A Study on Development & Application of the Level of Service for ITS

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Contents

- Introduction
- Definition & development concept of ITS LOS
- Development of ITS LOS
- Application of ITS LOS
- Conclusion

Introduction

■ Research background

- ITS in Korea has been promoted in major cities since 1997
- Evaluation on ITS-Service is important for the promotion of ITS
- Recently, the needs of development of the level of service in ITS has been raised.

■ Objective

- To develop the index to measure the level of service in ITS and apply this index in major cities in Korea

Definition & development concept of ITS LOS

■ ITS LOS (Level Of Service) ?

- As a comprehensive index it shows the ITS service level of selected cities, which is calculated by integrating indicators deduced from each individual service

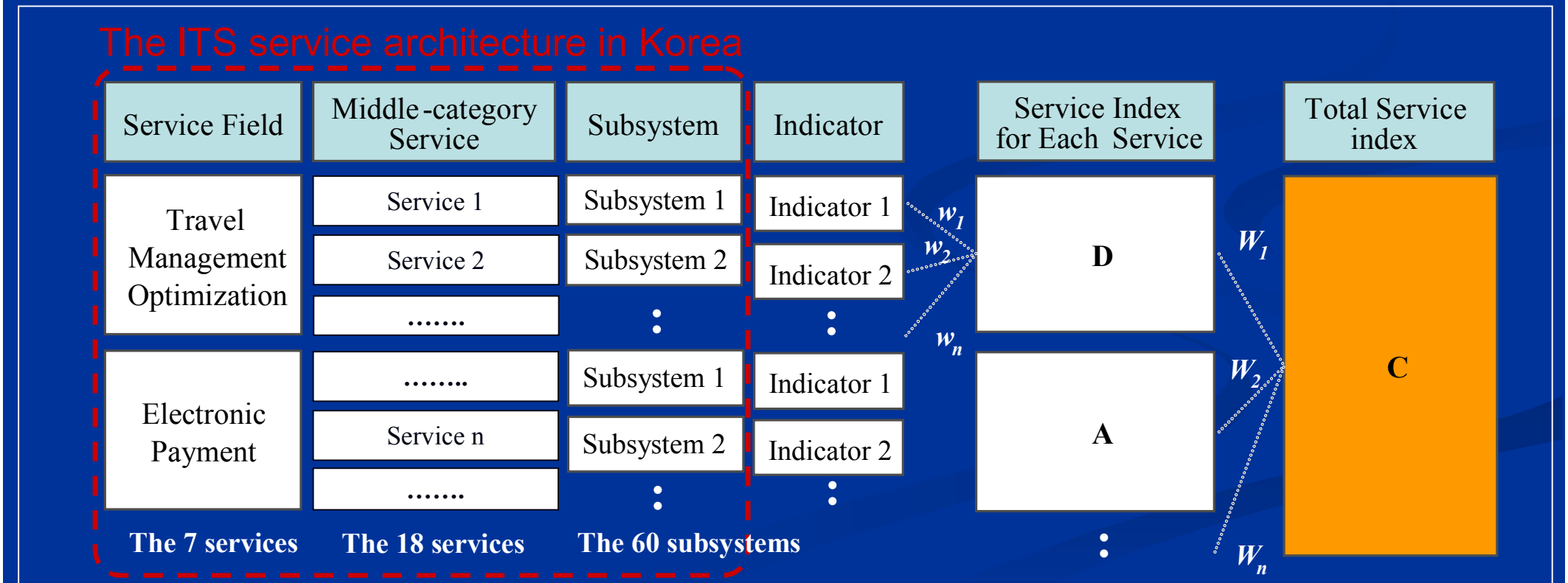


Figure1. The concept of developing ITS LOS

Development of ITS LOS - preliminary step

■ Deduction of evaluating target service/subsystem

- 11 mid-divided services which not suitable for urban unit evaluation are excluded
- As a result, ITS LOS will be developed for targeting 16 subsystems consist of the 7 mid-divided services

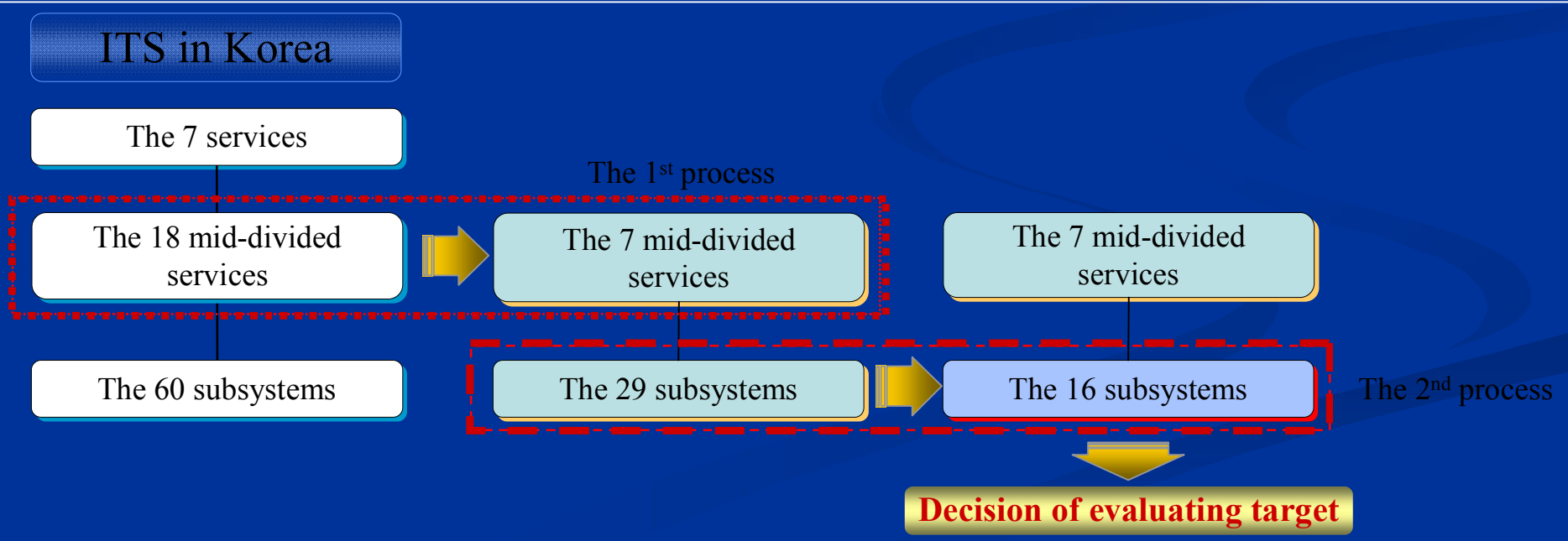


Figure2. Selection process of the Target Subsystem for evaluation

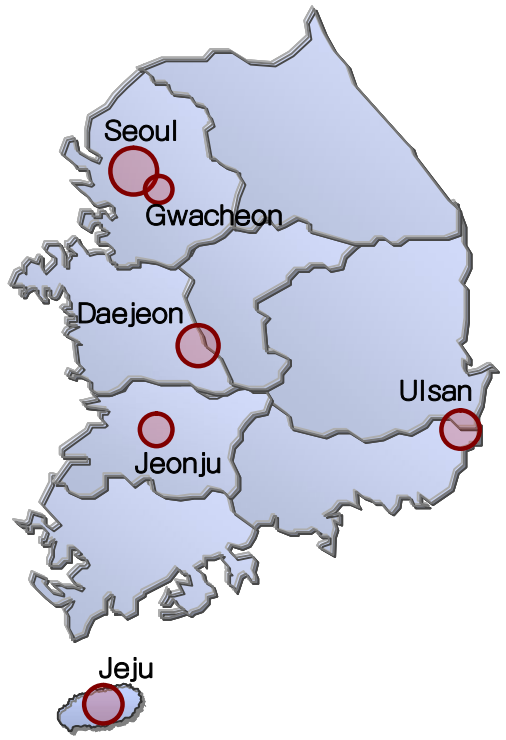
Development of ITS LOS - preliminary step

■ The review of installation status of ITS facilities in major cities in Korea (BIS 23 cities)

- In order to evaluate the supply level of ITS subsystem, the installation standard for each ITS facility is necessary

Table 2. The average interval of ITS facilities and key map

ITS Facilities	Mean Distance	Average interval between facilities installed in the cities reviewed in this paper
VMS	2.75km (expressway) ※ in arterial 6 km	- Expressway : Seoul(0.52㎞), Daejeon(4.97㎞) - Arterial : Jeonju(5.3㎞), Jeju(9.2㎞), Ulsan(8.2㎞), Gwacheon(1.8㎞)
CCTV	7 km	- Expressway : Seoul (1.09㎞), Daejeon (3.73㎞) ※ Expressway information related system - Arterial : Ulsan (2.9㎞), Gwacheon (1.6㎞), Jeonju (2.6㎞), Daejeon (17.2㎞) ※ Traffic management system related
IDS	0.5 km	- Seoul (0.5㎞)



Development of ITS LOS - preliminary step

- **The standard for the interval of facilities is different according to the facility and road type**
  - this presentation shows only the enforcement system
    - ※ Please see the conference paper for more details

Table 3. The Standard Installation Interval of the Enforcement System

Road type	Arterial road
Directly affected section	0.5km ahead / 0.5km behind
Indirectly affected Section	4km ahead / 1km behind
Distance affected by the enforcement system	5km

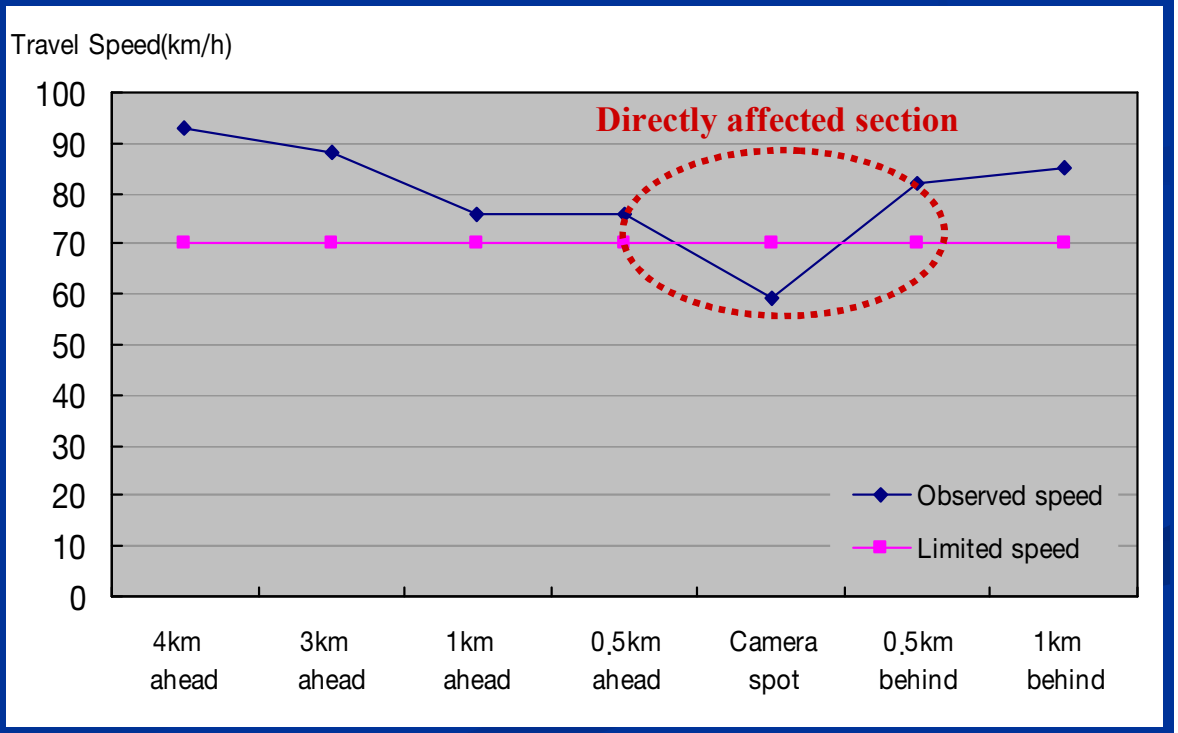


Figure3. The Travel Speed Profile of the Enforcement Camera Installation Section

Development of ITS LOS - preliminary step

■ Calculation of the evaluation indicator (M_{ij})

- The indicators are presented as follows ;

$$\frac{\text{Installed service scale being currently provided in a city}}{\text{The install-capacity in the future (standard)}}$$

- This concept is the same with Volume/Capacity (LOS) in traffic flow theory

※ Please see the conference paper for more details

Table 4. The Indicator deducted for each subsystem (example)

Subsystem	Indictor
Urban Arterial Traffic Signal Control Subsystem	The number of real-time signal control intersections ÷ The total number of the signal intersections
Urban Arterial Priority Treatment Signal Control subsystem	The number of priority treatment signal intersections ÷ The total number of signal intersections

Development of ITS LOS - main step

■ Step1 : Designation of the evaluation indicator weight

- The weight (w_{ij}) of each subsystem is decided according to the implement priority from national ITS architecture

※ Please see the conference paper for more details

Table 5. The priority score for each subsystem from national ITS architecture

Grade(Number)	Sub-system	Priority score	Total
A (4)	- Urban arterial traffic signal control - Regional traffic information center - Urban expressway traffic management - Speed violation enforcement	4	16
B (2)	- Urban arterial variable lane control - Bus information	3	6
C (7)	- Urban arterial wide-area traffic information/incident management - Urban expressway incident management - Urban expressway traffic-flow coordination - Bus lane management - Bus operation management - Public transportation fare collection	2	14
D (3)	- Urban arterial priority treatment signal / wide-area traffic signal control - Traffic signal violation enforcement	1	3
Total			**39**

Table 6. The Weight (w_{ij}) for each subsystem in a middle-category service

ITS service (Middle-category)	Sub-system (priority score)	The Weight (w_{ij})	
		urban+suburban	urban
Traffic flow management	Urban arterial traffic signal control (4)	0.24(4/17)	0.36(4/11)
	Urban arterial priority treatment signal control (1)	0.06(1/17)	0.09(1/11)
	Urban arterial variable lane control (3)	0.18(3/17)	0.27(3/11)
	Urban arterial wide-area traffic signal control (1)	0.06(1/17)	0.09(1/11)
	Urban arterial wide-area traffic information (2)	0.12(2/17)	0.18(2/11)
	Urban expressway traffic management (4)	0.24(4/17)	-
	Urban expressway traffic-flow coordination (2)	0.12(2/17)	-
	Total	**1(17/17)**	**1**
Incident management	Urban arterial incident management (2)	0.5(2/4)	1.0(2/2)
	Urban expressway incident management (2)	0.5(2/4)	-
	Total	**1(4/4)**	**1**
Automatic traffic enforcement	Speed violation enforcement (4) Traffic signal violation enforcement (1)	0.7(5/7)	
	Bus lane management (2)	0.3(2/7)	
	Total	**1(7/7)**	
Electronic toll collection	**Public transportation fare collection (2)**	**1.0(2/2)**	
Traffic information	**Regional traffic information (4)**	**1.0(4/4)**	
Public transportation information	**Bus information (3)**	**1.0(3/3)**	
Public transportation management	**Bus operation management (2)**	**1.0(2/2)**	
Total		**39 (31)**	

Development of ITS LOS - main step

■ Step2 : The computation for each service index (SI_i)

- The individual ITS service index (SI_i: Service index of service i) for each middle service is calculated by multiplying the weight (w_{ij}) by the value of the indicator

※ Please see the conference paper for more details

$$SI_i = \frac{\sum_{j=1}^{n_i} w_{ij} M_{ij}}{\sum_{j=1}^{n_i} w_{ij}}$$

where:

SI_i : the value of the ITS service index i

M_{ij} : the value of the evaluation indicator j in the ITS service i

w_{ij} : the weight of the evaluation indicator j in the ITS service i

n_i : the number of the evaluation indicator in the ITS service i

Development of ITS LOS - main step

■ Step3 : Calculation of the contribution (W_i)

- The contribution is applicable weight to estimate the ITS service index(SI_{total}) for the all ITS service installed in the city
- The contribution applied in this phase is defined as W_i

$$W_i = \frac{\sum_{j=1}^{n_i} w_{ij}}{\sum_{i=1}^{k}\sum_{j=1}^{n_i} w_{ij}}$$

where:

W_i : the contribution of the ITS service index i

w_{ij} : the weight of the evaluation indicator j in the ITS service i

n_k : the number of the evaluation indicator i

k : the total number of ITS services evaluated

Development of ITS LOS - main step

■ Step3 : Calculation of the contribution (W_i)

- W_i is calculated differently depending on whether a city has urban expressways or not

Table 7. The Contribution (W_i) for the ITS Service

ITS service (Middle-category)	The scores of priority order		The contribution for ITS (W_i)	
	urban+suburban area	urban area	urban+suburban area	urban area
Traffic-flow management	17	11	43.6	35.5
Incident Management	4	2	10.3	6.4
Automatic Traffic Enforcement	7	7	17.9	22.6
Electronic toll collection	2	2	5.1	6.4
Traffic Information	4	4	10.3	12.9
Public transportation Information	3	3	7.7	9.7
Public transportation Management	2	2	5.1	6.5
Total	**39**	**31**	**100**	**100**

Development of ITS LOS – main step

■ **Step4 : Calculation of ITS service index total (SI_{total})**

- The total ITS service index (SI_{total}) is finally estimated by applying the contribution (W_i) for the ITS service

$$SI_{total} = \frac{\sum_{i=1}^{k}\sum_{j=1}^{n_i} w_{ij} SI_i}{\sum_{i=1}^{k}\sum_{j=1}^{n_i} w_{ij}} = \sum_{i=1}^{k} W_i SI_i \left(= \frac{\sum_{i=1}^{k}\sum_{j=1}^{n_i} w_{ij} M_{ij}}{\sum_{i=1}^{k}\sum_{j=1}^{n_i} w_{ij}} \right)$$

Where ; SI_i : the value of the ITS service index of the ITS service i

M_{ij} : the value of the evaluation indicator j in the ITS service i

W_i : the contribution of the ITS service index i

w_{ij} : the weight of the evaluation indicator j in the ITS service i

n_k : the number of the evaluation indicator i

k : the total number of ITS services evaluated

Application of ITS LOS

■ Four cities is chosen for the application of *ITS LOS*

Table 8. The subsystem currently being operated in case cities

Classification of ITS services	Subsystem	The case cities			
		Daejeon	Bucheon	Jeonju	Ulsan
Urban arterial related system	Urban arterial traffic signal control	○	×	○	○
	Traffic information	○	×	○	○
	Incident management	○	×	○	○
Urban expressway related system	Urban expressway traffic management	○	×	No urban expressway	
	Traffic information	○	×		
	Incident management	○	×		
Enforcement system	Speed violation enforcement	○	○	○	○
	Traffic signal violation enforcement	○	○	×	○
Bus related system	Bus information	○	○	○	○
	Bus operation management	○	○	○	○
	Bus lane management	○	×	○	×
Toll and fare related system	Electronic toll collection	○	×	×	×
	Public transportation fare collection	○	○	○	○

Application of ITS LOS

■ Estimation of ITS service index (SI_i) in case cities

- the ITS service level of case cities is 50~60% on average
- these cities except for Bucheon have better ITS service environment than any other cities in Korea

Table 9. Calculation of ITS Service Index Total (SI_{total}) of the four cities

ITS service (Middle-category)	<urban+sub.> Contribution (W_i, %)	SI_{total}		<urban> Contribution (W_i, %)	SI_{total}	
		Daejeon	Bucheon		Ulsan	Jeonju
Traffic-flow Control	43.6	18.4	10.4	35.5	8.2	13.3
Incident Management	10.3	-	-	6.5	6.5	6.5
Automatic Traffic Enforcement	17.9	7.4	9.4	22.4	16.0	16.0
Electronic toll collection	5.1	5.1	5.1	6.5	6.5	6.5
Traffic Information	10.3	10.3	-	12.9	12.9	12.9
Transit Information svc.	7.7	7.7	7.1	9.7	0.7	1.5
Transit Management	5.1	2.1	5.1	6.5	6.5	6.5
Total	**100.0**	**51**	**37.1**	**100.0**	**57.3**	**63.2**

Application of ITS LOS

■ Comment of the results

- Level of ITS service of these cities is low unexpectedly

- We can say that the ITS service in Korea is not enough to satisfy the user yet

- Also it needs additional investment in human resources and budget for the improvement of ITS services

Conclusion

- **The most significant achievement of the study is that**
  - an attempt has been made to explore methods to measure the level of ITS services implemented
  - it enables to determine how many ITS facilities it needs to provide ITS services for a city under budget constraint
- **The ITS LOS index in this study enables also**
  - to present which and how many ITS services or subsystem are necessary under the existing infrastructure condition of a city
  - to forecast what the city needs in the long-term to achieve the political target of ITS

Thank you very much

for listening !