DESIRE

Designs for **I**nterurban **R**oad pricing schemes in**E**urope

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Work-package 6

Deliverable 6 Recommendations on IRPS for HGV

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EXECUTIVE SUMMARY

This is the final report of the DESIRE research project, dedicated to the identification of preferred Interurban Road Pricing Schemes (IRPS) for heavy goods vehicles (HGV) in Europe, which took place between September 2000 and February 2003. During this 30 month period, several political decisions have been made in various countries, in direct relation to the issues being treated in the project, thus clearly showing the relevance of the topic. Before this final report, five other reports have been delivered to the EC and made public, covering the analytical components of the project.

In this report we start by reviewing not only the diversity of tolling schemes in existence and in preparation, but also the diversity of political and economic objectives for the introduction of road charges in the various countries, and showing how the diversity of objectives justifies the different choices of tolling schemes. We then present the various technical solutions available, and identify the "natural" technology in relation with the basic form of tolling selected by any country. Then the reasons for Germany adopting a technology different from that "natural" option are discussed. This is followed by a chapter in which the situations of the various European countries are grouped into 3 clusters of identical situations with regard to application of road charges (plus one cluster where the issue is not under discussion).

Since some of the reasons for the diversity of choices may be temporary, the report then addresses the question of evolving from one basic form of tolling to another. Why, and how to change are discussed with a good level of detail for the three relevant evolutionary paths. In each of them, the arguments are presented with a structure of answers to the "most important questions".

Throughout the project it was acknowledged that the discussion and the political fight around road charges is largely made at national level, with little influence from what has been or is being done or discussed in other countries. However, it was considered that some attention should be dedicated to the European perspective on this issue. This is done considering two main dimensions: Directive 99/62 and its implications on the degrees of freedom available to EU member countries, as well as desirable improvements on a possible revision; and interoperability of the various Electronic Fee Collection (EFC) schemes across the European space.

The report concludes with a chapter of ***conclusions*** about the adoption of interurban road charges of HGV's and ***recommendations*** for action by national governments and by the European Union, which are reproduced next:

1 There is a considerable diversity of objectives and framework conditions surrounding the introduction of road tolls. Part of those objectives and conditions are dynamic, but others are rather stable, so there is and there will be for a long time legitimate reason for diversity of tolling strategies by national governments;

2 Prices are just one of the types of instruments in support of transport policy (the main others being supply [infrastructure and technology] and regulation [technical and economical]). In search for an optimal intervention on the transport system, governments should remember the availability of these three types of instruments. In parallel with some convergence on the regulatory front, the large differences existing with regard to supply make differences on the pricing front natural;

3 Just like companies in a market try to recur to different combinations of production factors to find their spaces of competitiveness, so do national governments recur to different combinations of those instruments to find situations where their transport systems may promote the competitiveness of their economies. This search has to be done in respect of some basic rules of the European Union, like the principle of territoriality and the promotion of the Internal Single Market and reduction of barriers to trade, of which free access to markets and a strong harmonisation of technical regulations are necessary supporting elements;

4 Identity of transport prices would make sense if countries were facing identical situations of density and sophistication of supply of transport infrastructure and services, and of density of demand, i.e. ultimately of identical situations of population density and purchasing power, which clearly is not the case in Europe;

5 Different tolling schemes, as well as the possible need to involve private financing of infrastructure, will lead to different recommendations regarding the institutional design, from all-public to all-private. However,

5.1 In all cases, it is recommended that ownership of transport infrastructure stays in public hands, as well as the decision to build it and to what standards;

5.2 In all cases, the State should ensure independent audit of the processes of revenue collection and application, as well as of the processes of handling customer complaints;

6 There are technological solutions available to allow comfortable and transparent application of EFC in the various tolling schemes studied. The choice of the most adequate technology depends not only on the basic form of tolling (NET vs. DAREA) but also:

6.1 For a NET scheme on whether tolling has been considered in the design of the motorways or not (retrofitting);

6.2 For a DAREA scheme, on the main objectives underlying the introduction of the tolls, and with them the need for variability of tariffs (i.e. time modulation of the tariff or higher tariff levels in more sensitive areas);

6.3 For any scheme, on the desired other functions to be developed on top of the tolling technology;

6.4 For any scheme, on the transaction costs and enforcement difficulties associated with the various technologies;

7 Diversity of national situations and strategies regarding application of the various instruments in support of their transport policies justify the diversity of tolling choices, but as some of the characteristics of national situations and the availability of resources change over time, it is normal that some countries would feel as adequate to evolve on their tolling choices. This has led to the decision to include in the project an analysis, not only about the circumstances in which tolls should be introduced, but also in which an existing tolling regime should be changed. In both cases, the analysis includes recommendations on how to manage those changes.

8 A complex set of mathematical models, combining traditional a transport network assignment model and a regional dynamics model has been used to estimate the economic and environmental impacts of the various tolling regimes. The main points coming out of that analysis are:

8.1 The introduction of road tolls (in either basic form) is expected to have very limited effects of modal shift, the stimulus of operating cost increases being translated specially into choice of alternative road corridors (if only some countries introduce road charges), as well as better commercial and logistic organisation. However, some reduction of trade and slowdown of economic growth should be expected due to higher transport costs;

8.2 When NET schemes are introduced in regions of high density and quality of road network, there is a considerably risk of traffic detour to secondary roads, with strong external costs to the populations living close to those roads;

8.3 In such cases a mixed NET / DAREA scheme might be considered a good solution, with DAREA being adopted only in the regions where the risk of traffic detour is significant, but this solution has considerable problems of acceptability for reasons of fairness;

8.4 If part of the revenues collected in a road charging scheme are used (directly or indirectly) to allow a reduction of indirect taxes, a positive welfare effect should be expected in the mid-term, but the above mentioned short term economic slump should not be ignored;

9 In all cases, introduction or change of tolling systems collides with long-term choices made by people and companies, located in the regions affected or having to cross them regularly. This implies:

9.1 That clear political objectives related to the introduction or change of the tolls have to be defined, and the comparison of tolls with other possible instruments to reach those objectives has to be carried out with great care;

9.2 That careful estimation of the impacts of the tolling scheme has to be carried out, and that engagement of stakeholders should be pursued in a systematic manner, so that acceptance issues may be managed in a sensible way;

9.3 That it is recognised that these processes always take several years to mature in public opinion and that the tough choices must be made in "political windows of opportunity" of relatively short duration;

9.4 In the light of these reflections, recommendations have also been produced on the justifiable scope of a possible revision of Directive 99/62, on application of road charges on roads of higher quality.

9.5 Expand the freedom of Member States to levy charges for heavy goods vehicles on the secondary road network, at least widening the exception rules. The setting of regulatory charges on the secondary network should also be allowed in cases where HGV traffic causes considerable problems for environment and for the inhabitants' quality of life.

9.6 Do not force Member States to price the usage of all inter-urban roads by goods vehicles;

9.7 Do not force member states to set road user charges to the full rate of average costs for motorway construction, maintenance and operation, and allow for setting lower charge levels. Average costs strongly increase when traffic volumes are low, creating severe problems in some peripheries of the EU, strongly affecting the competitiveness of these regions;

9.8 In NET charging schemes, allowing charges to exceed average infrastructure costs, e.g. by including environmental costs, would increase the problem of detour traffic and could bring an element of arbitrariness into play as the determination of the external costs of transport is much dependent on the methodology applied. For the sake of transparently defined charge levels and to maintain some instrument of control of road tolls in the EU, we recommend to keep the upper limit of HGV tolls on motorways to the average costs of constructing, maintaining and operating the road system as defined in the Directive, plus (in cases where all vehicles are tolled) a regulatory charge to manage traffic flow levels.

9.9 Application of high regulatory charges to fight congestion in densely populated areas may be considered as a barrier to trade, and requires some kind of positive discrimination in favour of long distance traffic crossing them.

10 Interoperability is an important element of convenience and efficiency for international hauliers, but the variety of starting conditions raises the costs of providing it across the board. Given that most hauliers are dedicated to domestic markets, and others are dedicated to specific foreign markets, interoperability should be provided "à la carte" as the market forces find it interesting. The same majority containment to domestic road networks applies to private cars.

11 However, there are possible important contributions from the EU in the short and medium term:

11.1 To impose open specifications for on-board units (OBU) in all countries;

11.2 To encourage convergence of standards in the GPS/GSM platform (as it has done for the DSRC platform);

11.3 To encourage convergence of vehicle classification.

1 Introduction

This is the final report of the DESIRE research project, dedicated to the identification of preferred Interurban Road Pricing Schemes (IRPS) for heavy goods vehicles (HGV) in Europe, which took place between September 2000 and February 2003. During this 30 month period, several political decisions have been made in various countries, in direct relation to the issues being treated in the project:

- Switzerland implemented its LSVA scheme, as of January 1st 2001, charging all heavy vehicles above 3.5 ton for each km on all roads in the country;

- The government of the Netherlands had decided to implement its *kilometerhefting* scheme, charging all vehicles in all roads, but then it fell and the successive government abandoned this purpose. That government also had a short life, and political developments since then suggest a gridlock around this issue;

- Austria and Germany decided and awarded contracts to implement road charges for HGV's above respectively 3.5 ton and 12 ton on all motorways;

- In Portugal, a total of 7 contracts were signed for construction and operation of a total of about 1000 km of motorways under a shadow toll regime applied to all vehicles. The new Government, installed in March 2002, has declared that it wants to apply the traditional scheme with real tolls on all (or most) motorways, for all vehicles;

- At the beginning of the project, the United Kingdom had stated that interurban road charges were a matter of no concern for the Government, but more recently has declared that this was being considered (no details have been announced).

In parallel, at the European level, the Commission launched the White Paper "European Transport Policy for 2010: Time to Decide", where infrastructure charging plays a central role and where for the first time it explicitly acknowledges the interest of cross-funding between infrastructures of different modes in the same corridor. This White Paper has recently had (December 2002) a resolution issued by the European Parliament where it supports charging for infrastructure use and promotion of interoperability, but with some disagreements with the positions expressed in the White Paper (namely with cross-funding). The European Commission has also been working towards presentation of two directives, one on Infrastructure Charging and another on Interoperability of Electronic Fee Collection.

This short list of recent events clearly shows that DESIRE deals with a subject of great current relevance, on which different countries are exercising different options.

This report has the objectives of presenting a set of "best" design schemes for interurban road pricing of heavy goods vehicles, and analysing the main factors that affect their implementation success. To do this, we start (chapter 2) by presenting the reasons and circumstances that justify the current diversity, as well as the main features of the schemes being adopted, followed (chapter 3) by presentation of the main technological options being considered or applied for interurban road pricing. Chapter 4 is dedicated to a structured presentation of the current options in various European countries.

Although we recognise that there may be a considerable inertia of the road pricing scheme adopted in any given country (especially if there are long term contracts attached), we have considered that there are at least two types of factors that may well force some evolution of current schemes:

- an evolution of the traffic, environmental or financial situation of the country concerned;
- an increasing importance given to the issue of interoperability of charging systems between different countries.

So, recognising the existence of current pricing schemes as a rather stable reality affecting almost one dozen European countries, it was decided that it would be more important to study and present recommendations on why, when and how current schemes should evolve than just to analyse them and present a critical appraisal.

The analytical part of the work in relation to the evolution paths has been presented in Deliverable 5: "Identification of Best Functional Schemes and Implementation Issues". There it has been possible to group the various national situations in 3 clusters, based on the key attributes of their current situation. The analysis of economic impacts of the introduction of road charges for HGV's (in several scenarios) has been developed and presented in Deliverable 4: "Impact Analysis and Assessment".

Since this report is dedicated to the presentation of conclusions and recommendations of the project, a different style was chosen: for each of the 3 typical situations, we go through a list of "Most Important Questions", related to the justification, opportunity and desirable direction of possible changes in the direction of greater complexity and finer focusing of charges. Chapter 5 is dedicated to the sequential presentation of these questions and respective answers. To facilitate selective reading, directly targeted to the interests of a specific case, when the arguments are identical in different sections, it was decided to repeat small blocks of text instead of pointing the reader to their earlier insertions.

Although the leading forces that are shaping road charging systems are at the national level, there are important elements that must be considered at European level: there is a clear case for a long-term perspective of a transport system that allows fair competition between regions, without discrimination between modes, and avoiding the presence of barriers to the Internal Single market. Chapter 6 is dedicated to the presentation and discussion of

several issues for which this European perspective is especially important. Finally, chapter 7 presents conclusions on these issues and recommendations for the process of implementation of these road charges.

2 DIVERSITY OF REASONS, DIVERSITY OF SOLUTIONS

2.1 Objectives of Road charges

If we want to have a thorough understanding of possible solutions to introduce interurban road pricing for HGVs, we have to understand the objectives that underlie its creation and the functions it is supposed to perform. The following list summarises the set of objectives that have been put forward as justifying the introduction of road tolls:

- **Financing a transport network upgrading or expansion program:** The revenues from tolls can be directed to support transport *network expansion* programmes or maintenance. In addition, some countries introduced tolls with a *regional equity* objective, the tolls being used to support transport infrastructure programmes in less developed regions. The toll revenue provides a source of revenue, not tied to the annual Government budget, which can be particularly important for raising *debt-finance* outside the national accounts. Toll revenues can be a source of finance for *public budget relief* as well, particularly where roads are supported by Government budget and where there are pressures to reduce taxes. Further objectives in this context may be the *development of the private sector* within the economy and the improvement of the *financial performance* in general.

- With a similar approach but of more limited scale, **financing traffic-dependent road maintenance (and possibly also local upgrades)** can also be a relevant objective associated to the introduction of road tolls. This is particularly aligned with a policy of charging users for the short-term marginal cost they impose on the road.

- **Management of traffic flows and quality of service:** Introduction of tolls can also be done in order to provide quality of service to the user, which includes fighting *congestion*, and with the more general aim of easing road conditions or even *containment of demand growth*.

- **Internalising external effects of transport:** At the EU level, pricing policy in the transport sector plays an increasingly important role. Correspondingly, the EU "Green Paper" on fair and efficient prices (EU 1995) propagates the pan-European internalisation of external costs in terms of air pollution, noise, congestion, accidents and impacts on human health. The subsequent work of the "High Level Group on Infrastructure Charging" was the basis for the White Paper on "Fair Payment of Infrastructure Use" (EU 1998). The White Paper stresses the idea of social marginal cost pricing and proposes as a first step that transport infrastructure users should cover the infrastructure costs they actually cause. This should encourage a more efficient use of the road network, thus helping to relieve traffic congestion. In its second report the High Level Group was concerned extensively with the procedure and methodology of estimating the pricing relevant cost.

- **Fair competition among transport modes:** From the point of view of the user pays principle every mode should cover its cost, e.g. road transport should cover the cost of road infrastructure use. For implementing the user pays principle an (highly differentiated) IRPS would be a good instrument to charge the specific costs caused by individual road use. The alternative is to postulate that transport should cover the cost of the transport sector (road, rail, waterways) as a whole. In this case, subsidies from one mode (e.g. road) to the other (e.g. rail) are possible.

2.2 Different Schemes

One or more of these objectives will be present and influence the choices made about price incidence and variability. The main choices in this domain are:

a) Who pays (HGV vs. all vehicles)?

b) On what roads (Motorways vs. all roads in a dense region vs. all roads in the country)?

c) Distance related vs. Time permit (vignette)

d) Price variability across fleet (segmentation by dimensions / weight vs. segmentation by dimensions / weight and emissions – including noise)

e) Price Variability across time (fixed vs. depending on traffic intensity - increase at peak periods and decrease at off peak periods)

f) Price variability across space (fixed vs. depending on environmental sensitivity of regions)

Although for each objective it would be relatively simple to identify the preferred set of choices in all these dimensions, in the real world there are frequently multiple objectives present when the principle of imposing road charges is adopted. Among the very great number of combinations of these decision variables, one will be selected according to the ranking of objectives, but considering as well (at least) the issues of public acceptability and transaction costs.

Still, in face of the multiplicity of objectives, one must not forget that there are various other instruments to apply the desired policies, and that it would certainly be ineffective and inefficient to rely on road charges alone to pursue all those objectives. So, obviously, the best choices for road charges in a given country will also depend on how the other instruments are being deployed.

The following table tries to relate the various objectives with the choices in each of these dimensions. Its indications must be read with some caution, given not only the potential presence of other policy instruments but also the fact that the pricing variables themselves are not independent of each other.

	Who pays		On what roads			HGV Vehicle Differentiation		Time Variation		Space Variation	
	HGV's	All veh.	Motorways only	All roads in dense regions	All roads in whole country	Dimension	Dimension + Emissions	Fixed price	Higher Price at peaks	Fixed price	Higher price at sensitive regions
Financing a transport network upgrading or expansion program	+	++	++	-	+	++	-	+	-	+	-
Covering traffic-related maintenance costs	++	-	+	-	+	++	-	+	-	+	-
Management of traffic flows	-	++	++	++	-	+	-	-	++	+	-
Internalising external effects of transport	+	++	-	++	++	+	++	+	++	+	++
Fair competition among transport modes	++	+	+	-	+	+	++	+	++	+	++

Table 1 - Cross-Analysis of Tolling Objectives and Forms

In this table the signs indicate adequacy of tolling options (columns) to policy objectives (rows). A "-" sign indicates that the option in question is inadequate or unjustifiable to aim at that objective, while a "+" sign indicates that, while not being the best choice, it can be justified, especially in the presence of multiple objectives. Naturally, a "+ +" sign indicates the best adequacy between tolling option and policy objective. For all objectives there is at least one combination of options with only positive signs.

In order to define the basic forms of IRPS we first differentiate between the following two classes:

- Distance related schemes;
- Access and/or dwell time related schemes.

Retaining only those relevant for interurban transport, we have:

NET – Distance-dependent network pricing is based on the kilometres driven on a net of interrelated motorways of the same hierarchy-level. The system-layout of network tolling can differ between open, closed and half-open systems. Tolls are at least differentiated according to vehicle classes.

DAREA – Distance-dependent area pricing is based on the amount of kilometres driven within the area limited by a certain perimeter. The fee is levied according to a kilometre charging concept, where the fee is proportional to the distance driven on all roads and at least differentiated according to vehicle classes.

PERM – Driving permit (area licensing): the charge is levied for the permit to drive within a certain perimeter and is differentiated according to vehicle classes.

In the two first forms, prices are dependent on the distance run by the vehicle in the road system under pricing, and thus constitute the main focus of our work. However, PERM is important because it is the currently implemented form in several countries through the Eurovignette scheme.

In the following chapters, the basic forms are defined on the basis of the set of roads subject to tolling, the remaining tolling options (which vehicles pay, vehicle differentiation, space and time variation) being treated as second order options. This is done simply for greater ease of presentation and also because the focus of DESIRE

is tolling for HGV's. But of course, the issue of private cars having to pay or not is a central part of the discussion on pursuit of some of the policy objectives and on acceptability of pricing measures.

3 TECHNICAL OPTIONS

The technical solutions found relevant for the DESIRE project are road side based (typically based on DSRC technology) and vehicle based autonomous systems (typically based on GPS). Both technical solutions may be applied to either of the basic forms (NET and DAREA), as shown in Table 2.

	DAREA	NET
Roadside based – dual system	**Equipped users:** DSRC – roadside equipment, on board unit, records the kilometres driven with an electronic connection to the tachograph, GPS for control functions. **Non-equipped users:** Check-in **and** Check-out before and after using service, in particular to declare the kilometre reading when entering and leaving the area.	**Equipped users:** Corresponds to the existing procedures at many of today's toll plazas: non-equipped users have to stop; equipped users have a simple on board unit and are charged on the basis of DSRC – roadside equipment. **Non-equipped users**: Check-in before **or** after using service.
Vehicle based, autonomous system	**Equipped users:** GPS / GNSS, cellular network, DSRC for enforcement; the solution may be supplemented with additional features (matching GPS with on board digital map, dynamic tariff modulation on the basis of DSRC or radio data system / digital audio broadcasting), **Non-equipped users:** Check-in **and** Check-out before and after using service.	**Equipped users:** Comparable to the DAREA vehicle based solution, distance covered may be determined by matching GPS information with a distance matrix. **Non-equipped users:** Manned and non-manned registration of vehicle when entering and leaving the network.

Table 2 - Technical options for electronic fee collection systems

3.1 The 'normal' choice of technology with respect to the basic form

In traditional tolling systems (in the NET basic form), manual fee collection imposed construction of toll plazas, which could be easily used for Electronic Fee Collection (EFC), by having one or more lanes fitted with DSRC equipment and exclusively dedicated to equipped vehicles paying electronically. This has been the evolutionary path taken by all countries with a tolling tradition.

When introducing road tolls after the motorways have been built, the decision on whether to admit (and charge) non-equipped vehicles on those motorways is critical: fee collection from non-equipped vehicles imposes stopping them and thus the construction of toll plazas to serve as a buffer for the accumulation of vehicles, which imposes huge costs and even problems of land availability. On the other hand, if all vehicles are equipped, charging with DSRC systems can easily be done in motion, through gantries either at all entry and exit points, or across the full section of the motorway.

The decision to accept only equipped vehicles on motorway network is not only political, but also based on practical questions:

- In the political dimension, when tolls are applied only to HGV's, acceptance of this constraint should be easy, as this deals exclusively with professional drivers and activities, but this would be a more delicate issue if applied also to private cars, as it may be considered abusive;

- In the practical dimension, if an occasional visitor of a country has to endure a significant cost and loss of time to equip his vehicle and be admitted to its motorway network, this may be considered an unfriendly gesture to those foreign visitors, and even an unacceptable limitation of the freedom of movement in the European Union geographical space.

The decision in Austria has been to impose tolls only on HGV's and accept only equipped vehicles. The adoption of DSRC solutions makes this constraint of easy and cheap implementation, as the on-board unit (OBU) has a rather low cost and an almost instantaneous installation (gluing a small box to the windshield).

The alternative of accepting non-equipped vehicles and not charging them had been the option of the Dutch government, but only for foreign vehicles, as the equipment was to be compulsory for all vehicles registered in the Netherlands (a reduction of purchase and registration taxes was foreseen to ensure fiscal neutrality to Dutch citizens and companies, as well as to avoid the incentive to register one's car in a foreign neighbour country in order to avoid the road charges).

When the basic form of road charging selected is DAREA, the "normal" technological choice is related to the objectives underlying the decision of introducing road charges:

- if the main objective is, like in the Swiss case, to finance expansion of the transport network (railway tunnels in this case), differentiation of the tariff levels is not critical and a relatively simple technology will suffice: a DSRC component to switch the billing system on or off at the perimeter line, plus an OBU connected to the odometer or tachograph, to keep count of the number of kilometres driven to the interior of the perimeter line. In the Swiss case, the perimeter is the national border, with a relatively small number of entry and exit points.

- if the main objective is fighting congestion or internalisation of external environmental costs, differentiation of tariff levels across time and space is essential. In theory this could still be done through DSRC based systems, with several cordon lines defining areas of special environmental sensitiveness or of recurrent congestion, and the road based equipment emitting signals not only of on or off switching but informing of the currently active price level in the area being entered. But the number of transition points and corresponding equipment needs would easily make such a solution more costly than a vehicle based one, with connection to the satellite system for precise location and cellular telephony as the support for the transmission of currently active tariff levels and the actual billing. So, if these are the relevant objectives underlying a DAREA

tolling scheme, a vehicle based solution should be considered as the “normal” technological choice, even if there is much less experience with such systems than with DSRC based ones.

3.2 Reasons for choosing other technological solutions (the German case)

Until recently, choice of technologies for road tolling in all countries had followed the “normal" path. However, Germany decided to adopt a NET basic form, tolling HGV’s only (at least in the near future) but opted for a GPS/GSM technology, allowing non equipped vehicles into the motorway network and devising a rather complex and costly control and enforcement system to prevent (high levels of) free riding.

Since the initial conditions and basic tolling form decision has been the same as for Austria, and the costs of this system are much higher than those of the DSRC system chosen there, both in investment on OBU’s and in transactions, we believe the reasons for such a choice should be sought.

Just like there is considerable diversity of national objectives that justify the introduction of road tolling, there can also be a diversity of objectives to pursue downstream of road tolling. Whereas the first type of diversity leads to different basic forms of tolling, the second may lead to diverse tolling technologies, because those different technologies will allow different collateral services to be deployed in better or worse conditions.

Both levels of diversity are respectable, but the second level has more critical implications on interoperability of tolling schemes across the European scene, at least in its current stage.

When Germany, in spite of having chosen a NET scheme, decided to adopt a vehicle autonomous technology, based on GPS / GSM, all vehicles equipped for the remaining countries are non-equipped in Germany, and consequently have to face the additional costs of stopping and declaring the parts of the motorway network travelled. Alternatively, these vehicles may be equipped with the German OBU, but this will not be a simple mounting like those of the typical DSRC unit, just glued to the windshield. Besides the cost of the OBU for the haulier (it might be given free by the concessionaire), there will be some loss of time and add some clutter on the cabin front space. On top of it, the German system has closed specifications and a monopoly supplier of the OBU, thus making it more expensive than it could be under open specifications.

The reason for the choice has been made explicit recently by the German government, as it declared that this was so because it believed that added value functions could and should be added to the basic road charging to make road transport more efficient, and that it wanted German companies to be at the forefront of such developments. But it should be recognised that, even if the system adopted in Germany is more powerful for development of future applications, these are all externalities imposed on foreign hauliers by the German choice of technology.

3.3 Questions of interoperability

What is interoperability of EFC? Different EFC systems are fully interoperable if the user of one EFC system can access a tolled road of another EFC system without being treated as a non-equipped user (no manual payment, pre-registration, etc.) and if he is charged for the trip by his domestic operator. In general, systems are fully interoperable when harmonisation in three aspects is achieved: (a) technical, (b) procedural and (c) contractual.

Why is interoperability important? It is important that EFC systems are interoperable across national borders in order to avoid creating new obstacles to traffic flows in Europe, in accordance with the Single Market provisions of the Treaty. Analyses show that many stakeholders benefit from interoperability: road users' are interested in easy passage on all roads throughout Europe without artificial barriers. The operators of roads are interested in an increasing share of 'equipped' users thanks to interoperability, as equipped users have lower transaction costs than non-equipped ones. Finally, manufacturers are economically interested in mass production of OBU's and other technical equipment, which makes their markets bigger. But road users who rarely drive outside their own country could be less than willing to pay much more for their OBU just to allow easier payment of tolls in the occasional trip abroad.

Why is interoperability so difficult to reach? The existing IRPS have been introduced by different countries and operators and for different political purposes. Compatibility with other tolling systems was in most cases a less important feature. Huge investments have already been made by the operators to set up their EFC systems. Interoperability with other operators would very often require new investments in the first place. But as shown above, even for newly designed IRPS, there is no "one and only" technical approach. Besides technical questions, interoperability also concerns issues like procedural and contractual harmonisation of schemes. These issues are even more challenging nowadays than technical harmonisation.

Can a country that introduces a DSRC (roadside based) solution ensure interoperability with other schemes? Basically yes. Technical interoperability with other DSRC solutions can be reached by sticking to international (pre-)standards with respect to specification, e.g. CEN TC278 for DSRC 5.8 GHz. Procedural interoperability - one important point here being the classification of vehicles - is also theoretically solved. The procedures have been defined by CARDME[1]/CESARE and are ready for implementation. E.g. the new Austrian solution is based on the CARDME specifications and will therefore be interoperable with other CARDME-applications. The aspect of contractual interoperability is being treated at the moment within the EU-co-funded project PISTA (Pilot on Interoperable Systems for Tolling Applications)[2]. This project intends to actually implement an interoperable Electronic Fee Collection (IO-EFC) throughout a corridor belonging to several European motorway networks. But basically, it is within the responsibility and scope of each operator to ensure contractual interoperability through negotiations and contracts with other operators.

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1 www.cardme.co.uk.

2 www.pistaproject.com

Drivers equipped with a 'simple' OBU for DSRC will be treated as non-equipped on all roads that are tolled exclusively by means of a GPS/GSM solution. There is no room for interoperability in this direction.

Can a country that introduces a GPS/GSM (autonomous) solution ensure interoperability with other schemes? No, not yet. Up to now, there are no autonomous solutions for EFC in operation. Germany will be the first country to rely fully on this technology for the purpose of HGV tolling on motorways. But if, in the future, several autonomous solutions will co-exist in Europe, their technical interoperability should be possible. The same holds for technical interoperability of GPS/GSM-equipment on DSRC-tolled roads. However, full interoperability also requires procedural and contractual interoperability. First attempts have been made to develop a standardisation of procedural aspects, but as there are no real-world experiences, these attempts have not produced very tangible results. With respect to contractual interoperability, no action has been taken so far.

For the GPS/GSM technology, no analogous action to CARDME/CESARE has been launched by now. However, ERTICO (a Europe-wide, not-for-profit, public/private partnership for the implementation of Intelligent Transport Systems and Services) intends to carry out an integrated FP6 project on road charging interoperability (RCI)[3]. The vision of RCI is to establish an open system architecture for road charging systems which will incorporate DSCR based and GPS/GSM based technical building blocks.

What have non-equipped users to do with interoperability? For a specific EFC system, a user with a technically or contractually non-interoperable payment equipment is like a user that is non-equipped at all. Both categories of users are weakening an EFC system because non-equipped or non-interoperable users reduce the cost-effectiveness of an IRPS that is based on a EFC system due to special payment procedures and/or reduced ability to enforcement.

Can non-equipped users be banned from an electronically priced road? Possibly yes, but with several difficulties. It is possible to make the installation of an OBU mandatory for domestic vehicles in one country (e.g. Switzerland). Even mandatory equipment for all users (including foreigners) is possible, as the example of Austria will demonstrate. Mandatory equipment will not face substantial resistance if the OBU's are given to the hauliers free of charge or at a very low price, and installation is quick and easy. However, if an internationally operating heavy vehicle needs to install different equipment for a multitude of European EFC, the problem of non-interoperability is not solved, but passed on to the hauliers. This development underlines the importance to improve interoperability between existing and newly developed EFC systems in Europe as a means of reducing the number of non-equipped users. Should a pan-European EFC system be introduced, mandatory equipment of vehicles would certainly make sense.

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3 www.ertico.com

The discussion takes a different dimension if tolling is to be applied to all vehicles. Through EFC, detection and location of private cars (almost coincident with individual persons) is made, which can raise questions about invasion of privacy rights. However, this can be avoided by recourse to OBU's with anonymous debit card systems.

But the legal question of imposing adherence to an EFC system (personalised or anonymous) as a condition to use the motorways or roads in a certain region or country should still be addressed.

An easy and reasonably reliable technical solution for non-equipped users seems to be available: video capture of licence plates, followed by automatic character recognition and direct billing to the vehicle owner. There are serious difficulties in general application of such a scheme: not only some licence plates will be dirty or deteriorated (and thus unreadable), but there is presently not enough cooperation between national authorities to allow direct access by entities (even official entities, let alone private concessionaires) of one country to the national car registries of another. So, foreign vehicles would be uncharged, and that element is sometimes central in support of fairness arguments and to improve acceptability.

Another hard question is that of financing the equipment for all users: if this is passed to the vehicle owners, many will complain; if this is subsidised by motorway concessionaires, it can be quite expensive given the volume of the subsidised set.

Should 'roaming' charges be allowed? Roaming charges in EFC systems are surcharges added to the actual cost for using a 'foreign' tolled road network with an interoperable OBU (very similar to what we know from mobile telephone services). Since users with a foreign OBU cause higher costs to the operator, the latter could want to claim a roaming charge. However, the idea of the Single Market based upon non-discrimination of foreign HGVs does not allow to charge foreign vehicles higher than domestic ones. Roaming surcharges in road pricing thus seem unacceptable within the EU. An identical agreement has been reached in 2002 concerning use of ATM machines within the EU by bank account holders in a EU country other than that where the machine is installed. But for GSM phones, substantial roaming charges are applied and have been subject to frequent complaints by user groups.

4 CURRENT POSITIONS OF THE VARIOUS EUROPEAN COUNTRIES

Based on the survey work done in DESIRE, it has been possible to group the current situation of the countries studied in the project in three sets of similar characteristics with respect to the tolling scheme adopted for HGV's. This clustering is presented in the following table in the column "Present":

Countries with a motorway tolling culture (France, Hungary, Portugal, Brazil)		
Element of IRPS	**Present**	**Future**
Basic Form (F)	NET	NET, DAREA
Technical Solution (T)	Roadside based	Extend to vehicle based autonomous system, Fulfil/achieve international standards, Roaming
Institutional Solution (I)	Mixed	Mixed, All Private
Pricing Principles (P)	Flat rate	Differentiation (time, emissions), Higher tariffs in sensitive areas
Countries with DAREA already introduced (Switzerland)		
Element of IRPS	**Present**	**Future**
Basic Form (F)	DAREA	DAREA
Technical Solution (T)	Roadside based	Extend to vehicles equipped with autonomous onboard unit (OBU), Extend to vehicle based autonomous system, Roaming
Institutional Solution (I)	All Public	All Public, Mixed
Pricing Principles (P)	Flat rate, emission differentiated	Higher tariffs in sensitive areas
'Mature' countries shortly before introduction of IRPS (Austria, Germany, the Netherlands)		
Element of IRPS	**Present**	**Future**
Basic Form (F)	PERM	DAREA, NET
Technical Solution (T)	Vehicle based (Vignette)	Extend to vehicle based autonomous system, Fulfil/achieve international standards, Roaming
Institutional Solution (I)	Public, Mixed	Mixed, All Private
Pricing Principles (P)	Flat rate, emission differentiated	Higher tariffs in sensitive areas

Table 3: Three basic IRPS and their evolutionary paths

Here, each type of scheme is described on the basis of the basic form, technical solution, institutional solution and pricing principles. The technological choices and their implications were treated in chapter 3.

The first group in table 3 is composed of the countries with traditional forms of tolling on the motorway network (NET), incident on all motor vehicles. Such tolls have been levied for several decades in most cases, and had financing of the construction of those motorway networks as the main (or even sole) objective.

The second group is formed by Switzerland alone, where only HGV's are charged, but the charge is applied on all roads (DAREA). The objectives behind this scheme were financing of road maintenance and of construction of rail tunnels, as well as internalisation of external costs.

The third group is formed by countries which do not yet have tolls in operation, but have long discussions on this issue behind them. Although the starting point was the same (PERM), the solutions adopted have not been the same, with Austria and Germany opting for a NET scheme and Holland having opted for (but then abandoned) a DAREA scheme. Naturally the objectives were also different in these countries, with financing of motorway maintenance the dominant one in the first two and fighting congestion the dominant in the third.

A fourth group could be added, for the countries where tolling is either non-existent or made through PERM, but in a premature state of public discussion about the introduction of distance based tolls.

We see DAREA as the most complex scheme, but NET as the most traditional and more easily justified in association with dedicated funding. But in several countries with a NET scheme there are already some situations, and there will be many more in the future, of systematic congestion on some motorway stretches. In such cases, fighting recurrent congestion on the motorway becomes a new objective, for which variable prices are the most natural instrument. As long as congestion is restricted to a relatively brief period each day, such variation may be an effective instrument, but as its presence widens across longer periods of the day, only higher toll levels, possibly accompanied by improved supply of alternative motorways or alternative modes, will allow progression towards solutions of better quality.

In all cases, it is conceivable that significant numbers of vehicles will prefer to use the same corridor as before, but divert their path to free access roads "parallel" to the tolled motorway. This detour traffic has several significant negative side-effects: much higher deterioration and maintenance costs on those free access roads, higher safety costs, and higher external costs.

If tolls are also applied on "normal" roads, the level of detour traffic can be managed, which is the reason why it was considered that, irrespective of starting position, all countries may in the future have to adopt a DAREA tolling scheme, at least in some of their regions. This does not mean that we believe or recommend that all countries adapt their strategies as if this scheme was necessarily their inevitable final scheme, but simply that we accept that it may be justifiable to adopt it to improve quality of road service. That is the reason why in all three country groups, the rightmost column, relative to a likely situation some time in the future, always includes the DAREA scheme.

An important question is whether a country with significant risks of detour traffic in only a small part of its territory should adopt a DAREA tolling scheme in all of its regions or only in the area affected by this problem. Although at first thought the answer could seem to be positive, things are not so simple: the introduction of a DAREA road charging scheme can be (as was foreseen in Holland) accompanied by changes in taxes applied to the purchase and circulation rights of motor vehicles, so that some compensation is achieved. Since vehicles schemes are defined nationally, application of regional DAREA tolling must be seen as a complex exercise in political negotiations, even if it would make much sense from a purely technical point of view.

Reasons For Diversity

Besides the multiplicity of objectives associated to the application of road charges in the various countries, there are also diverse framework conditions of this issue. For instance, the views on this issue change depending on whether a country is or is not a transit country, which leads to different degrees of maintenance costs of national roads and motorways attributed to the presence of foreign trucks. The same can be said in relation to the density of roads heavily used by trucks in the neighbourhood of residences, and the corresponding public pressure to transfer freight from road to rail.

In the opposite sense (i.e. against generic application of tolls) arguments are often heard related to the promotion of the Single European Internal market, and especially to the higher economic fragility of peripheral regions if the variable costs of transport are to increase.

Other examples can easily be found of physical and geographical factors that change the perspective of the tolling issues by those who are affected by those factors, in either direction.

But certainly another critical factor justifying diversity of tolling preferences is the diversity of fiscal regimes of motor vehicles in the EU. Naturally, all owners and operators of these vehicles consider the totality of the costs affecting their vehicles, and the question of road tolls cannot be fully separated from the other costs associated to ownership and operation of the HGV's in the various countries.

So, even if the economic rationale for imposing road charges to its users, especially those who cause most maintenance costs, is rather uniformly applicable, there are multiple "biasing" factors that have to be considered when analysing past and present national practices with respect to those charges. Some of those factors may be relatively temporary, like the state of public finances, but others like proximity between roads and residences and geographical location at the continental scale are very hard or even impossible to change, and so will be some of the arguments towards the existence of diverse tolling regimes in the various European countries.

We must however keep in mind that circumstances may change within single countries, namely in what regards traffic density, capacity of public budget to meet significant investment needs, or even public pressure towards environmental preservation. When such changes occur in any country, it should be expected that the tolling regime in that country is questioned, and forces to change it are enacted. So, while recognising the current diversity of tolling regimes as natural, we stress that national positions are likely to evolve, not necessarily all in the same direction.

5 EVOLUTIONARY PATHS

This chapter describes how to progress along evolutionary paths towards a more complex IRPS moving from the different overall national starting situations. The existence of different situations regarding road pricing schemes has been recognised as normal, given the facts that there may be different reasons and objectives for the application of the pricing instrument, as well as the availability of other policy instruments. But since some of those reasons for application of pricing are not permanent, so the basic form of road pricing may change.

Initially a country planning to introduce its first IRPS or to develop an existing system should identify its current position with regard to IRPS (see Figure 1). The two initial situations could be - apart from Switzerland who already has DAREA - a country with no IRPS introduced or a country with a NET-system.

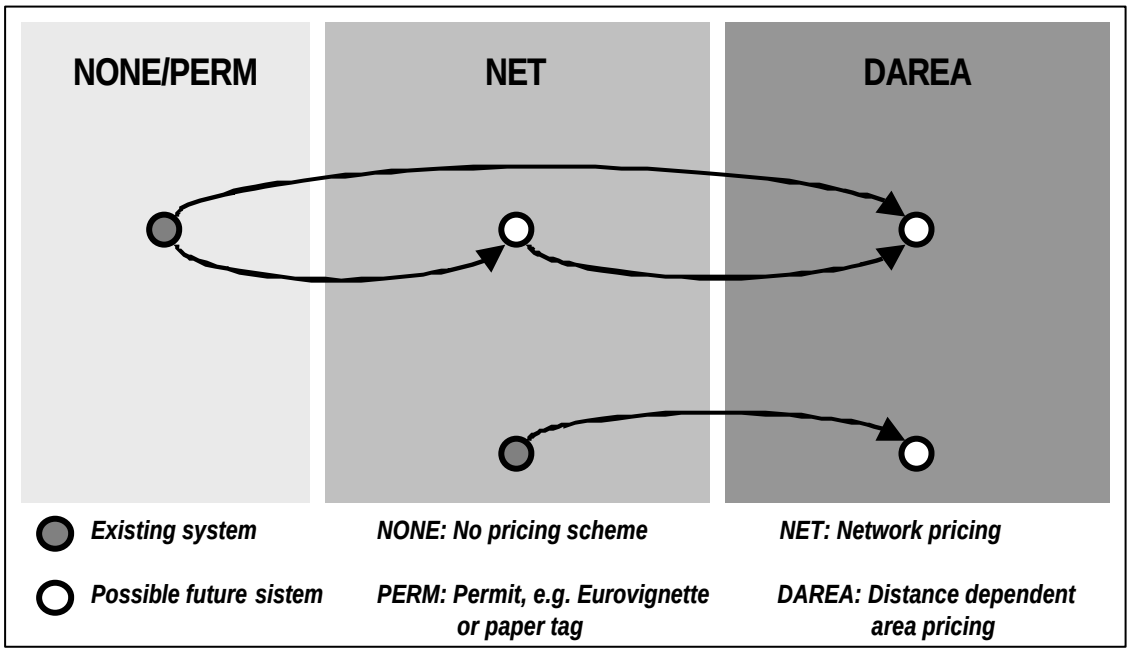


Figure 1 - Illustration of possible evolutionary paths to more complex schemes

Some of the countries with no IRPS are charging the usage of roads through a driving permit system. Examples are the Eurovignette system (BENELUX, Germany, Denmark and Sweden) or paper tags. Other countries have no specific charges for interurban road use at all as e.g. the UK. As shown in Figure 1 these countries could choose either to evolve to a NET system or a DAREA system, the latter either directly or via a NET system.

To decide on a migration path the purpose of introducing IRPS must be identified. For countries planning to introduce IRPS to finance road infrastructure and in some cases to handle congestion on specific sections a NET system could be selected, especially if the possibility for detour traffic is limited. In this case section 5.2 describes how to move along the evolutionary path.

Countries with a dense road network with many possibilities for detour traffic or countries where the objective of introducing IRPS is traffic management e.g. to reduce environmental impact, fight congestion or internalise the marginal social cost should implement a DAREA system. How to move along the evolutionary path to a DAREA system is described in section 5.3.

Countries with a NET-system are already charging the use of highways using traditional tolling. This is seen mainly in Southern Europe. How to move along the evolutionary path to the more complex DAREA system is described in section 5.4.

For each of the group of countries there are several issues when moving towards a more complex IRPS. A suggestion on how to bridge the gap between the present and future system is covered below for each evolutionary path for the following issues:

- What circumstances would warrant an evolution to the desired system?
- What is the economic impact?
- What are the institutional aspects and contractual issues?
- What pricing structure should be applied?
- How is acceptability promoted?
- How is interoperability favoured?
- Who should finance installation?

5.1 Managing Acceptability of Road Pricing (Introduction or Change of the Basic Form)

Although there are some acceptability issues that are specific of the change of the basic form of road pricing, most issues are rather general and must be faced and managed whatever the change that is being prepared. This occurs because transport is a basic component of the overall activity in our societies, directly involving a relatively small part of the economic agents, but indirectly affecting us all. So, whenever any of the basic conditions for the exercise of the transport activity are about to change, the prevailing balances are put in question (but that's the reason of the change) and some agents will fear the consequences, possibly amplifying their scale. Naturally, pricing rules and levels are one of the most important conditions in the exercise of any activity. An increase of transport prices is felt by many companies as corresponding to a loss of competitive access to some markets.

Fear is easy to propagate and, unless the reasons for change and solid and trustworthy estimates of the impacts, are clear to many people, gridlock in the decision process is a likely outcome.

So, a lot of work has to be done in the preparation of the changes and in the management of acceptability by the relevant stakeholders. This section presents the main results of our work in this direction. Then, each of the subsequent sections adds a short note on acceptability, with points that are specific to the evolution being dealt with in that section.

The main aspects related to acceptability of distance related road charges for HGV's are:

- The main reason why people oppose introduction (or generalisation) of pricing measures is lack of evidence (for them) that the added price they have to pay will be an effective instrument in solving the problems which are used as the justification for the application of these measures. Hypothecation of revenues is seen as a necessary condition (but maybe not sufficient) to increase this effectiveness, as it should allow investment in additional infrastructure, for instance through the instrument of a road (or more generally a transport infrastructure) fund.

- On a similar standing are concerns about collateral effects, namely that competitiveness of local industry will be hampered by the loss of some more distant markets to which access will become so much more expensive.

- Only as a second concern come matters of fairness, related to the distribution of the burden.

If also the case of introduction of tolls on private cars is considered, a similar, possibly more acute difficulty arises. Lifestyles and location of residence and work are all affected by the assumption of a certain pattern of costs for motorised mobility, which to many people is equivalent to mobility by private car. Significant changes in this dimension entail loss of convenience and value attached to those structural decisions, and thus a feeling of betrayal by Government, who made unannounced changes in such a sensitive domain.

What are the main aspects of IRPS?

The main themes on acceptability are related to the topics on:

- pricing purposes (for promoters; haulage companies; third parties and tax payers);

- technical aspects (for haulage companies; shipping industry and business);

- harmonisation (for haulage companies; shipping industry and business); and

- revenue spending (for haulage companies and third party, e.g. citizens directly exposed to negative impacts.

Pricing purposes

The level of acceptability varies with respect to the justification of pricing, the intended aims and the expected impacts. Acceptability will be influenced by the answers to questions like:

- What is/ are the main aims of IRPS?
- How are (these) measures justified?
- How can we be sure they will work (i.e. achieve the objectives)?

Technical aspects

Technical aspects with respect to IRPS influence acceptability depending on answers given to the following question:

- What are the transaction costs caused by IRP/HGV system (for haulage companies)?
- How sure can users be that they are not charged excessively?

Harmonisation

Harmonisation aspects with respect to IRPS influence acceptability depending on answers given to the following question:

- Is the proposed IRP/HGV a first-mover or is an EU wide introduction with corresponding pricing principles imminent?

Revenue spending

A crucial issue with respect to the acceptability of the IRPS design is what the revenues are spent for. The use of revenues generated by an IRPS influence its acceptability depending on the answers to the following questions:

- For what purposes will IRP/HGV revenues be spent?
- What kind of advantages can those subject to the charges, the economy as a whole, and also other specific actors expect to get from the IRPS in order to compensate for the extra charges?

What are the main acceptability barriers to decision-making?

In principle, these are financial, technical and institutional constraints. These constraints/ limitations can be divided into:

- Physical problems (e.g. availability of space);
- Legislative – regulative;
- Administrative;
- Political practice;
- Procedural problems (handling of non–equipped users and enforcement, free rider problem);
- Technical problems (vehicle classification and installation of OB equipment, ease of use and resistance to tampering);
- Legal problems (data protection, data security, protection of privacy);
- Financial problems (cost of equipment, of roadside infrastructure);
- General acceptance problems.

Specific acceptance problems:

Social acceptance plays a vital role in the feasibility of a road pricing scheme, but almost exclusively when road pricing is applied also to private cars, which leads to only a brief mention in this report. In general four difficult aspects have to be addressed:

- Social exclusion;
- Fairness;
- Privacy of users;
- Economic vitality of the areas affected.

Improving acceptability:

- involve the stakeholders at an early stage as possible;
- Identification must be made of the groups that will be strongly or weakly in favour or against, and those who will be approximately neutral, that is to say:
    - Identify winners and losers;
    - Develop mitigation strategies when needed;

- Review winners and losers position after mitigation measures;

- Consider the policy cycle, not only the implementation stage, as the balance between winners and losers is a dynamic one;

- Keep in mind that strong opposition has more energy and impact than strong support;

- Compensation measures and earmarking of revenues:

  - It is obvious that in many cases, recourse to the pricing instrument will be recognised as necessary, even if compensation measures (like reduction of fixed charges) have to be enacted to mitigate undesirable collateral consequences. Hypothecation of revenues will then only be required as far as it becomes clear that capacity expansion is not only possible but also a positive element for the solution of problems.

- For hauliers:

  - Justification for charging is much easier to understand and accept when explicitly connected to the need to finance construction of new roads, as it goes in line with traditional reasoning, but faces considerable difficulties when other arguments are dominant, requiring a bigger investment by the State in information and clarification measures. This is especially true for DAREA schemes.

  - Application of the revenues - if the charge is needed to solve some problems, then the revenues should be used primarily to solve those problems.

  - Economic impacts - fear of "killing the patient with the cure", by making local industries less competitive, and thus making hauliers lose some clients.

  - Fairness of fiscal treatment with respect to hauliers in other countries, especially when road charges are introduced without revision (decrease) of fixed charges related to the ownership of the trucks. Careful cross-country analysis should therefore be made in advance to prevent such claims and possibly to introduce some compensation.

Participation of stakeholder to define schemes:

The goal should be to provide transparent justification of charges to all affected parties. For this to occur, the recommendation is to provide citizens with access to information/raise level of knowledge about IRPS and improve scheme reliability: robustness against fraud and faimess.

In this case, positions of stakeholders are not related to the policy orientations, with which everyone basically agrees. Instead, what is evaluated here is the acceptability of the stakeholders in connection with their understanding of the justification for the charges in either system.

5.2 PERM / NONE to NET

This section suggests how to bridge the gap between the present and future system for countries planning to move from no IRPS or a permit system to a NET system. This is relevant for countries with the objective of financing road development through tolling and where the road network is not dense and thus the risk of detour traffic low.

5.2.1 Why choose NET as the basic form of pricing?

Does NET help finance the road network? Generally yes. The potential revenue of a NET pricing scheme is significantly higher than of a PERM solution (or of no road pricing at all, of course). In fact, NET is the 'classic' IRPS chosen by countries with a primary need to finance their transport network in most cases charging all vehicles. This is because the NET scheme is based in most cases on a relatively cheap and 'off-the-shelf' technical solution that is in operation in almost 30 countries all over the world. (DSRC/ dual system). Of course, the potential increase in revenue also depends on the level of the tariffs and on how much the government can withstand political demands to lower other taxes and fees correspondingly. Additionally, the financing objective is endangered if detour traffic on the non-priced road network is a valuable alternative for the drivers. As a consequence, NET is probably not an optimal solution for countries with a dense secondary road network, since detour traffic is easily possible here. DAREA would be a more sensible solution in this case.

Does NET help reduce congestion? Partially. NET is strong in reducing congestion on specific stretches of the priced motorway network, especially if tariffs are higher at peak hours. If congestion is shifted to other stretches of the motorway network, they could be integrated in the existing network of priced road infrastructure. On the other hand, NET is weak on managing traffic flows within conurbations (since the secondary road network is affected) and if the possibility of detour traffic exists.

Does NET help reduce the environmental burden of transport? Only to a limited extent. Of course, NET pricing is a way of internalising at least some of the external costs of transport and is therefore likely to reduce environmental aggression from HGV transport to some extent. Any distant-dependent pricing scheme - even with flat tariffs - sets incentives for fewer trips, especially less deadheads. However, if detour traffic on the non-priced road network is a valuable alternative for the hauliers, this will probably result in longer distances per trip and consequently in increased consumption of fuel. Especially in the likely affected densely populated areas, increasing noise and pollutant emissions are an even bigger problem. In addition, if the tariffs are calculated in accordance with Directive 1999/62/EC, only the infrastructure costs can be considered. At present, the inclusion of external costs is not possible in EU member states. The flat rates, as they are common in contemporary European NET countries, are too low to have an effect on the modal split between road and rail.

Does NET improve road safety? Unlikely, except to the extent that NET tolling allows earlier availability of motorways in a country: motorways are clearly safer than common two way roads. It has often been claimed that tolled NET roads are better controlled (by means of toll plazas, etc.) than the remaining motorway network. A positive relationship between the introduction of a NET pricing scheme and road safety could not be proved so far. In addition, detour traffic - should it occur - is likely to make the uncharged network less safe due to increasing HGV traffic.

Other reasons for choosing NET? With the EU legislation in force (1999/62/EC), EU member states that want to introduce road pricing for HGV's are allowed to do so only on their motorways (Art. 7/2).

5.2.2 Economic Impacts

a) Which impacts can be expected for the transport sector?

Traffic shift to the secondary road network

When implementing a new NET scheme, one important question deals with the volume of detour traffic that occurs because some vehicles will use the non-tolled secondary road network instead of the motorways in order to save tolling costs. This shift of traffic flows is unwanted because it can add to the problem of congestion on the secondary road network, especially in agglomeration areas. There are also other disadvantages:

- It reduces the revenues from road-pricing;
- It can cause additional maintenance costs on the secondary road network, because of its lower construction quality compared to the motorways;
- It could cause a relative increase of road accidents since the motorways are generally safer than any other roads with relation to vehicle-kilometres travelled;
- It causes additional emission impacts (noise, air pollutants) to the population, especially in agglomeration areas.

The volume of traffic shift caused by introducing the NET-scheme can be assessed by comparing the estimated reduction of vehicle-kilometres on the motorways with the development of vehicle-kilometres on all roads.

Model results indicate that these route shift effects are generally moderate when introducing toll-levels that are within the range of those necessary to cover road infrastructure costs. Traffic shifts from the motorways, caused by detour effects to reduce tolling costs, can be expected to be below 5% of the initial HGV traffic volume on motorways, with typical values for central European countries like Germany and Austria ranging between 2% and 4%. The total shift volume depends on the density and traffic situation (congestion) of the respective secondary road network. Thus for certain corridors or certain routes these shifts may be more pronounced and require addi-

tional measures. Nonetheless, in total, the volume of traffic shift expected seems to be acceptable. The model results for Europe are in line with other studies performed for Austria and Germany.

Long-distance detour effects:

The introduction of a NET-scheme in specific countries can also provoke shifts of long-distance routes for trans-European traffic flows in order to avoid whole networks or parts of networks where road-pricing has been newly introduced. This is especially relevant for central countries (Germany, Austria, Benelux, Switzerland, France) while for more peripheral countries (Portugal, Spain, Nordic countries, Italy, Greece) there are no alternative routes available. When introducing new NET-schemes in Austria and Germany shifts can be expected from routes via Germany and Austria to alternatives via the Benelux countries, France and Switzerland. An introduction of tolls also in the Benelux countries would cause a return to Germany and Austria. Further, the higher the tariffs in Western European motorways in relation to those in the motorways in candidate countries like Poland, Hungary and the Czech Republic, the more alternative routes through this countries will become attractive.

Long-distance detour effects are expected to range between 1% and 4% in the central European countries while for peripheral countries no significant effects are foreseen for moderate toll-levels.

Modal split is only slightly affected by the assessed changes in pricing policies. When introducing realistic (moderate) toll levels the decrease of the market share of road haulage hardly exceeds 1% in any of the distance- and goods-classes. Only in countries with very long transport distances like Sweden or on very specific transport corridors with very good modal alternatives by rail or inland waterways the modal shift could be a little above these values. Thus, the effect on modal shift should not be overestimated. Significant effects would require toll-levels well above the currently planned values.

Transport costs and adaptations of the haulage business:

Since transport costs usually do not exceed 5% percent of total product costs, realistic toll levels lead to an increase of total productions costs of max. 0.5 %. It can be expected that this is too low to cause significant effects on location decisions for production and distribution. Thus, the introduction of NET-scheme will not change the general economic structure of production and distribution in Europe. On the other hand, productivity increases of some hauliers by mergers, the establishments of vehicle pools and by improved tour planning (e.g. in combination with enhanced logistic possibilities created by advanced vehicle-based systems) can be expected. However, the resulting increase of average vehicle load factors is expected to be rather moderate and well below 1%, because of restrictions stemming from fixed package sizes, the limited capacity of special vehicles and from the demand structure. Nonetheless, although the cost pressure on the haulier business is increased (without compensatory reductions of other costs), a distance-depending pricing scheme reduces incentives to employ drivers in low wage or environmentally less regulated countries.

b) Which impacts can be expected for the national economy?

The impacts of introducing a NET-scheme for the national economy depends on the level of tolls, the costs for implementing the scheme and the use of the toll revenues. If the toll revenues are used to create a budget-independent source for the financing of the transport infrastructure, it increases the reliability of infrastructure investments. Alternatively, the revenues could be used to reduce indirect taxes or non-wage labour costs. In this case, and when applying moderate toll levels, the positive effects of internal adaptation processes of the transport sector and of the increased aggregated demand because of indirect tax relaxations could equal the effects of increased transport prices in the long-term. The relevance of the economic slump that can be expected in the years following the introduction of the new pricing scheme, should not be underestimated, though, and could well be capable of reducing the political feasibility of new IRPS significantly, especially in periods of general weak economic performance.

c) Which impacts can be expected for the environment and the road safety?

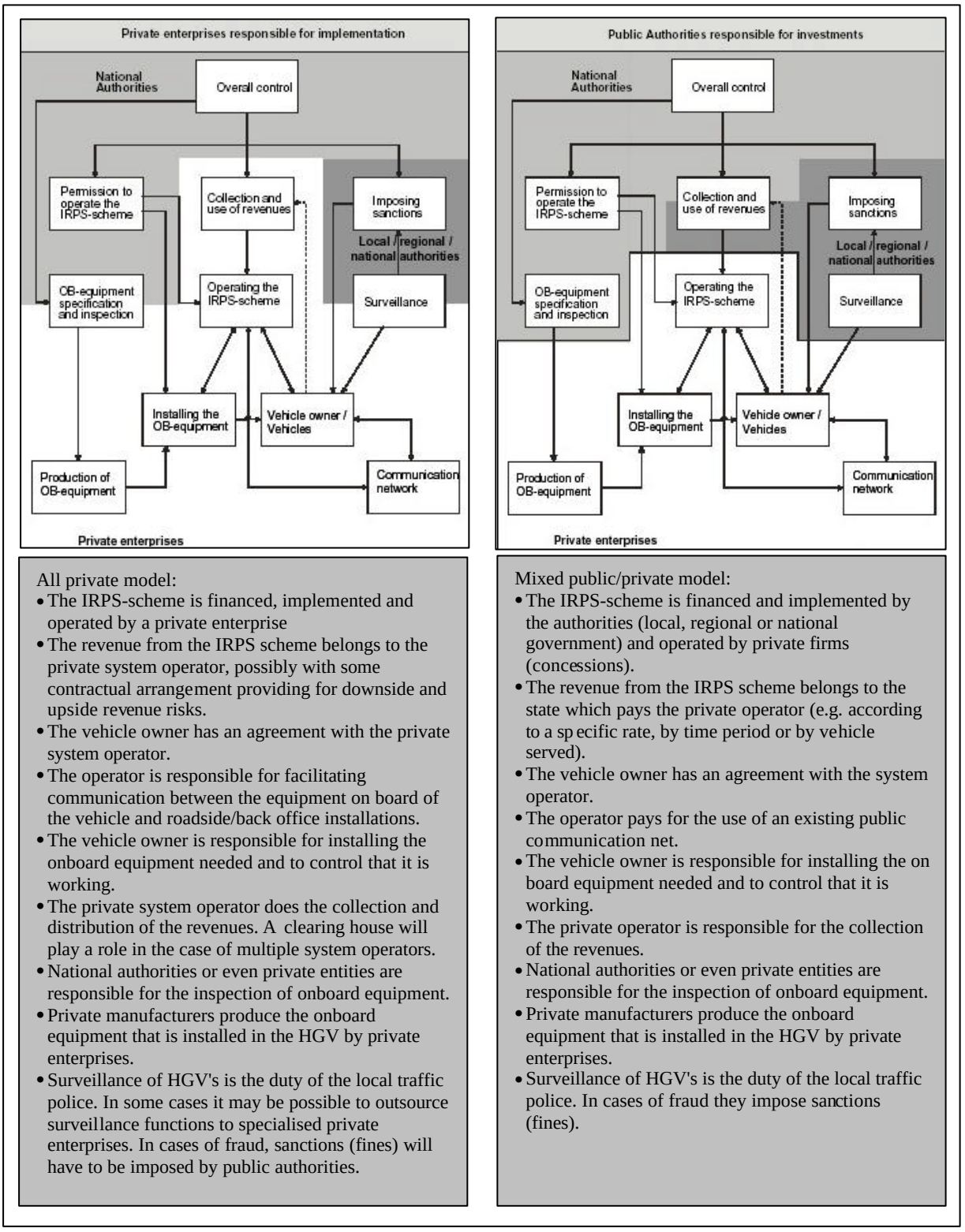
Generally, the reduction of total road transport volumes [tkm] because of modal shift effects and better logistics helps reducing emissions of air pollutants and greenhouse gases. However, when introducing NET, these effects are relatively small and can be overcompensated by negative effects of route shift effects in certain areas. On the other hand, a differentiation of tariff-levels according to emission categories is an effective instrument to induce an early renewal of vehicle fleets with higher emission and safety standards and thus helps improving environmental conditions in the short-term, even taking into account that some of the replaced vehicles will generally not vanish from the roads but will be re-sold in other countries.

As regards road safety, it can not be expected that the introduction of a NET-scheme can add to the goal of increased road safety. The small positive effects of slightly reduced transport volumes on roads and of new vehicles are compensated by the negative effects of detour traffic especially in affected areas.

5.2.3 Institution/contracts

The institutional and contractual issues when moving to a NET system mainly concern choosing the appropriate institutional design and defining the role of the public and private sector respectively.

For a NET system either an all private or a mixed public/private institutional model is favourable. An all public model is considered unfavourable for a NET system, since the advantages from involving the private sector are not utilised with that case. The main characteristics of the two relevant models are described on the figure below.



All private model:

- The IRPS-scheme is financed, implemented and operated by a private enterprise
- The revenue from the IRPS scheme belongs to the private system operator, possibly with some contractual arrangement providing for downside and upside revenue risks.
- The vehicle owner has an agreement with the private system operator.
- The operator is responsible for facilitating communication between the equipment on board of the vehicle and roadside/back office installations.
- The vehicle owner is responsible for installing the onboard equipment needed and to control that it is working.
- The private system operator does the collection and distribution of the revenues. A clearing house will play a role in the case of multiple system operators.
- National authorities or even private entities are responsible for the inspection of onboard equipment.
- Private manufacturers produce the onboard equipment that is installed in the HGV by private enterprises.
- Surveillance of HGV's is the duty of the local traffic police. In some cases it may be possible to outsource surveillance functions to specialised private enterprises. In cases of fraud, sanctions (fines) will have to be imposed by public authorities.

Mixed public/private model:

- The IRPS-scheme is financed and implemented by the authorities (local, regional or national government) and operated by private firms (concessions).
- The revenue from the IRPS scheme belongs to the state which pays the private operator (e.g. according to a specific rate, by time period or by vehicle served).
- The vehicle owner has an agreement with the system operator.
- The operator pays for the use of an existing public communication net.
- The vehicle owner is responsible for installing the on board equipment needed and to control that it is working.
- The private operator is responsible for the collection of the revenues.
- National authorities or even private entities are responsible for the inspection of onboard equipment.
- Private manufacturers produce the onboard equipment that is installed in the HGV by private enterprises.
- Surveillance of HGV's is the duty of the local traffic police. In cases of fraud they impose sanctions (fines).

Figure 2 - Relevant institutional setup for NET solution

The choice of a particular model is mainly influenced by considerations of investment needs, organisational and productive efficiency, competitive pressure and long-term flexibility. It should be stressed that the road financing objective in the all private model limits the freedom for political decisions on how to spend the revenue, since this

is typically committed to paying the concessionaire as opposed to the mixed public/private model where (most of) the revenue is at disposal for the public authorities.

Which countries should opt for the all private model ? This model is favourable for countries where there is a substantial need for investments in infrastructure and telecommunications. The private sector can help finance the infrastructure development and contribute with productive efficiency from innovative management processes. With complex schemes the state can benefit by taking a controlling role and handing over the operation of the system to the private sector. Introduction of shorter concession terms will introduce greater flexibility in the contractual arrangements between public authorities and private operators as well as facilitating competitive pressure, prevention of technical obsolescence and lower risks of inefficiency (but possibly imply moving away from the principle of full amortisation of the investment through revenues during the life of the concession).

Which countries should opt for the mixed public/private model ? This is favourable for countries where the infrastructure is well developed and the need for investments mainly concern communication systems e.g. telecommunications support. Since operators are detached from any function of road network management, their function is mainly a payment service. The organisational efficiency is comparable to the all private model to the extent that the allocation of responsibilities and duties as well as definition of data flows and controlling mechanisms are clearly defined.

The various institutional models are in general sensitive to the same critical issues for good performance although some issues are felt more sharply in particular models. Regardless of institutional model it is important to ensure that the following requirements are met:

- Tariff levels and allocation of revenues must be in line with policy goals and public expectations;
- Client's complaints must be treated properly and service must be guaranteed;
- Auditing components are necessary to verify that goals are being met;
- High levels of productive efficiency and transparency of accounts and procedures must be ensured;
- Risk of abuse towards State agencies, private companies or persons must be minimised.

Furthermore the user friendliness of the system must be supported by the principle of "one single onboard unit and one single contract for one vehicle".

5.2.4 Pricing Structure

Current legal status:

According to Council Directive 1999/62/EC motorway tolls are to be set to cover average costs of construction, maintenance and operation of motorways or similar roads caused by HGV's >12 t gross vehicle weight. In countries without motorways the primary network relevant for international traffic is meant.

In case of private companies involved in the financing and / or the operation of road infrastructure the full costs of these companies, including certain profit margins, are to be considered in the costs underlying the road user tolls.

Motivation for introducing NET tolls and pricing principles

The first motivation for introducing NET pricing systems (or for replacing an existing PERM-system by it) is most probably related to fiscal needs. In general, two possibilities exist: either the state operates the road network directly or it contracts the construction and / or the operation of the network or parts of the network to private concessionaires. Under either condition, full cost recovery can be achieved following the price-setting rules set out in directive 1999/62/EC. However, in case private capital is involved, profit margins of the operator and his freedom of price setting contained in the concession contract are to be considered.

Further, the introduction of NET pricing might be driven by welfare-oriented goals, possibly as an intermediate state towards a DAREA system. If the improvement of social welfare is in the foreground, prices can be differentiated by vehicle characteristics and / or regional settings, possibly using marginal cost information. Pure marginal cost pricing is not recommended as this would, with the exception of congestion charges, result in a major deficit related to the costs for providing and running the infrastructure.

The level of NET charges:

According to recent studies, charge levels may range between 0.11 Euro/km (UNITE-Results for Germany) and 0.26 Euro/km (Tariff calculation for Austrian primaries). Current motorway charges of most countries range within this spectrum, but exceptions are possible (Italy: 0.09 Euro/km).

Strictly following the rules set out by the EC Directive 1999/62, motorway tolls for HGV's would vary considerably between countries depending on (a) local construction costs, (b) traffic volumes and (c) on the methods used for calculating and allocating infrastructure costs. As the calculation methods are not specified in the directive, the Member states are provided with some degree of freedom for price setting. However, the most important factor determining average costs is the traffic volume accommodated by the road network, which may cause charges to get particularly high in sparely populated regions.

Including average environmental costs would raise tariff levels by 100% or more in case all generally accepted categories of external costs (accidents, air pollution, global warming, noise disturbance) are considered. How-

ever, the uncertainties on the level of these costs are very high (up to a factor 4 depending on the methodology applied). However, in general it is not recommended to add up all cost categories to a single price as the incentive structure would then vanish.

Compared to average costs, marginal costs of road infrastructure for heavy goods vehicles range between 20% and 30% of average infrastructure costs. A similar ratio holds true for the external costs of noise disturbance and the ratio is even more diverse for the marginal external costs of traffic accidents. In contrast, for air pollution and the risk of climate change marginal costs come close to average costs. Consequently, marginal social cost pricing would end in a major deficit for these cost categories. Only in the case of traffic congestion marginal costs are well above average costs and thus MSCP (Marginal Social Cost Pricing), especially in dense areas, recovers total costs.

Differentiation of charge levels:

Directive 1999/62/EC does not forbid a regional differentiation of motorway tolls. This might be done in order to reflect cost levels and thus to include an element of allocative efficiency, or take account of regional characteristics and economic requirements (support of poor regions by lower tolls). The prices will in particular vary in case different operators of different network parts are involved.

Motorway charges are also allowed to vary by time of day, whereas the highest toll level must not be more than 100% above that of the cheapest time period. Further, the price structures might vary with vehicle characteristics, such as weight and environmental standards. With these permits the price-setting authority is provided with tools to fight congestion, to enhance the environmental standard and the road damage potential of the vehicle fleet.

However, the differentiation of charges must be defined carefully as the acceptance of the system depends on the transparency of the price structure. E.g. strong differentiation of prices by area in combination with time-variant tolls must be considered a major obstacle for hauliers trying to anticipate operating costs. This consideration is particularly important for regions with high volumes of long-distance traffic.

Information requirement for different pricing principles

The determination of total annual infrastructure costs and their allocation to vehicle categories might either be carried out on the basis of historical expenses or by estimating replacement values of the existing road infrastructure assets. In any case detailed studies with periodical updates are required to either directly set road user charges or for benchmarking the charges set by private road operators.

Transferring average infrastructure costs from one country to another, between different institutional frameworks or between longer periods of time is not possible, as in all cases cost values as well as the degree of road use will vary to different degrees.

The transfer of marginal infrastructure and environmental costs is possible between countries, time periods or institutional frameworks as they vary less with traffic volumes.

In contrast, levels of marginal congestion costs strongly vary with traffic demand and with the configuration of the transport network. Thus, detailed local studies are required to set price levels accurately in accordance with the goals pursued.

5.2.5 Acceptability

There are different arguments for the introduction of NET road pricing, in the cases when it applies to all vehicles and when it applies only to HGV's. In the former case, this is normally connected to financing of construction of new motorways, and the acceptance question hardly exists: as long as the incapacity of facing the investment needs with public funds is clear, the choice becomes easy: either tolled roads in the near future, or maybe free access roads much later. And experience from several countries show that this is not a real dilemma, most people prefer to have better roads soon, even if there is an additional payment to be made.

When motorway tolls are applied only to HGV's, the reasons are connected with covering maintenance and upgrade costs. Even if this increases direct costs for hauliers, the acceptability management exercise must lead their representatives through the possible alternatives for financing this cost, evaluating for each alternative the corresponding score in the aspects of expected effectiveness and of fairness.

Revenue hypothecation (at least partially) will inevitably be invoked, and the overall economic balance of the sector vis-à-vis the State must be made transparent ("are we not paying enough in other taxes and duties ?"). The presence of significant volumes of foreign trucks on the national motorways is a positive factor for acceptability, as they will also contribute in an amount proportional to the damage caused.

5.2.6 Who should finance installation?

The different cost elements of the road pricing system are identified as follows:

- cost of onboard unit;
- cost of road side equipment;
- point of sale / point of registration for non-equipped users;
- cost of background system / IT application;
- operation of the system.

In a road-side based NET system the onboard unit and the background system are relative low cost components. The road side equipment however will - to the extent that the onboard unit is not mandatory equipment - be rather costly due to handling of non-equipped users recurring to manual payment.

In the **all private institutional model** the road pricing scheme is financed and operated by a private enterprise. Both the industrial and commercial risks are transferred to the concessionaire who at the same time has the right of exploiting the revenue generated from the operation of the concession. The vehicle owner is responsible for purchasing and installing the onboard equipment. The private operator could decide to subsidise or fully cover the cost of the onboard equipment in order to increase the number of equipped users.

In the **mixed public/private model** the IRPS-scheme is financed by the public authorities and operated as a concession by private firms. The vehicle owner is responsible for purchasing and installing the onboard equipment. The government or the private operator could decide to subsidise or fully cover the cost of the onboard equipment in order to increase the number of equipped users.

5.3 PERM / NONE to DAREA

This section suggests how to bridge the gap between the present and future system for countries planning to move from no system or a permit system to a DAREA system. This is relevant for countries wishing to manage traffic flow to reduce congestion problems and/or environmental impact and where a dense road network implies a risk of detour traffic. It is also relevant for countries with the objective of internalising marginal social costs

When deciding to use a DAREA system based on positioning technology it should be considered whether on-board units (OBU) should be mandatory for local and foreign trucks with the legal problems this implies. Special enforcement procedures have to be considered if a mandatory onboard unit (OBU) for all vehicles is not possible.

5.3.1 Why choose DAREA as the basic form of pricing?

Does DAREA help finance the road network? Generally yes, but this is not the main reason for a DAREA scheme. Although the potential revenue of a DAREA road pricing scheme is notably higher than that of a NET or of a PERM solution (or of no road pricing, of course), in a traditional NET scheme tolls are clearly aimed at financing the construction of the motorways where they are charged. Especially countries with a dense non-motorway network could increase their revenue significantly because all roads are subject to charges and detour traffic is not possible. Of course, a great deal of the financial success of the introduction of DAREA depends on the level of the fee and on how much the government can withstand political demands to lower other taxes and fees correspondingly. However, for a country in financial distress, it could be very difficult to take the burden of installing a DAREA pricing system since it requires high initial investing due to the most probably needed GPS autonomous technical solution and the corresponding high costs of the OBU's, telecommunication and enforcement systems.

Does DAREA help reduce congestion? Only under certain circumstances. With flat tariffs, a DAREA scheme is generally able to reduce the burden of the whole network but not to reduce congestion on specific spots or stretches of the network. However, DAREA can be a very appropriate instrument to fight congestion if it is combined with a flexible technical solution (GPS autonomous solution) that allows differentiated charging according to

the congestion situation. I.e. congested parts of the network could temporarily be charged higher in order to set incentives either to switch to other roads or to other times.

Does DAREA help reduce the environmental burden? Compared to a PERM solution or no pricing, DAREA is much more suitable to achieve the objective of environmental care since the whole network is being priced. Under a PERM pricing scheme, the average cost per vkm will even decrease with a higher traffic volume, which makes PERM a non-effective instrument of environmental policy, despite the possibility of price differentiation with respect to emission categories. On the contrary, DAREA sets a clear incentive to reduce the number and length of trips and/or to use the fleet more efficiently. Additionally, the differentiation of the charge with regard to the emission category of the vehicle will encourage the use of cleaner vehicles. Advanced forms of DAREA could even allow charging more in environmentally sensitive areas (e.g. the Alps).

Does DAREA improve road safety? Probably yes, in a small measure. Whereas PERM pricing is more or less neutral towards road safety, the introduction of DAREA pricing will probably reduce traffic volumes of HGV or at least slow its growth. This is a generally favourable development with regard to road safety. On the other hand, there is an incentive to make trips shorter, by using straighter connections on trunk roads, thus avoiding longer trips on motorways, except if the DAREA scheme would have lower tariffs on motorways. This is negative to road safety, since traffic on motorways is generally safer than on mixed roads in settled areas.

5.3.2 Economic Impacts

When moving from no distance-depending road pricing directly to a DAREA scheme and when introducing toll levels that are related to average infrastructure costs, the tolls per vehicle-kilometre have to be higher than in a NET scheme because of the significantly lower traffic volumes on the secondary road network. This implies, that the reactions of the transport sector to the new scheme as well as the impacts on the national economy and the environment are generally more expressed than in the case of moving to a NET scheme.

a) Which impacts can be expected for the transport sector?

Traffic shift to the secondary road network

Under the hypothesis that all roads have an equal base tariff[4], the effects of route shift to the secondary road network is noticeably less pronounced compared to the case of a NET scheme. However, a pricing of the entire network also causes moderate route shift effects as the distance gets more expensive in relation to travel time and thus, shortcuts are used by the vehicles. A shift from the primary to the secondary network of approx. 1.5%

[4] This hypothesis was the subject of decision in an earlier part of the project, as a compromise between two contradictory pricing principles: if tolls were based on marginal social costs, they would be higher on secondary roads, due to higher wear and tear, accidents and noise impacts; if tolls were based on quality of service to the user, they would be higher on motorways

can be expected. Certainly, the regional shifts depend on the availability and quality of shortcuts via the secondary road network.

Long-distance detour effects:

Like in the NET-case the introduction of a DAREA-scheme in specific countries can also provoke shifts of long-distance routes for trans-European traffic flows in order to avoid whole networks or parts of networks where road-pricing has been newly introduced. This is especially relevant for central countries (Germany, Austria, Benelux, Switzerland, France) while for more peripheral countries (Portugal, Spain, Nordic countries, Italy, Greece) there are no alternative routes available. When introducing new DAREA-schemes in Austria and Germany shifts can be expected from routes via Germany and Austria to alternatives via the Benelux countries, France and Switzerland. An introduction of tolls also in the Benelux countries would cause a return to Germany and Austria. Further, the higher the tariffs in Western European motorways in relation to those in the motorways in candidate countries like Poland, Hungary and the Czech Republic, the more alternative routes through this countries will become attractive.

In general, long-distance detour effects are more pronounced than in the NET scheme and are expected to be up to 5% for central countries, while for peripheral countries no significant effects should occur because of the lack of route alternatives. Generally, when introducing DAREA in central countries like Germany and Austria, shorter routes through Switzerland become more attractive because of the relatively higher price increases.

Modal split:

Slight modal shifts from road to rail and ship can be expected especially for bulk goods and general cargo and for long transport distances where modal alternatives are available. Reductions of road transport volumes [tkm] can be expected up to 3.5 % for bulk goods and approx. 4 % for the Long Distance Band (>700km). The modal shift for shorter distance bands and for road-affine unitised goods are very small.

Transport costs and adaptations of the haulage business:

Toll levels that are calculated with respect to the goal of recovering road infrastructure costs are approx. two times the respective values for a NET scenario. Thus, although this is most probably still too low to cause significant effects on location decisions for production and distribution, the cost-pressure driven productivity increases in the haulier business by mergers, the establishments of vehicle pools and by improved tour planning (e.g. in combination with enhanced logistic possibilities created by advanced vehicle-based systems) are higher compared to the introduction of a NET scheme. The resulting increase of average vehicle load factors can be expected to be between 1% and 2%.

b) Which impacts can be expected for the national economy?

The impacts of introducing a DAREA-scheme for the national economy depends on the level of tolls, the costs for implementing the scheme and the use of the toll revenues. If the toll revenues are used to create a budget-independent source for the financing of the transport infrastructure, it increases the reliability of infrastructure investments. Alternatively, the revenues could be used to reduce indirect taxes or non-wage labour costs. In this case, and when applying moderate toll levels the positive effects of internal adaptation processes of the transport sector and of the increased aggregated demand because of indirect tax relaxations could lead to a slight positive effect on GDP in the long-term. On the other hand, for the short-term perspective, the introduction of a DAREA-scheme will initially cause a drop of economic performance. Adaptation processes in the transport sector will take its time and the system will potentially need some time to be reliable. Furthermore, the costs of implementation will have their effect on the national budget. Thus, the possibility of a relative economic slump in the first years after the introduction of the new tolling scheme has to be taken into consideration.

c) Which impacts can be expected for the environment and the road safety?

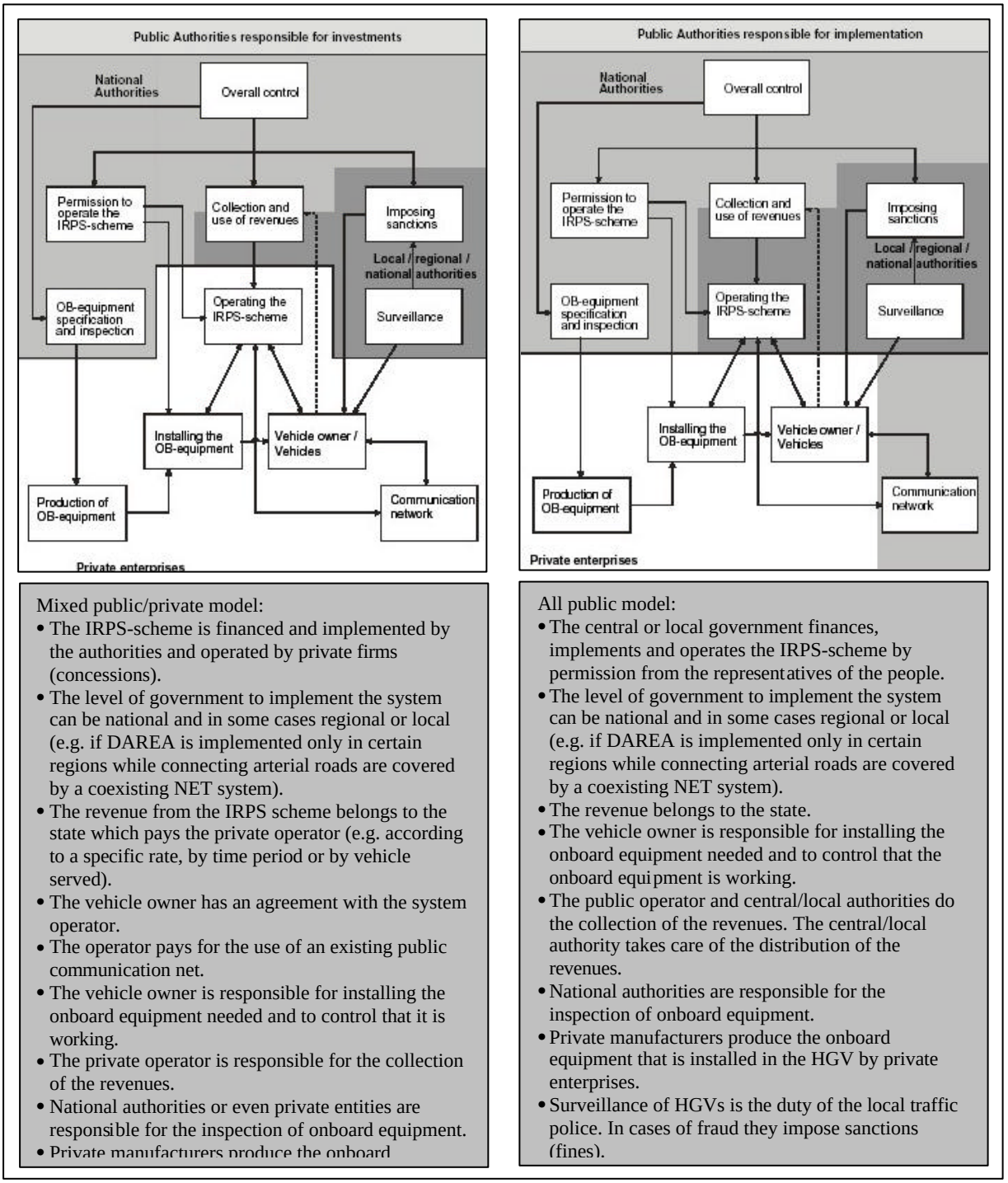
The reduction of total road transport volumes [tkm] because of modal shift effects and better logistics helps reducing emissions of air pollutants and greenhouse gases. Since, compared to a NET scheme, the volume of route shift to the secondary road network with its negative effects on emissions and road safety are relatively small, this will lead to a small but reliable reduction of air pollutant emissions of transport (around 1%). Furthermore, a differentiation of tariff-levels according to emission categories is an effective instrument to induce an early renewal of vehicle fleets with higher emission and safety standards and thus help improving environmental conditions in the short-term, even taking into account that some of the replaced vehicles will generally not vanish from the roads but will be sold in other countries.

As regards road safety, it can be expected that the introduction of a DAREA-scheme could have a small positive effect, because safety gains resulting from modal shift from road are not deteriorated enough by the small detour traffic on less safe secondary roads.

5.3.3 Institution/contracts

The institutional and contractual issues when moving to a DAREA system mainly concern choosing the appropriate institutional design and defining the role of the public and private sector respectively.

For a DAREA system either a mixed public/private or an all public institutional model is favourable. An all private model is virtually impossible since fine tuning of prices with respect to traffic management is a recurrent need that would require extremely innovative concession contracts. Furthermore it is undesirable to combine the incitement of revenue maximisation with practising market segmentation and price differentiation in order to achieve a better balance of traffic loads. The main characteristics of the two relevant models are described on the figure below.



Mixed public/private model:

- The IRPS-scheme is financed and implemented by the authorities and operated by private firms (concessions).
- The level of government to implement the system can be national and in some cases regional or local (e.g. if DAREA is implemented only in certain regions while connecting arterial roads are covered by a coexisting NET system).
- The revenue from the IRPS scheme belongs to the state which pays the private operator (e.g. according to a specific rate, by time period or by vehicle served).
- The vehicle owner has an agreement with the system operator.
- The operator pays for the use of an existing public communication net.
- The vehicle owner is responsible for installing the onboard equipment needed and to control that it is working.
- The private operator is responsible for the collection of the revenues.
- National authorities or even private entities are responsible for the inspection of onboard equipment.
- Private manufacturers produce the onboard

All public model:

- The central or local government finances, implements and operates the IRPS-scheme by permission from the representatives of the people.
- The level of government to implement the system can be national and in some cases regional or local (e.g. if DAREA is implemented only in certain regions while connecting arterial roads are covered by a coexisting NET system).
- The revenue belongs to the state.
- The vehicle owner is responsible for installing the onboard equipment needed and to control that the onboard equipment is working.
- The public operator and central/local authorities do the collection of the revenues. The central/local authority takes care of the distribution of the revenues.
- National authorities are responsible for the inspection of onboard equipment.
- Private manufacturers produce the onboard equipment that is installed in the HGV by private enterprises.
- Surveillance of HGVs is the duty of the local traffic police. In cases of fraud they impose sanctions (fines).

Figure 3 - Relevant institutional setup for DAREA solution

The choice of a particular model is mainly influenced by considerations of investment needs, organisational and productive efficiency, competitive pressure and long-term flexibility.

Which countries should opt for the mixed public/private model ? This is favourable for countries where the infrastructure is well developed and the need for investments mainly concern communication systems e.g. tele-communications support. Since operators are detached from any function of road network management, their function is mainly a payment service. A vital requirement for the choice of this particular model is that the remu-

neration of the private operator is not based on the actual tolls collected, since this would lead to segmentation to maximise revenue. Instead the success achieved towards the desired traffic distribution should be the basis of remuneration.

Which countries should opt for the all public model ? This requires the public organisation to function with great efficiency in order to be favourable. In this given situation there is a potential of synergy from having all the functions of IRPS concentrated in the same organisation. In a system with no private revenue interest the all public model eliminates potential conflicts regarding enforcement of the system. However it must be considered whether the public organisation is able to handle the operation with a competitive efficiency, since the complexity of a DAREA scheme increases the risk of higher costs due to inefficiency.

The various institutional models are in general sensitive to the same critical issues for good performance although some issues are felt more sharply in particular models. Regardless of institutional model it is important to ensure that the following requirements are met:

- Tariff levels and allocation of revenues must be in line with policy goals and public expectations;
- Client's complaints must be treated properly and service must be guaranteed;
- Auditing components are necessary to verify that goals are being met;
- High levels of productive efficiency and transparency of accounts and procedures must be ensured;
- Risk of abuse towards state agencies, private companies or persons must be minimised.

Furthermore the user friendliness of the system must be supported by the principle of "one single onboard unit and one single contract for one vehicle".

5.3.4 Pricing Structure

Current legal status:

EU directive 1999/62/EC does not allow a general pricing of the entire secondary road network. Exceptions are allowed in case NET pricing systems cause considerable problems with decreasing traffic safety and congestion. Consequently, EU legislation does not provide a framework for calculating DAREA charges.

Motivation for introducing NET tolls and pricing principles

The introduction of a DAREA pricing system will in most cases be motivated by considerations of social welfare improvements rather than by the simple attempt to transfer the financing of roads from tax money to user charges. Thus, the discussion of pricing structures in DAREA systems is focussing on adequate price differentiation and incentives than on cost calculation issues.

Level of DAREA charges:

A direct transition from no road pricing or PERM systems to DAREA will impose a drastic increase of costs for hauliers, which is even higher than the introduction of NET as (1) average costs in DAREA are higher than in NET and (2) the possibility of avoiding tolls by using the secondary road network is removed.

This strong increase of operation costs for the hauliers would in most cases have to be compensated by a reduction in their fixed costs, to improve the level of acceptance. Otherwise, strong criticism will be voiced, invoking the risk of killing not only the haulage industry, but also of grave reductions of market size for companies in many sectors of the economy. Even if that is not totally true, the perception in the minds of many will be this, and easily propagate to many other people. The tone of the discussion will be different from one country to another, and will also depend on the political talent of the proponents, but the notion of (quasi) budget neutrality should be kept in mind.

Of course, changing the fixed costs in one country (where DAREA tolling is introduced) and not in others (where that is not the case), raises the question of cost aggravation especially for the hauliers of those other countries, which can lead to resistance not only at domestic level but also at the European level, with accusations that such tolls effectively constitute barriers to trade.

On inter-urban roads the lower traffic volume on secondary roads leads to much higher average infrastructure costs than is calculated for the motorways. This relationship is supported by results of the UNITE project for Germany 2005, where average HGV infrastructure costs are twice as high on the entire network (0.21 Euro/km) than on motorways (0.09 Euro/km). This ratio might be somewhat different in or near agglomeration areas, where high traffic volumes decrease average costs.

Average and marginal costs of air pollution and noise disturbance are also considerably higher on secondary roads than on motorways as they are closer to built-up areas. For the costs of traffic accidents, global warming and congestion no clear statements on the difference of costs between the two network categories can be made.

Also in case the basic motive of setting DAREA charges is environmental protection or the financing of particular projects, the resistance of toll levels against legal claims and their acceptability will be drastically improved if they are based on a cost calculation.

Differentiation of charge levels:

If tariff levels were to be based on actual costs imposed by users, the tolls to be raised on the secondary road network would considerably exceed pure motorway charges. While for reasons of cost efficiency this structure might be appreciated, it contradicts the principle of prices to reflect the quality of supply. As the latter would mean to have higher tolls on motorways, the compromise of introducing equal prices on all road categories is intuitively fair and minimises market distortions.

A differentiation of charge levels by regions is more justified under DAREA conditions than under NET. In particular when introducing DAREA pricing from PERM, the high charge levels and the missing possibility of avoiding payment by detouring the motorways might cause considerable distortions in economically weak regions. Accordingly, a regional differentiation, possibly in the secondary network only, should be considered.

The differentiation of prices by environmental standards of the vehicles and by the sensitivity of regions will enhance the sustainable development of the transport sector and is thus recommended in case the motivation of introducing DAREA charges leads into the same direction. However, a high level of tariff differentiation according to the environmental sensitiveness of the region may be interpreted as barrier to movement through that region and be subject to strong opposition given the uncertainties of the cost estimation process.

Information requirement for different pricing principles

The determination of total annual infrastructure costs and their allocation to vehicle categories might either be carried out on the basis of historical expenses or by estimating replacement values of the existing road infrastructure assets. In any case detailed studies with periodical updates are required to either directly set road user charges or for benchmarking the charges set by private road operators. The underlying information acquisition will in most cases be particularly difficult for low-order road networks. Here, a simplified transfer of values from the higher-order roads might enable the price-setting authority to roughly estimate total and average costs of the entire road network.

Transferring average infrastructure costs from one country to another, between different institutional frameworks or between longer periods of time is not possible, as in all cases cost values as well as the degree of road use will vary to different degrees.

The transfer of marginal infrastructure costs is rather possible between countries, time periods or institutional frameworks as they vary less with traffic volumes. However, environmental effects alongside secondary roads, which usually are leading through built-up areas, are more local-specific than for the motorways and thus the transfer of values between different countries or regions is more difficult.

Further, levels of marginal congestion costs strongly vary with traffic demand and with the configuration of the transport network. Thus, detailed local studies are required to set price levels accurately in accordance with the goals followed.

5.3.5 Acceptability

The introduction or transition to DAREA causes additional problems of acceptability, because all trips will be charged, there is poor confidence in effectiveness of the system and politically it may also be more difficult as more people are targeted, especially if the system is also introduced to all vehicles. This is especially important in the case of transition from PERM/NONE to DAREA.

The arguments that need to be developed may be of two kinds:

- DAREA road pricing (for HGV's) is introduced because it is a fairer and more effective instrument to ensure financing not only of the road maintenance and upgrade costs, but also of financing the development of alternative means of transport that help fight the permanent growth of the volume of trucks on the road;

- DAREA road pricing (for all vehicles) is introduced as the only possibly effective and fair instrument to manage road congestion, in countries or regions where the density and quality of secondary roads makes them a real alternative to motorways as soon as these would be tolled for the same purpose.

In the first case acceptability should be easier to achieve than in the second, not only because the pricing only affects professional traffic but also the funds raised (and possibly hypothecated) should ensure the effectiveness of the scheme. There is a clear money-path and as soon as there is belief in the transparency of its management, the only key issue remaining is the legitimacy of charging one transport mode for financing the development of its rivals.

But the dominance of the road mode is such that its managers know that it is preferable to digest such a pricing scheme and enjoy the goodwill resulting from such a behaviour of "good citizenship" than to present an obstinate opposition to the scheme. The latter could well lead to unforeseeable and unpleasant initiatives of populist politicians, eager to please their constituents who keep complaining about too many trucks around them.

In the second case, things are much more complicated, because there is no obvious application of the revenues generated, apart from the odd bits of new road construction, far cheaper than the money collected. Pricing is enacted to induce behavioural changes, and a key question will be how the price levels will be determined, since there is no clear connection to money needs. To be effective in fighting congestion, prices need to be felt as a deterrent to at least some travel by road, but this will impose much broader adaptations in some people than in others, thus bringing the issue of fairness to the top of the discussion. In the end, the game here is between effectiveness and fairness of the pricing scheme. One possible answer, as was foreseen in Holland, was to make it budget neutral for the average driver (thus leaving the poorer ones, who drive under the average, better off), another option could be to allocate a ration of free mobility to all registered drivers, and start charging only above that threshold.

5.3.6 Who should finance installation?

The different cost elements of the road pricing system are identified as follows:

- cost of onboard unit;

- cost of road side equipment;

- point of sale / point of registration for non-equipped users;

- cost of background system / IT application;

- operation of the system.

In the satellite based DAREA system there is no road side equipment[5], however the onboard unit and the background system will typically be more costly. The same goes for the operation of the system due to the more complex enforcement of the system.

In the **mixed public/private model** the IRPS-scheme is financed by the public authorities and operated as concessions by private firms. The vehicle owner is responsible for purchasing and installing the onboard equipment. The government or the private operator could decide to subsidise or fully cover the cost of the onboard equipment in order to increase the number of equipped users.

In the **all public model** the IRPS-scheme is financed and operated by the central or local public authorities. The vehicle owner is responsible for purchasing and installing the onboard equipment. The government could decide to subsidise or fully cover the cost of the onboard equipment in order to increase the number of equipped users.

5.4 NET to DAREA

This section suggests how to bridge the gap between the present and future system for countries planning to move from an existing NET system to a DAREA system. This is relevant for countries experiencing congestion problems nationally or in specific regions wishing to manage traffic flow to reduce congestion problems, environmental impact or internalising marginal social costs.

It must be considered whether simultaneous operation of old and new onboard units (OBU) should be allowed and how this could be done in practise. This is discussed in the following sections.

When deciding to use a DAREA system based on a positioning technology it should be considered whether onboard units (OBU) should be mandatory for local and foreign trucks with the legal problems this implies. Special enforcement procedures have to be considered if a mandatory onboard unit (OBU) for all vehicles is not possible.

5.4.1 Why change the basic form of pricing from NET to DAREA?

Does DAREA help finance the road network better than NET? Not certainly. If a country started road pricing with a NET scheme, probably detour traffic was not a problem at that time. However, due to increasing congestion levels, network density or other reasons, drivers avoiding the tolled network for the free alternative might in the meantime have become a problem with negative consequences for the overall toll revenue. Changing to a DAREA pricing where all roads within a certain area are subject to charge might then be a suitable answer to this

[5] Although fixed infrastructure (antennas) is needed for proper performance of the cellular phone networks, this is generally in place and may thus be considered a sunk-cost.

problem. Detour traffic would no longer cause losses in toll revenues. However, there might be major investments needed in order to facilitate the shift in IRPS, especially if it takes a change of the technological solution.

Does DAREA reduce congestion more than NET? Under certain circumstances yes. NET pricing is generally not an instrument to fight congestion. Even if it occurs in the densely populated areas, NET is powerless against congestion. In this case, a switch to DAREA could improve the situation, especially if it is combined with a flexible technical solution (GPS autonomous solution) that allows for differentiated charging according to the congestion situation. I.e. congested parts of the network could temporarily be charged higher in order to set incentives either to switch to other roads or to other times.

Does DAREA reduce the environmental burden more than NET? Probably yes. Compared to a NET solution, DAREA is much more suitable to achieve the objective of environmental care since the whole network is being priced. DAREA sets a clear incentive to reduce the number and length of trips and/or to use the fleet more efficiently. Additionally, the differentiation of the charge with regard to the emission category of the vehicle will encourage the use of cleaner vehicles. Advanced forms of DAREA could even allow for charging more in environmentally sensitive areas (e.g. the Alps).

Does DAREA improve road safety more than NET? With NET, there is always the danger of detour traffic on the non-motorway road network. A change to DAREA results in a diminution of detour traffic of HGV on smaller roads. Such a shift will improve road safety in two ways: (a) Shifted HGV will be safer because traffic on motorways is more secure; (b) the remaining (passenger) traffic will be safer because of fewer HGV.

Is a combination of NET and DAREA schemes a reasonable solution? For countries with strong regional differences in population density (and therefore in road network density as well), a combination of the NET and DAREA schemes might seem as a way to combine the advantages of both schemes.[6] In the rural, sparsely populated regions only motorways would be charged, whereas in the urban, densely populated areas all roads would be subject to charge in order to prevent detour traffic. However, since the fiscal regime of motor vehicles is identical in all regions of the same country, this combined scheme could give rise to equity concerns between the regions, since the citizens and companies of the DAREA priced areas are discriminated with respect to the rest of the country. On the other hand, this unequal treatment of regions could be acceptable under certain conditions. First, if the DAREA region is clearly richer than the rest of the country (no additional equity problems, but rather a form of compensation). Second, if the tariffs applied for the DAREA scheme are lower than on "NET-tolled roads". Third, if the revenues from the DAREA scheme are used for specific road infrastructure investments in the DAREA region (e.g. for the development of road and public transport infrastructure). An additional element favouring acceptability could be the allocation of a ration of free mobility to the residents on the DAREA-tolled regions, so that some of their essential mobility could be free of charge, without compromising the overall goal of

6 See also DESIRE Deliverable 4, p. 36f.

congestion management. In these cases a combination of NET and DAREA may be accepted as a reasonable solution.

5.4.2 Economic Impacts

a) Which impacts can be expected for the transport sector?

Traffic shift to the secondary road network:

To avoid detour effects that can occur in a NET tolling scheme, the evolution to a DAREA scheme can be a sensible option. Detour effects can be expected mainly in densely populated areas. Thus, it is of a main interest here, how the implementation of DAREA pricing in agglomerations can help reducing traffic shifts from the motorways. In high-density-areas, the density of the secondary road network is relatively high as well as the traffic loads on those roads. These two items lead to contrary incentives of leaving the motorways and avoiding secondary roads that can be expected to approx. equal out each other. The remaining incentive for detour traffic is caused by the relatively high share of regional traffic in those areas that react much more sensitive to price changes on the motorways than long-distance hauls. Estimations show that the route shift probability for regional traffic is roughly 50% higher than it is for longer distances. Calculations for a combined NET-DAREA scenario[7] show that the area pricing in agglomeration areas is able to avoid much of the high readiness of HGV traffic to leave the motorways in areas with dense networks. This is particularly true for countries with dense road networks and when motorway charges are high. However, considering that even pure DAREA pricing systems causes route shift effects because of increasing costs per kilometre and constant values of time, we suggest that the level of DAREA-prices in agglomerations should not be set too high in a combined NET/ DAREA scheme.

Long-distance detour effects:

Long-distance detour effects can occur because of higher toll levels in a infrastructure cost based calculation compared to a NET scheme. This holds especially for central countries whereas for peripheral countries there are no or only few route alternatives and in the case that the introduction of DAREA in a country is not accompanied by the introduction of new distance-depending pricing schemes in neighbouring countries. The introduction of DAREA pricing only in High-Density-Areas should not cause significant changes of traffic routes for long-distance-hauls.

Modal split:

Slight modal shifts from road to rail and ship can be expected in a complete DAREA scheme especially for bulk goods and general cargo and for long transport distances where modal alternatives are available. Reductions of road transport volumes [tkm] can be expected up to 3.5 % for bulk goods and approx. 4 % for the Long Distance Band (>700km). The modal shift for shorter distance bands and for road-affine unitised goods are very small.

When introducing DAREA only in agglomerations, no modal shift effects should be expected because this would only affect regional traffic with few modal alternatives.

Transport costs and adaptations of the haulage business:

Toll levels that are calculated with respect to the goal of recovering road infrastructure costs are approx. two times the respective values for a NET scenario. Thus, although this is most probably still too low to cause significant effects on location decisions for production and distribution, cost-pressure driven productivity increases in the haulier business by mergers, the establishments of vehicle pools and by improved tour planning (e.g. in combination with enhanced logistic possibilities created by advanced vehicle-based systems) can be expected.

b) Which impacts can be expected for the national economy?

The impacts of introducing a DAREA-scheme for the national economy depends on the level of tolls, the costs for implementing the scheme and the use of the toll revenues. If the toll revenues are used to create a budget-independent source for the financing of the transport infrastructure, it increases the reliability of infrastructure investments. Alternatively, the revenues could be used to reduce indirect taxes or non-wage labour costs. In this case, and when applying moderate toll levels the positive effects of internal adaptation processes of the transport sector and of the increased aggregated demand because of indirect tax relaxations could lead to a slight positive effect on GDP in the long-term. On the other hand, for the short-term perspective, the introduction of a DAREA-scheme will initially cause a drop of economic performance. Adaptation processes in the transport sector will take its time and the system will potentially need some time to be reliable. Furthermore, the costs of implementation will have their effect on the national budget. Thus, the possibility of a relative economic slump in the first years after the introduction of the new tolling scheme has to be taken into consideration.

c) Which impacts can be expected for the environment and the road safety?

The reduction of total road transport volumes [tkm] because of modal shift effects and better logistics helps reducing emissions of air pollutants and greenhouse gases. Since, compared to a NET scheme, the volume of route shift to the secondary road network with its negative effects on emissions and road safety are relatively small, this will lead to a small but reliable reduction of air pollutant emissions of transport (around 1%). Furthermore, a differentiation of tariff-levels according to emission categories is an effective instrument to induce an early renewal of vehicle fleets with higher emission and safety standards and thus help improving environmental conditions in the short-term, even taking into account that some of the replaced vehicles will generally not vanish from the roads but will be sold in other countries.

[7] NET in general, DAREA in higher density agglomerations.

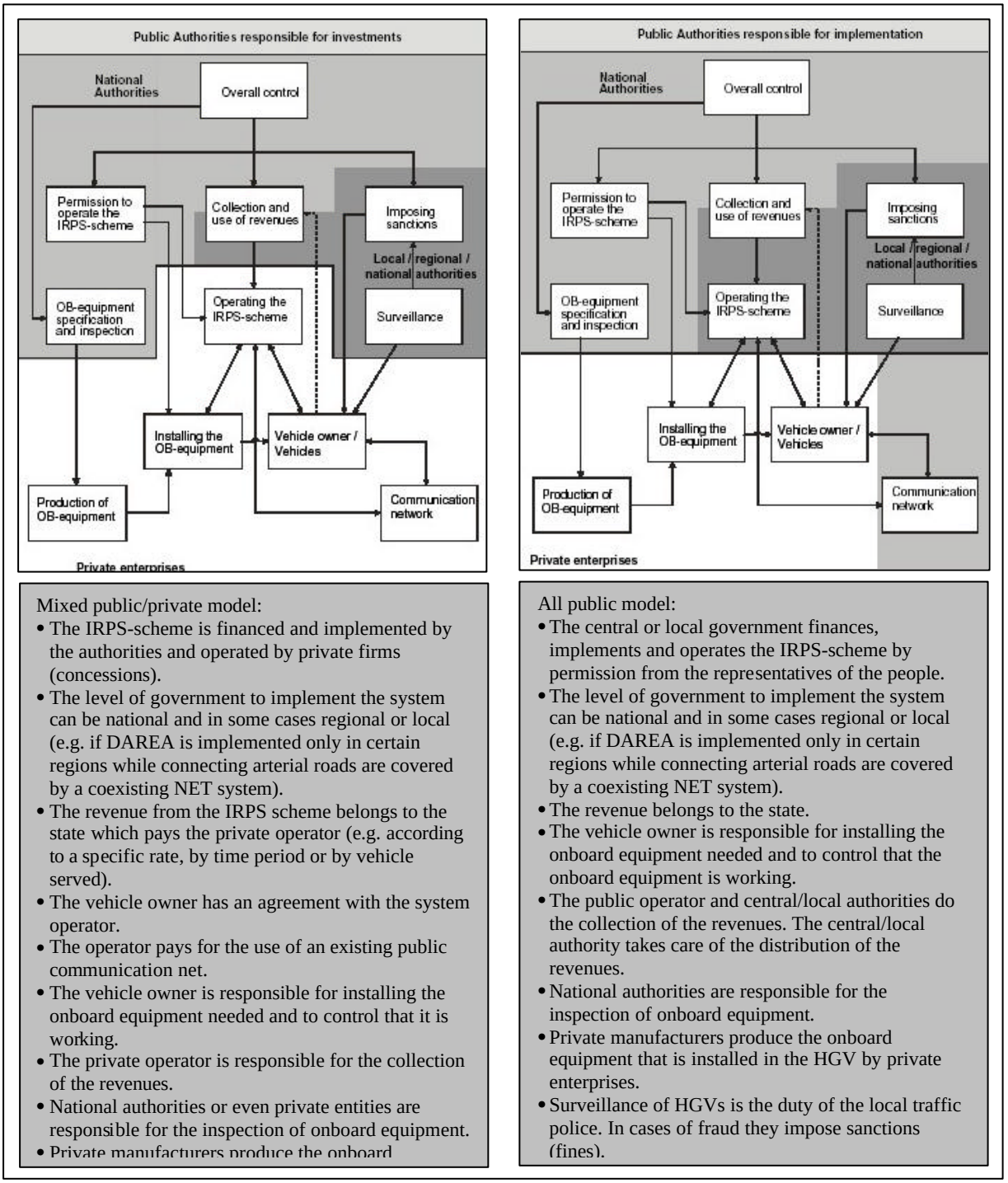
As regards road safety, it can be expected that the introduction of a DAREA-scheme could have a small positive effect, because safety gains resulting from modal shift from road are not deteriorated by the small detour traffic on less safe secondary roads.

5.4.3 Institution/contracts

Existing motorway concessions are the main obstacle in the transition from a NET system to a DAREA system. The two radical solutions for handling existing concessions in a transition phase are either having the motorway concessionaire evolving into a mobility manager or withdrawing the concession back into public hands. The first implies that the remuneration is based on the quality of the mobility in the region as opposed to the number of vehicles being the source of revenue, while the latter implies economic compensation for terminating the contract. In between there is the possibility of maintaining existing concessions as they are and simply exempt the roads in question from the network subjected to DAREA pricing. This may give rise to contractual issues since implementing DAREA on the network surrounding concession roads will impose changes in the commercial basis for the concession, requiring financial re-balancing. Either way there are costs related to termination or incorporation of existing concessions in the transition phase.

Besides dealing with existing concessions, the institutional and contractual issues when moving to a DAREA system mainly concern choosing the appropriate institutional design and defining the role of the public and private sector respectively.

For a DAREA system either a mixed public/private or an all public institutional model is favourable. An all private model is very difficult since fine tuning of prices with respect to traffic management is a recurrent need that would require extremely innovative concession contracts, effectively transforming the concessionaire into a mobility manager. Furthermore it is undesirable to combine the incitement of revenue maximisation with practising market segmentation and price differentiation in order to achieve a better balance of traffic loads. The main characteristics of the two relevant models are described on the figure below.



Mixed public/private model:

- The IRPS-scheme is financed and implemented by the authorities and operated by private firms (concessions).
- The level of government to implement the system can be national and in some cases regional or local (e.g. if DAREA is implemented only in certain regions while connecting arterial roads are covered by a coexisting NET system).
- The revenue from the IRPS scheme belongs to the state which pays the private operator (e.g. according to a specific rate, by time period or by vehicle served).
- The vehicle owner has an agreement with the system operator.
- The operator pays for the use of an existing public communication net.
- The vehicle owner is responsible for installing the onboard equipment needed and to control that it is working.
- The private operator is responsible for the collection of the revenues.
- National authorities or even private entities are responsible for the inspection of onboard equipment.
- Private manufacturers produce the onboard

All public model:

- The central or local government finances, implements and operates the IRPS-scheme by permission from the representatives of the people.
- The level of government to implement the system can be national and in some cases regional or local (e.g. if DAREA is implemented only in certain regions while connecting arterial roads are covered by a coexisting NET system).
- The revenue belongs to the state.
- The vehicle owner is responsible for installing the onboard equipment needed and to control that the onboard equipment is working.
- The public operator and central/local authorities do the collection of the revenues. The central/local authority takes care of the distribution of the revenues.
- National authorities are responsible for the inspection of onboard equipment.
- Private manufacturers produce the onboard equipment that is installed in the HGV by private enterprises.
- Surveillance of HGVs is the duty of the local traffic police. In cases of fraud they impose sanctions (fines).

Figure 4 - Relevant institutional setup for DAREA solution

The choice of a particular model is mainly influenced by considerations of investment needs, organisational and productive efficiency, competitive pressure and long-term flexibility. In case there are ongoing concessions it should be stressed that to the extent that road financing is still an objective there are limitations related to political decisions on how to spend the revenue, since this is typically committed to paying the concessionaires.

Which countries should opt for the mixed public/private model ? This is favourable for countries where the infrastructure is well developed and the need for investments mainly concerns communication systems e.g. tele-

communications support. Since operators are detached from any function of road network management, their function is mainly a payment service. A vital requirement for the choice of this particular model is that the remuneration of the private operator is not based on the actual tolls collected, since this would lead to segmentation to maximise revenue. Instead the success achieved towards the desired traffic distribution should be the basis of remuneration

Which countries should opt for the all public model ? This requires the public organisation to function with great efficiency in order to be favourable. In this given situation there is a potential of synergy from having all the functions of IRPS concentrated in the same organisation. In a system with no private revenue interest the all public model eliminates eventual conflicts regarding enforcement of the system. However it must be considered whether the public organisation is able to handle the operation with a competitive efficiency, since the complexity of a DAREA scheme increases the risk of higher costs due to inefficiency.

The various institutional models are in general sensitive to the same critical issues for good performance although some issues are felt more sharply in particular models. Regardless of institutional model it is important to ensure that the following requirements are met:

- Tariff levels and allocation of revenues must be in line with policy goals and public expectations;
- Client's complaints must be treated properly and service must be guaranteed;
- Auditing components are necessary to verify that goals are being met;
- High levels of productive efficiency and transparency of accounts and procedures must be ensured;
- Risk of abuse towards state agencies, private companies or persons must be minimised.

Furthermore the user friendliness of the system must be supported by the principle of "one single onboard unit and one single contract for one vehicle".

5.4.4 Pricing Structure

Motivation

The motivation to develop from a NET pricing scheme to a DAREA scheme can either be to reduce the negative impacts of NET prices (detours of traffic to secondary roads), to enhance the basis for setting incentives for a more sustainable transport development of simply to increase revenues. In general we assume that welfare-oriented motivations are more decisive than fiscal ones when changing from NET to DAREA.

Price Levels

The average prices per vehicle kilometre on the road network will be higher under DAREA conditions than under NET conditions as the number of vehicle kilometres on the secondary road network usually are much lower than on the motorways. I.e. the lower construction costs of the secondary network per road kilometre are over-compensated by the lower traffic volume.

Apart from the higher average costs, the cost increase from NET to DAREA is considerable as the possibility to save tolls by using the secondary road network is removed.

The marginal costs of infrastructure use will be higher on secondary roads than on motorways as they are generally designed to accommodate less traffic. Average and marginal costs of air pollution and noise disturbance are also considerably higher on secondary roads than on motorways as they are closer to built-up areas. For the costs of traffic accidents, global warning and congestion no clear statements on the difference of costs between the two network categories can be made.

The price increases between NET and DAREA will be different between countries, depending on the density of the various network types and on the traffic volumes accommodated by them. Therefore, no general rule can be given how prices develop when changing the pricing scheme.

This strong increase of operation costs for the hauliers would in most cases have to be compensated by a reduction in their fixed costs, to allow some level of acceptance. Otherwise, strong criticism will be voiced, invoking the risk of killing not only the haulage industry, but also of grave reductions of market size for companies in many sectors of the economy. Even if that is not totally true, the perception in the minds of many will be this, and easily propagate to many other people. The tone of the discussion will be different from one country to another, and will also depend on the political talent of the proponents, but the notion of quasi budget neutrality should be kept in mind.

Of course, changing the fixed costs in one country (where DAREA tolling is introduced) and not in others (where that is not the case), raises the question of cost aggravation especially for the hauliers of those other countries, which can lead to resistance not only at domestic level but also at the European level, with accusations that such tolls effectively constitute barriers to trade.

Differentiation of prices

If tariff levels were to be based on actual costs imposed by users, the tolls to be raised on the secondary road network would considerably exceed pure motorway charges. While for reasons of cost efficiency this structure might be appreciated, it contradicts the principle of prices to reflect the quality of supply. As the latter would mean to have higher tolls on motorways, the compromise of introducing equal prices on all road categories is intuitively fair and minimises market distortions.

A differentiation of charge levels by regions is more justified under DAREA conditions than under NET. In particular when introducing DAREA pricing from PERM, the high charge levels and the missing possibility of avoiding payment by detouring the motorways might cause considerable distortions in economically weak regions. Accordingly, a regional differentiation, possibly in the secondary network only, should be considered.

The differentiation of prices by environmental standards of the vehicles and by the sensitivity of regions will enhance the sustainable development of the transport sector and is thus recommended in case the motivation of introducing DAREA charges leads into the same direction. However, a high level of tariff differentiation according to the environmental sensitiveness of the region may be interpreted as barrier to movement through that region and be subject to strong opposition given the uncertainties of the cost estimation process.

Information requirement for different pricing principles

The determination of total annual infrastructure costs and their allocation to vehicle categories might either be carried out on the basis of historical expenses or by estimating replacement values of the existing road infrastructure assets. In any case detailed studies with periodical updates are required to either directly set road user charges or for benchmarking the charges set by private road operators. The underlying information acquisition will in most cases be particularly difficult for low-order road networks. Here, some simplified transfer of values from the higher-order roads might enable the price-setting authority to roughly estimated total and average costs of the entire road network.

It is in particular not possible (justifiable) to simply apply the existing motorway tolls to the entire network.

Transferring average infrastructure costs from one country to another, between different institutional frameworks or between longer periods of time is not possible, as in all cases cost values as well as the degree of road use will vary to different degrees.

The transfer of marginal infrastructure costs is rather possible between countries, time periods or institutional frameworks as they vary less with traffic volumes. However, environmental effects alongside secondary roads, which usually are leading through build-up areas, are more local-specific than for the motorways and thus the transfer of values between different countries or regions is more difficult.

Further, levels of marginal congestion costs strongly vary with traffic demand and with the configuration of the transport network. Thus, detailed local studies are required to set price levels accurately in accordance with the goals followed.

5.4.5 Acceptability

Naturally, evolution from a NET to a DAREA scheme is seen as a punitive movement, since all trips, on any road, will be charged. And while on a NET scheme you can be (almost) sure of getting a good road when you pay a toll,

in a DAREA scheme there it no obvious relationship between the act of being charged and the quality of service received.

The fact that this poor acceptability is derived mainly from poor confidence in the effectiveness of the schemes strongly calls for adoption of a discursive approach, in which the main stakeholders are invited to participate in the formulation and diagnostics of the problem, and then on the identification and evaluation of alternatives types of instruments to solve those problems.

Transition of a NET scheme to a DAREA scheme (thus effectively covering urban areas) is prone with difficulties of acceptability related with the perceived low effectiveness of an attack on urban congestion mainly based on pricing. One possible way to minimise these difficulties would be a commitment for a strong hypothecation of revenues to local transport, both for individual and for public transport, benefiting respectively those who pay and keep on driving, and those who will be priced out of individual transport, at least on most days.

Evolving from NET to DAREA is most likely justified by the need to fight congestion, and this should imply that all vehicles should be tolled in the DAREA scheme, even if only trucks were being charged in the NET scheme: private cars always make the bulk of occupation of road space and there is little point of fighting congestion by targeting HGV's alone.

Several other issues can also constitute a barrier to acceptability of this charging scheme, at least in its initial implementations, as they are related to "youth problems":

- Inexperience with the system reliability and operation in general;
- Legal issues regarding mandatory equipment;
- Uncertainty of future cost of GPS-signals and Cellular Network telephony for the transmission of the date related to road charging;
- Complexity of pricing scheme affects user friendliness and transparency;
- Anonymity possible, but with less automatic and comfortable technical solutions.

None of them seems to constitute an insurmountable barrier, but this might be a case in which it would be preferable to separate the application of the principle of paying for use of congested roads and the sophisticated technical solutions required to charge most correctly. Possibly, there would be advantage in introducing first an urban road pricing cordon-based scheme (in parallel with the existing NET schemes for motorways) and only later let it evolve to a high-tech solution covering motorways and urban agglomerations in the same scheme.

Two more problems of acceptability should be pointed out, although they are related not to the general public but to the political agents:

- In a DAREA scheme covering all roads in the country, there will be problems of authority in supervision of the scheme and of allocation of the revenues, as some roads will be dependent of national governments, others of regional and others of local governments. Resolution of these disputes could be one of the major hurdles until all of them agree that there is no better solution. But also here, the gradual approach suggested above, with separate application first and unified payment later is the better approach.

- If parts of the country are subject to recurrent congestion and others are not, it could be difficult to justify evolution from NET to DAREA in all regions of the country, as all trips would be subject to charges in some regions and not in others. This issue has been treated above in section 5.4.1

5.4.6 Who should finance installation?

The different cost elements of the road pricing system are identified as follows:

- Cost of onboard unit;
- Cost of road side equipment;
- Point of sale / point of registration for non-equipped users;
- Cost of background system / IT application;
- Operation of the system.

Additionally there are the costs arising from the transition phase with termination or incorporation of existing concessions. In the latter case both an industrial and a commercial risk persists for the concessionaires due to clauses related to maintaining a certain quality of service and level of safety.

In the DAREA system the cost of the road side equipment is rather low, however the onboard unit and the background system will typically be more costly. In this case of transition from NET to DAREA, it is likely that owners of NET-equipped vehicles will not be willing to fully pay the DAREA-OBU ignoring the investment already made in the first OBU. Thus, the state or the concessionaire would have to cover this cost. The same goes for the operation of the system due to the more complex enforcement of the system.

In the **mixed public/private model** the IRPS-scheme is financed by the public authorities and operated as concessions by private firms. The vehicle owner is responsible for purchasing and installing the onboard equipment. The government or the private operator could decide to subsidise or fully cover the cost of the onboard equipment in order to increase the number of equipped users.

In the **all public model** the IRPS-scheme is financed and operated by the central or local public authorities. The vehicle owner is responsible for purchasing and installing the onboard equipment. The government could decide to subsidise or fully cover the cost of the onboard equipment in order to increase the number of equipped users.

6 THE EUROPEAN PERSPECTIVE

6.1 Conditions for long-term convergence

Apparently, a Single European Internal Market should have similar regulations and charges across the countries and regions concerned. This should create identical conditions for all agents competing in the markets, and thus provide conditions of fair competition.

Reality is a lot more complicated, though. Particularly in the transport sector, factors like geographical location and proximity to regions of high population density have a strong influence on the conditions of operation, and through them on the necessary relations between fixed and variable costs of operation of the vehicles to have a chance of being competitive. On the other hand, the possible extent of allocation of the costs of construction and maintenance of roads to the vehicles using them is certainly very dependent on the traffic density on those roads, and so the same cost coverage rule is simply not possible to apply throughout Europe.

Moreover, the single market in the EU has started and is evolving from a situation of multiplicity of regulations, charges and fiscal regimes that were and still are quite different. And one should not forget that the nation-state is the dominant power in fiscal decisions, which are, as shown above, a critical aspect in the discussion on road tolls. Possibly because of the very significant role that road transport fiscal revenues play in the State budget of several member countries, the associated inertia is very heavy.

So, no matter whether for reasons of preserving competitiveness of their economies or for reasons of fiscal inertia, the fact is that there has been little, if any, significant convergence of fiscal policies, in particular of those related to road vehicles and their operation.

The question must then be posed: Should there be a long-term European perspective on the issue of road tolls for HGV's ? The answer is a moderate positive, in the sense that some convergence could be welcome, if accompanied by some convergence in other domains, namely in fiscal policies with regard to road transport vehicles.

The common ground could be to charge HGV's for the marginal effect they impose on the maintenance costs of the roads they use, but for this to be acceptable by hauliers and their clients, clear identification of the application of State revenues coming from fuel duties and purchase taxes in different countries should be achieved.

Adding the external cost element to the tolls would also be justified, although that would possibly significantly add to the controversy. So, this point could possibly be addressed in a first phase by simply charging the additional cost imposed by vehicles with an engine of an emission standard less clean than the best available. In a second

phase, requiring a much higher degree of harmonisation of fiscal policies and of consensus on the economic value of the external costs, these could also be included in the bill.

A third element that can be included in road tolls is a variable charge, with the purpose of controlling traffic volumes, ensuring at all times pre-established minimum levels of quality of service, by avoiding excessive congestion. It must be recognised that this practice makes very little sense if tolls are applied only to HGV's, since in the vast majority of cases, road congestion is much more caused by private cars than by trucks.

In the case of congestion pricing applied only to HGV's, not only would they be ineffective but they could be considered as unjustified trade barriers imposed on foreign hauliers, who in any case always make a small proportion of the vehicles present on the congested road sections. On the contrary, if applied to all vehicles, such variable prices may be welcome by hauliers as they have a much higher value of time than private drivers, and so it will mostly be private cars that will be priced out of the road, leaving much better driving conditions for the HGV's.

Another important practical matter making convergence of road tolling principles very difficult (expensive) in the short- and mid-term is the fact that several countries have signed concession contracts with a duration typically between 20 and 30 years with concessionaires that made very heavy investments either to build and operate, or to buy the right to operate motorway networks. In those roads, users (HGV's like private cars) are paying to cover not only the marginal maintenance costs, but the full investment and maintenance cost. Changing the rules governing the revenue to those concessionaires implies that the State balances the contracts to compensate for those changes, which in all cases means paying them very large amounts, an action those States are not in a condition to take without grave disruption of their public accounts.

So, motorway concession contracts in the usual conditions constitute a blocking factor against any transport pricing policy change in general, and against EU convergence on road tolls in particular.

But it is not only the difficulties of convergence of fiscal policy and the high rigidness of concession contracts that make a unified EU perspective on road tolls unlikely in the next 10 or 20 years, since there are several other reasons for diversity in the use of this policy (and revenue) instrument. Several of these reasons, e.g. geographical situation or density of settlements, are of a permanent or semi-permanent nature (see chapter 2).

If we accept this judgement, the question becomes much less one of convergence, and much more one of interoperability of Electronic Fee Collection (EFC), i.e. of easy, transparent and discrimination free toll transaction for HGV's registered in any European country, when using the road networks of any other European country.

In this domain, it is important not to overstate the importance of interoperability of EFC: The vast majority of HGV's registered in any European country travel almost exclusively within their own country, and thus under a scenario of multiple technological solutions in place across Europe, it should be possible for vehicle owners to select the spectrum of EFC solutions with which they want each of their trucks to converse fluently. As long as the

costs of On-board-units are significantly higher when they are to provide this flexibility than just for the home market, two or more degrees of OBU sophistication should be expected in the market and accepted by member States and the European Commission.

Interoperability of EFC is an interesting feature, but it should not be imposed to the whole fleet and rather made available as the market requires it, for the relevant vehicles. For the European Commission, it should not be a matter of imposing it, but of circumventing or mitigating the barriers that might prevent it.

6.2 Realistic short-term steps forward

6.2.1 Reform of EC/1999/62

What is the motivation of setting out an European regulation for road tolling?

Directive 1999/62/EC of the European Council and the European Parliament sets out very strict rules of charging for the use of inter-urban roads by HGVs above 12 t gross vehicle weight. The motivation for determining tolls to equal allocated average costs of the construction, the maintenance and the operation of the road network is more driven by fiscal considerations than by scientific recommendations. Depending on the perspective from which one looks at the directive, it appears to have several shortcomings, which continuously keep the discussion on ways to reform it alive. Some of the most frequently raised points of criticism at the Directive are listed in turn, while the recommendations evolving from the DESIRE research on its amendment are presented in the subsequent paragraphs.

Internalisation of external costs: Transport externalities (air pollution, contribution to global warming, noise disturbance, traffic accidents, deterioration of nature and landscape, visual intrusion and other effects) directly or indirectly cause considerable costs to society. Referring to the polluter pays principle it is frequently claimed that the transport sector should cover these costs, ideally by kilometre-based externality charges. However, this is strictly prohibited under the framework of Directive 1999/62/EC.

Marginal social cost pricing: In a great number of economic studies funded by the EC and other bodies as well as in the Commission's 1998 "White Paper on Fair and Efficient Payment for Infrastructure Use" transport user charges equal to short-run marginal costs caused by infrastructure use are strongly promoted. For most internal and external cost categories, and in particular for the marginal costs of road maintenance and operation, marginal social costs are well below average costs, and thus may not be applied under the prevailing terms and conditions of Directive 1999/62/EC. Further, economic theory, among many other conditions, requires that marginal social cost prices are levied in all economic sectors, or at least in all parts of the considered sector according to the specific level of marginal costs. This means, that all roads must be priced, which is again not supported by the Directive. Even if that were allowed, this would lead to higher tariff levels in secondary roads than on motorways, which is contrary to normal practice in a market economy, where prices reflect quality of service received.

Prevention from detour traffic: Solely pricing the motorways can cause sharp increases of traffic loads on specific parts of the secondary road network, entailing all negative impacts on environment, noise pollution and traffic safety. The Directive allows fighting such unwanted effects by location-specific regulatory charges, but it forbids to generally charge the secondary road network in order to create the incentive to hauliers to use the less sensitive motorways.

Traffic demand management: The terms and conditions of the Directive provide the charging authority with some degree of freedom concerning the differentiation of charges by environmental standards of the vehicles and by time of day. However, the allowed margin of tariff variation is limited and as such may complicate the achievement of specific goals followed by Member States.

Cost calculation rules: With the limitation of eligible costs serving as the basis for tariff calculations to the costs of construction, maintenance and operation of the considered road network Directive 1999/62/EC clearly excludes all kinds of transport sector external costs, such as environment, noise and safety-related costs, from consideration. However, the details of cost calculation (e.g. in- or exclusion of interest on capital, depreciation procedures or cost allocation schemes) are not tackled and thus leave space for political dispute and legal claims. This should be clarified.

Should the entire secondary road network be included?

Directive 1999/62/EC allows to set regulatory charges at the secondary network in case transport safety is heavily deteriorated by introducing motorway charges. The Directive states explicitly, that pricing of roads outside the motorway network has to be justified by a negative development of road safety, and thus it opens the possibility of specific stakeholder groups to raise legal claims in case of a weak justification of the geographical extension of the pricing system. Under the vision of the European Union to provide conditions of a free exchange of goods and services between the EU Member States, in which all customs duties therefore have been removed, the pricing of all roads which are relevant for international traffic could be regarded as an alternative form of border crossing tolls, and thus may contradict the Community's spirit. In this sense, road tolls outside the motorway network should be the exception and must be agreed by the Commission.

For these reasons, in its current formulation the Directive must be understood in the sense that the general pricing of the entire inter-urban road network is forbidden. This interpretation holds true even though the Directive explicitly states that it does not want to prevent Member States from introducing urban road pricing or congestion charges on the entire road network. The latter by definition strongly varies with traffic levels (and thus with time and space) and therefore is not appropriate as a general means to protect all parts of the secondary network from international traffic bypassing the motorways.

The results of the DESIRE research reveal that even under moderate NET pricing conditions (around 0.15 Euro/km) considerable additional traffic loads may have to be accommodated by the non-priced network, de-

pending on its density and quality. The implication of this for road traffic safety can be little or even positive as an increased number of heavy vehicles can slow down traffic speeds and thus reduce the severity of traffic accidents. In the sense of the Directive this means, that regulatory charges on the respective network links are not justified, expect for the occurrence of heavy congestion. Nevertheless, the consequences for inhabitants might be severe due to increasing noise disturbance and environmental loads.

Based on the research carried out in the project and bearing in mind the requirements of the European free trade market, the DESIRE consortium recommends to expand the freedom of Member States to levy charges for heavy goods vehicles on the secondary road network. The rationale for this extension is the protection of inhabitants and the environment from detour traffic from the motorways, but also to limit additional burdens of the local public budgets caused by the additional damages to the secondary roads from heavy international traffic.

In case it is considered as a priority principle of the free trade market to have generally free-of-charge routes for international traffic as an alternative to tolled motorways it is strongly recommended by the DESIRE consortium to widen the exception rules. The setting of regulatory charges on the secondary network should also be allowed in cases, where HGV traffic causes considerable problems for environment and for the inhabitants' quality of life.

The level of charges required to effectively limit the growth of HGV traffic on secondary roads will differ from region to region depending on the capacity, the quality and the density of the road network. Thus, they should not be fixed by the Directive; only an upper limit, e.g at the level of the national motorway charges, might be prescribed.

On the other hand, a revised directive on road tolling in Europe should not force Member States to price the usage of all inter-urban roads by goods vehicles. Here, the principle of subsidiarity is to be highlighted, which makes it possible for the Member States to embed the pricing policy on the secondary road network, which is mainly affecting local, regional and national traffic, within the overall national policy of economic and regional development.

To what extent can regulatory (congestion) charges affect freedom of trade ?

An important contradiction between desirable results at micro level (optimum efficiency of use of each road section, including consideration of environmental impacts) and at macro level (promotion of free trade and economic development of all regions in Europe) can be found when considering the case of very densely populated areas, with their own transport networks frequently under heavy congestion. These congested networks can be seen as a barrier to movement and trade between the regions located in different sides of those areas, particularly if congestion charges are applied to long distance traffic.

The EU recognises the existence and sensitivity of natural barriers of higher environmental sensitiveness, but has fought the imposition of higher tolls on the roads crossing them (in the name of environmental preservation),

because of the effects they would have on free trade between regions in different sides of the barrier. To solve / mitigate this dilemma, it defends the urgency of development of transport alternatives, possibly by construction of rail tunnels, so that a sensible compromise is found between the effective promotion of free trade and the preservation of the environment.

Similar arguments could (and perhaps should) be applied with respect to the barriers formed by densely populated and congested areas: since their congestion is largely due to the presence of local and regional traffic (mostly of private cars), application of high toll levels (to long distance traffic) on the roads of those dense areas would be equivalent to hardening the barrier that in any case already exists because of recurring congestion.

If the application of higher tolls is related to congestion levels and intended to reduce them, then necessarily private cars should also be tolled, as they are the largest contributors to congestion and those with greater elasticity of demand to the toll levels.

But the argument may be pursued deeper: Just like tunnels will be built especially for long distance traffic and not paid exclusively, or even mainly, by this type of user, the concept of positive discrimination (i.e lower toll levels) to long distance traffic when crossing densely populated areas could be applied. Although at first sight this seems to contradict the principle of territoriality, i.e. equal treatment of all in the same space, independent of nationality, we believe it can be shown that is not the case, at least not more than in the case of long tunnels to cross natural barriers:

- access to positive discrimination would only be possible for long trips, easily identified by the EFC systems as such, and independent of the nationality of the haulier or country of registration of the vehicle;

- a lower price for some traffic segments clearly is a form of subsidisation, but only equivalent in the price dimension to what a privileged access condition to an infrastructure not fully paid by its users constitutes in the supply dimension;

- higher population density and corresponding saturation of transport networks by local / regional traffic constitutes an external cost to those traffic streams that want to cross those regions. Since the agents involved in that long-distance traffic (shippers and hauliers) have had no interference on the democratic decision processes leading to those high densities, it is fair that the generators of that external cost (the agents in the dense region and its economy) contribute with some cost relief for those affected by its consequences on traffic conditions and trade barriers.

Should the freedom to determine charge levels be expanded?

Directive 1999/62/EC fixes motorway charges at the average costs allocated to HGV's for the construction, the maintenance and the operation of the road network in question. The motivation of this idea is the conversion of the tax-based financing of transport infrastructure to a user fee financed system. This intention would be contra-

dicted by reducing the charges to only parts of these costs, e.g. to marginal costs of road use. As these amounts to roughly 1/3 of average total costs, the resulting deficit then has to be financed by tax revenues. Depending on the degree of road use by national and international traffic, the result of raising road user charges according to marginal costs would most likely be a major imbalance in the burden of cost carriage between national (tax-paying) and international traffic and thus raise equity concerns.

Apart from these considerations, member states might have other motives for keeping road user charges at a low level, e.g. to prevent from massive shifts of traffic to secondary roads or to avoid major re-adjustments of the complex national taxation system. As the results of the DESIRE model applications have dimmed the expectations of road pricing to result in a major stimulation of markets and transport shares by alternative modes, we do not see much reason to commit member states to set road user charges to the full rate of average costs for motorway construction, maintenance and operation. Consequently, the Directive could well be opened to allow for setting lower charge levels.

This recommendation is strongly supported by the fact, that average costs will increase when traffic volumes are low. Although the construction of roads gets cheaper for low levels of expected traffic, the high share of fixed costs for road construction, maintenance and operation has to be shared by less users. Further, the costs of road construction is influenced by topology and climate conditions. In combination, these factors might cause average infrastructure costs to get rather high in some peripheries of the EU, as e.g. in some of the Scandinavian countries or in Spain and Portugal. As this strongly concerns the competitiveness of these regions the Directive should either recommend upper limits of motorway charges, or it should allow for defining a proportion of total costs, which is disregarded when calculating user charges.

Allowing charges to exceed average infrastructure costs, e.g. by including environmental costs, would increase the problem of detour traffic and would bring an element of arbitrary into play as the determination of the external costs of transport is much dependent on the methodology applied. Moreover, while average infrastructure costs do affect the Member States budgets, the costs of environmental quality and safety are not related to fiscal flows and as such can hardly serve as the basis for determining user fees in a legal sense.

For the sake of transparently defined charge levels and to maintain some instrument of control of road tolls in the EU, we do recommend to keep the upper limit of HGV tolls on motorways to the average costs of constructing, maintaining and operating the road system as defined in the Directive, plus (in cases where all vehicles are tolled) a regulatory change to traffic flow levels. Defence of environmental values in this case is more effective and more easily accepted through tariff differentiation according to vehicle emission class.

Should the Directive be extended to other vehicle classes?

The Directive concentrates on HGV's above 12t gross load weight, which are obviously those occasioning nearly all road and bridge maintenance costs and – depending on the allocation method applied – which are contributing

to a major part of road construction costs due to their weight and size. Moreover, these heavy goods vehicles do perform much more of international traffic, which is the concern of EU policy, than private cars. Therefore we conclude, that in terms of equity the Directive covers the most responsible vehicles, but leaves the less damaging light vehicles according to the principle of subsidiarity to the decisions of the Member States. We do not see any reason to deviate from this definition.

The Directive states that it does not intend to prevent Member States to adopt congestion charges on whatever level of the road network. However, it does not give a recommendation to the Member States on how these should be designed. Congestion charges do only efficiently improve traffic quality and are only fair in case they are levied to all road users according to their contribution to capacity use. Therefore we consider it necessary that the Directive explicitly encourages Member States to levy congestion charges on all types of vehicles.

6.2.2 Interoperability from a European perspective

In chapter 3.3, the importance of interoperability for an efficient European road network has already been pointed out. In chapter 6.1, the difficulty to reach convergence has been addressed. In this section, we look into the possibilities of the European Union to improve the interoperability of EFC systems throughout Europe within a shorter period of time.

What has the European Union done so far to improve interoperability of EFC?

Through several research projects, the EU has tried to set the basis for interoperability between different operators in Europe (MOVE-It, CESARE, CARDME, etc.). In its communication COM(1998)795 final, the European Commission outlined a Community strategy for the convergence of interoperable electronic fee collection systems to facilitate traffic flow and the payment of fees. This communication examined the obstacles to interoperable electronic fee collection systems and put forward certain recommendations for arriving at an appropriate level of interoperability on a European scale. More recently, in 2002, the European Commission has carried out Consultation meetings with Member countries with respect to its intention to issue a Directive on Electronic Fee Collection, according to which all tolled motorway operators should install technical equipment that is interoperable.

A short-term goal would be interoperability of all European DSRC systems. The problem with this proposal is that it dismisses agreements reached at CEN, where existing systems were taken into account, and focuses instead on the interests of “the majority of European suppliers”, ignoring the conversion costs for concessionaires and over 2 million users.

In the longer term (2008), the proposal is directed to GNSS / GSM + DSRC solutions, thus hopefully covering all national systems in Europe. Hopefully, the more expensive OBU’s for this solution would be “integrated when constructing the vehicles, at approximately the same price than the present DSRC onboard units”.

Besides the doubts about the feasibility of this cost reduction of the more complex OBU, this proposal has not been very well received, as it forces the majority of countries with tolling systems, which are based on DSRC, to migrate to a more complex and expensive system, especially on operating costs.

What should the European Union do to improve interoperability of DSRC solutions?

With the support of the already mentioned research projects on interoperability, the European Union has played an important role on the way towards interoperability. Now, it's up to the players in the field to use this spadework and start getting really interoperable. Most operators will have an interest to harmonise as far as possible for reasons of cost-effectiveness. New players building up a DSRC solution will certainly use the CARDME standards (even if it's only for the cheaper, off-the-shelf equipment).

What should the European Union do to improve interoperability of GPS/GSM solutions?

There is nothing it can do in the near future. In August 2003, Germany is expected to introduce the first area-wide, commercially used GPS/GSM road charging system. Only based on the experiences gained thanks to this work, the European Union should start new initiatives similar to what has been done with regard to DSRC solutions. It would then be likely that two standards emerge, one based on DSRC and another on GNSS/GSM. On board units should be available separately for these two standards, as well as joining them in a single device.

Only if costs of the dual unit are rather low (as the European Commission seems to expect) would it make sense to have only one type of OBU, with full dual capability; otherwise such capability would only be acquired for those vehicles which are expected to travel frequently to countries using one and the other system.

Moreover, there is the question of "open specification" or "closed specification" of the technologies involved, and its implications on monopoly of supply of the corresponding OBU's. In Holland, it was decided by the Government before introduction of the *Rekeningrijden* project, that all specifications had to be open, in order to allow multiple manufacturers to develop and market the OBU's, and possibly also include added-value services on their top models, but in Germany the option has been for a closed specification, thus giving the concessionaires / manufacturers of the OBU's a monopoly on a virtually compulsory equipment for the hauliers. This seems to be contrary to competition rules in the EU, and will probably be challenged some time in the future, probably closer to the start of operations of the German tolling system. The fact is that there seems to be little sense in interoperability across tolling schemes while one of the key players keeps his specifications (and its market through it) closed. So, a very important contribution of the EU to improve interoperability of GPS/GSM solutions would be to impose that their specifications be open, thus favouring not only price reductions of the simpler OBU's in the domestic markets, but also earlier and cheaper introduction in the market of interoperable OBU's.

Should the classification of vehicles be harmonised?

Yes. Even if harmonisation in this field is not absolutely required in order to achieve interoperability, it would certainly facilitate comparability and simplify users' understanding of charges. To enable EFC systems to fulfil the likely requirements of future charging and pricing legislation, the set of classification parameters includes in addition to the usual vehicle characteristics, environmental attributes, such as emission or noise characteristics. With the definition of the EURO emission categories, a step in the direction of harmonisation has already been taken; some optimism is permitted here because vehicle classification does not seem like a very sensitive issue for the Member States. Since this harmonisation has implications of existing concession contracts, price levels in the various classes should be adjusted in each country so that total revenue is not affected.

Will the market (operators, users, etc.) reach full interoperability without legal pressure from the EU?

Full interoperability between all European EFC should not be expected within the next 10-20 years. This is obvious since some countries are building up new systems based on DSRC while others are introducing the advanced technology of GPS/GSM. In this situation, the Member States are not willing to accept any legal pressure from the EU which would force them to abandon their solution. The difference in existing technical solutions will therefore persist. The risk exists that standardisation on the GPS/GSM front will take as many years as it has taken on the DSRC front.

However, it can be expected that the market forces create interoperability where it is economically reasonable. In the absence of an easy-to-use pan-European EFC, or relatively cheap dual-use on-board units, it is even undesirable to have everything interoperable just because it would be technically possible, since each step of interoperability requires costly negotiations and payment procedures. For example, it would be inefficient to make all Portuguese trucks interoperable with the Greek motorway network. It would be cheaper if the few Portuguese trucks that will ever use Greek roads pay their charge manually. If the German GPS/GSM experience proves to be successful and if other big European countries should change to this technology, it is imaginable that HGVs will be equipped with a standardized GPS/GSM + DSRC equipment *ex fabrica* in the future. Such vehicles could circulate on all European EFC roads.

To sum up, although full interoperability in Europe will probably not be reached within the next 10-20 years, market forces can be stimulated to define standards and will create interoperability where it is economically reasonable, i.e. the adequate level of interoperability for many hauliers should be available within a shorter period of time.

7 CONCLUSIONS AND RECOMMENDATIONS

1 There is a considerable diversity of objectives and framework conditions surrounding the introduction of road tolls. Part of those objectives and conditions are dynamic, but others are rather stable, so there is and there will be for a long time legitimate reason for diversity of tolling strategies by national governments;

2 Prices are just one of the types of instruments in support of transport policy (the main others being supply [infrastructure and technology] and regulation [technical and economical]). In search for an optimal intervention on the transport system, governments should remember the availability of these three types of instruments. In parallel with some convergence on the regulatory front, the large differences existing with regard to supply make differences on the pricing front natural;

3 Just like companies in a market try to recur to different combinations of production factors to find their spaces of competitiveness, so do national governments recur to different combinations of those instruments to find situations where their transport systems may promote the competitiveness of their economies.

This search has to be done in respect of some basic rules of the European Union, like the principle of territoriality and the promotion of the Internal Single Market and reduction of barriers to trade, of which free access to markets and a strong harmonisation of technical regulations are necessary supporting elements;

4 Identity of transport prices would make sense if countries were facing identical situations of density and sophistication of supply of transport infrastructure and services, and of density of demand, i.e. ultimately of identical situations of population density and purchasing power, which clearly is not the case in Europe;

5 Different tolling schemes, as well as the possible need to involve private financing of infrastructure, will lead to different recommendations regarding the institutional design, from all-public to all-private. However,

5.1 In all cases, its is recommended that ownership of transport infrastructure stays in public hands, as well as the decision to build it and to what standards;

5.2 In all cases, the State should ensure independent audit of the processes of revenue collection and application, as well as of the processes of handling customer complaints;

6 There are technological solutions available to allow comfortable and transparent application of EFC in the various tolling schemes studied. The choice of the most adequate technology depends not only on the basic form of tolling (NET vs. DAREA) but also:

6.1 for a NET scheme on whether tolling has been considered in the design of the motorways or not (retrofitting);

6.2 for a DAREA scheme, on the main objectives underlying the introduction of the tolls, and with them the need for variability of tariffs (i.e. time modulation of the tariff or higher tariff levels in more sensitive areas);

6.3 for any scheme, on the desired other functions to be developed on top of the tolling technology;

6.4 for any scheme, on the transaction costs and enforcement difficulties associated with the various technologies;

7 Diversity of national situations and strategies regarding application of the various instruments in support of their transport policies justify the diversity of tolling choices, but as some of the characteristics of national situations and the availability of resources change over time, it is normal that some countries would feel as adequate to evolve on their tolling choices. This has led to the decision to include in the project an analysis, not only about the circumstances in which tolls should be introduced, but also in which an existing tolling regime should be changed. In both cases, the analysis includes recommendations on how to manage those changes.

8 A complex set of mathematical models, combining traditional a transport network assignment model and a regional dynamics model has been used to estimate the economic and environmental impacts of the various tolling regimes. The main points coming out of that analysis are:

8.1 The introduction of road tolls (in either basic form) is expected to have very limited effects of modal shift, the stimulus of operating cost increases being translated specially into choice of alternative road corridors (if only some countries introduce road charges), as well as better commercial and logistic organisation. However, some reduction of trade and slowdown of economic growth should be expected due to higher transport costs;

8.2 When NET schemes are introduced in regions of high density and quality of road network, there is a considerably risk of traffic detour to secondary roads, with strong external costs to the populations living close to those roads;

8.3 In such cases a mixed NET / DAREA scheme might be considered a good solution, with DAREA being adopted only in the regions where the risk of traffic detour is significant, but this solution has considerable problems of acceptability for reasons of fairness;

8.4 If part of the revenues collected in a road charging scheme are used (directly or indirectly) to allow a reduction of indirect taxes, a positive welfare effect should be expected in the mid-term, but the above mentioned short term economic slump should not be ignored;

9 In all cases, introduction or change of tolling systems collides with long-term choices made by people and companies, located in the regions affected or having to cross them regularly. This implies:

9.1 That clear political objectives related to the introduction or change of the tolls have to be defined, and the comparison of tolls with other possible instruments to reach those objectives has to be carried out with great care;

9.2 That careful estimation of the impacts of the tolling scheme has to be carried out, and that engagement of stakeholders should be pursued in a systematic manner, so that acceptance issues may be managed in a sensible way;

9.3 That it is recognised that these processes always take several years to mature in public opinion and that the tough choices must be made in "political windows of opportunity" of relatively short duration;

10 In the light of these reflections, recommendations have also been produced on the justifiable scope of a possible revision of Directive 99/62, on application of road charges on roads of higher quality.

10.1 Expand the freedom of Member States to levy charges for heavy goods vehicles on the secondary road network, at least widening the exception rules. The setting of regulatory charges on the secondary network should also be allowed in cases where HGV traffic causes considerable problems for environment and for the inhabitants' quality of life.

10.2 Do not force Member States to price the usage of all inter-urban roads by goods vehicles;

10.3 Do not force member states to set road user charges to the full rate of average costs for motorway construction, maintenance and operation, and allow for setting lower charge levels. Average costs strongly increase when traffic volumes are low, creating severe problems in some peripheries of the EU, strongly affecting the competitiveness of these regions;

10.4 In NET charging schemes, allowing charges to exceed average infrastructure costs, e.g. by including environmental costs, would increase the problem of detour traffic and could bring an element of arbitrariness into play as the determination of the external costs of transport is much dependent on the methodology applied. For the sake of transparently defined charge levels and to maintain some instrument of control of road tolls in the EU, we recommend to keep the upper limit of HGV tolls on motorways to the average costs of constructing, maintaining and operating the road system as defined in the Directive, plus (in cases where all vehicles are tolled) a regulatory charge to manage traffic flow levels.

10.5 Application of high regulatory charges to fight congestion in densely populated areas may be considered as a barrier to trade, and requires some kind of positive discrimination in favour of long distance traffic crossing them.

11 Interoperability is an important element of convenience and efficiency for international hauliers, but the variety of starting conditions raises the costs of providing it across the board. Given that most hauliers are dedicated to domestic markets, and others are dedicated to specific foreign markets, interoperability should be provided "*à la carte*" as the market forces find it interesting. The same majority containment to domestic road networks applies to private cars.

12 However, there are possible important contributions from the EU in the short and medium term:

12.1 To impose open specifications for OBU's in all countries;

12.2 To encourage convergence of standards in the GPS/GSM platform (as it has done for the DSRC platform);

12.3 To encourage convergence of vehicle classification.

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