpaths of Switzerland, Austria and Germany, and implement charges as a way of managing the demand for road usage of the heavy goods vehicles. The public opinion supports this, as they are also affected by the increased traffic in terms of accidents, pollution and congestion. EU member states in Western Europe are also looking into road user charging possibilities (Sweden, The Netherlands, Belgium and more) in order to pursue their transport policies.

Implementing states have come to different conclusions on which technology is the most suitable for them, based on the transport policy and business case the solution shall fulfil. Each country has its own characteristics and its own objectives (fairness, modal shift, financing…) to fulfil, resulting in different solutions on scope for pricing, geographical limits for charging and technical system for doing this. One of the most complex problems to solve during the technology choice is how the occasional users should be treated. The countries also differ in their approach to implementation, based on factors such as authorities’ and ministries power, belief in commercial forces making right choices and cultural differences. It is important to realise that several perspectives will have to interact during an implementation in order to be successful.
The European Commission is acting as a counterforce to the member states of the European Union. The initiatives from the Commission of financing projects working with the common European electronic toll service to bridge the disparate national solutions are very positive for the future European road network and the free movement of people and goods. It is also reassuring that the European legislation has to be implemented in the respective national legislations, thus making the European Union and its decisions powerful. Another good example and counterforce to the disparate technical systems is the NORITS cooperation, where the toll operators and road authorities in the Nordic countries are working to reach interoperability between systems. The Swedish example of outsourcing the toll collection service to another, foreign entity shows how un-orthodox solutions actually can work well in reality.

The seven actor groups in a distance based road user charge innovation system have been coupled with their most significant roles in the system:

- The public: acceptance
- The political body: legal framework, decision making, considerations for successful implementation, responsibility assignment
- Authorities: institutional aspects, responsibility for procurement, implementation and operation
- Social scientists: initiator of ideas and new schools of thought, knowledge providers, decision support, evaluation
- Consulting engineers: information and knowledge brokers, process drivers, concept developers
- System providers: system integrators
- Technology providers: technology developers, provision of sub-systems

The most important tasks to deal with during an implementation process have been identified and are illustrated in Figure 8 below:

- Public acceptance and use of opportunities and public opinion
- The political process and decision points
- The legal framework
- The institutional framework
- Responsibility assignment
- System procurement and implementation
  a. Procurement strategy
  b. Technology choices
  c. Testing and Demonstration
  d. Interoperability

Figure 8 shows the most important aspects of implementation of road user charges for heavy goods vehicles.

A general conclusion from the analysis is that all implementation projects differ due to differing objectives and requirements. It has also been stated that it is very hard to manage this kind of large and complex projects (Interviews Leyendecker 2006, Sampson 2006, Oehry 2007). The legal framework is often hard to solve before a technical solution matching the business case is decided upon, and still it has been argued that it is very important that the preparatory legislation is done right so the procurement is positioned rightly (Woodward et al 2007). As in all industrial projects with a policy aspect to it, the timeline is usually unrealistic. Another conclusion from the research is that it is important to be clear on which authority is responsible for the different implementation steps. Political risks with implementation requires good timing and utilisation of converging factors, as the Swiss system clearly shows as well as the UK failure.

An open innovation process is beneficial to reach success and should be encouraged, as several interviewees state (interviews Hamet, Höök, Oehry, Gustafsson and Stappert 2006, Källström 2007). Along the way there must be enough money for knowledge building and
knowledge exchange. The financing institutions should adhere to this and provide money for research and demonstration projects as well as seminars and conferences to ensure information exchange and knowledge building during this slow implementation process. The consulting engineers’ task as information brokers and technological gatekeepers is important for keeping the implementation process alive, as Brulin et al. (2003) stresses around the fact that innovative development of products always contains a great deal of networking and experimentation under rather chaotic circumstances.

The legal framework should be done in accordance with the system concept and should function also for enforcement purposes. The procurement should be as functional as possible in its requests and outlines, giving suppliers as large freedom of choice of technical solution as possible. The interoperability aspect must be considered in a procurement process, so the system decided upon is interoperable with the EETS. Incremental innovations should be allowed to surface as possible system solutions. The system procurement system should not hinder earlier cooperation between several types of stakeholders, why any cooperation should be set up that ensure possibility to become a supplier in the future.

It is important to realise that acceptance, legal aspects and framework, responsibility and political issues are important questions to deal with in an implementation process of a road user charging system, even before technology choices and organisational issues are dealt with. This is important to be aware of before applying a strict engineering perspective and approach to an implementation process.
6. Future studies

This thesis contains research of a dynamic, ever-changing field. To catch the true picture is never fully possible in such a field, why constant updates are required, and there is a constant need for more research and to connect to researchers present in neighbouring countries or active in adjacent fields of research.

The conclusions and recommendations in this thesis are based on data from many European countries; however most of my knowledge comes from the Swedish area. It would be very interesting in the future to validate the implementation model presented in this thesis to other countries’ experiences from implementations. Are the actors the same, or do they differ from country to country?

The field of public private partnerships (PPPs) is growing in the road sector, why issues related to this also needs more thorough research and understanding. Another field for future research is to study adjacent policy based implementations, where policy concerns and decisions have caused a change and introduction of new technical solutions. Examples of this could be the digital tachograph, pay-as-you drive systems and ISA\textsuperscript{44}.

An interesting aspect this research has uncovered is how science and society mixes during the innovation processes and how the innovation system’s actors meanwhile step in and out of different roles during this process. Complexity in systems is increasing and chaotic circumstances for work are rather the rule than the exception. Systems are self-organizing and usually the result of complex patterns of interaction. Both science and society are subject to the same driving forces; the overall growth of uncertainty; the growing influence of new forms of economic rationality; the transformation of time into the extended present; the flexibilisation of space and an increasing capacity for self-organisation in both scientific and social arenas. This generates a new society and new methods for doing work, research and science as well as new methods for how knowledge is produced. This modern way of innovating would be interesting to examine further, including the new leadership required, the new organisation models and how this work should be financed.

\textsuperscript{44} ISA – intelligent speed adaptation
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(available at http://qp.bth.se/tac):

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- Report 3: Analysis of the current situation on road charging for heavy goods vehicles in Germany, Austria, Switzerland, Sweden, Great Britain and Netherlands.
- Report 4: Teknik, tjänster och transportbranschen – en översikt (Swedish) (Free translation: Technology, services and the Transport Industry – an overview)
- Report 5: Scenario och övergripande system för Tango Collect – kilometerbaserade avgifter för tung trafik (Swedish) (free translation: Scenarios and governing systems for the Tango Collect – kilometre charges for heavy goods vehicles)
- Report 6: The Tango Collect approach to functional architecture of a Swedish system for road charging of heavy goods vehicles
### Interviews, presentations and study tours

#### Interviews:

**Philippe Hamet**
European Comission, DG TREN, Belgium (2006)
“Father” of Directive 2004/52/EC

**Birger Höök**
Swedish Road Administration (2006)
Project manager for the Stockholm Congestion Charging Trial during 2006

**Jan Larsson**
Ministry of Finance, Sweden (2007)

**Hans Rode**
Swedish Road Administration (2006)
Responsible for implementing new services in SRA

**Bernard Oehry**
RappTrans, Switzerland (2006)
Involved in most projects regarding road user charging for heavy goods vehicles in Europe, including CESARE III

**Brian Stoneman, William Gillan and Dave Tindall**
TRL, UK (2006)
Experience from many trials for tolling and road user charging (UK, Holland, Germany…)

**Eric Sampson**
Department for Transport, UK (2006)
Long term experience from tolling in UK. Large network within the road user charging world.

**Phil Blythe**
University of Newcastle upon Tyne (2007)
Long term expert in the field of road user charging. Organiser of several seminars and workshops in Europe. Broad network in the RUC field.
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<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
<th>Role</th>
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<tbody>
<tr>
<td><strong>Karl Heinz Stappert</strong></td>
<td>TÜV, Germany (2006)</td>
<td>German expert involved in specification, procurement, implementation and operation monitoring of the heavy vehicle tolling systems in Germany and Austria and the M50 free-flow tolling scheme in Dublin/Ireland.</td>
</tr>
<tr>
<td><strong>Michael Leyendecker</strong></td>
<td>Vitronic, former Toll collect Germany (2006)</td>
<td>Involved in the German implementation of Toll Collect.</td>
</tr>
<tr>
<td><strong>Bob Tatchell and Grant Klein</strong></td>
<td>Road Pricing Framework Division Department for Transport, UK (2006)</td>
<td>Experience from the studies performed by DfT in UK during several decades.</td>
</tr>
<tr>
<td><strong>Ueli Balmer</strong></td>
<td>Deputy Head Transport Policy Section Federal Office for Spatial Development, Switzerland (2007)</td>
<td></td>
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<tr>
<td><strong>Mirka Ticivici and Uwe Leinberger</strong></td>
<td>Satellic, Germany (2007)</td>
<td></td>
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<tr>
<td><strong>Michael Blum</strong></td>
<td>Dornier Consulting, Germany (2007)</td>
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<tr>
<td><strong>Name</strong></td>
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<tr>
<td><strong>Christer Rydmell</strong></td>
<td>Swedish Road Administration, Sweden (2007)</td>
<td>SRA’s expert on RUC. Member of Comité Télépéage as well as the Stockholm Group. Representing SRA in the ARENA project.</td>
</tr>
<tr>
<td><strong>Andrew Pickford</strong></td>
<td>Transport Technology Consultants, UK (2007)</td>
<td>Long-term expert in the electronic fee collection field. Author of textbook covering most aspects of ETC (with Phil Blythe)</td>
</tr>
<tr>
<td><strong>Lars Källström</strong></td>
<td>BMT-ts (2007)</td>
<td>Long-term expert in the RUC field as well as the logistics sector. Highly experienced from EU research programs.</td>
</tr>
<tr>
<td><strong>Inge Vierth</strong></td>
<td>VTI 2007-11-21</td>
<td>Inge is expert on Internalisation of external effects.</td>
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**Referenced presentations**

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<th><strong>Name</strong></th>
<th><strong>Company/Position</strong></th>
<th><strong>Presentation</strong></th>
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<tr>
<td><strong>Paul For</strong></td>
<td>Siemens, Austria</td>
<td>Presentation at the ITS World Congress in London 2006</td>
</tr>
<tr>
<td><strong>TI Woodward</strong></td>
<td>Systems Engineering &amp; Assessment Ltd, UK</td>
<td>Presentation at the ITS World Congress in London 2006</td>
</tr>
</tbody>
</table>
Study Tour May 2007, presentations by:

- Jürgen Menge, Head of Advisory Department, Ministry of Road Safety, Highway Operation and Maintenance, Road Traffic Administration and Road Traffic Regulations
- Berhard Oehry, Rapp Consultants: Swiss Heavy Vehicles Fee (LSVA) – System Overview
- Ueli Balmer, Deputy Head of Department for Transport Policy, Federal Office for Spatial Development, Switzerland
- Heini Sommer, ECOPLAN

Berlin June 2007

- Mirka Tikvicki, Satellic
- Uwe Leinberger; Satellic
- Jochen Cieslak, Bundesministerium für Verkehr, Bau und Stadtentwicklung
- Siegfried Klar, Bundesamt für Güterverkehr, BAG
Appendix A: Questionnaire

The questions below were used as guidelines during the interviews, which however often took interesting turns and angels, revealing more knowledge that I had expected beforehand.

1. Who is responsible for the initiative and who is involved?
2. What are the driving forces?
3. Which users are being addressed?
4. What are the goals and the expected improvements?
5. Way of implementation?
6. Where could enablers be found, where could hurdles be found, which were the greatest barriers to a successful implementation?
7. How did roles, rules, legislation and obstacles affect the process?
8. How did the institutional factors enable or disable the implementation?
9. How was responsibility given and transferred over time?
10. Which actors had been involved in the implementation processes?
11. Were some actors missing?
12. Were there too many involved?
13. How did the actors act during the different phases of the process?
14. Were there any regional factors to take into consideration during the process?
15. Were there cultural barriers present?
16. Soft aspects of political and technical implementations such as the importance of dedicated persons capable of driving the process, rivalry and personal ambitions were also discussed during the interviews.