A PLANNING METHODOLOGY OF ITS MASTER PLAN ON DEVELOPING COUNTRIES

Jun OKUNO[1], Kenichi KOUCHI[2], Wataru OZONO[3], Ryo FUJII[4]

[1] Highway and Bridges Dept, infrastructure development Division,
Overseas Consulting Administration, Nippon Koei Co., LTD
(Kojimachi 5-4, Chiyoda-ku, Tokyo 102-8539, Japan)
E-mail:a6066@n-koei.co.jp
[2] Urban and Transportation Planning Dept, Social System Engineering Division,
Domestic Consulting Administration, Nippon Koei Co., LTD
(Kojimachi 4-2, Chiyoda-ku, Tokyo 102-0083, Japan)
E-mail:a6302@n-koei.co.jp
[3] Highway and Bridges Dept, infrastructure development Division,
Overseas Consulting Administration, Nippon Koei Co., LTD
(Kojimachi 5-4, Chiyoda-ku, Tokyo 102-8539, Japan)
E-mail:a6344@n-koei.co.jp
[4] Social System Engineering Group, Fukuoka branch, Nippon Koei Co., LTD
(Higashihie 1-2-12, Hakata-ku, Fukuoka 812-0007, Japan)
E-mail:a7012@n-koei.co.jp

The emergent countries and some developing counties are greatly motivated to develop infrastructures for maintaining higher economic growth and catching up with their citizen's demand in recent years. There is no exception for Intelligent Transport System (ITS), which is rapidly deployed in those countries. In fact, there is a compelling need for developing ITS to achieve modern infrastructure management and control.

However, inherence of ITS, there are multiple problems for smooth development of ITS. Firstly, it is difficult to have common understanding of ITS due to absence of ITS national architecture in developing countries. Secondly, ITS master plan planning methodology is not established as a guideline. The last problem is ITS project evaluation methodology is not defined well.

Considering circumstances, we proposed ITS master plan methodology and ITS projects evaluation methodology based on traffic network analysis. In addition, we conducted comparative analysis between ITS project and classical infrastructure project to clarify effectiveness of ITS project. The results of this study show total ITS planning methodology.

Key Words : *Infrastructure Planning in Developing Countries, ITS, Economic Evaluation, Dynamic Analysis,MicroSimulation*

1. INTRODUCTION

The emergent countries and developing countries are greatly motivated to develop infrastructures for maintaining their higher economic growth and catching up with their citizen's demand in recent years. There is no exception for Intelligent Transport System (hereinafter, ITS). ITS is also rapidly deployed in not only the emergent countries but also some developing countries. There are some reasons to be considered.

The primary reason is that governments of emergent countries believe financial efficiency of ITS is higher than a new construction of civil infrastructure because ITS can enhance the efficiency of existing infrastructure by utilizing ITS equipment for dynamic management. In general, cost of ITS installation is much lower than classic civil infrastructure. Moreover, a small package of ITS can be deployed much more easier than huge type of civil infrastructure.

By contrast, there are three (3) main issues in terms of ITS deployment in those countries as below:

(1) Lack of Common understanding
(2) Planning methodology
(3) Evaluation method

(1) Lack of Common understanding

It is quite important to have a common understanding of entire the ITS world among ITS related stakeholders, since the shared understanding expedites integration of different ITS sub-systems and interoperability between stakeholders. Above all of things stakeholders archieve to abtain common future perspective of ITS.

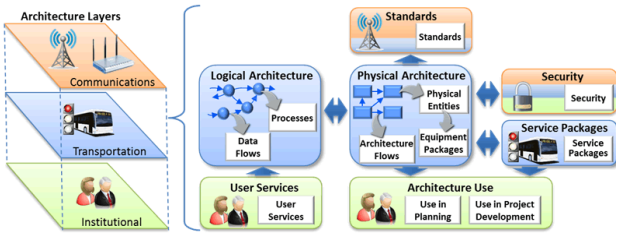
To achieve those objectives, developed countries such as Japan, U.S. and, countries in EU, formulated ITS architecture, which has been keep on revising to catch up current new ITS related technologies in the world. In addiotion, the ITS architectures were developed based upon their own experience in ITS fields.

According to U.S. Nationl ITS architecture, The architecture defines:

The functions (e.g., gather traffic information or request a route) that are required for ITS

The physical entities or subsystems where these functions reside (e.g., the field or the vehicle).

The information flows and data flows that connect these functions and physical subsystems together into an integrated system.



Source: The National ITS Architecture of U.S.

Fig.1 The National ITS Architecture of U.S.

As presented above, The ITS architecture shall provide entire picture of ITS from a panoramic view in multiple perspectives to obtain common understanding. However, in general, the development of ITS is not started from higher national level, is evolving simultaneously in region wide.

In addition, there are some difficulties to develop ITS architecture, due to shortage of ministerial enforcement and sectionalism. The developing process of ITS architecture is quite hectic, by ordinary, ITS covers different technical fields such as transportation filed as well as information technology field, multiple stakeholders from governmental agencies to private transporation operators. It indicates that this is challenging situation for especially developing countries, because matured administrative management is demanded for these kind of cross-ministerial issues.

Even though a development process of ITS architecture is intricate, the role of ITS arhictecture assumes the most important component to have common understanding in terms of ITS field for all of the stakeholders.

(2) Planning Methodology

Absence of ITS architecture was discussed previous section, there is an another missing key for ITS development. It is ITS planning methodology, which is not establish yet in developing countries. There are some difficulties to formulate a planning method for ITS, since coverage area of ITS is broadly and intricately interrelated, a great number of stakeholders are involved.

Therefore, based on the circumstances, a proposal of ITS Planning methodology will be discussed chapter three (3) in this paper.

(3) Evaluation Method

This object is maily discussed in this paper. Inherence of ITS, it isn't easy to evaluate of ITS effect in quantitative measure compare with the classic civil infrastructure. Even in Japan, ITS evaluation methodology has not formulated yet as a guideline. For example, ITS expedites dynamic route choice to road uses by provisioning real time congestion information and also makes possibile non-stop electic tolling at highway toll gate. Hence that, static macro assignment of classical 4 step method is not adaptable to analyze these dynamic phenomena.

In chapter four (4) , ITS evaluation based upon traffic simulator is discussed as a case study to construct a pragmatic ITS evaluation methodology.

2. OBJECTIVES

The primary objective of this study is to propose a methodology of formulating regional ITS master plan with concrete example of ITS master plan of Rio de janeiro, Brazil.

The second objective is to study a ITS systems evaluation methodology by utilizing dynamic traffic simulation tool with an actual case in Brazil.

The last objective is to confirm an effectiveness of ITS project by conducting comparative analysis with new road project and ITS project.

3. A PROPOSAL FOR ITS PLANNING METHODOLOGY

It is important to build up concrete methodology for ITS planning because a large number of ITS systems are developed without planning, contemplaining interoperability among stakeholders. In addition, generally, systems are not integrated in developing countries.

Before starting making a plan, it is necessary for ITS planner to know current condition and its issues

and needs in ITS field. The issues and needs are came from bunch of the categories like regional characteristics, traffic/ transportation characteristics, existing ITS system condition, road/mass transit operators needs, passengers and road users needs, and current ITS related plan. ITS planner must take into account all of the perspectives in ITS field, which shall be carried out one by one approach with ITS solutions.

To propose a regional-wise ITS planning methodology, we established a problem-oriented approach. An entire planning workflow is shown as following figure.

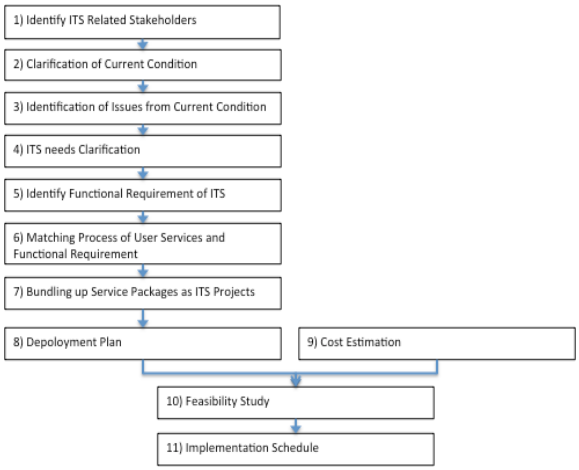


Fig.2 An ITS planning workflow

The proposed planning methodology is divided into 11 processes:

1) Identify ITS related stakeholders
2) Clarification of current condition
3) Identification of issues from current condition
4) ITS needs clarification
5) Identify functional requirements of ITS
6) Matching process of user services and functional requirements
7) Bundling up service packages as ITS projects
8) Deployment Plan
9) Cost Estimation
10) Feasibility Study
11) Implementation Schedule

Those processes above are supposed to utilize existing national ITS architecture occasionally, however, as described previous chapter, developing countries don't often have ITS architecture in general. In that case, ITS planner had better refer existing formulated ITS architecture by developed countries, which has similar characteristics of objective country.

(1) Identify ITS Related Stakeholders

One of the most important processes is identification of stakeholders in ITS field. Stakeholders shall be sorted out and categorized as in objectives, roles, legality, and its hierarchies. Stakeholders can be a private road operator, municipality public transport agency, weather monitoring authority, or private IT system solution provider, and shall be cyclopaedically identified.

It is important to sort out the personas in ITS field at the very first step for planning to figure out multiple perspectives of issues and needs.

Table 1 An example form of thrashing out ITS related stakeholders in Rio de Janeiro, Brazil

Category	*Name*	*Roles*
Road	**ANTT**	**Administrator of Federal Road Concessionaire, International, Interstate Bus Concessionaire, Flight Railway.**
	DNIT	**Federal Road Operation and Maintenance**
	DER	**State Road Operation and Maintenance**
	CET-Rio	**City Road Operator**
	CCR Ponte	**Federal Road Concessionaire of Ponte Niteroi**
	LAMSA	**City Road Concessionaire of Linha Amarela**
Transport	**SETRANS**	**State Transport Department**
	SMTR	**City Transport Department**
	Rio Onibus	**Biggest Private Bus Operator in RJ**
	METRO Rio	**Rio METRO Operator**
	Super Via	**Rail Operator**
Emergency	**CICC**	**Emergency Monitoring and Control Center**
Weather	**INEA SIMARJ**	**Weather/ Atmosphere Monitoring Agencies**
Private Company	**IBM Google Map link Telebench**	**IT/ITS Service Providers**

(2) Clarification of Current Condition

In order to identify the issues caused by current condition, all of the current condition shall be clarified. The planner must take into account those categorized field below:

- Regional Characteristics;
- Traffic, Transport and Logistics Characteristics;
- Existing ITS systems and
- Existing Traffic/Transport Related Plans

The most important thing in this process is all issues should be clarified with a famous methodology named MECE; mutually exclusive and collectively exhaustive. Clarifying process shall be carried out with traffic data analysis, interviewing with stakeholders, figuring out existing ITS systems drawing by entire system diagram, and so on. The table below shows how to clarify current condition with technical analysis.

Table 2 A correspondence table clarifying techniques and elements of current condition

Category	*Items*	*Data should be referred*
Regional Characteristics	**Population**	**National Statistics**
	Economics	
	Tourism	
	Weather	
	Hazard	**National Statistics or GIS Analysis(possibility of Land Slide, etc.)**
Traffic/Transport Characteristics	**Basic Situation**	**Traffic/Transportation Master plan**
	Hourly traffic situation	**Existing Traffic Counter Data**
Existing ITS System	**System Diagram**	**-Interviewing or Reviewing Exiting Design Report (if it's existed)**
	Location of Equipment	**-Ledger(if exist) or site surrey**

(3) Identification of Issues from current condition

Issues identification process should be carried out considering with result of clarification of current conditions. The issues are extracted from bunch of perspectives and time series.

(4) ITS needs clarification

ITS needs can be clarified with several basic survey methodologies such as interview, questionnaire or a meeting with stakeholders. The planner must categorize these needs from stakeholders carefully, and relate issues and needs.

Table 3 Examples of needs identification survey

Survey	*Outline*
Interview	**Interview should be conducted to clarify stakeholder's needs. At the same time, it is important to figure out existing ITS systems condition and its issues. To clarify all of the things, ITS planner should conduct interview several times as necessary.**
Questionnaire	**Questionnaire survey is useful to figure out normal user needs by showing concrete examples what ITS can provide to their actual life.**
Mail or Web	**Surveyor must explain some additional supplemental explanation to participants for more clear understanding of ITS.** **Mail or Web site also can be applied to figure out user needs.**

(5) Identify functional requirements of ITS

Functional requirement is a statement that specifies what a system must do. Functional requirements don't have to be described in detail but should indicate main function of user services in master plan phase.

(6) Matching process of user services and functional requirements

User services document what the system should do from user perspectives. Planners have to decide what user services are necessary or not for target regional area. After this matching process, ITS planner will realize what kind of user services are needed for objective area.

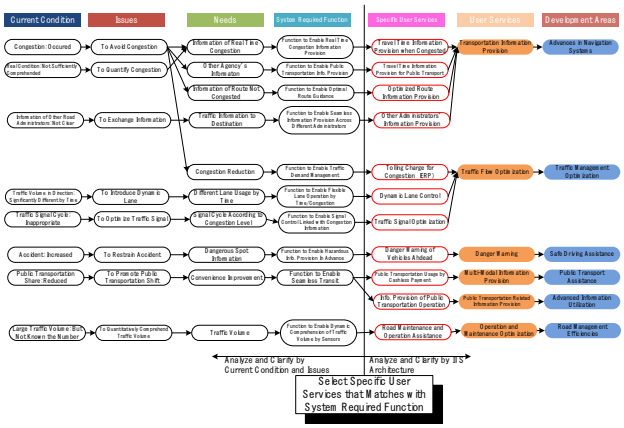


Fig.3 An example of matching process

(7) Bundling up service packages as ITS projects

Service packages are actual system packages in the real world and are related each user service bundles. Hence that, ITS planner can realize what system packages are necessary for objective region automatically.

However, ITS projects aren't developed as a single service package in general. it is important to bundle several service packages as an ITS project. For example, if there is no real-time traffic information provision center in objective region, the planner may plan to have a real-time traffic information provision center. The center should contain not only data collecting devices but also information processing unit, and provision devices etc.

This bundling up process requires wider perspectives to ITS planner.

(8) Deployment Plan

The deployment process field of ITS is mainly categorized by four (4) fields; Centers, Filed equipment, Vehicles, and Users. Those 4 fields are connected by fixed line communication system, wireless communication system that is provided by private telecom companies or administrative agencies, dedicated short-range communication, and vehicle-to-vehicle communication.

In addition, ITS equipment is sorted out three (3) types; 1. Data collecting/gathering device, 2.information provision devices, and 3. Traffic Controlling device.

The figure below shows typical physical architecture. In order to develop a deployment plan, ITS planner must contemplate role of equipment and its location, especially, roadside equipment.

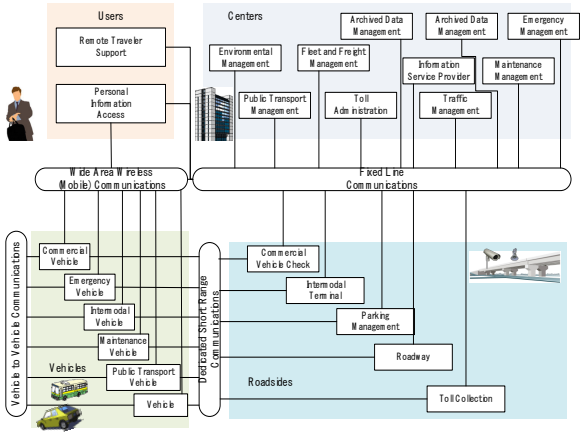


Fig.4 Physical Architecture

Table 4 An example of appropriated location for roadside equipment

Name	*Appropriated Location*	*Remark*
CCTV	**-Important road for monitoring or intersection -High frequency location of traffic accident**	**Data gathering**
Traffic Detector	**-Important road -Intersection for dynamic signal optimization**	**Data gathering**
VMS	**-Diverging point -In front of important civil structure(Tunnel or Bridges etc.)**	**Information Provision**
ERP Gantry	**Entrance route of planned ERP area: area should be decided based on network simulation**	**Traffic Management and Control**

*VMS:Visual Message Signboard, ERP: Electronic Road Pricing

(9) Cost Estimation

It is difficult to estimate cost of ITS equipment precisely, however, precise cost estimation is not required at master plan phase.

According to project management institute or the U.S. department of energy and many others, there are five (5) classes of estimation as the table below

Table 4 Five classification of cost estimation

Source:U.S. Department of Energy

Estimate Class	*Name*	*Purpose*	*Project Definition Level*
Class 5	**Order of Magnitude**	**Screening or Feasibility**	**0 or 2 %**
Class 4	**Intermediate**	**Concept of Study or Feasibility**	**1% to 15%**
Class 3	**Preliminary**	**Budget, Authorization, or Control**	**10% to 40%**
Class 2	**Intermediate**	**Control or Bid/Tender**	**30% to 70%**
Class 1	**Definitive**	**Check Estimate or Bid/ Tender**	**50% to 100%**

For cost estimation, there are two methods in practical way, one is request for quotation to ITS vendor, and the other one is referring exiting report to figure out average cost of ITS equipment. ITS planner must decide cost of each ITS equipment utilizing by those methodology after bundling up ITS projects.

(10) Feasibility Study

It is necessary to clarity feasibility of every infrastructure in economical perspective. Some analysis technique can be adaptable to measure quantitatively feasibility of ITS systems. ITS planner must consider about what kind of economical evaluation methodologies are suitable to their proposed ITS systems. The table below shows examples of combination of evaluation methodology and ITS systems.

Table 5 Examples of evaluation analysis techniques

Name of ITS System	*Analytical Methodology*	*Remark*
Real Time Traffic Information Provision Center and OBUs	**Meso-scopic traffic analysis (With-without)**	**Dynamic network analysis with dynamic route choice.**
ETC: Electronic toll Collection	**-Micro or Macro network analysis (With-without)**	**Simple micro simulation at toll gate**
ERP:Electonic Road Pricing	**-Micro or Macro network simulation (With-without) -Contingent valuation**	**-ERP gantry with without network analysis -Figure out al-**

	method	lowable fare structure of ERP for Users
Bus location system	Contingent valuation method	Confirm allowable price of bus location system

In general, project period of normal infrastructure like new by-pass road is 40 years or 50 years for economic analysis. However, for ITS systems should be 20 year or less, because ITS equipment is in one of the IT fields, which is ever-changing market. To evaluate their effect precisely, we recommend project period less than 20 years.

A result of case study for ITS evaluation is described in chapter 4, based on network analysis methodology.

(11) Implementation Schedule

A stepwise implementation schedule is important factor of ITS master plan. A routine work of ITS systems is 1. collecting/gathering information, 2. Processing data, 3. provision information and 4. control and manage traffic/transport. First step of implementation is should be collecting/ gathering information to start monitor on time traffic/transport situation. Secondly, information provision to all of users and stakeholders is necessary. Managing and controlling traffic/transport shall be final phase after installing necessary ITS equipment. ITS planner must consider about several perspectives of traffic/transport management for fulfillment of stepwise ITS development.

4. A CASE STUDY OF ITS PROJECTS EVEALUATION

We conducted a pragmatic case study for ITS evaluation to confirm feasibility by traffic network simulation. This case study conducted in Rio de Janeiro, Brazil.

(1) Simulation Model

We selected AIMSUN, from TSS Spanish company, because it has multiple functions of traffic simulation such as macro, meso and micro simulation. In addition, AIMSUN has original API that assures extensibility of system. We decided to use this simulation tool because it is quite compatible tool for ITS evaluation at this moment.

(2) Basic Database Construction

a) Road Network

The objective road network is shown the figure below. In general, road network data for traffic analysis is not prepared in the emergent countries and developing countries. Analysis can utilize Digital Road Map (DRM) in the marketplace or free digital map service such as Open Street Map in recent years.

Capacity of road network is set up based on highway capacity manual.

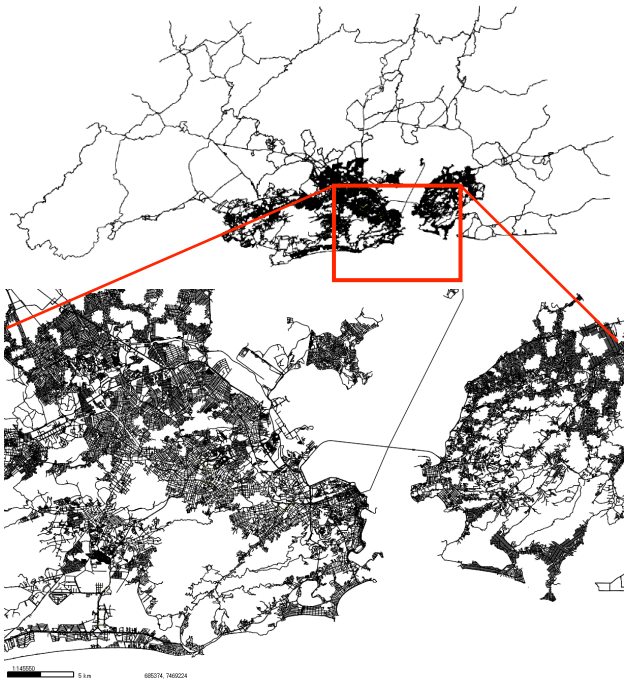


Fig.6 Objective Road Network

b) OD table

Based on transport master plan (PDTU) OD data, we forecasted future OD based on GDP, population increasing ratio and Olympic related plan.

c) Traffic Signal

It is necessary to get traffic signal time set data to conduct dynamic traffic analysis. We conducted signal timing survey at main intersections to input signal data.

(3) Selection of ITS Projects and Analytical Method for evaluation

13 ITS projects were proposed as Rio de Janeiro ITS master plan. Among them, 4 ITS projects were selected as a case study of ITS projects evaluation by traffic network analysis.

Table 6 Selected ITS projects and analytical method

No.	*Name*	*Outline*	*Analytical Method*
1	ITS Center	Real time traffic congestion information provision center and on-board unit for vehicles	Meso scopic dynamic simulation. ITS center promotes dynamic route choice to drivers providing by real time congestion information.
2	BRT Signal	Public transport	Micro simulation at

	Priority System	**priority system: signal priority for Bus rapid transit**	**BRT line. Prioritize incoming buses utilizing AIMSUN API.**
3	**ETC**	**Electronic toll collection**	**Delay time improvement by Simulating non-stop driving at tollgate.**
4	**ERP**	**Electronic road pricing**	**Effect of traffic volume reduction installing by ERP.**

(4) Evaluation Results

We conducted traffic network analysis and calculated 2 types of benefits such as travel time improvement benefit and vehicle operating cost improvement benefit. Based on these benefit and ITS projects cost, we calculated the basic economical indicaters which is shown table below.

Table 7 Result of Economic Evaluation

Project Name	*EIRR (%)*	*NPV Million R$*	*B/C*
ITS Center	44.3	225.2	4.99
BRT Priority System	75.3	290.0	8.86
ETC	51.9	71.5	5.89
ERP	23.2	695.1	6.18

* Project Period: 20 years

Overall, economical effect of ITS projects is high. This can be contemplatable with two reasons: lower cost and high effectiveness to traffic congestion.

Firstly, ITS proejcts cost is comparatively much lower that it is normal infrastructure development. Sometimes it is tenth or hundredth of classical infrastructure development. This fact permits predicting the value of healthy feasibility of ITS projects.

Secondary,economical impact of ITS projects is simply much higher than what we expected. ITS can act on dynamic traffic behavior of users and can reduce economic loss dramatically. This result may develop incentives to have ITS projects instead of classic civil infrastructure in metropolis of developing countries.

5. COMPARATIVE ANALYSIS

In order to confirm of effectiveness of ITS, we conducted comparative analysis between normal infrastructure and ITS system.

For comparative analysis two projects are selected. first one is ITS center which can provide dynamic real time traffic information to users, the other one is North and South by-pass corridor in central area of Rio de janeiro. The by-pass includes tunnel section, and its length is length total 5.9km.

The result is shown in table below.

Table 5 Result of comparative analysis

Project Name	*EIRR (%)*	*NPV Million R$*	*B/C*
ITS Center	**44.3**	**225.2**	**4.99**
Bypass	**2.1**	**-7.26**	**1.10**

* Project Period: 20 years

According to the result of analysis, in this case, investment efficiency of ITS project is much higher than classical civil infrastructure. The main reason is that ITS project is normally much lower cost than normal civil infrastructure. A new road project in city central is costly in general, because of compensation of the land. On the other hand, ITS projects don't need to compensate land and equipment cost is comparatively low price.

6. CONCLUSION

In this paper, we proposed a new ITS master plan planning methodology based on a problem oriented approach. To confirm feasibility of ITS projects, we showed traffic network analysis base approach to ITS projects evaluation with several case studies. Furthermore, we showed effectiveness of ITS project compared with classic civil infrastructure.

REFERENCES

1) National ITS Architecture: http://www.iteris.com/itsarch/
2) AIMSUN User reference