TRANSPORT NOTES

ROADS AND RURAL TRANSPORT THEMATIC GROUP

THE WORLD BANK, WASHINGTON, DC Transport Note No. 38 November 2009

Planning and Implementation of Road Use Charging: Options and Guidelines

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Road use charging is used by agencies for activities ranging from revenue collection, through demand and environmental management. It is applied on individual road segments, such as an expressway, or over geographic areas, such as zones in a city or even an entire country. When a government is considering implementing a road use charging system, it needs to consider four broad issues: (i) the technology to adopt; (ii) how it will be operated; (iii) how compliance will be enforced; and, (iv) the social impact of the system. This transport note addresses each of these four issues, and presents guidelines towards implementing a successful road use charging scheme.

This note was produced by the World Bank's Europe and Central Asia Transport Unit to share the current state of knowledge with its clients.

1 Introduction

Road use charging (RUC)[1] consists of imposing various forms of fees or taxes on access to, or use of, road infrastructure. At its simplest level, it consists of collecting tolls for using a section of road or vignettes for access to a part of, or the entire, road network in a country. At its most complex level, it can use satellite technology to calculate cost for users based on the distance traveled, the type of vehicle, and the location and type of roads used. It allows for the road owner/operator to charge for internal as well as external costs of infrastructure.

RUC can be used to raise revenues only, or as a more sophisticated mechanism to influence user behavior. For example, in London, the introduction of congestion charging reduced traffic levels by 15 percent and congestion by 30 percent by shifting users to public transport (Transport for London, 2008).

[1] The term "road use charging", instead of "road user charging", is used to define what to charge, rather than who to charge. It emphasizes a direct linkage between the charge and the actual use of road infrastructure. On the other hand, "road user charging" includes charges on potential road users that are not reflective of their use, such as vehicle registration fees, vehicle excise taxes, and so on.

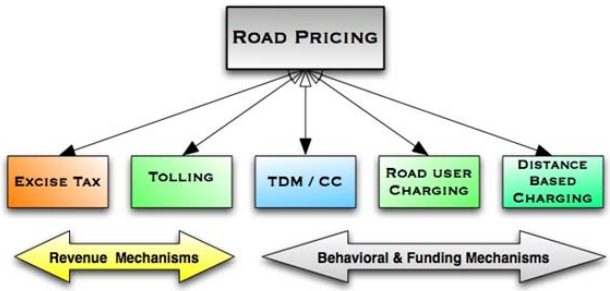


Figure 1.1: RUC related definitions

For the purposes of RUC, it is useful to differentiate between the two situations where RUC is applied:

- **Road segments:** Charges are made for travelling on specific segments of the road network, such as tunnels or along motorways; and,
- **Zones**: Charges are made over an area, for example portions of a city or even an entire country.

RUC on specific segments has been used for many years. As technology has advanced in recent years, zone pricing has become more feasible and attractive.

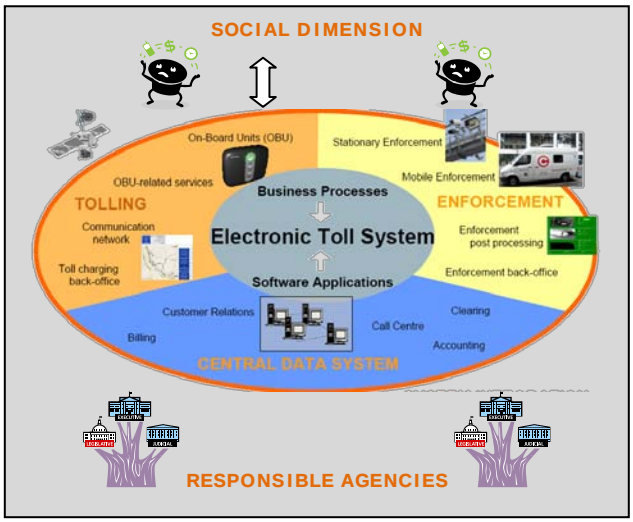
For agencies considering implementing RUC, there are a number of issues which need to

be considered beyond the technology for successful implementation:

- **Charging technology:** How the RUC is to be collected;
- **Operations:** The organizational structure and the 'back office' elements of the system—how users will pay the charges, how they will be remitted to different participants, and how the system will be maintained and improved;
- **Enforcement of user compliance:** How compliance will be ensured; and,
- **The social dimension:** How the system can be introduced and get public support, how to set the appropriate charge level, and how to mitigate the negative impact on certain users.

The purpose of this note is to provide an overview of the above listed issues as well as of available technologies. It also contains guidelines for selecting the most appropriate RUC solution for a given local situation.

Figure 1.2: Various aspects of RUC using electronic toll system



2 Technology Options for RUC

There are a variety of different technology options to charge for road use. The selection of the appropriate technology depends upon two key factors:

- **RUC objectives:** Whether the RUC is to be used to raise income or to address congestion or environmental issues; and,
- **Type of network to be covered:** Whether RUC is to be applied to specific road segments or for an area/zone.

2.1 RUC on Road Segments

Road segments, such as motorways, tunnels, and bridges, have a long history of RUC, which is also called "tolling". Tolls are typically collected through a 'closed' system, i.e. an access-controlled network, wherein road users are charged based on the locations where they enter and exit the road. An 'open' system charges vehicles at selected road sections irrespective of their entry/exit points.[2] A closed system generally sets its rates proportionate to distance traveled on a toll road and there are few opportunities to avoid payment. Open systems are less expensive to implement, since entry/exit control are not required, but are not as effective at collecting revenue since not all vehicles must pass through the collection points. They also do not charge equitably for the distance traveled.

2.2 RUC for Zones

The most common example of RUC for zones is urban congestion charging such as applied in London and Singapore. More recently, it has been adopted by cities such as Milan, Italy for reducing vehicle emissions. RUC in zones generally follows one of two different approaches:

- **Cordons:** Charges are made when entering and/or leaving a zone; or,
- **Area:** Charges for driving within a zone irrespective of the number of entries and exits.

[2] Another related terminology, "Open Road Tolling", refers to an Electronic Toll Collection (ETC) system wherein users pay tolls without stopping or slowing down, and thus, can free-flow. This paper avoided this term, which is particularly used in North America, and instead, categorized such systems under ETC.

The charges can be applied in a variety of ways:

- For entrance/exit from the zone;
- For the time spent in the zone; and/or
- For the distance travelled in the zone.

Box 1: Terminology
• CCTV: Closed Circuit Television
• DSRC: Dedicated Short Range Communications
• ETC: Electronic Toll Collection
• GPRS: General Packet Radio Service
• GPS: Global Positioning System
• MTC: Manual Toll Collection
• OBU: Onboard Unit
• RFID: Radio Frequency ID

2.3 Trends in Technology

As shown in Figure 2.1 (Siemens, 2007), there is a pronounced trend away from manual tolling towards electronic and satellite based tolling. Manual tolling is mainly used on legacy road segment based systems in developed countries, and is still common in many developing countries.

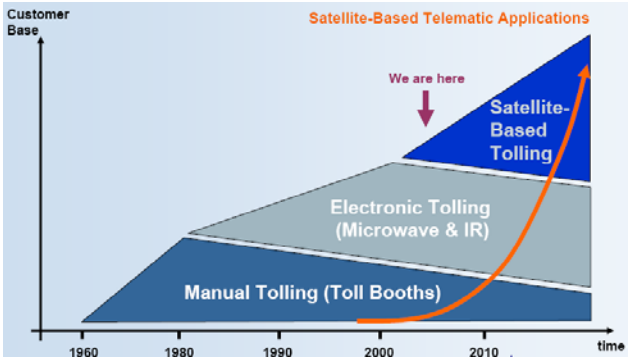


Figure 2.1: Tolling Trends

Satellite based tolling is still in its early stages while microwave/infrared tolling is a mature, established technology.

2.4 Overview of Technologies

The technologies can be divided into two groups: video, which reads license plate numbers and all others which require 'on-board units' (OBU).

- **Video:** CCTV linked to license plate recognition software. Example: London congestion charging or Highway 407 in Toronto, Canada. It allows for various payment options.
- **Microwave and Infrared:** The OBU communicates with roadside gantries. Example: Czech open road system, Stockholm congestion charging, tunnels and bridges.
- **Satellite with GSM:** The OBU identifies the specific location on the network and the distance travelled by using GPS. Charges are deducted from a pre-paid card or charged to an account. Example: Germany, for all trucks above 12 t.
- **Satellite with Smartcard:** The OBU measures the distance, often with a tachograph, and GPS verifies the distance which is recorded on a smartcard. Microwave is used for enforcement. Example: Switzerland for all trucks above 3.5 t.

Table 2.1: Technology comparison[3]

	Capital cost	Operating cost	Reliability (accuracy)	Privacy concern
Video	Low	High	Medium	Medium
Microwave / Infrared	Medium	Low	Medium	Low
Satellite + GSM	High	Medium	High	High
Satellite + Smartcard	Medium high	Low	High	Medium high

3 Operational Considerations

RUC requires several operational and administrative functions to meet its policy objectives and business needs. Generally, a central system, also called a back-office, needs to be established to conduct such functions. Key functions of a central system can be categorized as follows:

[3] This table provides a generalized comparison, which may vary depending on the scope and type of a RUC scheme. For example, privacy concerns may not be an issue if charges are applied only for commercial vehicles. Also, the capital cost of the microwave option can increase and be significantly high if applied for a large area. Other criteria to be considered may include scalability, flexibility, interoperability, etc.

3.1 User Account Registration and Management

Depending on its scope and charging policy, a RUC system may require identification of individual users/vehicles. In such cases, a user account registration system must be established and managed. Types and amounts of information to be stored and managed in a user account vary, depending on whether segment- or zone-based pricing is applied and the type of technology used.

- **Manual toll collection (MTC):** User accounts are not required, except when discounts or subsidies are offered to specific users.
- **Vignette**: Usually does not require user accounts since it is generally based on vehicle registration system.
- **ETC**: User account registration is required upon acquisition of an OBU (either through purchasing, renting with deposits, or pilot deployment at no user cost). Enforcement may be necessary to make sure that an OBU is correctly informed of the identity of a vehicle to which it is attached. It is to prevent fraud in variable toll systems, where toll rates vary depending on vehicle types and, in some cases, configuration of specific vehicle type, such as emission levels, weight, and the number of axles.

To minimize the possibility of fraud, many existing systems allow only authorized agencies to install OBUs. Nevertheless, establishing and maintaining correct physical links between registered vehicles and their OBUs can be logistically challenging (Pickford and Blythe, 2006).

3.2 Payment Service and Customer Relations

Payment service consists of the translation of chargeable road use into billing information, subsequent actual financial transactions, and handling of any inquiries and complaints related with accounts. There are largely four arrangements for the payment service: (i) point of sales (PoS); (ii) prepayment (debit account); (iii) post payment (credit account); and (iv) a blended system.

In manual systems, calculation of fees and transactions generally occurs at toll booths (PoS), although a prepay system, such as the issuance of prepaid passes/coupons, is also an option. On the other hand, the vignette system is solely based on prepayment and involves no instant charging or payment. Its payment service thus, in most cases, can be merged into existing taxation systems.

ETC schemes can operate either as prepay, post-pay, or as a blended system. A customer can deposit a certain amount into the OBU prior to use of roads where charges apply; regularly receive invoices and pay them; pay at petrol stations or wherever OBU readers are installed; or a mixture of the above. An example of how this was done in New Zealand is at www.tollroad.govt.nz.

Segment-based and fixed-rate charges are normally straight forward to calculate. Only vehicle type information needs to be captured from the OBU and verified. Tariff rate information stays in the central system.

Payments become more complicated in zone-based systems and/or when the toll rates change by location and/or over time (either in a pre-timed manner or based on traffic conditions). Under these schemes, charging data in terms of the amount of usage (i.e. distance-traveled or time in an area) must be captured separately for different locations and/or times of day, and total fees must be calculated by applying the appropriate rates. With success of such pricing schemes largely depending on the accuracy of detection technologies, a backup system is often necessary to identify and correct errors.

In order to minimize the possibility of identification errors, a payment service authority may need to develop a customer profile of travel patterns in addition to the above detection technologies. As practiced by many credit card companies, demand profiles can be used to detect anomalies or errors. In such case the payment service authority can exercise discretion to correct fees (Pickford and Blythe, 2006). However, this may have critical privacy implications.

The payment service authority should also be equipped with the capacity to provide adequate information to customers, to handle complaints and inquiries regarding accounts information and billing data, and to resolve potential claims.

3.3 Operational Management

Regardless of the type of RUC used, the continuous management of the system is necessary to ensure adequate maintenance of facilities and equipment, detect problems, and report system performance to the agencies concerned. In addition, action plans for disaster recovery should also be in place. The cost of the operational management varies by geographical scope and technological configuration of a RUC system. It has been reported that many developing countries experience higher than envisaged operational costs due to the lack of capacity within the implementing institutions. Therefore institutional arrangements should take into account available capacities, and capacity building should be emphasized. It is generally accepted that economies of scale apply for the system's operating cost (DfT, 2004).

3.4 Data and Information Management

A central system needs to have the capacity to collect, store and analyze a vast amount of traffic information that will be collected during the operation of a RUC scheme. The more sophisticated the technological configuration of the system, the more detailed traffic information can be collected.

Even the simplest segment-based fixed-fee system, however, can record and trace traffic volume by time of a day, day of a week, and so forth. More so, a nationwide distance-based pricing scheme using GPS technology will collect traffic volume and travel speed information for every link within the subjective area, during different times of a day. When well-managed, the traffic database can be utilized in various ways, including detection of anomalies in operation, traffic management, demand analysis, incident detection, etc.

3.5 Tariffs and Demand Management

Before implementation, it is a planning/policy issue to determine the initial toll levels of a road segment or an area. However, once the project is launched for implementation, the central system may need to track actual responses of traffic demand to pricing signals, and to introduce necessary adjustments in toll levels to manage demand.

In many countries, when toll roads are operated by a private concessionaire, the contracts normally include a clause that allows the operator to adjust toll rates reflecting inflation, for example on the basis of consumer price index. However, such clauses should be included with caution, supplemented with a contractual instrument to protect the public interests.

Box 2: Turn-Key Solutions

Due to the challenges of implementing all aspects of RUC, from installing the technology to establishing the back-office and other support systems, some agencies have adopted a 'Turn-Key' approach wherein a vendor supplies, installs and operates the system on behalf of the agency for an agreed time upon annual fee, usually calculated as a percentage of the revenue. This can be an attractive solution, particularly when there is limited or no experience with RUC in the agency.

4 Enforcement of User Compliance

In the context of RUC, compliance means a state in which the driver pays a charge for usage of road according to regulations. Compliance is critical for the revenue collection and financial stability of the services provided. Costs of enforcing user compliance vary depending on the scope and technology of RUC.

Experience shows that although road users generally understand that compliance is necessary, in order to maintain a high level of compliance, an effective enforcement system is needed (EC DG TREN, 2005). Thus, to

maximize compliance, institutional support is required in the following areas:

- Enforcement and control mechanisms; and
- The national legal and regulatory framework.

The following provides "operational" rather than a legal or enforcement perspective.

4.1 Enforcement and Control Mechanisms

Physical barriers (manual or automatic) are traditional approaches that allow only prepaid vehicles to enter tolled segments or areas. This approach forces authorized customers to stop (manual) or to slow to a near-stop (automatic), which causes losses in travel time and, especially in the case of ETC, negates some of the speed and capacity benefits of electronic tolling.

Although such mechanisms control access to tolled roads, they do not prevent a variety of frauds (e.g. ticket swapping) and abuse of methods used to deal with non-payers (e.g. acknowledgement of debt). In manual systems, one of major concerns is internal fraud, i.e. collected revenues are not properly recorded in the system. Systems with automatic barriers rely on vehicle identification and classification devices to ensure that users were making appropriate toll payments, identifying violators immediately. The reliability of these devices should be regularly maintained and improved. There are still other types of fraud which difficult to address, such as driving closely behind a vehicle in front ("*petit train*"), license plate hiding/swapping, etc.

Automatic License Plate Recognition (APR) can be used as a primary enforcement mechanism in most ETC systems. It can be fully or semi automated, where the latter is more reliable. One barrier is that many jurisdictions require significant changes in legal and regulatory frameworks to permit APR-based enforcement.

Physical presence of authorised toll enforcement entities (e.g., operator's employee, police patrol) at toll gates and in moving traffic can be highly effective. Such activities should be carefully organized given trade-offs between the effectiveness (probability for a violator to be caught) and the costs (number of staff-hours). The toll enforcement entities should be vested with the necessary authority in order to monitor compliance of payment (see below). This mechanism is usually used in combination with technical measures described above.

4.2 Legal and Regulatory Framework

In order to allow effective and efficient enforcement, the following should be defined under the legal framework:

- The criteria on which a violation becomes a fraud since this dictates how it will be handled; and
- Operator's access to necessary information and to ability to enforce corrective measures in case of violation.

The legal framework of RUC should lay out unambiguous definitions of different types of non-compliance, including **violation, fraud, and aggravated fraud**, and their consequences. Differences lie in the intention of such behaviors, frequency or the accumulated number of violations committed by a violator, and total financial amount outstanding. The framework should be approved by relevant legislative body. In order to avoid congesting the judicial system, it is recommended that simple cases of violation are dealt with outside the judicial system. However, any violation and fraud that is not followed by a repayment within a prescribed period of time should be treated as an offence where the offender is subject to legal proceedings.

Generally, efficiency and effectiveness of enforcement can be improved by granting the operator the legal authority to (EC DG TREN, 2005):

- Inspect vehicles which are required to pay charges;
- Stop and immobilize an offender's vehicle on their own networks, for the purpose of investigating a violation;
- Issue and apply a compromise penalty to offenders corresponding to the amount of unpaid charge plus reasonable

administrative costs or, at least, to require the offender to sign an acknowledgement of a debt; and
- Report offenders to the district administration authorities and initialise prosecution process.

In situations where the private sector operates the network, these functions can be performed only by employees that are trained and certified by relevant public authority. In the case of APR, operator should be given the authority to:

- Identify the registered owner of a vehicle by accessing (under same conditions for all operators) national and, if possible, international vehicle licence plate database without starting any formal legal proceedings;
- Ensure that a picture of a violation with licence plate information is admissible as evidence for the purposes of enforcement;
- Stipulate the registered owner of the vehicle as being responsible for any violations unless they nominate another person as the driver at the time of the violation; and
- Allow that operator does not have to identify himself/herself before issuing the infraction.

A prerequisite for successful functioning of such system is possession of up-to-date licence plate database. For prevention, the operator may need to create a database for users who are known to have repeatedly offended the system. If legally allowed, the database should be made available to all operators for effective enforcement.

National justice departments should cooperate in matters relating to the treatment of toll collection offences. Where cross-border enforcement is involved, international collaboration is required, usually through bilateral agreements.

The status of violation data should be defined in the national law—ideally under regulations of data protection law. All information should be signed electronically, encrypted separately and transmitted to the central offices via a dedicated, secure data line. The central offices should also be protected against unauthorized entry and access.

4.3 Internal Fraud

Independent monitoring and control mechanisms are needed to check if all charges have been collected and stored at appropriate rates, in order to identify internal frauds. Control of charging operators should ideally be done by independent body or, a government agency. Traffic detectors at toll gates are one example of a parallel data collection system which enables independent vehicle counting and classification. Data collected in such a way can be crosschecked with the data from collected revenues. A secure on-line central system coupled with its back-up would reduce possibilities of manipulating the charging data, since the data are transmitted in real time. When fiber optic cables are not available, the GPRS technology can provide relatively inexpensive on-line communication. Video surveillance of employees at tolls is another additional means of control. Videos should be monitored randomly and/or in cases where some irregularities have been observed.

5 The Social Dimension

Despite its added-values to the society in terms of increased system efficiency and stability of revenue stream, a RUC initiative often faces opposition from the public. Public opposition has, in some cases, led to canceling of tolling initiatives (e.g. Cambridge, Edinburgh, Manchester, New Jersey). Public acceptance of a RUC project depends on the following aspects:

- Characteristics of a charging scheme in terms of its affordability and fairness;
- Effectiveness of a RUC scheme in achieving its intended objectives, such as financing of new infrastructure and congestion mitigation;
- Reliability and security of technology, including the level of privacy protection; and
- Public perception, awareness, and familiarity of transport issues, new technologies, and RUC schemes.

5.1 Impact of RUC on Various Users

RUC schemes have different implications for different stakeholder groups, particularly in two dimensions—socio-economic group and geographic location.

Affordability and socio-economic equity centers on how RUC schemes impact different income groups in terms of costs and benefits. Typically the social equity concerns involve the belief that RUC costs and benefits favor those who can afford to pay road tolls or congestion charges without altering their travel patterns. For example, a review of the Stockholm experience in 2006 found that while wealthy men represented 4 percent of the drivers, they paid one third of the total fees (Sena, 2007). Removed from rush hour traffic were those who refused or who could not afford to pay the charges.

Indeed, lower income groups typically spend a higher proportion of their income on transportation and are the most vulnerable if transport costs increase. It is important during design phase to introduce countermeasures to relieve the burden on the most impacted users. Adverse impacts of RUC on lower income groups can be mitigated by providing specific benefits or alternative travel options (e.g. discounts, time differentiated charges, public transport services, alternative roads, etc.).

Geographic equity relates to the location of RUC schemes and how the boundaries impact different groups, particularly in zone and cordon tolling schemes. It is believed that those persons with relatively easy access to the facility are more likely to benefit from RUC. In addition, RUC can influence the relocation of businesses, land use and value, etc. The nature and extent of economic impacts resulting from RUC are highly dependent on the structure of the pricing scheme, the characteristics of the road network and the area. The service provider should investigate such impacts at the design phase.

The impact of RUC on social and geographical equity also depends on how the revenues are allocated. In particular, the presumed regressivity of RUC, which in purely financial term favors the wealthy over the poor, can be mitigated or eliminated by a **revenue allocation strategy**. A revenue allocation system that provides less expensive modes to users (i.e. public transit) can be viewed as cross-subsidy from automobile users (generally the wealthier) to public transit users (the poorer).

5.2 Effectiveness and Efficiency of RUC

A RUC project will gain a greater level public acceptance when it achieves its objectives such as congestion mitigation, generation of revenues to recoup new construction costs, etc. (USDOT, 2006). In many projects, initial skepticism and opposition often turned into support and favor, once a RUC scheme was proven to be effective in tackling the existing transport problems (e.g. Stockholm, California).

Another key success factor, especially in the case of congestion charges and zone-based system, is to work in favor of market efficiency, instead of undermining it. When there are only limited travel options available, imposing high charges on key routes will significantly lower the benefits to captivate travelers, and consequently, the overall welfare of the community. On the other hand, high charges on certain road sections are justified if they are appropriately priced for their marginal benefit, while more affordable options are available for users with lower willingness to pay.

Concerning the above, it is critical at the initial design stage to set appropriate charge rates taking into consideration their impacts on the market. Finding appropriate toll rates is often a complex task that requires intensive analysis of current trip patterns, user characteristics, opportunity costs, and availability of options.

5.3 Cost, Reliability and Security of Technology

The primary technology-related issues in RUC systems include: (i) delays associated with paying the charges and enforcing collection,

and (ii) preventing corruption which reduces total amount of collected revenues. On the other hand, main technology-related challenges of RUC systems are noted in the following areas (USDOT, 2006):

- **System entry costs:** The OBU cost can be a barrier for some users to enter a system. High costs can cause resistance or delayed decisions by users, especially when the benefits are not clear or viewed lower than the costs. In many countries, the public sector has subsidized initial deployment of OBUs to encourage participation.
- **Reliability:** Users often worry that the equipment could fail and result in lost charges, incorrect fines, or cheating. The reliability will improve by pairing a supporting technology that can detect abnormal outputs of the primary system. It is also important to create a responsive and efficient complaint handling system and inconsistency resolution scheme.
- **Privacy:** One of the major concerns of road users on ETC systems is that their privacy may be jeopardized. This is rooted in a perception that a system can trace individual trip information, which can then be used or sold for unintended, potentially commercial, purposes. Contrary to common beliefs, a system can be designed to not allow details of trip itinerary to leave individual OBUs. The information can also be protected legally through data protection laws.

5.4 Public Perception and Attitude

There is no one-size-fit-all solution to win public acceptance towards RUC, and more generally, resolving transport issues. As shown in Table 5.1, there is always public opposition, particularly towards Cordon/Area pricing (Zmud, 2007).

Table 5.1: Public Opinion by Type of RUC

Type of RUC	Majority Support	Majority Oppose
HOT Lanes	73%	15%
Traditional Tolling	71%	26%
Express Toll Lanes	62%	23%
Zone/Cordon Pricing	32%	53%
Private Ownership	0%	60%

However, experience has given some important lessons towards increasing public acceptance and the likelihood of success:

Political support is the critical success factor for a RUC project. Implementation of the RUC scheme usually takes a long period of time and it is important that there is stable political support toward it during the entire process.

A **pilot project** is an easier and less risky approach to test public acceptability of a RUC project. If the actual experience with the system is positive, then users tend to change their perception and attitude relatively easily. In addition, failures in small pilot areas have limited impacts on overall public acceptance, and lessons from it can be useful for a broader implementation.

A public awareness campaign, both prior to and during implementation, can be a tool to improve public understanding of the RUC. The implementing agency should develop a communication strategy detailing contents, media, target audience, and time frame. Key information to publicize includes objectives, rationale, technology, costs, and benefits of a system. The key issue is that the public wants to see value. This is critical because without a good understanding of a project, the public tends to focus on the increased costs and complexity of the tolling and fees. It is often more effective when such information is provided in the context of broader transport strategy.

The communication strategy should **focus on how a RUC can contribute to resolving transport problems.** Public acceptance is likely to increase when transport users can view a RUC project as a solution to current transport issues, and especially when it is clear that the revenues are linked to specific uses. RUC projects have been particularly well received by the public where traffic congestion was a severe issue affecting a large group of people. Therefore, the implementing agency should identify specific issues (e.g. congestion) and how the project will address them (e.g. by diverting peak hour traffic).

Transparency in revenue allocation plays a key role in winning public acceptance. General distrust in revenue gathering authorities or in government causes great opposition to the RUC initiative. The implementing agency should adequately document and publicize all relevant financial information, including flows of revenues and outcomes of investment made using the revenues. Reducing other tax burdens, as well as explaining benefits of the proposed use of revenues to the users and community, tends to positively influence user satisfaction.

A road project will gain public support when **its impacts on transport and economy are periodically monitored and evaluated**. Also, the system should be flexible enough to be adjusted when found necessary through the regular monitoring and evaluation.

6 A Path to Full Implementation

This section offers some general guidance towards the implementation of RUC.

Step 0 – Project Objectives and Scope

Prior to implementation, the agency needs to clearly identify the goals, objectives, and scope of a RUC project. Only on the basis of this the most appropriate implementation plan can be established. A plan to implement a simple revenue raising scheme is fundamentally different from that for demand management. A schematic decision tree to determine scope and technology option of a project is presented in Figure 6.1. This figure represents general guidance, and for each specific case it is necessary to make detailed analysis in order to develop the best approach for the specific implementation.

Step 1 – Development of institutional structure and requirements

This paper proposes an architecture consisting of three functional units.

- **System installation and operation unit** (SIOU), which builds, installs, deploys, operates and maintains facilities and equipment;
- **Payment service and customer relations unit** (PSCR), which manages user accounts, charges and collects bills, and manages customer relations; and
- **Data collection and demand management unit** (DCDM), which collects and processes charging data, feeds the charging data to PSCR, ensures data security, and analyzes traffic data for purposes of demand management.

As a first step to implement a RUC scheme, the implementing government agency should lay out the structure, scope of tasks, and required resources in terms of the number of staff and budget for each functional unit. Details of such arrangements and requirements vary by scope and technology options of a RUC scheme.

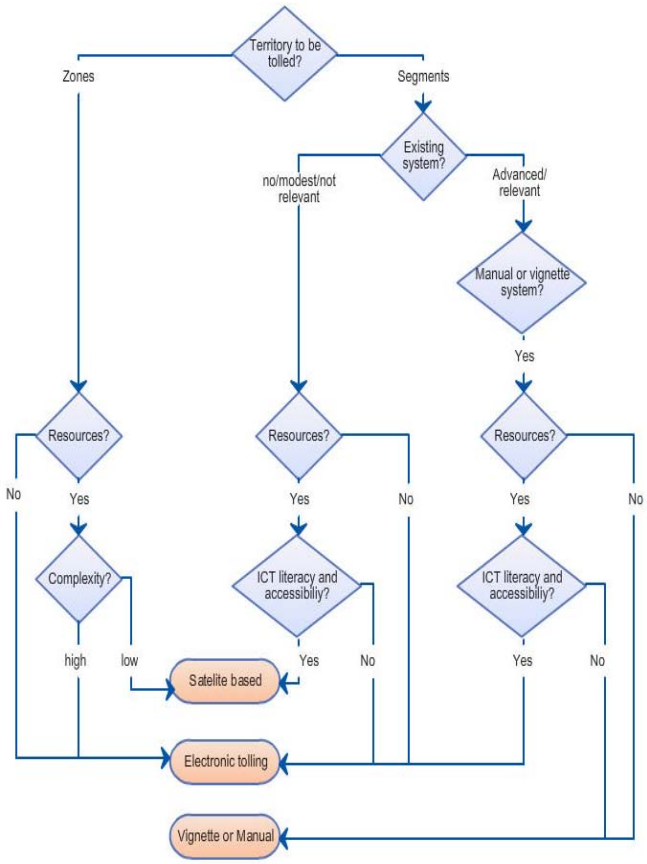


Figure 6.1: Decision Tree for project scope and technology

The diagram schematically depicts the essential questions to be asked to select the most appropriate RUC technology for specific circumstances. One of the first considerations should be the scope of a RUC scheme—

whether a segment or an area—for which different technologies have certain advantages and disadvantages. If an area is to be charged, satellite-based or other ETC solutions are appropriate, depending on available resources, agency's capacity, and complexity of a scheme. In segment charging, MTC or ETC could be used. The choice on the most appropriate one will depend on any RUC system(s) already in place, their characteristics, as well as on available resources and ICT literacy.

In addition, requirements for road users should also be determined, including whether or not to mandate account registration and installation of OBUs, whether to be based on prepayment, post-payment or a blend system, whether and to whom to allow toll exemption or discounts and how to manage their accounts, etc.

Step 2 – Implementation of pilot projects

For many systems around the world, especially for ETC systems, pilot deployment has been a very effective tool in many aspects. It has helped with assessing economic feasibility and technological viability, evaluating project risks, assessing adequacy of developed architecture and requirements (Step 1), identifying potential stakeholder issues, raising public awareness, and developing and selecting competitive and cost-effective procurement strategies (Pickford and Blythe, 2006; Sorensen and Taylor, 2005; Whitty et al., 2006).

Deployment and implementation of pilot projects involve the establishment of a task team, selection of pilot segments or areas, public advertisement to vendors and operators, and recruitment of participants (road users). The performance and issues identified during the pilot deployment should be documented to inform the full-scale implementation plan.

Step 3 – Procurement strategy

Functional units (e.g. SIOU, PSCR, and DCDM) can either be contracted separately or integrated, and thus, largely three procurement options are considered: (i) public financing (in-house procurement), (ii) separate concessions for each unit with their partnership provisioned, or (iii) a turn-key concession with a joint venture or system integrator. Figure 6.2 schematically suggests a general process of selecting procurement methods.

A decision on the procurement strategy should be made by considering existing in-house capacity of the implementing agency, available funds, risks involved in projects, industry landscape, (i.e. capacity and the level of competition), value for money, (i.e. economies of scale and scope), and interoperability challenges. For example, in the case of a small-scale segment-based pricing scheme, integration of the PSCR and DCDM can result in higher value for money due to economies of scope across the two units. In a zone-based urban pricing scheme or when in-house capacity is very limited, a turn-key option can bring in maximum economic efficiency, provided that there is sufficient competition within the industry. On the other hand, a turn-key option is known to increase associated risks, especially in cases of large-scale zone-based schemes (DfT, 2004).

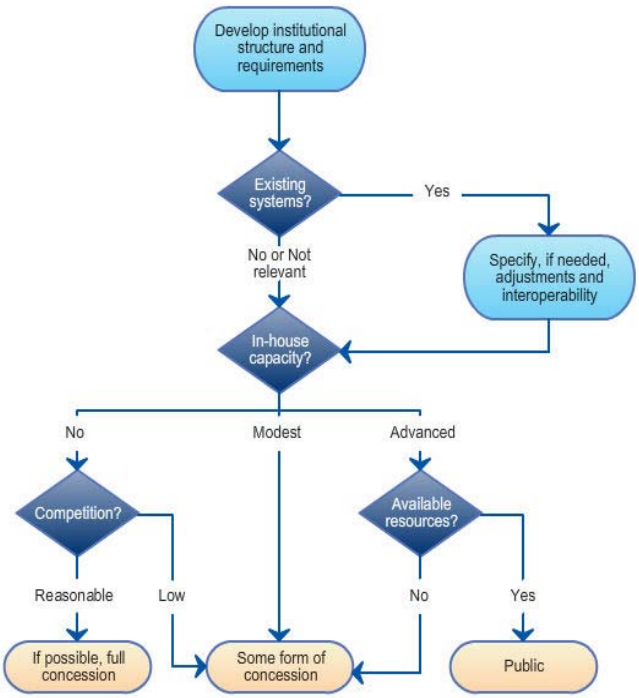


Figure 6.2: Decision Tree for procurement method

In the face of project risks and commercial profits, the implementing public agency should exercise leadership in protecting the public benefits. In particular, a procurement strategy that encourages market competition should be developed, and quality of products and services should be contractually managed. To address key public concerns, the public agency should incentivize operators or joint ventures (integrators) to (i) provide streamlined and user-friendly account registration and management systems; (ii) handle enquiries and complaints efficiently; (iii) properly manage facilities and equipment, (iv) have a disaster management strategy in place, and (v) keep the tariff at reasonable levels.

Step 4 – Start-up demand management and retrofitting

As experienced in most ETC systems, demand of OBUs peaks at the initial stage of implementation causing temporary overloading and delay, and consequently can jeopardize service quality. Therefore, a strategy to proactively respond to the initial demand should be prepared either by the public sector or a private concessionaire. A complete penetration of an ETC system can take up to ten years as in many European cases (Pickford and Blythe, 2006), since the process involves retrofitting of vehicles, revision and updates of regulations and standards, and cross-border issues.

Step 5 – Operations and maintenance

The physical and operational components of a RUC system should be maintained at a satisfactory quality. As mentioned above, system performance should be contractually managed with clearly defined targets.

Step 6 – Scaling-up and interoperability

In light of the trans-Europe RUC agenda (EC DG TREN, 2005), a system that can be easily scaled-up and interoperable is more cost-efficient in the long-term than otherwise. In this respect, it is important to use well-established and proven ITS architecture and pre-defined communication protocols.

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