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CRITICAL SUCCESS FACTORS FOR IMPLEMENTING ROAD CHARGING SYSTEMS

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Critical Success Factors for Implementing Road Charging Systems

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FROM ROAD USER CHARGING TO CONGESTION CHARGING

Road user charging is used as an 'umbrella' term to describe a wide range of applications of pricing roads and infrastructure. Road user charging includes a number of charging measures that governments and other road owners use to:

- Finance new or maintain existing road infrastructure,
- Manage traffic (e.g. reduce congestion),
- Minimise environmental impacts of transport,
- Internalise the external costs of road transport caused, e.g., by pollution and noise emissions.

Historically, the common approach to charging for road use is some form of general taxation rather than differentiated road user charging. Road user charging has long been proposed as an efficient and equitable method to pay for road use and to fund road infrastructure projects. However, there is an important distinction between charging for revenue generation purposes as opposed to pricing roads to provide congestion relief. The two basic objectives, revenue generation and congestion management, differ in several ways, as shown in the following table.

Revenue generation	***Traffic management***
▪ **generate funds** ▪ **rates set to maximise revenues or recover specific costs** ▪ **revenue often dedicated to road infrastructure projects (construction and maintenance)** ▪ **traffic diversion to alternative routes and modes not desired as it reduces revenue collections.**	▪ reduce peak-period vehicle traffic ▪ used as a travel demand management strategy ▪ revenue not dedicated to road infrastructure projects ▪ requires variable charging rates (i.e. higher during congested periods) ▪ travel shifts to other modes and times considered desirable.

[*TDM Encyclopaedia* - *http://www.vtpi.org/tdm/tdm35.htm*]

Road user charging objectives: revenue rising vs. congestion management

Road user charging can improve transport efficiency by rationing road capacity, including influencing the demand for road capacity as it applies to various road classes, vehicle classes or peak traffic conditions. It can be a useful travel demand management tool. Effective pricing schemes can change travel patterns by exposing road-users to the marginal social cost of their travel choices. Pricing affects all stages of travel decision making from choosing to make a trip to destination choice, mode choice, time of travel choice and route choice.

Electronic pricing and related Intelligent Transport Systems (ITS) technologies have matured considerably in recent years. Improvements in coverage, ease of implementation, cost and public acceptance are occurring at a rapid pace.

The importance of road user charging as an effective instrument against congestion is increasing. The well known London Congestion Charge, the Stockholm City Ring and the Cordon Pricing in Oslo are European examples of successful realisation of such a charging policy.

AN INDISPENSABLE CONGESTION MANAGEMENT TOOL

Traffic is increasing. There is no limit in sight. In many areas of the world, congestion is going to be amongst the most pressing problems of this century.

Supply-side solutions alone do not suffice. Demand management, including the use of price incentives, is also needed. The need to combat traffic congestion and the desire to find new revenue sources for transport investments have stimulated the interest in schemes where charges for road use are introduced, such as parking fees and charges to allow vehicles to use certain roads. The theoretical advantages of charging for road use have long been discussed in economic literature. Practical experience with such schemes is more recent. A key element of demand management in urban transport is the allocation of road space. As this space is a finite resource, absence of regulation can lead to overuse, which appears in the form of congestion. Reserving road space to public transport vehicles or to private vehicles with high occupancy are two ways of allocating road space. Another way is to restrict access to certain areas of the city. This latter kind of control measure does not make a distinction between trips of different value. Conversely, if travellers are faced with a road user charge, they will be encouraged to make their own judgement on the value of their trip. Charging for road use, often referred to as road pricing, has long been advocated by economists on the grounds that it is socially advantageous. Congestion occurs as every additional trip made forces those vehicles already on the road to slow down. The introduction of a corrective charge will make each driver aware of the cost he imposes on other drivers. This may help reduce traffic volumes and have positive effects in terms of reduction of congestion and overall travel time on the network. In reality, the efficiency effects of road charging policies are the consequences of both the actual behavioural responses of the travellers as well as the way the revenues from charges are spent. In addition to travel time savings, benefits include increased travel time predictability, reduced pollution and noise, reduced accidents and improved travel conditions for public transport (from Ref. [1]).

Economic theory and mathematics of road pricing also dictate that the charge should be equal to the monetary value of the additional travel time imposed by each driver on other drivers. This is the ‘marginal cost pricing’ principle. The principle extends into ‘marginal social cost pricing’ if, in addition to time, other costs, for example pollution, are considered when setting the charge. Economists have gone on to extend the welfare maximisation framework to cases where the price of public transport is set together with road charges. The other motivation for introducing road charges is to provide financial resources for infrastructure investment programmes. Revenues from road charges can be spent as well to improve transport at large. Both demand management and fund raising make charging for road use of interest to policy makers.

Research efforts as well as the introduction of toll rings and congestion charging schemes in a few European cities in the last two decades provide considerable experience to draw from and support the translation of theoretical principles into practical policies. This paper looks at factors that make a pricing measure a success. The approach taken is not a theoretical one, but looks at practical implementation aspects.

Access to inner cities is becoming a scarce resource and has to be managed. According to market theory pricing is the most effective means to allocate scarce resources. Congestion pricing will become an indispensable tool for managing the challenges of urban mobility.

WHAT MAKES A CHARGING MEASURE A SUCCESS ?

Simply put, a charging measure is a success if it works in all relevant aspects:

Technical implementation

Obviously an important precondition of success is a technical implementation that works smoothly, i.e. is implemented in time and at budgeted costs, and operates without hick-ups. Choice of technology is one important aspect of the technical system. **Charging technologies** as such are mature but other system aspects remain demanding. One such aspect is the special technical challenge imposed by the **urban surroundings**, where many design constraints apply. Another aspect of core importance is the handling of **occasional users**, who may enter the charging system without being properly informed, not being equipped and not willing to spend undue time and money to become compliant. Enforcing **compliance** of all users is a further critical aspect where no ready-made solution is available. Finally the technical system has to be implemented at acceptable overall **system costs** and must encompass a **security concept** that defends the system against all conceivable threats.

Scheme layout

Successful technical operation is only a precondition for a charging measure to achieve its true goals, namely to manage traffic and to generate revenue in the desired way. This requires a proper scheme layout, where foremost the **scheme principle** is decisive, namely whether the charge is only a flat fee, a distance-based area charge, cordon pricing, or a combination of such basic principles. Besides the principle, the right choice of **charging perimeter** is decisive, namely which geographic areas are subject to the measure and therefore which types of trips become subjected. Whether the size of the effect is as expected will depend on the right choice of **tariff level**. Often disregarded at first, but actually one of the core decisions to make in system layout is the **legal nature of the charge**, namely whether the charge is legally constructed as a public levy, say a tax, or as a private levy, like a fee for use.

Acceptance

Actually the single most important aspect for successful introduction of a charging measure is its acceptance. Without acceptance the system will simply never become reality.

Acceptance needs to be actively planned and **public perception has to be managed**. A precondition to achieve acceptance is that the public perceives a **pressing traffic problem**. No majorities in favour of a pricing measure thought to relieve congestion can be found without sufficient daily pain. No less important is the **use of revenue**. If the pricing measure smells like "just another tax", political failure is guaranteed. Finally acceptance by the general public requires a **transparent and understandable system** and careful treatment of the user's **privacy**. Acceptance can be increased if **accompanying measures** are designed into the system from the very beginning, with the intention to bring additional benefits to the individual users.

In the following, this paper looks into the three core success factors in turn.

A successful measure
- works smoothly regarding the technical implementation,
- achieves its traffic management goals, and
- most importantly: becomes accepted.

TECHNICAL DESIGN ISSUES

Technology

Choice of technology is less critical than is appears at first glance. Actually, the technologies employed in road user charging devices are standard technologies, for example short range communication (DSRC), satellite localisation (GPS) and mobile communications (GSM).

More important than mere technology is the system concept that is made out of the technical building blocks. Here we see four basic concepts that can all be considered mature, including practical proof in real systems:

- Manual, manned and barrier controlled **toll stations**. Such stations are the traditional means to collect charges on interurban motorways, especially on networks operated by concession companies. Due to the tight space constraints in an urban environment, such toll stations are rarely an option for congestion charging.
- User **self-declaration systems**. In such a system concept, road usage has to be declared by the user either before or after the trip. An on-board device is not required. The operational processes for such a manual charging system strongly depend on the details of the charging scheme. Users may book and pay trips at kiosks, fuel stations, with their cell phone via SMS or via internet. An indispensable part of any manual system is an Automatic Number Plate Recognition system that can be used to check whether users have actually paid for their trip.
- In **DRSC systems**, on-board equipment communicates with road side beacons for an electronic charging process. The on-board equipment works as an electronic tag, which will be recognized when passing specific beacons which have to be installed at

pivotal points of the road network. DSRC on-board equipment is low price, can be battery powered and does not need a proper installation.

- **GPS/GSM based systems** use GPS for localizing the vehicle. The GPS positions are then identified on a map and matched to the most likely roads. This map matching can occur in the on-board equipment or in a central system. Cellular communication via GSM or similar transfers either the raw GPS position data or the map-matched road usage data to the back office system. This technical concept requires comparatively sophisticated on-board equipment that needs at least some minimum installation since it requires electrical power supply from the vehicle, either via permanent installation or from the cigarette lighter.

GPS/GSM systems are the ultimate dream of any traffic manager since the capabilities for differentiated charging are nearly unlimited. The price for this is the need for capable on-board equipment, which is not only a cost issue but implies a number of complex challenges, e.g. the logistics of distribution and installation, the handling of occasional users, and means of protecting the privacy of the users in a convincing way.

The choice of technology can nowadays considered a mere engineering decision and should under no circumstances become a political issue ("we want the technically most advanced satellite system"). Technology is mature and choices should be made for technical reasons only.

In several countries have been examples of projects where the choice of technology has been made even before other critical questions, such as the determination of charged road network, of liable vehicles and of basic charging rules have been made. Especially satellite technology appears to be magically attractive but should not become an implicit pre-requisite of system design since it is not by necessity the best choice. Especially for congestion charging in the typical city environment, with a small geographical perimeter, many occasional users and limited financial room for manoeuvre, more mundane technologies usually make for a better overall outcome, with lower costs, lower risk and faster implementation.

Technology is mature and available, and as such not a critical success factor – at least as long as optimal choices from an engineering perspective are made.
Technology should not become a political issue or a matter of national pride.

Urban constraints

In an urban context a successful technical system design must address the challenges imposed by the urban environment with high priority. Charging technologies have initially been designed for the inter-urban motorway environment and do not naturally blend well into an urban situation. Several issues have to be considered (Ref. 2):

Aesthetic impact

The physical appearance of roadside installations is a much more politically sensitive issue in urban areas than in inter-urban contexts. There are generally tighter restrictions as well as existing visual, environmental and historical contexts. Street furniture needs to be sympathetic to such contexts, including colour, style, size and location. Only rarely will it be possible to even contemplate the use of gantries and thick structural elements in these locations. This reflects the fact that many more people live and work in urban areas and they have some degree of ownership of that landscape. As a policy, road user charging is sensitive enough without the controversy associated with physical changes to the local built environment. Therefore, any system that is deployed in the urban environment must be discreet, have minimal impact and be sympathetic to the surrounding environment.

Chaotic traffic behaviour

The traffic characteristics in urban areas are different from inter-urban contexts, including much more chaotic patterns of movement and behaviour. The urban road can be just as much a destination as it is a through-route, for a wide range of people and goods. With road works, building works, parked or static objects, contra-flow bus lanes, slow traffic, overtaking and general chaotic driving behaviour in urban areas, there is often no real concept of a left or right hand “side” of the road, no real concept of a lane, and the potential for unusual manoeuvres (e.g. u-turns and reversing) at any location on the road at almost any time. Unlike inter-urban roads, urban thoroughfares have a very diverse range of traffic restrictions and traffic management measures on them, including segregated lanes, traffic islands, chicanes, barriers, rising bollards, road humps, textured surfaces, pedestrian crossings and roundabouts. Finally charges may be applied which are direction dependant. Therefore, any system that is deployed should provide complete carriageway coverage for the monitored directions and have the capability to determine the direction of travel.

Diversity of road users

The range of objects using or adjacent to roads in urban areas is different from inter-urban contexts, reflecting the greater diversity of travel activities taking place in urban areas. This includes a much wider range of powered and un-powered vehicles, pedestrians and static objects (e.g. refuse skips, parked vehicles, trees). It is also reasonable to expect that for any particular urban charging scheme there will be a mixture of equipped and non-equipped vehicles legally using the road, with potentially a relatively high proportion of non-equipped users. Again this reflects the fact that, as a destination, the urban area cannot always be by-passed, unlike most inter-urban routes and it is unlikely that all objects using the road will be subject to a charge.

Highly variable road topology

The topology of a road in an urban area is much more likely to vary between different charge point locations than in an inter-urban context. Road widths are highly variable ranging from as little as 3m through to 5 or 6 lanes in each direction at busy intersections. Footways, narrowing roads, bends, skew junctions and roundabouts all reflect the extent to which urban roads are as much multi-purpose spaces between the buildings (and the subject of historical precedent and shared usage) as they are a thoroughfare designed to move traffic.

Examples of Variable Road Topologies (courtesy of Transport for London)

Challenging installation

With lower traffic speeds, urban roads are much more likely than inter-urban roads to have other physical structures immediately adjacent to, over and below the road surface. This will include railway lines, tram lines, power lines, telephone lines, buildings, sewers, ducts, water, gas and electricity supplies. The works involved in constructing charge points may require a degree of consultation with the owners of such assets in terms of disruption and future access. This creates straightforward physical as well as logistical and administrative challenges in trying to erect structures, tune performance and maintain systems. Ultimately this may limit the range of locations where charge points can be erected.

The special challenges of the urban context need to be addressed from the very beginning and are not restricted to purely technical issues but also a matter of aesthetics and perception of the required technical gear.

Occasional users

The handling of occasional users strongly determines charging system design. If charging requires the use of on-board equipment then it can be assumed that frequent users will equip themselves in order to take part in the scheme. But according to the UN Convention on Road Traffic (Ref. 3) all users, including non-equipped ones, must equally be admitted to the road network.

The UN Convention on Road Traffic from 8 November 1968, also known as the “Vienna Convention”, is an international treaty that facilitates international road traffic by standardising uniform traffic rules among the contracting parties. It defines that signatory states have to admit unconditionally vehicles to their territories if they fulfil the requirements of the convention. Charging on-board units are not a requirement listed in the convention. Hence, also vehicles without installed charging devices have to be admitted to the road

network. It is possible though to require vehicles to carry something non-permanently on board, such as a simple sticker or a windscreen mounted tag.

Occasional users will not be prepared to equip themselves with permanent equipment. If the technical solution is based on complex on-board equipment with high effort for integration into the vehicle, requiring e.g. several hours of installation in a dedicated workshop, then a second solution must be offered to cover the needs of occasional users. This second solution must ensure that unequipped or occasional users can have access to the system in a simple way and with minimal effort, e.g. with a ticket based solution.

In charging, equal treatment means that all user groups pay the same when using the same roads under the same conditions. System design must ensure that equipped users essentially pay the same as non-equipped ones. Especially with vehicles coming from abroad it is usually not possible to give equipped users better tariffs or to treat occasional users with a simplified charge without violating international treaties such as European Community law.

Therefore even the most sophisticated technical charging solution is limited in its charging capabilities (tariff modulation, complex tariff structure, flexible extensibility, etc.) to the capabilities of the solution for the occasional user. Only what can be done for the occasional user can also be done for the equipped frequent users. One solution to the problem of occasional users, which are often foreign users on transit, is to construct the road user charge as a national tax which foreign users do not have to pay.

In city schemes a high number of users will be occasional visitors from the wider surroundings of the city. Costs to treat these users adequately are usually rather high, and revenue will be very limited. In many systems, the handling of occasional users is the single most important cost driver. Hence, a proper solution for the occasional user has to be seen a core problem of system design and is by no means a fringe problem.

Occasional users require high attention in system design. A simple and cost effective solution for this user group is decisive for overall system success.

User compliance

A charging system is all about compliance. There are traditional toll stations where the user stops in front of a barrier, then throws coins into a basket and the barrier will open. If there is no coin in the basket the barrier does not open. The barrier and not the basket has made the user pay.

In an electronic fee collection system the on-board equipment will automatically via some modern technology “throw coins into the basket” and free the user from this task. But there is a catch: The on-board equipment replaces the basket but does not replace the barrier. The vehicle is not stopped by the on-board equipment if the coin is not thrown. Hence some kind of virtual barrier is required to make the user pay. This virtual barrier is the compliance checking system. In essence a charging system is as good and reliable as its compliance regime.

Compliance control by barrier

The aim of compliance activities is that on average a compliant user pays less than a non compliant one. There are two extreme options to achieve this target. The first is to have many compliance checks and a low penalty. The second is to have only occasional compliance checks but high penalties. There is a limit to penalties that is given by political and legal acceptance. This limit defines the minimum density of compliance checking activities required in a system.

Advanced technical solutions that allow for charging and enforcement in free, unconstrained traffic exist. Usually there is a mix of permanently installed automatic enforcement stations combined with a certain number of mobile enforcement units, i.e. manned patrol cars with special enforcement equipment. The fixed enforcement stations check the correctness of payment of vehicles passing by without any obligation to stop. This is achieved by a combination of technologies, including laser scanners to determine vehicle and tariff class, automatic licence plate reading equipment to check for user registration, and video cameras to create pictures for proofing the case.

The processes of compliance checking and prosecution can not fully be transferred to private organisations because of legal constraints. Especially for a public levy, enforcement is in the overall responsibility of and has to be controlled by an agency equipped with the required legal powers.

Enforcement of correct toll payment is amongst the most important single issues in a charging system. The reliability and the strictness of the enforcement system is the basis for ensuring the revenues and the overall acceptance of a system. Only an enforcement system which detects violators in a proper way can assure the integrity and acceptance of the system. In a system where incorrect payment or non-payment is tolerated confidence in the system decreases and acceptance by the paying majority may become critical.

The compliance system is also a major cost driver. For every system, there is an optimum balance between enforcement effort and revenue loss due to violations.

Every charging system is only as good and reliable as its enforcement system.

System costs

A lot has already been said about cost drivers in charging implementations. Experience shows that people have a tendency to focus on capital expenditure at implementation time and often pay less attention to operational costs.

In fact one should consider overall costs of ownership over the whole operational lifetime. In our experience from many implementations, the operational costs over a typical system lifetime of ten years exceed the implementation costs by about a factor of ten.

Cost drivers are all non-automated processes needing manual intervention:

- Handling occasional users creates little revenue but requires costly infrastructure and a dense network of points of sales. In addition every single payment transaction comes at some cost.
- Operation of the compliance system requires a considerable number of staff either on the road for compliance checking patrols or in the back office for checking automatically generated evidence.
- Back office operations are costly especially if there is high number of non-standard activities such as user data mutations and user requests or complaints via the user front desk.
- Payment transactions eat a fraction of the revenue. Every loading of an account and every credit card transaction has an associated cost. Costs of payment are usually in the order of 2-5 % of total revenue.

A successful system must focus on good solutions for the cost drivers. Neither policy makers nor users easily accept a charging system that itself consumes an appreciable fraction of the revenue. It is rather important, though, to communicate quite early in the political process that a complex measure such as a time-distance-place differentiating charging system comes at cost. It is close to impossible to design a system where operational costs are below 10% of revenue. Operational costs of 15 to 20% of gross revenue are a more typical goal of a city-size charging system. Even these figures have proven to be difficult to achieve in practice.

Operational costs by far outrun implementation costs. Complex charging systems come at costs. Realistic costs have to be communicated as being an intrinsic property of capable road pricing solutions.

Security

Charging systems are payment systems with large money flows. System security is an important issue that has to be considered in the design of every system aspect. The issues regarding the security of a road user system can be grouped into:

- Security of the data, payment and information flows against fraud and external interference.
- Protecting the operations against system breakdown.
- Overall system security regarding the correctness of the charged toll and its solidity in case of legal disputes.

External and internal threats to the correct flow of data, payment and information must be analysed and appropriate countermeasures be designed. High attention has to be paid to all conceivable ways of users attempting to fraud the system. Available countermeasures are physical protection of critical system elements and cryptographic protection of communication channels. Especially fraud by internal users (tolling personnel) has to receive high attention.

In case of system breakdown it is necessary to have a fall back solution ensuring that no loss of data occurs. The probability of an extended system breakdown strongly depends on the technical approach chosen, the dependence on external entities and the system distribution into central and de-central components. Core central components have to be designed fully redundantly.

Ultimately system security relies on the availability of data that allow monitoring of the system. Errors and frauds can only be detected if sufficient data is available. It is essential that security requirements are designed into the system from the very beginning in order to be able at any time to have correct data that can stand detailed scrutiny in front of a court in case the need arises.

Road charging systems are large payment systems. System security is a critical design issue. Security is an end-to-end problem, where the complete and long path from use of the road to booking of the payment in the central system needs to be protected.

SCHEME LAYOUT ISSUES

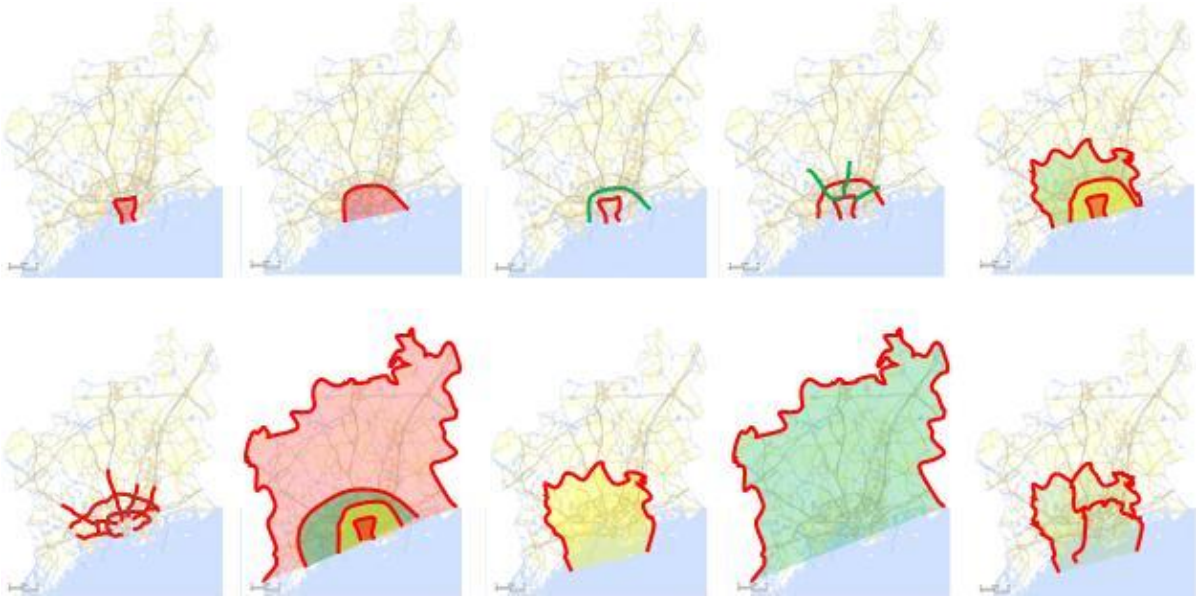
Scheme principle

In theory, the charging scheme as defined by its rules for charge determination can take many forms. Basically we distinguish cordon-oriented schemes where crossing of a defined border triggers the charge and area schemes where being in a certain area defined by a border triggers the charge, which might be a fixed sum per day, time dependent such as a parking fee, or distance dependent. Schemes can be designed with any complexity, e.g. where one charging cordon with high tariff is situated within another larger cordon with lower tariff, or where a distance dependent system is simultaneously time dependent with tariffs varying according to the time of day.

This is not the place to contemplate all available possibilities. Modern charging equipment, especially of the GPS/GSM type, will enable all conceivable scheme principles.

In practice, only the most simple scheme principles stand a chance of realisation. This is for the following practical reasons:

- In order to have an effect on the user, the system must have simple rules like “driving in the rush hour is costly” or “driving off motorway is costly” or “using an old stinker is costly”. Users must be able to react to the price incentives given. This means that the rules must be understandable and must give clear indications on how to best react.
- In fact the system component caring for the occasional user will limit system complexity. As discussed above, it is difficult to equip occasional users with sophisticated equipment. Occasional user solutions typically are simple booking systems that cannot support a complex, highly differentiated and variable charge.
- As laid out in the next section, every city has a structure leading to natural perimeters for charging zones. Theoretical considerations work in idealised surroundings. In practice, historically grown structures of spatial development or of traffic flow will lead themselves to a very limited choice of feasible options.



Ten options discussed for a congestion charging scheme for the city of Helsinki
(Ref. 4)

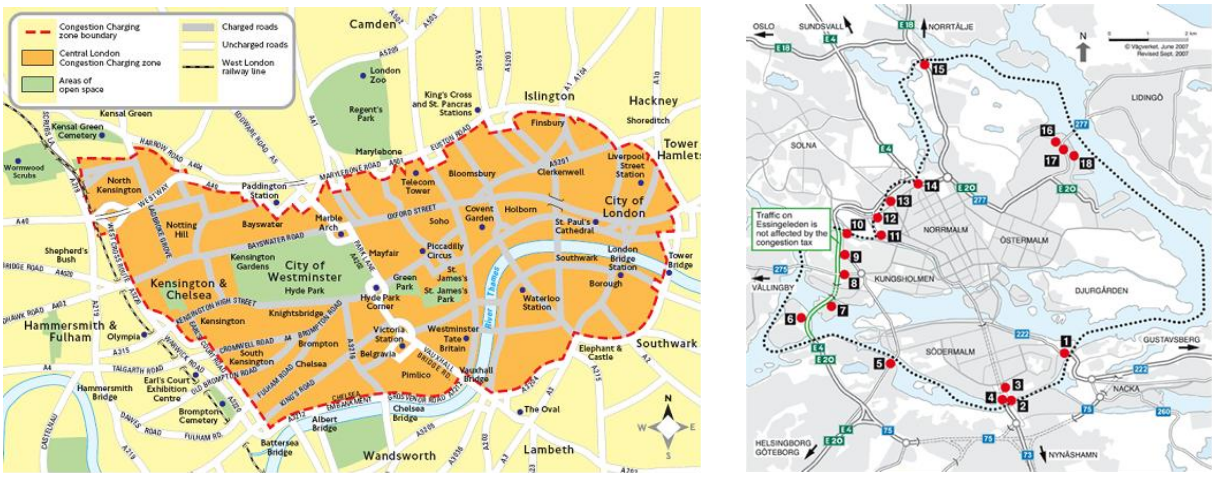
Marginal social cost pricing is a theoretical concept. Practical implementations will try to consider these results but will in practice be limited by very mundane considerations.

In theory charging principles of any complexity can be designed that would lead to optimum outcomes and efficiency. In practice, systems must have simple rules in order to be understandable, must support simple solutions for occasional users and must work in grown urban patterns. “Keep it simple” is the best advice one can give in this respect.

Geographic perimeter

When road pricing is being planned as a tool to combat congestion, it is critical to choose the right border of the area where the charging sets in. This is true irrespective of the choice of scheme principle, e.g. cordon pricing or area pricing. It is essential to set the border such that a large fraction of the commuter traffic is being captured, without disrupting modes of traffic that are less relevant for congestion, such as delivery traffic, transit, occasional trips, and – especially critical for some stakeholders – shopping traffic.

Again, theory will provide for excellent guidelines on crossing which line should trigger a charge or at least start liability or an increased tariff. In practice there always is very limited choice. Many cities have a natural structure that is visible already at a cursory glance at the city map, and is also reflected in the mental representations, the "personal maps", of the city inhabitants. Such natural structures might be a ring road, as e.g. used as the perimeter of the London congestion charge, or a natural barrier, such as the waterways surrounding Stockholm's inner city.



Charging perimeters of the London and Stockholm congestion charges

Although such natural choices for the charging perimeter are usually not the ones that would be optimal from theory, they are very effective in practice. Such natural structures have over a long history been shaping the spatial development of living and working areas, of shopping streets and quiet neighbourhoods, and to an amazing extent even cultural identity. For a Londoner born south of the Thames it is close to unthinkable to live north, and vice versa. These grown spatial and behavioural patterns are reflected in the daily traffic flows. These considerations may explain why "logical" or "natural" choices of charging perimeters, even if not necessarily optimal in theory, will normally be quite effective in practice.

Perimeters cannot be chosen in a clean environment. Since the Western Extension of the London Congestion Charge has been implemented, there is an uncharged transit route cutting through the congestion charging zone. In Stockholm, inhabitants of the island Lidingö cannot travel anywhere without crossing the charging zone. This situation requires a special arrangement. The inhabitants of this special area may cross the inner city at any time without

being charged. The administration of this special measure causes an appreciable fraction of the operating costs of the Stockholm congestion charge.

When setting the perimeter for the charging measure it is also important to consider the availability of other transport modes. In many cities there is a rich choice of public transport means in radial direction, i.e. in an out, but much less convenient choices for going from one peripheral destination to another. Paris is a very good example of such a centralised city. If one is living in the west but working in the north, there are far less good public transport connections as compared to living west and working centrally. Congestion charging will only flourish if good transport alternatives are available to commuters. These considerations are to be taken into account when designing a pricing measure, and especially when defining the charging perimeter.

Most cities have historically grown structures that lead themselves to natural choices for charging perimeters. It is wise to benefit from them rather than to contemplate "optimal" but artificial boundaries.

Tariff level

It is difficult to find the right tariff level for a congestion charge. The charge must be hurting sufficiently such that people react, and at the same time being acceptable enough that people will not heavily oppose.

Theory offers several approaches to tackle the problem. One can look, e.g., into the value of time in order to see what the monetary equivalent of a quarter hour lost in congestion might be, or one can look at marginal congestion costs to society. In practice, these deliberations may give some indication on where the right tariff level should be, but ultimately the tariff is a political decision that will rather be oriented towards creating acceptance than at creating an optimal traffic management outcome.

The political promise often is "revenue neutrality". This sounds like a good deal for the citizen: Before introduction of the pricing measure, everybody pays some fixed taxes or fees, like the annual registration fee, vehicle tax, or the like. If this fee is replaced by a variable congestion price that is revenue neutral, it is likely that the citizen buys in. If I have to pay something anyway, why not pay for something intelligent, which has positive traffic effects? In addition, the majority of citizens will drive less than average, and is most likely better off in the new regime, thereby creating a natural majority of winners.

This sounds like a clever strategy to create acceptance, but in fact carries quite some inherent risks. In most communities, tax income from the road sector can under no circumstances decrease. Revenue from the road sector is essential for financing a lot of public duties, like road maintenance, road construction or even a major contributor for the general community budget. Hence, whatever the new pricing measure, net revenue must remain at least the same. Neutrality in terms of net revenue means that gross revenue has to increase – but gross revenue is what is being collected from the users. The difference between net and gross revenue is the collection costs, which are close to zero for annual registration fees and similar levies, but even under very favourable circumstances hardly can be below 20% of revenue for city road pricing schemes.

Hence it is politically dangerous to promise revenue neutrality when in fact gross revenue needs to increase in order to keep budgets balanced. Public acceptance might well be better if the pricing measure is from the very beginning designed to create some additional income which is earmarked to do something that is widely accepted as beneficial, such as the construction of a new bridge or tunnel or the introduction of new tram or bus lines.

The right tariff level is a political decision rather than the result of theoretical considerations. “Revenue neutrality” sounds like an attractive way to go, but has proven to be difficult to achieve in practice.

Legal status of the charge

A road charge can have the legal status of a tax, which is a public levy that is owed unconditionally, or a fee, which is a private levy and a price for a certain service consumption.

For a tax only an authority has the fiscal sovereignty to collect it. Daily operations may be outsourced but control and governance must remain in the public sector. A tax is usually defined as a levy that does not give a right to a certain service. Taxes are simply instruments for financing community budgets. For taxes strict regulations and procedures apply. There is e.g. a well defined way to appeal. Toll charges with a tax status usually also rely on a user self declaration of road usage and the technical equipment is only considered a tool to help the declaration. For a tax, compliance checking and prosecution are legally rather simple to implement, since public servants can be sworn and receive the necessary powers, e.g. to stop a vehicle or to access the national licence plate database.

In contrast, a fee is usually defined as a charge that is directly related to the use of a service. A fee can be collected by a public authority or a private organisation alike. With fees, the freedom in system design is higher since the environment is less regulated. For a fee it is, for example, acceptable that the road side system measures road usage without a user declaration. Compliance checking and enforcement is more of an issue, though. A private company cannot prosecute ordinary citizens like a sworn public servant might do. For a fee, special legal or organisational measures are required to set up a tight enforcement regime.

A simple way to distinguish between tax and fee often is Value Added Tax (VAT). If a road usage charge is legally considered a tax, it is not subject to VAT. If the charge is considered a fee, VAT normally applies. VAT adds some complexity in handling and processing payments, but not an issue for the road user charging scheme itself.

The legal status tax or fee might appear to be a minor issue, but in practice it is of crucial importance to get the legal status right. For the Stockholm scheme, e.g., this single issue has caused many months of delay. The legal status reaches deep into many aspects of the charging processes, from the right to collect, the need for fully equal treatment, over the legal significance of the user “declaration”, compliance and enforcement powers, applicable court processes for legal recourse, and applicability of VAT.

The legal status “Tax” or “Fee” is not a minor design issue but of crucial importance and requires early and careful consideration for a successful implementation.

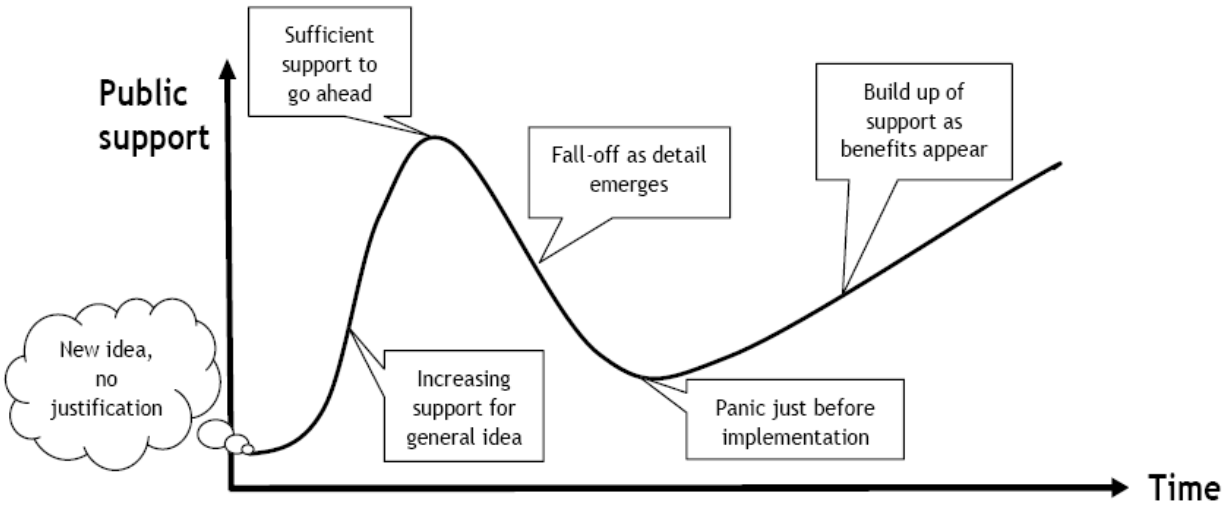
ACCEPTANCE ISSUES

Managing public perception

Acceptance for a measure is not constant but changes with the development of the public discourse. When looking at the available examples one recognises a pronounced temporal development.

Obviously people first focus on their individual costs, without any believe regarding positive personal effects. Accordingly one often experiences fierce initial rejection. Costs are imaginable, but not the benefits. Discussion usually is polemic and undifferentiated.

It is the task of a well managed public discourse that preconceptions and outright fears are addressed and not repressed. Precondition is that the public indeed perceives a problem, as discussed below. Over time, emotions will calm. This is the point where opinions are being made.



Public acceptance changes over time (from Ref. 7)

From observation a critical success factor appears to be that this process is actively managed. A positive factor is strong political leadership. Leadership and decidedness appear to support identification with the measure and also lead to a deeper involvement in the discussion.

This is the "window of opportunity", when there is sufficient support to trigger deployment. From then on support will fade away again as issues emerge in detailed planning and law making. Support is lowest just before introduction, since fears will peak and benefits are not yet visible. Only after introduction "seeing is believing" and support will build up.

Public opinions need to be managed through leadership, decidedness and skilful timing.

Pressing traffic problems

Studies have shown – and this comes at no surprise - that in all successful implementations it has been essential that road pricing has been perceived as a true solution to a problem (see e.g. Ref 5). This finding entails three elements:

- There has to **be a major traffic problem**. People are only prepared to pay for mobility if there is a massive congestion issue without simple and common solutions. Interestingly also financial issues, like a lack of financial resources to fund construction of important infrastructure, such as a relieve road or an important tunnel or bridge to combat congestion in the inner city, are perceived as relevant problems.

Unfortunately, these findings mean that pricing cannot be used to combat congestion before the problem occurs. Pricing as a pre-emptive measure will find neither political nor public acceptance. Consensus in society appears to be a precondition that the state of affairs regarding traffic that can no longer be tolerated – irrespective whether the individual person is concerned in daily life.

- It is also important that people **trust that charging will have a true contribution** to alleviating the problems. Acceptance can only be expected if the pricing measure "works" according to the judgment of the concerned people. Since pricing measures are new instruments in traffic management, lack of personal experience is a hindrance in this process. Humans learn from experience and the effects of a pricing measure cannot be felt beforehand. Effects are predicted but cannot be experienced before the measure is introduced.
  Tests and pilot projects can have an important contribution by proofing effects and even making them perceptible for the individual. This concept was exceptionally successful in introducing the Stockholm charging system.

- Finally the traffic problems need to be **perceived** as severe and pricing as a suitable measure. The public dialogue in London and Stockholm has moved congestion into public awareness. At the beginning of the discussion congestion has in both cities been accepted as unavoidable and "god-given". Only the public discussion has created awareness about the extent of congestion and on its disrupting influence on quality of life in a city. In the UK, phrases like "we cannot build our way out of

congestion" have become common wisdom. This perception is an essential basis for widespread acceptance of pricing as a traffic management tool.

World-wide all studies, see e.g. Ref. 6 for a typical example, underline the importance of the perceived necessity and effectiveness for the acceptance of a road pricing measure. In the cited study the authors compare systems across the globe and conclude that publicly perceived necessity is the single most important success factor.

Prerequisites for success are: a massive congestion problem that is perceived as such and that at the same time pricing is believed to be effective.

Use of income

As discussed in the section about tariff level, revenue neutrality is probably not the best approach to win the public. If a new pricing measure is introduced it is wise to abolish or reduce some other taxes and fees, but creating extra net revenue is nothing to shy away from. Under no circumstances extra revenue should be a hidden agenda (like: "We will be grossly revenue neutral. Later tariff increases cannot be excluded as this point in time").

Use of revenue is critical. Initially it was believed that broad acceptance of a measure requires that revenue is earmarked to go into the road sector again and that especially public transport is an acceptable destination for spending the money. More recent experience, as collected e.g. in Ref. 5, shows that earmarking is the essential element. As a destination for the money also other generally "good" places are acceptable to the public. It is important that those that pay also benefit. Revenue from city pricing needs to be spent in the city, for road infrastructure, public transport, or even to subsidise ecological projects. My money should be used in my neighbourhood.

Revenue is an essential element of pricing. Instead of promising "revenue neutrality" that is difficult to achieve and to maintain in practice it might be well worth being courageous and use the extra revenue for something that is widely welcomed.

Transparent, fair and understandable system

Acceptance requires trust. Trust can only be won through transparent, open communication. Transparency implies that the system rules are clear and simple. Everybody must understand where he has to pay, when and how much. There should be simple rules to follow, without undue complexity and without many exceptions.

The successes of the charges in London and Stockholm are to a large extent due to the simple and transparent rules. The charge perimeter is easy to recognise and well communicated. It is simple to understand at what time of day the different tariffs apply. It is clear where one can pay and what to do if one did not manage to pay before use.

It is essential that people feel treated fairly. Nobodies wants to be fined just because he did not know some detail or because of a minor neglect. This implies clear and simple rules but also a simple access to the system. I personally do not mind to pay a few Euros for parking or for road tolls, but I do not want to be hassled. I do not want to search for the right coins, or to have to stop and leave the vehicle, or to fill in long forms, and the like. The "front desk" of the charging system must be user friendly. National charging systems for heavy vehicles, such as the ones deployed in Germany, Austria or Switzerland, and as currently being procured for France, have no need to be overly simple to use. Truck drivers are professionals used to pay fees, tolls and taxes of all sorts. One can reasonably expect that commercial drivers are informed and can manage more complex tasks. This is not true for a city charging system that has to accommodate everybody, not just the interested and informed, young and active citizen.

Fair treatment also implies a credible compliance regime. It is essential that people trust that everybody pays and not only the "honest idiots". Compliance checking has to be recognised as proportionate. It must have a certain visibility but should not be perceived as constant surveillance, and must not be intrusive.

A transparent, fair and understandable system is achieved through clear rules, simple access to the system and a credible compliance regime.

Privacy

Privacy aspects influence the technical solution for a road user charging system and its public and legal acceptance. In a charging system, privacy must be guaranteed regarding:

- Personal user data
- Payment and contract data
- Movement data

The privacy requirements regarding personal user data, payment and contract data of a road charging system are basically the same as in similar systems such as telecommunication, banking, or retail and must be handled in the same way.

A special property of a road user charging system is that a vehicle is identified as being at a certain location at a certain time. Depending on the charging concept and the technical solution, this may imply that data on the daily movement profile of a user is available in the system. System design must ensure that such data are treated according to privacy laws and in a transparent and understandable way for the public. Privacy is more an issues for private vehicles than for commercial fleets since private vehicles can be associated to a certain person (owner/driver) whereas commercial vehicles cannot (changing drivers).

There is a tendency to treat privacy issues by technical means. Various measures based on cryptographic techniques are being proposed. There is also a discussion on keeping data within certain environments, such as processing all data in the on-board equipment, and only transferring daily aggregates to the back-office. Such privacy-protecting concepts usually

imply some costs and a certain inconvenience in system design. The solutions are fine in principle and are normally sufficient to fulfil the legal requirements.

The perception is not influenced by design, though. It is probably better to look into the institutional arrangements. I have, e.g. no problems with the fact that my mobile phone provider knows every movement I make, or that my bank knows a lot about my financial capabilities. People like to have a choice regarding whom to give their data, and they are more relaxed about it if they receive a clear benefit. I would like to be able to pay my road user charge with somebody unsuspicious, such as my automobile club, the supermarket or my mobile phone company. Authorities usually outsource operations of the charging system anyway. Why not use this also to provide for good user privacy, especially in the eye of public perception.

Movement data is sensitive and has privacy implications. Again, perceived privacy is decisive. The feeling of having a "spy in the car" has to be avoided.

Accompanying measures

A price is only acceptable if there is something of the correct value offered in return. As discussed before, the benefits of congestion relief cannot be experienced beforehand and are vague promises to most citizens.

It is therefore wise to bundle the pricing measure with more return for the individual. To my personal amazement, the focus in this discussion has been on providing "value added services". The message is this: "Dear user, you will need a box in your car that charges you, but it can also provide some useful services for you". A long list of such value added services has been proposed in the past especially with the introduction of heavy vehicle charging systems that required rather capable on-board equipment. Proposed services included navigation, traffic information, fleet management, emergency call, automated payment for parking, pay at pump, and even McDonalds drive through payment.

The proposals have been very technology driven and have not achieved market success. When it comes to useful applications in a city environment, modern mobile devices such as the iPhone are hard to beat. I do not need a charging box to tell me which way to go, to find the next restaurant or to pay for my burger.

What I would love, though, is a proper integration of the whole charging measure into daily mobility in the city. If the congestion charge, e.g., would be the same as a day pass for public transport, or would have an option to include city parking, or would at least have the same cordon layout as the public transport tariff zones, I would feel that someone has invested some thoughts and has being caring about my daily life. If I feel that I am not simply being charged but that this is part of a package that improves my city mobility, I am less opposed to pay a price.

As discussed before it is advisable to plan for some extra revenue and not go for full "revenue neutrality". Extra money is well spent on accompanying measures such as improving public transport, providing park-and-ride facilities or introducing a city mobility card

that can be used to access all transport offers, from public transport, over parking to road pricing.

Strictly speaking not an accompanying measure but quite akin to it is providing for interoperability. Currently city pricing schemes are confined to larger metropolitan areas and are lone islands in the sea. As soon as more regions employ charging for demand management purposes and as soon as interurban motorway tolls increasingly become electronic, users must be offered a single device with a single contract to pay for all road-use related charges and fees. The focus today is on commuters within city limits with usually little need for interoperable equipment. With the increasing success and inevitability of pricing measures, interoperability will become a must, and not a nice accompanying goodie.

Pricing should be part of a package. Individual users will more likely accept a new charge if there are clear benefits that accompany the pricing measure.

CONCLUSIONS

In order to make charging a success, three core aspects need to be planned and implemented skilfully:

- technical design
- scheme layout
- acceptance

The order of priorities is in fact bottom-up: Without sufficient acceptance and support a new charging measure will not stand a chance to pass early political hurdles and implementation will not even start. A clever scheme layout comes next, since the charging rules determine whether or not the desired traffic effects will be seen. Proper technical design is certainly also an important success factor, but appropriate technology is available and should not become a driver of the project.

Unfortunately also the level of difficulty is bottom up: Acceptance is hard to steer. The report gives some hints on where the focus of activities should be according to experience from projects world-wide, but there is no guarantee. The subject is emotional, non-linear, time-dependent and multi-faceted. The good message is that knowledge and understanding about proper scheme layout has increased over the last years, and especially that technical issues are no longer an obstacle. Good solutions and products exist and only require proper engineering and project management.

Yet the main conclusion of this review of critical success factors is that pricing as a traffic management measure has become a tool that is now available to tackle the problems of our growing cities. Congestion pricing is not yet a tool as ready to use as any other traffic management tool. Success is not guaranteed, but the effects are unsurpassed. Besides a driving ban, no other traffic management tool has a better effect on congestion than pricing.

Designing a nation-wide high-tech charging system for trucks needs good engineering and project management - it requires good craftsmanship.

Designing a congestion pricing system for a city needs careful handling of a number of acceptance-critical implementation issues - it requires vision, inspiration, leadership and luck.

City congestion pricing is art, not craft.

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