5.4 Implementation Packages for Non-stop Toll Collection

1) Service Requirements

Non-stop toll collection is the priority ITS user service whose implementation is to be started in the 1st stage (by 2015) as shown in Chapter 3. That can be detailed and defined by the following service requirements. Reference numbers attached to the subtitles indicate the corresponding implementation packages and the alternatives to be hereinafter described.

(1) Toll Collection → 6

(a) **1st Stage**

(i) Non-stop toll collection responding to the distance-proportional/sectional/flat tariff system,

(ii) Capability of combined use of non-stop toll collection and one-stop toll collection for efficient implementation of roadside equipment: in-coming by non-stop and out-going by one-stop, and in-coming by one-stop and out-going by non-stop as well,

(iii) Average service-time less than 4.5sec/vehicle by non-stop toll collection such as ETC,

(iv) Average service-time less than 6.0sec/vehicle by one-stop toll collection such as Touch & Go,

(v) Toll payment by prepayment,

(vi) Capability of checking sufficiency/shortage of prepaid balance by the driver in advance or en-route using OBU and contact-less IC-card: balance-in-card,

(vii) Shared use of OBU among different road sections under the different road operators for convenience of the user,

(viii) Achieving a low error ratio (less than 0.01%) of treating the short prepaid balance as sufficient, and the sufficient prepaid balance as short,

(ix) Achieving a low error ratio (less than 0.01%) of falling into inoperable situation by system errors, and easy procedure to recover the system errors,

(x) Conformance to the vehicle classification defined by the Vietnamese Government,

(xi) Identifying vehicle class without costly detectors, and easy system modification for revision of the vehicle classification,

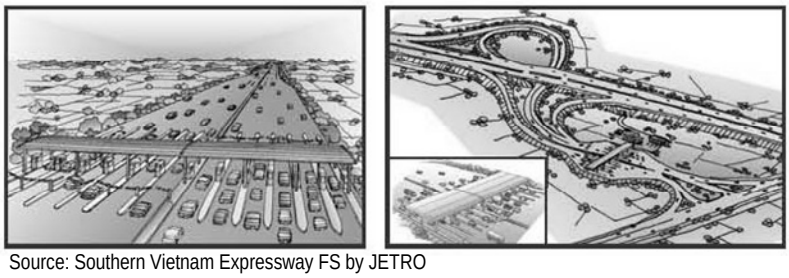
(xii) Capability of sure prevention of unlawful passage including violation,

(xiii) Simple roadside equipment component for non-stop/one-stop toll collection to be connected to existing system for manual toll collection by the stepwise implementation.

(b) **3rd Stage**

(i) Shared use of OBU and contact-less IC-card with ERP (Electronic Road Pricing) in the urban area.

Figure 5.4.1 Toll Collection



Source: Southern Vietnam Expressway FS by JETRO

(2) Center-to-center Data Exchange for OBU Management → 9-5

(a) **fr 1st Stage**

(i) Storage of the OBU registration data in the center, which is transferred from the OBU shop where OBU is issued to the user and installed in the vehicle,

(ii) Reception of the notification of lost OBU from the user to the OBU registration center,

(iii) Transmission of the lost OBU list from the OBU registration center to the toll management centers of the road operators for invalidating the lost OBU over the whole expressways and other toll roads.

(3) Center-to-center Data Exchange for Toll Clearance → 9-6

(a) **1st Stage**

(i) Toll clearance to be prepared for many different road operators over the whole expressways and other toll roads

(ii) Toll clearance by using contact-less IC-card for prepayment,

(iii) Issue/recharge of contact-less IC-card to be utilized conveniently in the city as well as the roadside,

(iv) Adequate data exchange for toll clearance between the toll management center of the road operator and the prepayment service center such as the center of the bank,

(v) Appropriate and reliable apportionment of the toll revenue among the road operators preventing unfair billings to the prepayment service center for establishing the sustainable toll clearance system,

(vi) Stepwise establishment of the toll clearance system for enhancing convenience for the users.

(4) Center-to-center Data Exchange for IC-card Operation → 9-7

(a) **1st Stage**

(i) Storage of the IC-card issue/recharge data in the prepayment service center for prevention of illegal recharge,

(ii) Reception of the notification of lost IC-card from the user to the prepayment service center,

(iii) Transmission of the lost IC-card list from the prepayment service center to the toll management centers of the road operators (through the clearing center) for invalidating the lost IC-card over the whole expressways and other toll roads.

(5) Center-to-center Data Exchange for Toll Enforcement Assistance → 9-8

(a) **1st Stage**

(i) Framework for the assistance of toll enforcement based on the negative list,

(ii) Negative list of the license plate numbers of the vehicles of unlawful passage without adequate toll payment responding to the vehicle classification,

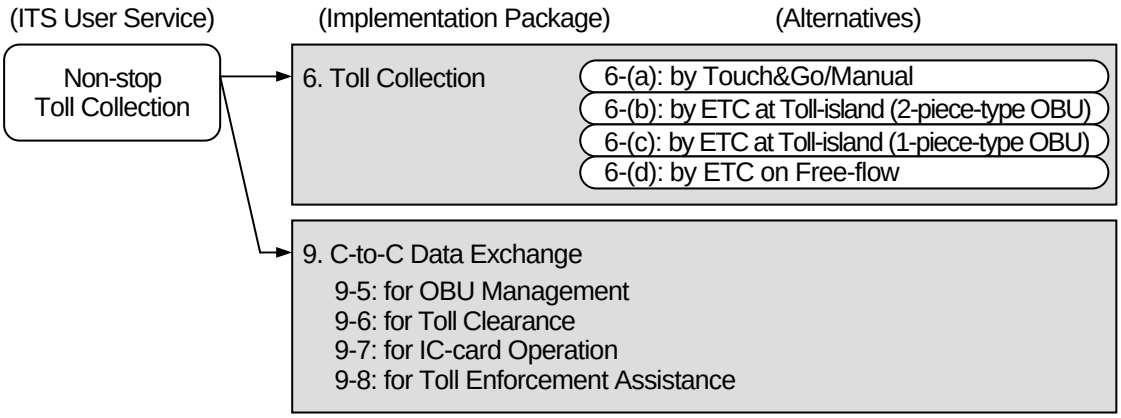
(iii) Negative list updated/stored by the OBU management center,

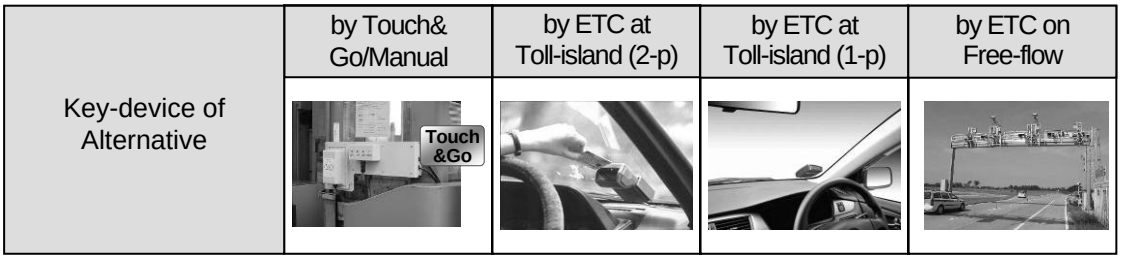
(iv) Delivery of the negative list to all road operators and all toll management centers of the whole expressways and other toll roads every two hours.

2) Breakdown of Implementation Packages

Non-stop toll collection can be broken down into the two implementation packages as shown below. Each package has one or more alternatives, and four use cases are assumed for the package of center-to-center data exchange.

Figure 5.4.2 Implementation Packages and Alternatives of Non-stop Toll Collection





Source: VITRANSS 2 Study Team / Southern Vietnam Expressway FS by JETRO

System descriptions for the non-stop toll collection are shown in the following pages and in ***Appendix 1*** corresponding to the implementation packages and the alternatives above.

3) System Descriptions

(1) Toll Collection

(a) Touch & Go/Manual

Toll collection is conducted by stopping the vehicle once at the toll-island using contact-less IC-card. Prepayment of toll fee is settled by using IC-card and data communication is conducted between IC-card and the roadside reader/writer. The license plate of the vehicle is captured by camera for identifying vehicle class and is recorded for toll enforcement. Vehicle passage is controlled by traffic light and barrier.

Figure 5.4.3 Touch & Go

Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.6)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.6)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.6)).

(iv) **Needed Standardization:**

- Toll rate system (flat tariff, distance proportional tariff, both) including vehicle classification,
- Payment/recharge method (prepayment, credit, direct debit),
- Type of contact-less IC-card communication (type-A, B, C),
- Issue/set-up/certification rule of IC-card,
- Protocol/Message of the interface between IC-card and R/W,
- Procedure of vehicle identification and enforcement,
- Definition of data for toll collection.

(v) **Advantages:**

- Capability to collect toll without OBU,
- Capability to store the prepaid balance in IC-card,
- Easy modification for revision of the vehicle classification,
- Easy procedure to recover system errors,
- Easiness in the prevention of unlawful passing including violation,
- Capability of flexible tollgate lane operation by mixed use with ETC (2-piece type OBU).

(vi) **Disadvantages:**

- Necessity of stopping the vehicles for toll collection,
- Small effect on relieving congestion.

(vii) **Grading:** Useful as a complement.

(b) ETC at Toll-island (2-piece-type OBU)

Toll collection is conducted without stopping the vehicle at the toll-island using OBU (on-board unit) and contact-less IC-card. Prepayment of toll fee is settled by using IC-card put in OBU and data communication is conducted between OBU and the roadside antenna. The license plate of the vehicle is captured by camera for identifying vehicle class and is recorded for toll enforcement. Vehicle passage is controlled by traffic light and barrier.

Figure 5.4.4 ETC at Toll-island (2-piece)

Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.6)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.6)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.6)).

(iv) **Needed Standardization:**

- Toll rate system (flat tariff, distance proportional tariff, both) including vehicle classification,
- Payment/recharge method (prepayment, credit, direct debit),
- Type of contact-less IC-card communication (type-A, B, C),
- Issue/set-up/certification rule of IC-card and OBU,
- Protocol/message of the interface between IC-card and R/W,
- Method of road-to-vehicle communication (DSRC, infrared-ray, etc.),
- Message template/sequence of the interface between OBU and roadside antenna,
- Procedure of vehicle identification and enforcement,
- Definition of data for toll collection.

(v) **Advantages:**

- Capability to collect toll without stopping the vehicles,
- Effect on relieving congestion,
- Capability to store the prepaid balance in IC-card,
- Easy modification for revision of the vehicle classification,
- Easy procedure to recover system errors,
- Capability of flexible tollgate lane operation by mixed use with Touch&Go.

(vi) **Disadvantages:**

- Necessity to diffuse OBU,
- OBU at higher cost than 1-piece type OBU.

(vii) **Grading:** Recommended.

(c) ETC at Toll-island (1-piece-type OBU)

Toll collection is conducted without stopping the vehicle at the toll-island using OBU (on-board unit). Prepayment of toll fee is settled in the bank account and data communication is conducted between OBU and the roadside antenna. The license plate of the vehicle is captured by camera for identifying vehicle class and is recorded for toll enforcement. Vehicle passage is controlled by traffic light and barrier.

Figure 5.4.5 ETC at Toll-island (1-piece)

Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.6)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.6)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.6)).

(iv) **Needed Standardization:**

- Toll rate system (flat tariff, distance proportional tariff, both) including vehicle classification,
- Payment/recharge method (prepayment, credit, direct debit),
- Method of road-to-vehicle communication (DSRC, infrared-ray, etc.),
- Message template/sequence of the interface between OBU and roadside antenna,
- Procedure of vehicle identification and enforcement,
- Issue/set-up/certification rule of OBU,
- Definition of data for toll collection.

(v) **Advantages:**

- Capability to collect toll without stopping the vehicles,
- Effect on relieving congestion,
- OBU at lower cost than 2-piece type OBU.

(vi) **Disadvantages:**

- Necessity to diffuse OBU,
- Necessity of bank account to store the prepaid balance,
- Necessity of OBU re-initializataion for revision of the vehicle classification,
- Complicated procedure to recover system errors,
- Incapability of mixed use with Touch&Go.

(vii) **Grading:** Not suitable.

(d) ETC on Free-flow

Toll collection is conducted on the free-flow traffic without the toll-island using OBU (on-board unit) and contact-less IC-card. Prepayment of toll fee is settled by using IC-card put in OBU and data communication is conducted between OBU and the roadside antenna. The license plate of the vehicle is captured by camera for identifying vehicle class and is recorded for toll enforcement.

Figure 5.4.6 ETC on Free-flow

Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.6)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.6)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.6)).

(iv) **Needed Standardization:**

- Toll rate system (flat tariff, distance proportional tariff, both) including vehicle classification,
- Payment/recharge method (prepayment, credit, direct debit),
- Type of contact-less IC-card communication (type-A, B, C),
- Issue/set-up/certification rule of IC-card and OBU,
- Protocol/message of the interface between IC-card and R/W,
- Method of road-to-vehicle communication (DSRC, infrared-ray, etc.),
- Message template/sequence of the interface between OBU and roadside antenna,
- Procedure of vehicle identification and enforcement,
- Definition of data for toll collection.

(v) **Advantages:**

- Capability to collect toll at cruising speed of the vehicles on free-flow,
- Largest effect on relieving congestion,
- Capability to store the prepaid balance in IC-card,
- Easy modification for revision of the vehicle classification,
- Easy procedure to recover system errors,
- Capability of flexible tollgate lane operation by mixed use with Touch&Go.

(vi) **Disadvantages:**

- - Necessity to diffuse OBU,
- - OBU at higher cost than 1-piece type OBU,
- - Difficulty in the prevention of unlawful passing including violation.

(vii) **Grading:** Too early.

(2) Center-to-center Data Exchange

(a) OBU management is performed by exchanging messages/data among the servers installed in the toll management center and the OBU registration center.

(b) DSRC probe is performed by exchanging messages/data among the servers installed in the toll management center, the toll/traffic integration center, the traffic information/control center, the clearing center and the prepayment service center.

(c) IC-card operation is performed by exchanging messages/data among the servers installed in the toll management center, the clearing center and the prepayment service center.

(d) Toll enforcement assistance is performed by exchanging messages/data among the servers installed in the toll management center and the OBU registration center.

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.9)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.9)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.9)).

(iv) **Needed Standardization:**

- Definitions of the segmentation of the vehicle classification and the toll rate system.
- Definitions of the message/data of OBU registration, IC-card issue, toll collection, negative database, and other basic data.

(v) **Grading:** Necessary.

4) Detailed Discussion on Non-stop Toll Collection

(1) Recommendations on Alternatives

The foregoing recommendations on the alternatives for non-stop toll collection (discussed in the ITS Working Group shown in ***APPENDIX-5***) are summarized in the table below.

Table 5.4.1 Recommendations on Alternatives for Non-stop Toll Collection

	Non-stop Toll Collection	Pre-payment	Balance-in-card	Processing Error Rate /Recovery	Violation Prevention	Combined Use with Touch & Go	Cost of OBU	Grading
by Touch&Go/Manual 6-(a)	Not Capable	Capable	Capable	Low/Easy	Easy	-	-	Useful as a Complement
by ETC at Toll-island (2-piece) 6-(b)	Capable	Capable	Capable	Low/Easy	Average	Capable	Average	Recommended
by ETC at Toll-island (1-piece) 6-(c)	Capable	Difficult	Not Capable	Low/Difficult	Average	Incapable	Low	Not Suitable
by ETC on Free-flow 6-(d)	Capable	Capable	Capable	Low/Ignore	Difficult	Capable	Average	Too Early

Source: VITRANSS 2 Study Team

Comparison factors shown in the first line of the table above are discussed in detail in the following pages.

(2) Payment Method

Toll payment can be settled by the methods of prepayment, credit and direct debit as shown in the table below.

Table 5.4.2 Comparison on Toll Payment Method

	Prepayment	Payment on Credit	Payment by Direct Debit
Outline and Procedure	Toll fare is took off from the prepaid balance when OBU passes the tollgate. Deposit for prepayment ↓ OBU passes the tollgate ↓ Toll fare is took off from the prepaid balance	Toll fare is claimed to user's bank account by the credit company later on. Deposit in bank account ↓ OBU passes the tollgate ↓ User-ID and passage data are sent to the credit company (by telecommunication) ↓ Toll fare is claimed to user's bank account by the credit company (later on)	Toll fare is deducted from user's account by direct debit later on. Deposit in bank account ↓ Open a credit ↓ OBU passes the tollgate ↓ User-ID and passage data are sent to the bank (by telecommunication) ↓ Toll fare is deducted from user's bank account by direct debit (later on)
Available user	Unlimited	Limited to the credit card holder	Limited to the bank account holder
Suitability for small amount payment	Good	Average	Average
Exclusive payment scheme/means	Necessary	Not necessary (by existing scheme of credit)	Not necessary (by existing scheme of bank)
High-quality telecommunication	Not necessary	Necessary	Necessary
Familiarity in Vietnam	High	Not high	High
Grading	Recommended	Not Suitable	Average

Source: VITRANSS 2 Study Team

From the results of comparison in this table, prepayment is recommended as the appropriate toll payment method in the Master Plan.

(3) Utility of Balance-in-card

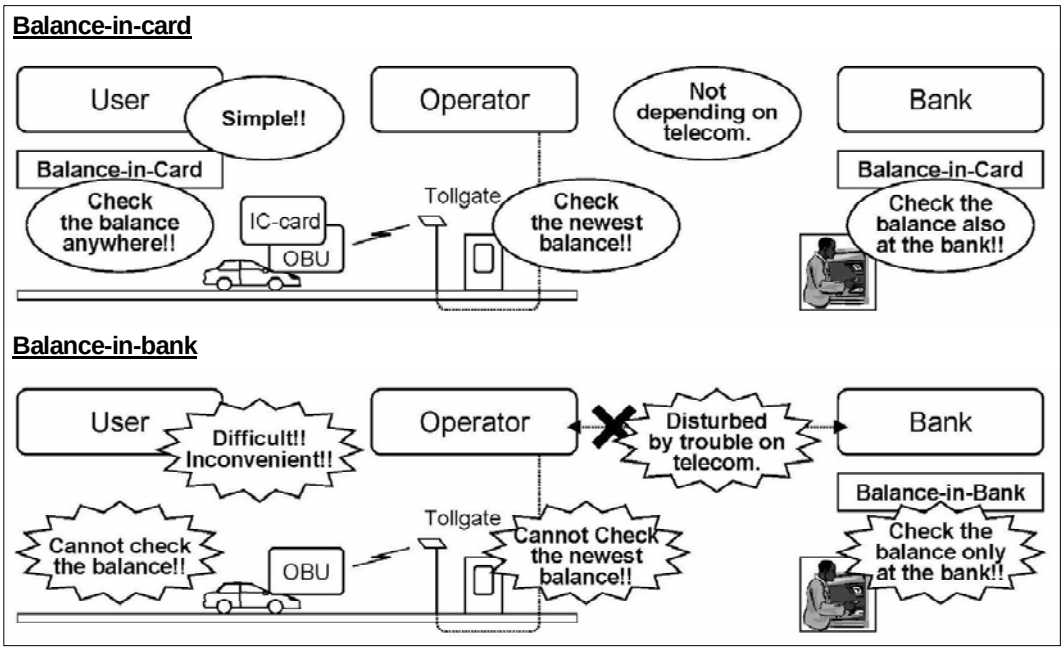
Prepaid balance can be managed by different two ways: balance-in-card and balance-in-bank. Balance-in-card allows users to check the prepaid balance anywhere, but on the other hand, balance-in-bank limits checking the prepaid balance only to the bank. For this reason, balance-in-card is recommended in the Master Plan.

In the case of balance-in-bank, it is required to send the short-balance-user-list from the bank to the tollgates. In the trials in Malaysia, low-quality telecommunication disturbs the data exchange and causes the following trouble:

(i) Even if a user's balance is not enough, the system cannot check his balance, and the operator cannot stop him,

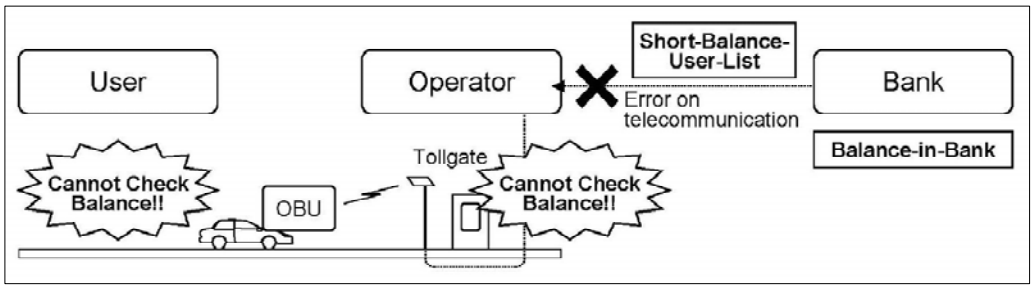
(ii) Even if a user recharged his balance, the system cannot check his balance, and he cannot pass the tollgate.

Figure 5.4.7 Two Ways for Checking Prepaid Balance



Source: VITRANSS 2 Study Team

Figure 5.4.8 Problem of Balance-in-bank on Low-quality Telecommunication

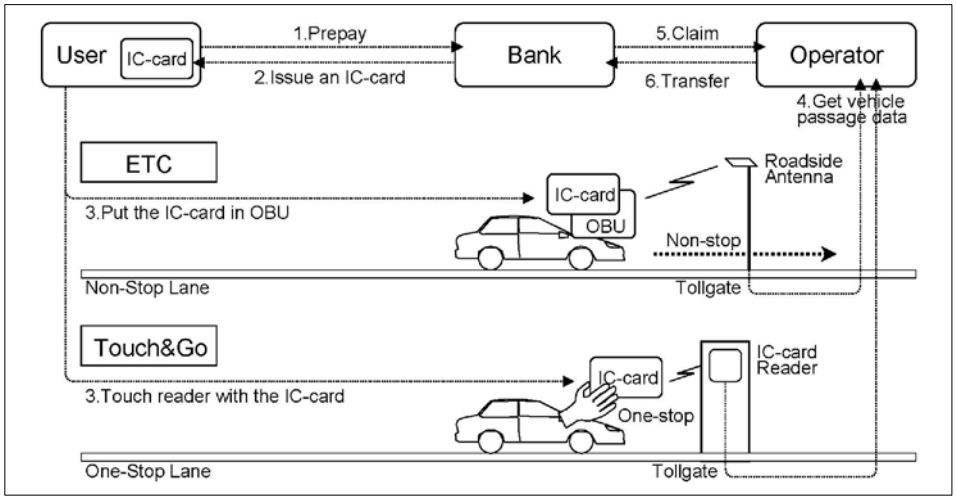


Source: VITRANSS 2 Study Team

(4) ETC Combined Use with Touch & Go

A single IC-card shall be shared for ETC as well as Touch & Go for the convenience of road users and road operators.

Figure 5.4.9 ETC Combined Use with Touch & Go

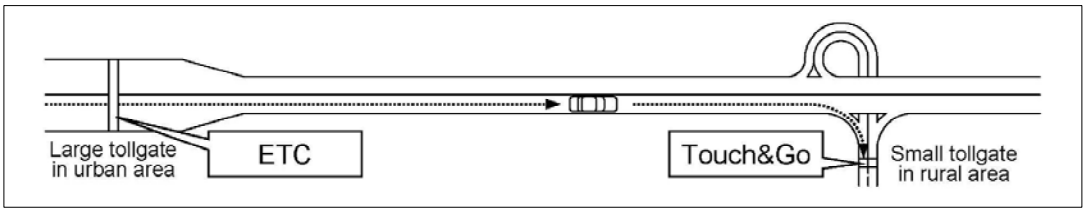


Source: VITRANSS 2 Study Team

ETC combined use with Touch & Go provides the following advantages:

(i) Flexible operation by mixed use of the toll collection methods: incoming by ETC and outgoing by Touch & Go, and incoming by Touch & Go and outgoing by ETC as well,

Figure 5.4.10 Mixed Use of Toll Collection Methods

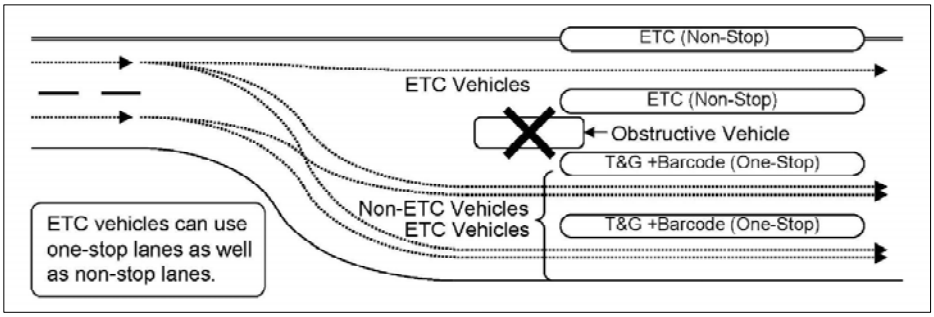


Source: VITRANSS 2 Study Team

(ii) Cost-cutting by excluding ETC installation in the small tollgates in rural areas, and capability of stepwise ETC installation from the large tollgates in urban areas.

(iii) Flexible tollgate lane operation that prevents mix-ups caused by inexperienced ETC vehicle drivers and/or accidents at ETC lanes.

Figure 5.4.11 Flexible Tollgate Lane Operation



Source: VITRANSS 2 Study Team

(5) ETC Lane Operation at Tollgate

Two types of ETC lane operation can be applied to the tollgates: ETC exclusive operation and ETC/manual mixed operation. The ETC exclusive operation is recommended based on the comparison shown in the table below.

Table 5.4.3 Comparison of ETC Lane Operation at Tollgate

	ETC Exclusive Operation	ETC/Manual Mixed Operation
Outline	Only the vehicles equipped with OBU can pass exclusively through the ETC lane at the tollgate. A human collector is to be attended for dealing with wrong tollgate lane selection of the vehicles without OBU.	The vehicles without OBU can pass through the ETC lane at the tollgate as well as the vehicles equipped with OBU. A human collector needs to be attended for toll collection of the vehicles without OBU.
Capacity	Vehicle processing capacity for design: 800 vehicles/lane/hr.	Vehicle processing capacity for design: 450–600 vehicles/lane/hr.
Advantages	- Attainment of large vehicle processing capacity on the ETC lane, - Large effects on relieving congestion at the tollgate, - Promotion on diffusing OBU by smooth vehicle passing through the ETC lane.	- Reduction of the possibility of congestion on the manual lanes caused by low diffusion rate of OBU in the early stage of ETC introduction.
Problems	- Possibility of congestion on the manual lanes caused by low diffusion rate of OBU in the early stage of ETC introduction.	- Lowering of vehicle processing capacity of the ETC lane due to the longer processing time for the vehicles without OBU, - Small effects on relieving congestion at the tollgate, - Delay in diffusing OBU by unsmooth vehicle passing through the ETC lane.
Grading	Recommended	Not Suitable

Source: VITRANSS 2 Study Team

(6) Vehicle Classification

In Vietnam, specific toll amount is based on the vehicle classification shown in the Circular No.90/2004/TT-BTC of MOF. (→ See Section 2.8.) The vehicle classification is defined by the combination of the number of seats and the loading capacity, focusing on the benefits provided by road use.

This classification can be carried out automatically by using license plate scanners based on the adequate license plate system.

Table 5.4.4 Vehicle Classification in Vietnam

Vehicle Class		Definition
Ordinary Vehicle	1	Two wheelers, three wheelers, mopeds and the like
	2	Lambretta, rudimentary trucks, tractors
	3	Cars with seats of 12 or less, trucks with a capacity less than 2 tons, mass transit buses
	4	Cars seats between 12 and 30, trucks with a capacity between 2 and 4 tons
	5	Cars with seats of 30 or more, trucks with a capacity between 4 and 10 tons
	6	Trucks with a capacity between 10 and 18 tons, 20ft-container lorries
	7	Trucks with a capacity of 18 tons or more, 40ft-container lorries
Defense Ministry Vehicle	1	Military cars
	2	Military trucks
Police Force Vehicle	1	Cars with seats less than 7
	2	Cars with seats of 7 or more
	3	Specialized automobiles
	4	Trucks
	5	Two wheelers, three wheelers

Source: VITRANSS 2 Study Team

(a) Vehicle Classification in Indonesia

In Indonesia, vehicle classification by the number of axles is adopted for the toll rate system focusing on the damage by the trucks to the road structure. This classification can be carried out automatically by using simple sensors.

Table 5.4.5 Vehicle Classification in Indonesia

Vehicle Class	Definition
Class I	Sedan, Jeep, Pickup truck, Small truck and Bus
Class II	Truck with 2 axles
Class III	Truck with 3 axles
Class IV	Truck with 4 axles
Class V	Truck with 5 or more axles

Source: VITRANSS 2 Study Team

(b) Vehicle Classification in Malaysia

In Malaysia, vehicle classification by the number of axles is adopted for the toll rate system focusing on the damage by the vehicles to the road structure. In addition, lower toll rates are prepared for the taxis and the buses highly public. This classification can be carried out automatically by using simple sensors.

Table 5.4.6 Vehicle Classification in Malaysia

Vehicle Class	Definition
Class 0	Motorcycles, bicycles or vehicles with 2 or less wheels
Class 1	Vehicles with 2 axles and 3 or 4 wheels excluding taxis
Class 2	Vehicles with 2 axles and 5 or 6 wheels excluding buses
Class 3	Vehicles with 3 or more axles
Class 4	Taxis
Class 5	Buses

Source: VITRANSS 2 Study Team

(c) Vehicle Classification in Japan

In Japan, vehicle classification by the combination of the number of axles, the vehicle weight and the vehicle dimension is adopted for the toll rate system focusing on the damage by the vehicles to the road structure and on the occupancy on the road. This classification can be carried out automatically by appropriate license plate system and using many kinds of sensors including the license plate scanner, the treadle and the vehicle detectors.

Table 5.4.7 Vehicle Classification in Japan

Vehicle Class	Definition
Light Vehicle	• Light vehicle • Motorcycle
Ordinary Vehicle	• Small size vehicle (excluding light vehicle and motorcycle) • Sedan • Light tractor with trailer (which has an axle)
Medium Vehicle	• Small bus with seats of 11 to 29 and a weight less than 8 tons • Truck with a weight less than 8 ton and axles of 3 or less • Light tractor with trailer (which has 2 or more axles) • Tractor with trailer (which has an axles)
Large Vehicle	• Bus with seats of 30 or more or a weight more than 8 tons, and a length less than 9 m • Truck with a weight of 8 to 25 tons and axles of 3 or less • Tractor with trailer (which has 2 or more axles) • Large tractor with trailer (which has an axles)
Extra Large Vehicle	• Bus with sheets of 30 or more, a weight more than 8 tons, and a length more than 9 m • Truck with axles of 4 or more • Large tractor with trailer (which has 2 or more axles) • Large construction vehicle

Source: VITRANSS 2 Study Team

(d) Vehicle Class for Discussion in the Master Plan

In the Master Plan, it is assumed that the vehicle class practicable by using simple sensors, such as the license plate scanners and treadles, is to be adopted for cutting implementation costs.

For example, the vehicle classification responding to the vehicle weight can be actualized by the number of axles without equipment for measurement.

Table 5.4.8 Measurement for Vehicle Classification Responding to Vehicle Weight

Measurement Value	Measuring Method
Loading Capacity of Vehicle	Manpower (No necessity of equipment)
Number of Axles	Manpower (No necessity of equipment)
Axle Load	Axle load scale (Necessity of equipment at high cost)
Total Vehicle Weight	Weighing scale (Necessity of equipment at high cost and wide space)

Source: VITRANSS 2 Study Team

5.5 Implementation Packages for Heavy Truck Control

1) Service Requirements

Heavy truck control is the priority ITS user service whose implementation is to be started in the 1st stage (by 2015) as shown in Chapter 3. That can be detailed and defined by the following service requirements. Reference numbers attached to the subtitles indicate the corresponding implementation packages and the alternatives to be hereinafter described.

(1) Overloading Regulation → 7-(a), (b)

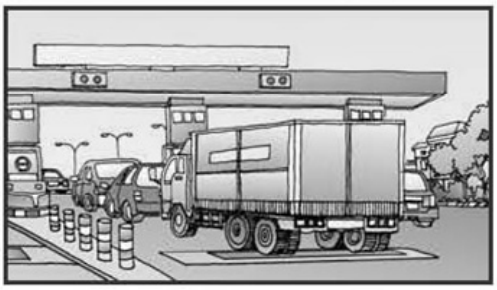
(a) 1st Stage

(i) Weighing heavy trucks with/without stopping them,

(ii) Identification of illegally loading (including/excluding the vehicle weight according to the standardization),

(iii) Assist the regulation of illegally loading (according to the standardized procedure of the standalone method to weigh/reject the overloaded trucks at roadside, or of the online method to store overloading records in the negative database for the penalty later on).

Figure 5.5.1 Overloading Regulation



Source: Southern Vietnam Expressway FS by JETRO

(2) Heavy/Hazardous-material Truck tracking → 8-(a), (b)

(a) 2nd Stage

(i) Notification to the road operator at the coming of the heavy/hazardous-material truck into the expressway network,

(ii) Tracking the actual driving route of the heavy/hazardous-material truck and the section where the truck exists,

(iii) Identification of the management office in charge of response/clearance of the incident caused by the heavy/hazardous-material truck,

Figure 5.5.2 Heavy/Hazardous-material Truck tracking

Source: Southern Vietnam Expressway FS by JETRO

(iv) Information of the heavy/hazardous-material truck to the management office in case of incident,

(v) Information of actual position of the truck to the cargo-truck operators,

(vi) Provision of heavy/hazardous-material truck data to the road operator at the occurrence of the accident.

(3) Center-to-center Data Exchange for Heavy Truck Control → 9-9

(a) 2nd Stage

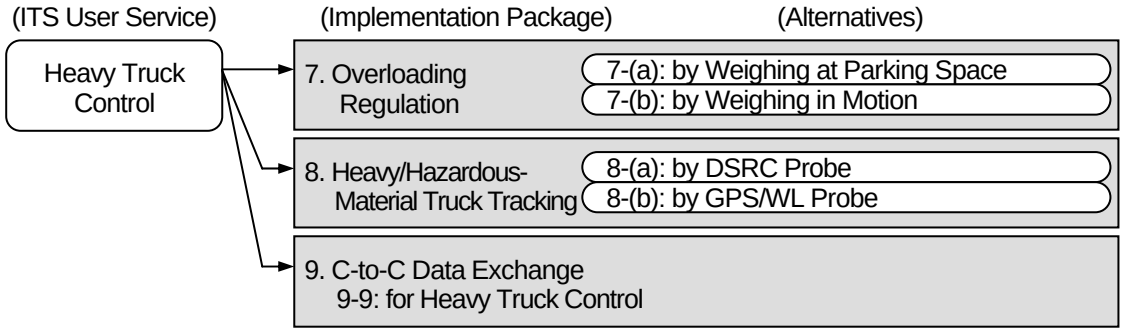
(i) Actual positioning data of the heavy/hazardous-material trucks generated in the centers of DSRC probe and GPS/WL probe,

(ii) Provision of the positioning data to the centers of heavy truck control and cargo-truck operation.

2) Breakdown of Implementation Packages

Heavy truck control can be broken down into three implementation packages as below. Each package has one or more alternatives, and a use cases is assumed for the package of center-to-center data exchange.

Figure 5.5.3 Implementation Packages and Alternatives of Heavy Truck Control



	by Weighing at Parking Space	by Weighing in Motion	by DSRC Probe	by GPS/WL Probe
Key-device of Alternative				

Source: VITRANSS2 Study Team / Oriental Consultants Co., Ltd.

System descriptions for the heavy truck control are shown in the following pages and in ***Appendix 1*** corresponding to the implementation packages and the alternatives above.

3) System Descriptions

(1) Overloading regulation

(a) Weighing at Parking Space

The weight of the heavy truck is measured by stopping the truck in parking space for overloading regulation. The license plate of the truck is checked by human operator and is recorded in the negative database with the measured weight for enforcement. Penalty is to be collected immediately at the site and the overloading truck can be rejected.

Figure 5.5.4 Weighing at Parking Space

Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.7)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.7).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.7)).

(iv) **Needed Standardization:**

- Performance, interface and installation of Axle scale,
- Detailed classification of overload,
- Rule to generate the message of Heavy truck information,

(v) **Advantages:**

- High accuracy of measurement without influence by the bias of luggage.

(vi) **Disadvantages:**

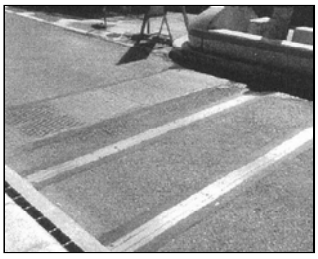
- Necessity of the land for the lead-in/parking space,
- Necessity the manpower distribution on site,
- Difficulty of preventing unfairness/avoidance,
- Difficulty of preventing the structural damage dispersion.

(vii) **Grading:** Not suitable.

(b) Weighing in Motion

The weight of truck is measured without stopping the truck on the lane for overloading regulation. The license plate of the truck is captured by camera and is recorded in the negative database with the measured weight for enforcement. Penalty is to be collected at the exit tollgate or other place later on.

Figure 5.5.5 Weighing in Motion



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.7)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.7).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.7)).

(iv) **Needed Standardization:**

- Performance, interface and installation of Axle scale,
- Detailed classification of overload,
- Rule to generate the message of Heavy truck information,
- Display priority of Heavy truck information

(v) **Advantages:**

- No necessity of the land for the lead-in/parking space,
- No necessity the manpower distribution on site,
- Possibility of mostly preventing unfairness/avoidance,
- Possibility of mostly preventing the structural damage dispersion.

(vi) **Disadvantages:**

- Accuracy lowering of measurement due to the condition of speed/acceleration/ deceleration of the vehicle.

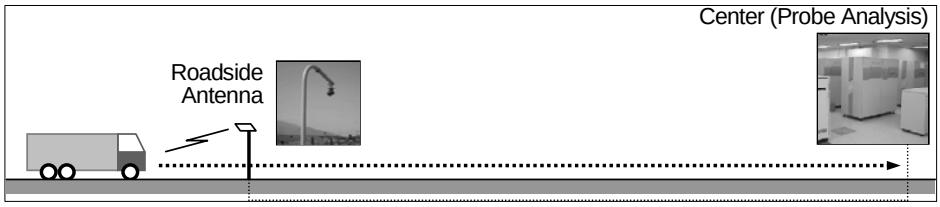
(vii) **Grading:** Recommended.

(2) Heavy/Hazardous-material Truck tracking

(a) DSRC Probe

Movement of the heavy/hazardous-material truck with OBU is traced by DSRC antenna at the specific point on the road. Information of the heavy/hazardous-material truck is to be provided to the management office in charge of response and clearance in case of the incident.

Figure 5.5.6 DSRC Probe



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.8)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.8).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.8)).

(iv) **Needed Standardization:**

- Performance, interface and installation of roadside antenna,
- Logic and processing of prove data analysis,
- Detailed classification of overload,
- Rule to generate the message of Heavy truck information,
- Display priority of Heavy truck information

(v) **Advantages:**

- Availability of concurrent use of the roadside equipment with ETC,
- No necessity to install the in-vehicle equipment,
- Capability to distinguish the vehicle existing points on the expressway and on the adjacent ordinary road.

(vi) **Disadvantages:**

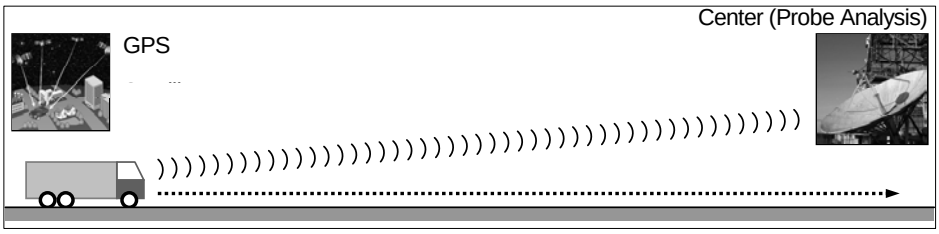
- Difficulty of tracking vehicle at short time intervals,
- Necessity of additional installation of the roadside equipment to track vehicle at shorter time intervals and to extend the tracking area.

(vii) **Grading:** Recommended.

(b) GPS/WL Probe

Movement of the heavy/hazardous-material truck is traced by GPS-unit in the vehicle, and is transmitted by wireless communication to the center. Information of the heavy/ hazardous-material truck is to be provided to the management office in charge of response and clearance in case of the incident.

Figure 5.5.7 GPS/WL Probe



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.8)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.8).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.8)).

(iv) **Needed Standardization:**

- Interface of GPS/radio (wireless) communication,
- Logic and processing of probe data analysis,
- Detailed classification of overload,
- Rule to generate the message of Heavy truck information,
- Display priority of Heavy truck information.

(v) **Advantages:**

- Availability of vehicle trucking at short time intervals and at any point,
- Availability of concurrent use of the in-vehicle equipment with the driving recorder system,
- No necessity of installation of the roadside equipment.

(vi) **Disadvantages:**

- Necessity to install the GPS on-board unit and the radio terminal,
- Necessity to secure sufficient bandwidth of radio communication for tracking a large number of trucks,
- Incapability to distinguish the vehicle existing points on the expressway and on the adjacent ordinary road.

(vii) **Grading:** Useful as a complement.

(3) Center-to-center Data Exchange

Heavy truck control is performed by exchanging messages/data among the servers installed in the heavy truck control center, the DSRC probe data center, the GPS/WL probe

data center and the cargo-truck operation center.

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.9)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.9).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.9)).

(iv) **Needed Standardization:**

- Definitions of the concept of overloading and its classification.
- Definitions of the message/data of DSRC probe, negative database, and other basic data.

(v) **Grading:** Necessary.

4) Detailed Discussion on Heavy Truck Control

(1) Recommendations on Alternatives

The foregoing recommendations on the alternatives for heavy truck control (discussed in the ITS Working Group shown in ***APPENDIX-5***) are summarized in the table below.

Table 5.5.1 Recommendations on Alternatives for Heavy Truck Control

Overloading Regulation	by Weighing at Parking Space 7-(a)	by Weighing in Motion 7-(a)
Measuring Value	Vehicle Weight	Axle Load
Accuracy of Measurement	High	Lowering by Condition
Lead-in/Parking Space	Necessary	Not Necessary
Manpower Distribution on Site	Necessary	Not Necessary
Prevention of Unfairness/Avoidance	Difficult	Can be Controlled
Prevention of Damage Dispersion	Difficult	Can be Controlled
Grading	Not Suitable	Recommended

Heavy/Hazardous-material Truck Tracking	by DSRC Probe 8-(a)	by GPS/WL Probe 8-(a)
Tracking Area	Limited	Not Limited
Time Intervals of Tracking	Long	Short
Roadside Equipment	Concurrent Use with ETC	Not Necessary
In-vehicle Equipment	Concurrent Use with ETC	Concurrent Use with Driving Rec.
Grading	Recommended	Useful as a Complement

Source: VITRANSS 2 Study Team

Comparison factors shown in the left side row of the table above are to be discussed and detailed in the following.

(2) Weighing Methods

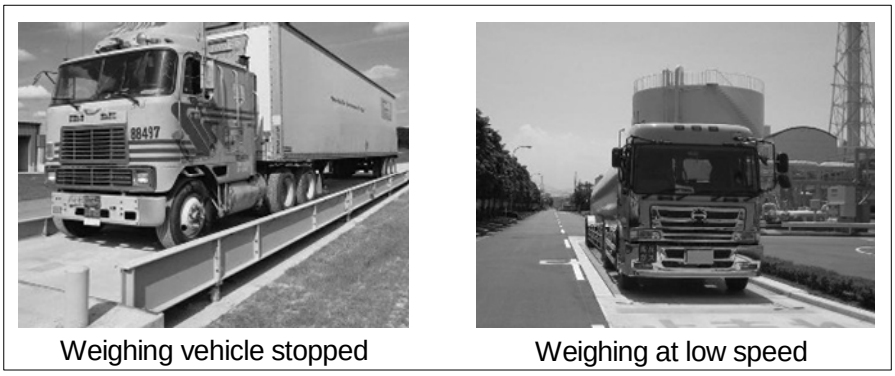
(a) Vehicle Weight Measurement:

Two types of vehicle weight measurement can be adopted for overloading regulation:

- Weighing vehicle stopped (at the parking space)
- Weighing at low speed (around 5 km/h at the lead-in space)

These methods provide high accuracy of measurement without influence by the bias of luggage; however, that require the manpower for enforcement with the efforts for securing fairness and the land for the lead-in/parking space.

Figure 5.5.8 Vehicle Weight Measurement



Weighing vehicle stopped | Weighing at low speed

Source: VITRANSS 2 Study Team

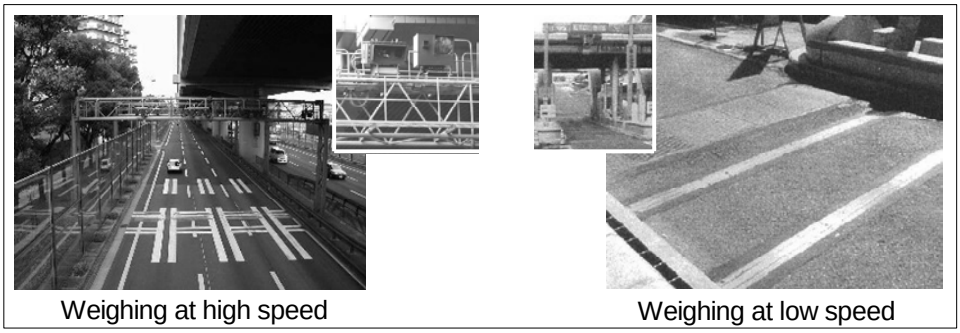
(b) Axle Load Measurement:

Two types of axle load measurement can be adopted for overloading regulation:

- Weighing at high speed (around 80 km/h on the through lane)
- Weighing at low speed (around 20 km/h on the ramp)

These methods are possibly affected by accuracy reduction due to acceleration/deceleration of the vehicle; however, that can be completed without the land for the lead-in/parking space and without the manpower by scanning the license plate number automatically.

Figure 5.5.9 Axle Load Measurement



Weighing at high speed | Weighing at low speed

Source: VITRANSS 2 Study Team

(3) Policy of Overloading Regulation

(a) Immediate Rejection at Roadside:

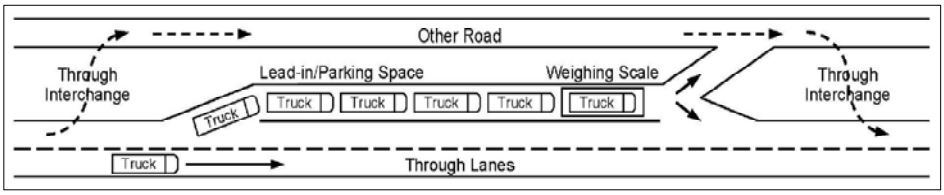
The policy of immediate rejection at the roadside for overloading regulation has the following problems:

(i) Limitation in the lead-in/parking space → difficulty to eliminate unfair passage caused by full capacity of the space,

(ii) Limitation in the number of installations due to the necessity of wide lead-in/parking space → difficulty to prevent avoidance through other roads with dispersing the structural damage,

(iii) Limitation in regulation hours due to the necessity of manpower → difficulty to prevent avoidance by staggered passage (e.g. time difference).

Figure 5.5.10 Problems on Immediate Rejection at Roadside

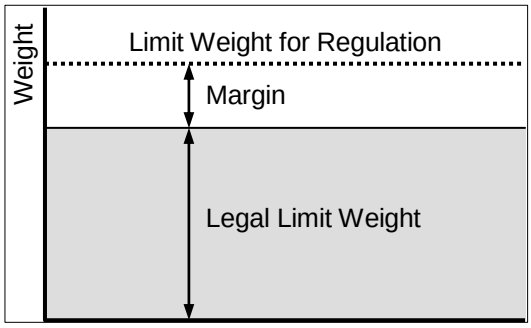


Source: VITRANSS 2 Study Team

(b) Penalty based on Negative Database

The policy of penalty based on the negative database of overloading measured by weighing in motion has the problem of accuracy-lowering by the conditions. However, this problem can be resolved by defining the limit weight for regulation having a margin to the legal limit.

Figure 5.5.11 Definition of Limit Weight for Regulation



Source: VITRANSS 2 Study Team

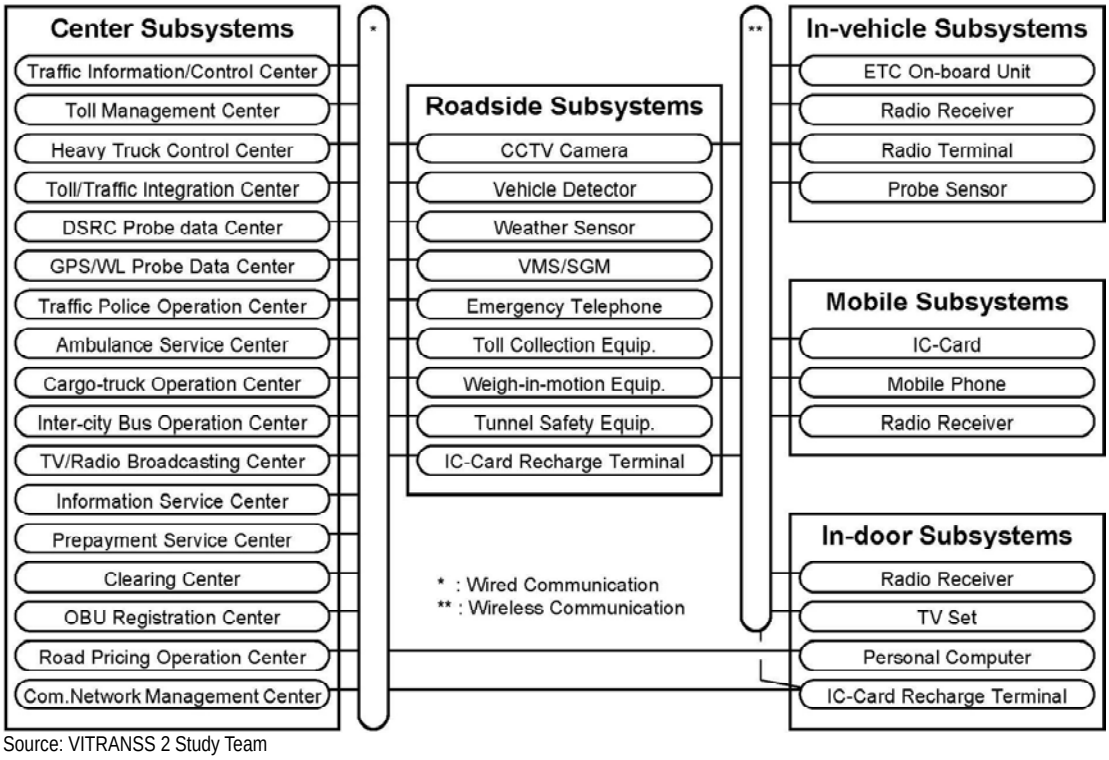
When adopting this policy, the penalty is to be collected at the exit tollgates or at the window of the competent authority. By doing so, it provides the following advantages:

- No necessity of the lead-in/parking space
- Possibility of preventing avoidance through other roads by the installations in adequate number of places
- Impossibility of avoidance by staggered passage, which is to say time difference.

5.6 Total System Architecture

As the result of discussion on the implementation packages in the foregoing sections, the total system architecture of ITS to be implemented in the inter-city road network in Vietnam is illustrated below. The whole discussion in the Master Plan is premised on the system architecture, which is to be referred to and upgraded by the persons responsible for ITS standardization in the next stage of the Master Plan.

Figure 5.6.1 Total System Architecture of ITS



Source: VITRANSS 2 Study Team

The total system architecture is illustrated using only the top-level subsystems indicated by ( ), which is called as the "Sausage Diagram". The top-level subsystems are categorized into five groups: centre, roadside, in-vehicle, mobile and in-door, and that are connected through the wired communication and the wireless communication.

In the Master Plan, the system of ITS to be implemented on the inter-city road network are discussed based on the following terminology:

(i) **Subsystem:** element of the system architecture defined by considering function, location and envisioned operating body, which can be broken down to the lower-levels

(ii) **Equipment**: an aggregate of subsystems

(iii) **Interface:** a connection for distributing information between two different subsystems, or between a subsystem and an object outside of ITS, and that is important for discussing the standardization and the cooperation among operating bodies.

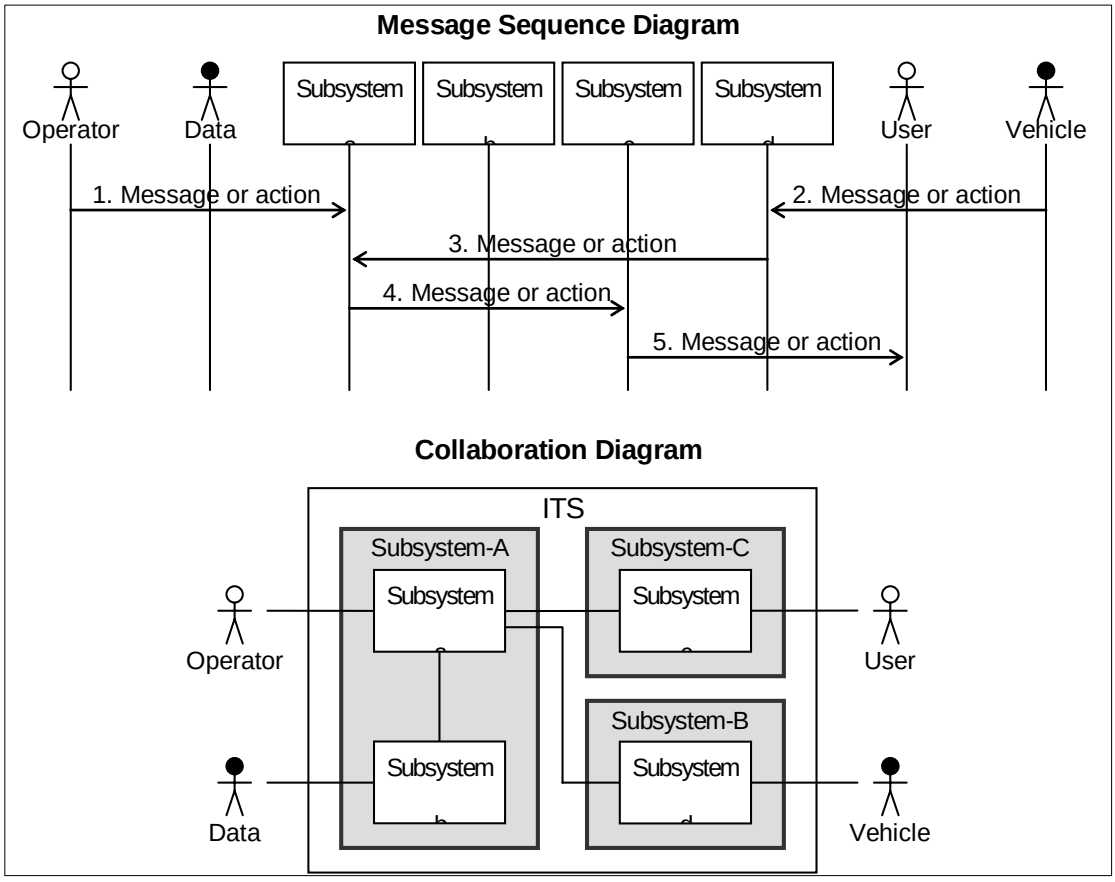
The lower-level subsystems are illustrated by using the following three kinds of diagrams in ***Appendix 1*** as the detailed system architecture based on the notation of UML (Unified Modeling Language).

(iv) **Use case diagram:** Illustration of the cases to use ITS responding to the implementation packages and the alternatives discussed in Chapter 5

(v) **Message sequence diagram:** Illustration of the sequence of exchanging messages for realizing the implementation package

(vi) **Collaboration diagram:** Illustration of the architecture of lower-level subsystems for realizing the implementation package.

Figure 5.6.2 Conceptual Illustration of System Architecture



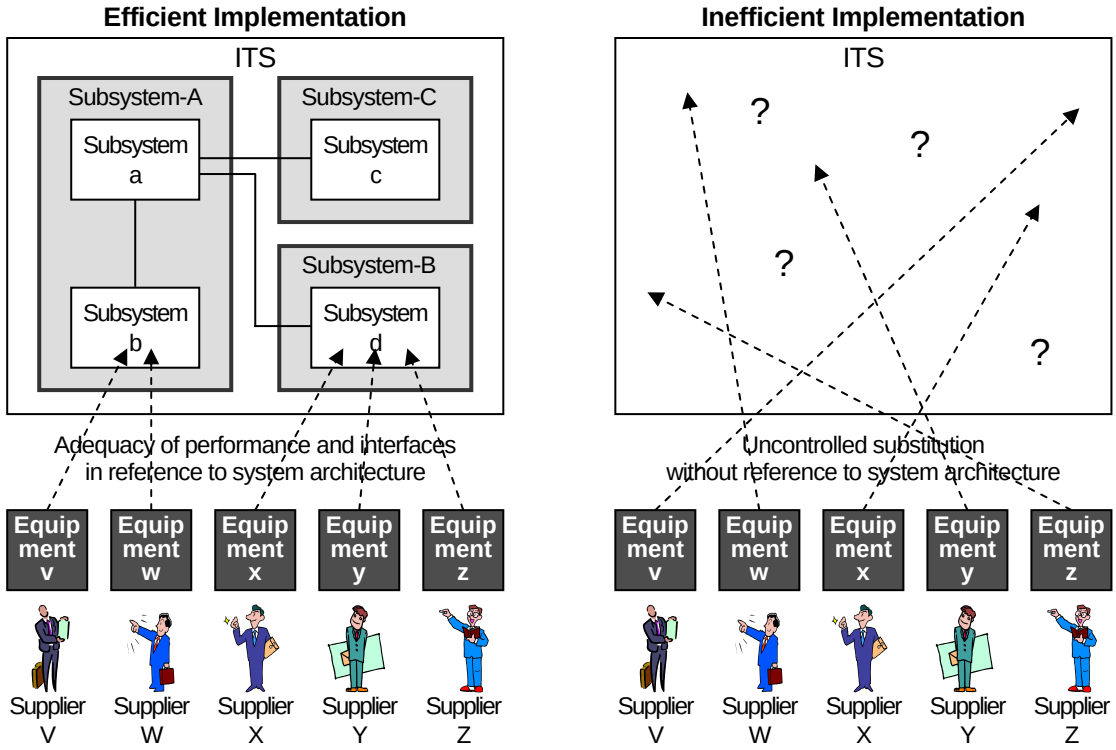
Source: VITRANSS 2 Study Team

Note, A Top-level subsystem, a Lower-level subsystem, ——: Interface

The diagrams of detailed system architecture provides a common ground for the discussion on standardization and allows to share the specific recognition of ITS among the persons in charge.

In the actual ITS implementation, each subsystems will be substituted by the equipment provided by the supplier. The implementation is to be controlled in the aspects of adequacy of performance and interfaces in reference to the system architecture.

Figure 5.6.3 Actual Implementation (=Substitution)



Source: VITRANSS 2 Study Team