Technical Note 2

Two Stage Selection Model for ITS Applications

Toshiyuki Yokota
NRI

July 22, 2004
Acknowledgements

The authors and other people involved in this project would like to thank the members of the Transport Sector Board and numerous members of the World Bank's Transport Network as well as external ITS authorities for their helpful contributions to this ITS Technical Note.


The project has become a reality thanks to the hard work and professionalism of those who worked on it.

Toshiyuki Yokota
Sr. Transport Specialist
Transport and Urban Development Department
World Bank
# Table of Contents

## INTRODUCTION
- INTRODUCTION .............................................................................................................. 3

## 1 STAGE 1: BENEFIT OVERVIEW MODEL
- 1.1 OVERVIEW MODEL: THE BENEFITS AND INCENTIVES FOR INTRODUCING ITS ...... 4
- 1.2 CURRENT STATUS OF ADOPTING VARIOUS ITS FIELDS .............................................. 5

## 2 STAGE 2: APPLICATION SELECTION MODELS
- 2.1 UNDERSTANDING MAJOR REQUIREMENTS BEFORE STARTING ......................... 6
- 2.2 APPLICATION SELECTION MODELS: ITS APPLICATIONS AND REQUIREMENTS .......... 6
- 2.3 SELECTION EXAMPLE: CONSTRUCTING A TOLL ROAD THROUGH PUBLIC-PRIVATE PARTNERSHIP, AND INTRODUCING ELECTRONIC TOLL COLLECTION (ETC) 7

## APPENDIX 1 APPLICATION SELECTION MODELS .......................................................... 9

## APPENDIX 2 FIGURES AND PICTURES OF THE BASIC DEVICES OF ITS ....................... 22

## GLOSSARY ....................................................................................................................... 29
Introduction

*ITS Technical Note 2* describes the relationship between ITS applications and their benefits, including the requirements that must be met to actually introduce ITS applications. These requirements include areas of needed knowledge, needed technology, and infrastructure issues. These requirements must be met, not only at the time of initial deployment, but throughout the life the system, including its management and maintenance. Therefore, the process for selecting ITS applications must not only consider whether the benefits justify the cost, but also whether it is possible to meet all the necessary requirements for deployment.

The intended audience for this Note are decision makers and planners in developing countries that are considering introducing ITS, as well as those individuals who will be responsible for deploying ITS applications and who are trying to determine the knowledge and technology requirements needed to accomplish the introduction.


ITS is the application of IT to surface transportation and since IT can be applied to surface transportation in multiple ways, this gives rise to numerous applications. The fact that there are so many applications is itself a good thing. However, it is also true that this complex array of applications makes it difficult for road managers and other potential ITS adopters to decide on which ITS applications to introduce.

*ITS Technical Note 2* introduces a model to support this decision making process. To make these decisions, an evaluation must be made of existing capabilities, as well as of the potential benefits to be gained by introducing the applications. The model is organized as a Two-Stage Selection Model.

- **Stage 1 – Benefit Overview Model:** ITS and Benefits/Motivations
- **Stage 2 – Application Selection Models:** ITS applications and Requirements

The overall process of Two-Stage Selection is shown in figure 1.

Stage 1 models the relationship between the three kinds of benefits/motivations of ITS (Society-wide benefits (see *ITS Technical Note 1* Section 2.2 for a description), Benefits to individuals (see *ITS Technical Note 1* Section 2.2 for a description), and Additional motivations (see *ITS Technical Note 1* Section 3.1 for a description)) and the nine fields of ITS.

In Stage 2, eight ITS fields, excluding Advanced Driving Assistance, is further subdivided into 40 ITS applications, and the overview on the requirements (technical requirements including standard and institutional requirements) for the introduction of each application is given. The reason for not including Advanced Driving Assistance in Stage 2 is that, although the possibility of vehicles with Advanced Driving Assistance capabilities cannot be denied entirely, the author considered it very unlikely that the assumed readership of this ITS Technical Note would undertake an initiative to actually plan and develop such systems.

![Figure 1 The Application Selection Process](image-url)
1 Stage 1: Benefit Overview Model

1.1 Overview Model: The Benefits and Incentives for Introducing ITS

The nine ITS fields introduced in ITS Technical Note 1 are as follows:

- Traveler Information (TF): Services to support traveler decision making before and during a trip: the travel mode to use, starting time, specific route, etc.
- Traffic Management (TM): Services to manage traffic flow on roads.
- Demand Management (DM): Services to reduce traffic demand on roads and congestion in urban areas by charging for road use and access to city centers and promoting the use of other travel modes.
- Road Management (RM): Services for the physical maintenance of roads and pavements, including repairs, snow clearance, etc.
- Advanced Driving Assistance (ADA): Automated systems to improve the performance of the vehicle and driver to make driving safer.
- Electronic Financial Transactions (EFT): Services to allow automatic electronic payment of tolls and fees, primarily on roads and bridges, but also to enter restricted city centers and sometimes to pay for parking charges, drive-through meals, etc.
- Commercial Vehicle Management (CVM): Services to support fleet and freight management, including automatic safety and credentials checking at borders.
- Public Transport Management (PTM): Services to improve the convenience and performance of public transport, for example schedule management and common fare payment mechanisms.
- Incident and Hazard Response (IHR): Services to respond to accidents and other emergencies, for example, by dispatching ambulances, fire trucks, etc.

Table 1 shows the relationship between the nine ITS fields and the three kinds of benefits/incentives. Some important points about this table include the following:

- It is based on approximately 130 ITS cases (including planned deployments) that are shown in the Appendix of the ITS Technical Note 1.
- Stars appear in the table to indicate direct, short-term effects. A ★ means that the effects are quantifiable. A ★★ means that the effects are not readily quantifiable.
- Some effects are difficult to classify as Society-wide benefits, Benefits to individuals, or Additional incentives. Here, the following criteria are used: 1) Society-wide benefits affect not only the road users but the whole society; 2) Benefits to individuals are enjoyed mainly by users and road operators including infrastructure managers; and 3) Additional incentives are not directly related to surface transportation benefits, but rather to the effects of ITS on industry as a whole and on national policy.
- Within Society-wide benefits, “Increased Mobility” refers to effects that increase the speed of travel, but do not relieve congestion. “Congestion Relief” refers to effects that lead directly to less congestion.

<table>
<thead>
<tr>
<th>Direct effects and issues to be solved by ITS in short term</th>
<th>Traveler Information</th>
<th>Traffic Management</th>
<th>Demand Management</th>
<th>Road Management</th>
<th>Advanced Driver Assistance</th>
<th>Electronic Financial Transactions</th>
<th>Commercial Vehicle Management</th>
<th>Public Transport Management</th>
<th>Incident &amp; Hazard Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increased Mobility</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>2. Congestion Relief</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>3. Environment</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>Improved Safety</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>Better Highway Asset Management</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>1. Less Travel Uncertainty</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>Efficiency for Operators</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>Efficiency for Users</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>Regional</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>IT Industry</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Nine ITS Fields and Three Kinds of Benefits/Incentives
The intended use of the table can be summarized as follows:

• If, for example, congestion relief is desired, the ITS fields that make it possible are TM and DM (since stars appear under these ITS fields in the “Congestion Relief” row). The readers can consider the full range of benefits from these fields and then move to stage 2 to select appropriate applications. Conversely, if the reader is interested in a specific ITS field such as EFT or TI, the effects of the selected field can be understood by looking for stars in the corresponding column.

• If the desired effects cannot be had, the reader should consider options other than ITS.

1.2 Current Status of Adopting Various ITS Fields

Based on ITS deployments to date, the relationship between the nine ITS fields and the benefits/incentives can be summarized as follows:

Decision making

• Among the various ITS fields, certain ones can directly benefit individual or commercial entities. Adopting a field depends, however, on a sufficient number of individual or commercial entities finding it beneficial to procure the application (e.g., IT, ADA, EFT, CVM, PTM, and possibly RM and IHR).

• Certain other fields, like TM and DM, have large society-wide benefits, and benefits for individual and commercial entities are limited. Hence, adoption of these fields is only possible as a result of a political consensus.

• Less than half of the benefits shown are classified as easy to quantify (★). Quantifying “Efficiency for Operators” will require a business management perspective. This situation makes it difficult to justify introduction of ITS which provides society-wide benefits by using traditional cost-benefit analysis.

Adoption

• TM and DM for congestion reduction etc. have limited benefits for individuals and few additional incentives, besides signal control. This has resulted in resistance from users and low adoption rates. These applications cannot be expected to be very popular. Other kinds of TM and DM have been difficult to introduce without a significant congestion problem or powerful political influence.

• The ITS fields where all three areas of benefits/incentives are well represented -- EFT, CVM, and PTM -- have been well accepted by all stakeholders in many global regions. Based on this development, it can be concluded that ITS applications for fields with benefits in all three areas will be widely supported, making them easier to introduce.

• With ITS introductions in the past, the primary focus was on Society-wide benefits. However, by also considering benefits to individuals and additional incentives, RM and IHR will have significant benefits overall. Thus, RM and IHR are fields with potential and can be introduced simply and effectively, particularly in developing countries.

• TI was considered to be promising in the early stages of ITS (1990s), partly due to the simplicity of the applications and perceived demand. So far, however, there are few examples where TI systems have proven popular and produced admirable effects. One reason for this may be that the uncertainty of society-wide benefits has resulted in reluctant or slow infrastructure development by the public sector. Nevertheless, it is clear that applications can be highly successful if they provide benefits to individuals and have additional incentives. Moreover, they can be supported by the private sector alone (e.g., car navigation).

• In the ITS fields where automobile manufacturers have strong interests, such as TI, ADA (e.g., driving assistance), and IHR (e.g., incident response), ITS has experienced some popularity. Yet, this is limited to people who can afford vehicles with ITS options.
2. Stage 2: Application Selection Models

Stage 2 involves the process whereby one selects application(s) and identifies the requirements of specific services as a basis for assessing the feasibility of their introduction.

2.1 Understanding Major Requirements Before Starting

Major requirement areas are as follows:

- **Required devices.** Some services depend on users having access to a dedicated on-board unit (or a mobile phone), which may or may not be feasible in a particular area.
- **Communications between users and the infrastructure or a communications center.** Some applications may require dedicated systems, which may be difficult to obtain. Some systems may be able to use generic communications technology, which would make it easier to introduce the application.
- **Communication between the infrastructure and communications centers.** The issues are similar to those above.
- **Required functions at centers.** With some applications, communications centers may require extremely sophisticated software and operational resources. In other instances, a single server may be all that is necessary. If there is an existing center that handles similar or related tasks, the deployment will be significantly easier.
- **Data needed prior to system operation.** Many ITS services and applications rely on the availability of certain data, such as traffic volumes. It makes a substantial difference whether this data is readily available, or if additional technology is needed for to begin collecting it.
- **Regulations.** This refers mostly to the legal restrictions that may apply to the system. Regulations differ from place to place. For example, in areas that give high priority to information privacy, certain traveler information systems or surveillance systems may be difficult to implement.
- **Institutional.** This refers to other legal and the organizational issues that affect ITS. Organizational structures and legal frameworks will have a large impact on the ease of ITS deployment.
- **Technological standards.** This refers to the various technical standards that may be applicable to the system.

Note that requirements of each country or area will vary significantly. Thus, policy makers should review their circumstances thoroughly before making any decisions.

2.2 Application Selection Models: ITS Applications and Requirements

Appendix 1 depicts the eight application selection models (corresponding to the eight ITS fields – other than ADA), including identified 40 applications, based on the 130 ITS cases listed in the Appendix of ITS Technical Note 1. The overview of the services and their advantages and disadvantages are described in each application selection models. It should be noted that potential applications are not limited to those listed here, and that many other applications are likely to appear in the future. In addition, the 40 services are not necessarily stand alone applications. In many cases, the systems can be combined with other systems. For example, traffic and road condition sensors that are introduced for “Traffic Management” can also be used for “Road Management.” A “Traveler Information” system may also contribute to many other applications. In this sense, the 40 ITS applications are interdependent. For an explanation of interdependencies, refer to the Box at the end of Section 3 and to ITS Technical Note 5: ITS System Architectures for Developing Countries.

Starting from the ITS fields selected in Stage 1, candidate applications can be selected based on the services that each application provides. Next, the requirements for introducing the selected applications are described, including requirements on the user side, infrastructure requirements that service providers must meet, which entities can be service providers, the related legal framework, and technical standards that need to be considered in defining the system. If these requirements are met, or could be met, then the application can be introduced.

In order to make the requirements easier to understand, Appendix 2 shows several basic ITS components in pictures and figures.

The flow of the application selection models is as follows:

1. **Selecting the Application (Selecting the Service)**

   - The desired applications are selected based on service type, characteristics, and benefits

2. **Identifying the Requirements**

   - For example:
     - User requirements for device features
     - Requirements for communications between users and the infrastructure or communications centers
     - Requirements for communications between portions of the infrastructure
     - Requirements for center functionality
     - Data that must be acquired prior to the start of system operation
     - Regulations
     - Institutional issues
     - Mandatory standards
     - Optional standards

**Judgment Criteria**

- Whether the services provided by the application can provide the intended benefits
- Whether it is possible to meet the requirements

After the application has been selected and in order to make a final judgment about introducing an ITS application, consideration must be given to its quantitative and qualitative benefits, costs, financial management issues, and the likelihood of public acceptance of the actual location of the installation site.
2.3 Selection Example: Constructing a Toll Road through Public-Private Partnership, and Introducing Electronic Toll Collection (ETC)

1) Selecting the Service

- Determine the charging basis for the toll structure (e.g., flat rate, distance based, point-to-point, etc.).
- For flat rate tolls, toll gates are needed only at the entrance.
- For distance-based systems, the on-board unit of the vehicle records where the vehicle entered and exited and payment is based on the distance traveled. The infrastructure side also records the usage.
- Determine whether the toll would be pre-payment or post-payment.

2) Requirements

User equipment
- The vehicle requires an on-board unit that communicates with the ETC system.

IT Infrastructure
- For communications with the vehicle, Dedicated Short-Range Communications (DSRC) is the typical choice.
- For communications between infrastructure components, dedicated lines or public communication lines can generally be used. In some areas, wireless communications (e.g., cellular) may be easier to implement. The decision should be based on installation cost, reliability, expected volume, and security considerations.
- Equipment to capture images of vehicles that did not pay tolls (e.g., CCTV cameras) is also required.
- A management center to monitor and control ETC operations will be necessary.

Prerequisite Data
- To pursue vehicles that avoid paying tolls, coordination with the vehicle registration system is necessary.

Regulation
- A determination must be made as to whether ETC is compatible with existing regulations concerning toll roads, information privacy, etc.

Selection of Organization
- Since this model is for public-private partnerships, the intention is for the system to be developed and operated by the private sector.

Standards
- Some common standards for ETC are DSRC (communication standards), data dictionary format, standards for the on-board unit, and electronic payment standards/protocols.
- Are standards already in existence? If so, their applicability to this project should be determined.
- If there are no applicable standards available, they may need to be created. All major stakeholders, including public agencies, device manufacturers, and private sector concessionaires should participate in this process.

3) Criteria for selection

Service
- Will users accept electronic payments? (ETC leads to reduction of labor costs and more reliable collections, which may make it possible to lower tolls for ETC users).
- Will the cost of the on-board units be acceptable to users?

Requirements
- Will it be possible to meet all the necessary requirements both at the time of construction and also throughout system operation?

• ETC has many de facto standards in existence. When evaluating de facto standards, consideration should be given to the standards being used by other ETC systems within the country and/or region and whether the vendors of products meeting the de facto standard can serve the needs of this project.
Box. Selecting Multiple Applications and the System Architecture

It will be apparent, by actually going through Stage 2, that several similar items come out again and again. The nine ITS fields (Traveler Information, Traffic Management, Demand Management, Road Management, Advanced Driving Assistance, Electronic Financial Transactions, Commercial Vehicle Management, Public Transport Management, and Incident and Hazard Response) may seem like totally independent systems, but they actually have many overlaps, particularly in the devices that they use. In addition, many of the fields use traffic information (e.g., traffic volume, travel speed, vehicle location, etc.) Using cooking as an analogy, the ingredients and utensils may be similar between French and Italian culinary schools, but the cooking process makes for a quite different results. The same can be said of ITS.

When introducing two ITS applications, opportunities to share common elements should be explored, since this can reduce costs and produce efficiencies. At the same time, care must be taken to keep the cooperating systems from interfering with one another.

An ITS architecture can help sort out the sharing relationships among systems (see Technical Note 5 for detailed discussion of ITS system architectures). A system architecture provides an overall framework for ITS, showing the relationship among ITS (and other kinds of) applications. Having a system architecture beforehand is most helpful.

The U.S., Europe, and Japan have each created respective ITS system architectures that cover the nine fields of ITS. These architectures were intended to cover both current and future ITS services. Consequently, creating (and maintaining) the architectures was the result of great expense and effort.

In consideration of this, developing countries are urged to focus their system architectures on known, near-term applications and to develop them step by step, as new requirements arise.
Appendix 1  Application Selection Models

1. Traveler Information

1) Information to Personal Devices
   2) Information to Vehicles with General Purpose Communication Devices

   Transmits travel information to the Internet, mobile phone, radio, TV and/or vehicle.

   **Benefits:** Increase mobility by providing information, allowing the choice of efficient routes, thereby adding to the environment, and less uncertainty. Increased activity will also promote benefits for the region and IT industry.

3) Information through DSRC

   Vehicles receive information when passing by a roadside antenna. Bidirectional communication is also possible.

   **Benefits:** Same as 1). Mostly benefiting vehicles and operators. Improved vehicle efficiency will also bring indirect benefits to the general community.

4) Information through VMS

   Provides congestion information and restriction information on VMS:

   **Benefits:** Same as 3).
5) Information through Kiosks

Information provision to public transport users:

Benefits: Same as 1). Benefiting public transport users, who will benefit from accurate and reliable information that would aid their mobility.

6) Subscription Services

Fee based provision of information collected (or processed) by the private sector:

Benefits: Same as 1). Well established service and business method that provides business opportunities for private sector and/or Public Private Partnership.

7) Personalized Service

Information provision tailored to individual demand. Ex: travel time forecast based on actual traffic, information on restaurants and hotel, events:

Benefits: Same as 1). Also able to provide tailored information for each individual. Business opportunities for private sector and public private partnership.
2. Traffic Management

Type of Service

Preparation for Management: Traffic Surveillance

1) On-Site Data Collection by Road Side Unit
   - Acquiring information at a fixed point
   - Benefits: Better information collection for real-time traffic management and/or creating database for traffic analysis, planning, and other management, leading to less congestion and less impact to the environment. Increases certainty, and opportunities for infrastructure industry.

2) Mobile / Probe car
   - Acquiring information using mobile equipment and specially equipped vehicles
   - Benefits: Same as 1), with the added benefit of flexibility of data collection.

Traffic Control

3) Variable Message Sign (VMS)
   - Conveying real time information on congestion, restriction, parking availability through VMS
   - Benefits: Less uncertainty and better opportunities for optimal actions based on better information.

See Selection Model 1: Traveler Information for Technical requirements, Institutional Issues and standards
1) Use Existing (SCATS, SCOOT, etc.)

Pros: Many systems are extremely well established and tested, excellent track record, highly scalable

Cons: May not be fit for the region’s requirements

2) Create Original

Pros: Can be tailored to the region’s situation

Cons: Funding, time consuming, no testing.

---

**Traffic Regulation Enforcement**

**6) Warning**

Automatic warning using speed displays and sensors

Benefits: Improved driver behavior and compliance. Safer traffic leading to increased mobility, less congestion and environmental impact, leading to less travel uncertainty.

**7) 1 Ticketing (on-site)**

Automatic enforcement using speed cameras and red light running sensors

Benefits: Same as 6).

**7) 2 Ticketing (off-site) (Hazmat etc.)**

Violation detection using secure OBU that records driving information

Benefits: Same as 6).

---

**Incident Management**

8) Incident notification, 9) Incident Response, 10) Incident & Hazmat Response: See Model 8: Incident Management System
3. Demand Management

To Utilize Public Transport

1) Park & Ride
   - Provides information on public transports and parking space at the stations
   - Benefit: Less congestion through increased public transport use, leading to less environmental impact and increased certainty of travel. Mainly in urban areas.

   Users’ Equipment
   - Internet, phone

   Prerequisite Data
   - Public transport information, parking availability information

   IT Infra
   - Internet, general purpose / dedicated communication system, VMSs

   Center Facility
   - None

   Organization
   - Highway administrators, public transport operators, private sector or PPP

   Data format
   - N/a

To Reduce Demand by Charging

2) Pricing by ETC
   - Pricing using Electronic Transaction to exploit the tendency to avoid financial burdens to lower traffic
   - Benefit: Eliminate traffic congestion in charged areas or on charged routes, also leading to increased safety, mainly in urban areas. Opportunities for equipment vendors for infrastructure.

See Selection Model & EFT
4. Road Management

**Type of Service**

**Asset Management**

1) Asset management based on highway data and traffic data

- **Users' Equipment**
  - See Model 1: Traveler Information
- **Prerequisite Data**
  - Maintenance records, road network, geographical information along roads
- **Center Facility**
  - Information management system, vehicle dispatcher according to maintenance plan based on traffic surveillance

**Benefit**: Better maintenance, leading to higher security, longer infrastructure life and lower cost. Better service for users due to less closures and road works.

**Snow/Ice Response**

2) Snow/Ice Response

- **Users' Equipment**
  - See Model 1: Traveler Information
- **Prerequisite Data**
  - Road network, geographical information along roads
- **Center Facility**
  - Information management system, Maintenance vehicle dispatcher according to maintenance plan based on traffic surveillance

**Data Collection Equipment**
- Roughness meters, profile measures, skid resistance, weight sensors, various traffic sensors

**Benefit**: Same as 1). Quick and accurate response to snow/ice emergency and minimizing risk and damage of disasters.

**Requirement**

- **User**
  - IT Infra
- **Service Provider**
  - Related Institution
- **Standard**

**Regulation**
- Laws on highway management

**Select Organization**

**Select necessary standards for:**

1) Public (highway administrator)

- **Pros**: Capability to provide services in nationwide or region wide, easy to keep interoperability and expandability with the national standard.
- **Cons**: Coordination of vehicle organizations, generally slow decision making, generally inefficient.

2) Private sector (concession)

- **Pros**: Efficiency of Management, reduce public burden, business opportunity for private sector and/or PPP.
- **Cons**: Less interoperability and expandability, requires a concession contract.

** related measures, effective for:**

- Data dictionary
- Digital road map
5. Electronic Financial Transaction

**Type of Service**

**Requirement**

**Service Provider**

- ITS Technical Note For Developing Countries

**User**

**Related Institution**

**Standard**

**Charge Vehicle: ETC**

1) Flat Fee/Entry Fee Collection

**Users’ Equipment**

- OBU for payment, DSRC (communication)

**Prerequisite Data**

- Vehicle registration data (License plate, transponder tag)

**IT Infra: Vehicle-infra**

- DSRC gates at check in

**IT Infra: Gate/Center**

- Dedicated or general purpose communication system, CCTV cameras, management center

**Benefits:** Improved gate throughput by allowing easier and faster payment of tolls. Increased efficiency for operators and users. Improved mobility leads to less environmental impact and better safety.

2) Mileage-Based Fee Collection

**Users’ Equipment**

- OBU for payment, DSRC (communication system)

**Prerequisite Data**

- Vehicle registration data (License plate, transponder tag)

**IT Infra: Vehicle-infra**

- DSRC gates at check in and out

**IT Infra: Gate/Center**

- Dedicated or general purpose communication system, CCTV cameras, management center

**Benefits:** Same as 1). Easier to apply for networked highways with many ramps.

3) Mileage-Based fee collection with GPS or tachograph

**Users’ Equipment**

- Communication system (DSRC, mobile phone), secure OBU

**Prerequisite Data**

- Vehicle registration data (License plate, transponder tag)

**IT Infra: Vehicle-infra**

- OBU reader (Periodic reporting eg. Monthly) or automatic

**IT Infra: Gate/Center**

- Depends on the reporting system, Management center

**Benefits:** Same as 1). No toll gate facilities required.

**Select Organization**

**Select necessary standards for:**

- DSRC (communication)
- Data Dictionary format
- OBU/locked-box
- Electronic payment protocol

**Regulation**

- Toll road/area regulation, information security, and for 3). Strong regulation or institution to collect users’ fee periodically or automatically

1) Public

**Including:**

- Highway administrator
- Vehicle Registrars, if any
- Traffic Control Administrators, if any

**Pros:** Capability of Enforcement. Coordination with the national standard and interoperability

**Cons:** Coordination of vehicle organizations, generally slow decision making, generally inefficient

2) Private sector or PPP

**Pros:** Efficiency of Management, reduced public burden

**Cons:** Less interoperability and expandability, requires a concession contract

1) Use Existing

**Pros:** well established and tested

**Cons:** Establishing the standard is costly and time consuming, difference with other ETC if exists, limited competing vendors to provide devices before creating enough market of ETC.

2) Create new standards

**Pros:** Can be tailored to purpose and traffic state

**Cons:** Establishing the standard is costly and time consuming, difference with other ETC if exists, limited competing vendors to provide devices before creating enough market of ETC.
6. Commercial Vehicle Management

For Logistics

1) Cargo/vehicle tracking
- Monitors the truck location and cargo to enhance logistics operations
- Benefits: Increased efficiency for each trip and the overall delivery system, adding to security certainty, and efficient logistics. Efficiency leading to increased mobility and less impact to the environment.

2) Monitoring / Operation Recording
- Monitors and records operation data using recorders. This service could include engine telemetry/monitoring and emergency notification
- Benefits: Better management of drivers and vehicles, leading to increased security certainty and/or better compliance with regulations and standards.

- User Equipment
  - Tachograph, data storage device
  - Prerequisite Data
    - None

- Center Facility
  - Data recording and processing system
  - Prerequisite Data
    - Data readers for tachograph/storage device or data transmission device

- Regulation
  - None

- Organization
  - Private sector

- Data format
  - Not required, if it is a closed system in a private company

- Data format
  - None

- Data format
  - Data dictionary format needs to be selected. See Model 1: Traveler Information
For Security

3) Border Crossing
Electronic border customs and immigrations safety inspection using pre-registration
Benefits: Improved efficiency of cross-border trade and security, leading to the same benefits as 1) and 2).

4) Roadside Inspection
Checks vehicle weight and cargo content from the roadside
Benefits: Improved security and compliance leading to similar benefits as 2). Less overloading and damage to the infrastructure.

For Emergency

5) Roadside Incident & Hazmat Response
Emergency response system for accidents involving vehicles with hazmat.
Benefits: Better and faster response to incidents. Improved logistics efficiency, security and certainty through better handling of incidents.

See Selection Model 8: Incident/security and Hazard Notification System
7. Public Transport Management

**Type of Service**

**Requirement**

**Quality of Service**

1) **Electronic Payment**
   - Tariff payment for public transport using IC cards
   - Benefits: Easier and faster fare payment leading to increased use of public transport. Increased mobility and less environmental impact.

2) **Bus Location**
   - Acquiring the location of public transport vehicles, which is conveyed to the users
   - Benefits: Improved certainty leading to increased use of public transport. Better mobility for users, and efficiency for operators and users.

3) **Bus Signal Priority**
   - Traffic signals adapt their phase to give priority to buses
   - Benefits: Better adherence to schedule. Improved reliability and convenience, leading to increased use of public transport.
4) Demand Responsive Bus/ Taxi
Changes routes or dispatches of bus and taxis based on demand
Benefits: Higher convenience for users. Improved reliability and efficiency for busses, leading to increased use of public transport.

Quality of Operation
5) Monitoring / operation Recording
Monitors and records operation data using recorders. This service could include engine telemetry/monitoring and emergency notification
Benefits: Better management of drivers and vehicles, leading to increased security certainty and/or better compliance with regulations and standards.
8. Incident and Hazard Response

1) Incident Notification (system for enforcement officers)

- Law enforcement filing an accident report using mobile terminals connected to a database:
- Benefits: Better data collection adding to security and efficiency, and helping to create "traffic accident data base".

2) Incident Management

- (Automated) incident report and the dispatch of emergency vehicles. Tracking services for stolen vehicles:
- Benefits: Better and faster response to incidents. Improved security and certainty through better handling of incidents.

3) Hazmat Response

- Emergency response system for accidents involving vehicles with hazmat
- Benefits: Same as 2).

User's Equipment:
- PDA with mobile function
- Mobile with position reporting function, incident detectors at accident-prone spots
- Communication system (mobile phones, Internet, etc.)

Center Facility:
- Management center
- Mobile phones, dedicated radio with emergency vehicles, Management center
- Vehicle registration, Road network, information on the hazmat

Prerequisite Data:
- Location of police offices and emergency service, hospital
- Vehicle registration
- Toll road/area regulation, information security
- Highways administrator, law enforcement

Select Necessary standards:
1) Use existing
2) create original

Goal:
- Data Dictionary format
- Digital Road Map
- Positioning System

Public
- Enforcement, emergency, road operator
- Pros: Capability to provide services nationwide or region wide
- Cons: Relatively slow decision making

Private sector or PPP
- Efficiency of Management, reduce public burden, business opportunity for private sector and/or PPP, providing personalized service
- Cons: Limited authority in emergency, limited capability to provide services, requires strong coordination with related authorities
Appendix 2  Figures and Pictures of the Basic Devices of ITS

1 Users’ Equipments

Figure 1  On-board Unit for ETC (Germany)

Figure 2  An On-board Unit for ETC (Japan)

Figure 3  On-board Unit for ETC (Italy)

Figure 4  The Equipment for Collecting Mileage Data for the Heavy Vehicle Fee (Switzerland)

Figure 5  Adding Value to SmarTrip on a Passes/ Farecards Machine (USA)

Figure 6  Octopus Card (Hong Kong)
2 Communication System/Interface

Figure 7  Communication Between the Gate and Vehicle in ETC (Japan)

Figure 8  ETC in the Philippines (the Philippines)

Figure 9  ERP Implemented Zone (left) and Entry Gate (right) (Singapore)

Figure 10  Various Communication Using Beacons (Japan)
3 Data Collection Equipment

Figure 11  CCTV Traffic Camera (USA)

Figure 12  CCTV image (Colombia)

Figure 13  Surface Sensors

Figure 14  RWIS (Road Weather Information System) (Sweden)

Figure 15  Radar Camera for Enforcement (USA)

Figure 16  Speed Warning System Using Speed Radar (USA)
4 Center Facilities

Figure 17  Traffic Control Center (Argentina)

Figure 18  Road Traffic Control Center (China)

Figure 19  Traffic Management and Control System for the City of Poznan (Poland)

Figure 20  Monitor Room for a Tracking System Using GPS and Mobile Phone (Romania)
5 Information Provision

Figure 21  Webpage Providing Traffic Information (Thailand)

Figure 22  Road Traffic Information Provision by Cellular Phone SMS (the Philippines)

Figure 23  VMS at Rio-Niteroi Bridge

Figure 24  Public Transport Information System (Left: Britain, right: Australia)
6 System Configuration

Figure 25  A Radio Station Studio in Jakarta (Indonesia)

Figure 26  Border Crossing System on Texas-Mexico Border
Figure 27  Public Transport Management System

Figure 28  System Diagram for Commercial Vehicle Management Systems

Figure 29  System Diagram for Incident Management Systems
## Glossary

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCTV</td>
<td>Closed circuit television</td>
</tr>
<tr>
<td>DSRC</td>
<td>Dedicated short range communication</td>
</tr>
<tr>
<td>ETC</td>
<td>Electronic toll collection</td>
</tr>
<tr>
<td>GNSS</td>
<td>Global navigation satellite system. Generic term for systems such as GPS (US) or Galileo (EU etc.)</td>
</tr>
<tr>
<td>GPS</td>
<td>Global positioning system. A GNSS of USA</td>
</tr>
<tr>
<td>HOV</td>
<td>High occupancy vehicle</td>
</tr>
<tr>
<td>ITS</td>
<td>Intelligent Transport System</td>
</tr>
<tr>
<td>OBU</td>
<td>On-board unit</td>
</tr>
<tr>
<td>PDA</td>
<td>Personal digital assistance</td>
</tr>
<tr>
<td>PPP</td>
<td>Public private partnership</td>
</tr>
<tr>
<td>RDS-TMC</td>
<td>Radio data system - traffic message channel.</td>
</tr>
<tr>
<td>SMS</td>
<td>Short message system</td>
</tr>
<tr>
<td>VMS</td>
<td>Variable message signs</td>
</tr>
</tbody>
</table>

**Positioning System**: A system used to determine the geographic location of a movable object, like a vehicle or cargo container.

**Data dictionary**: A formatted, computer-readable listing of data elements (including meaning and format) and data messages (including meaning, usage, and format) for a particular application or family of applications.

**Smart card**: A card containing an integrated circuit that can store and (in some cases) process data.