# ITS: Traffic Baseline Information Obtained Using Probe Cars is the Key to Address Metro Manila Traffic Congestion

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**Abstract:** Intelligent Transportation Systems (ITS) technologies can supplement construction-based methods to improve the capacity of existing transportation systems. ITS then, presents viable solution to traffic congestion problems rather than focus only on the intensive road infrastructure developments and improvements. Baseline traffic information such as speed, and travel time along road networks, a fundamental knowledge-based resource used in traffic management, assessments and planning, can be obtained only through sustainable data collection system. Examination of ITS technologies shows that probe car survey system is a sustainable data collection method to gather real-time and historical traffic information.

***Key Words***: ITS, probe car system, sustainable data collection system

## 1. INTRODUCTION

### 1.1 Background of the Study

A concept on Intelligent Transportation Systems (ITS) introduced in the 1990s which has the goal of resolving road transportation issues such as traffic accidents and congestion through application of information and communication technologies is nearing its maturity stage in developed countries like Japan, United States and Europe. This key technology however, is still at its immature stage in the country.

The component elements of ITS are shown in Figure 1. The main goal of ITS is to improve the overall efficiency of transportation systems by using Information and Communications Technology (ICT) without substantial capacity additions to the existing road networks. Some developed countries have attained advances in realizing benefits of ITS in terms of safety, efficiency and improved transportation systems. Latest applications of ITS such as advances in navigation systems, assistance for safe driving, optimization of traffic management, increasing efficiency in road management among several others  are already observed in developed cities. (Shibata, 1998) According to Japan's experience, ITS promotions involved research, institutional and regulations systems, building architectures, platforms and operation organizations. It is implicitly understood then that transportation system is not just about road infrastructures but actually involves interaction of the three elements of road system. The three elements of road system is similar to the component elements of ITS but the latter introduces ICT for an effective interaction of each element.

The traditional and current approach in reducing traffic congestion has been to build or widen roads. This is particularly evident in the UP side of Commonwealth Avenue which has become 24-lane road for both directions. However, economic and social costs as well as geographic restrictions do not allow continuous construction of sufficient road network. Thus, new approaches like ITS are needed to address congestion.

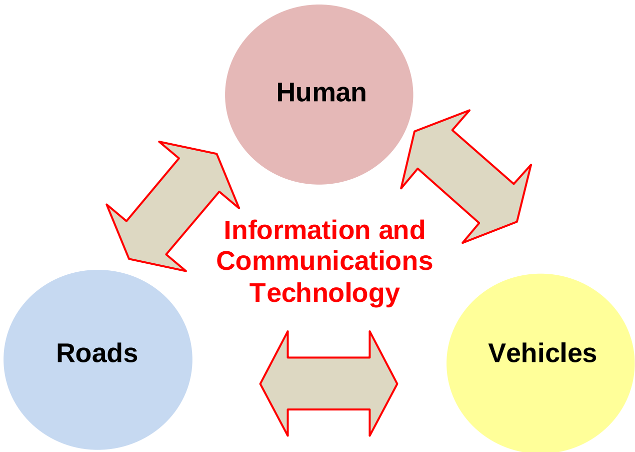



**Figure 1. The component elements of ITS**
**(taken from ITS Introduction Guide, 2006)**

ITS is not a separate entity in transportation system development but may be integrated in the present plans and programs of the government. Currently, the only deployments of ITS in the Philippines are the dynamic signal control that utilizes Sydney Coordinated Adaptive Traffic System (SCATS) technology both installed in Metro Manila and Cebu, and the electronic toll collection (ETC) system. The question now is: what is next? Actually, there are several approaches for advancing ITS applications. The Philippines can either follow by learning from the experiences of developed countries or adopt some specific ITS applications according to the needs of society. Thus, this study presents review of ITS framework and World Bank study on ITS as well as examination of local conditions towards advancement of ITS in the country. It further recommends potential solution to traffic management issues especially on traffic congestions through application of ITS technologies.

### 1.2 Rationale of the Study

In the Philippines, urban road and rail network projects are always behind the planned timeline of development due to limited budget. The Metro Manila experiences rapid urbanization and motorization alongside the recognized road infrastructure inadequacy. Thus, transport facilities can not keep up with the increasing travel demands. Moreover, inefficient and ineffective management of road resources contribute to worsening traffic problems such as congestion, pollution and accidents.

The Department of Transportation and Communications (DOTC) estimates that traffic congestion in Metro Manila alone costs P140-Billion. The losses include the cost of fuel wasted on slow moving traffic, lost productivity of workers stuck in traffic jams, and increased stress on vehicles running low on gear most of the time. Furthermore, the Metro Manila Development Authority (MMDA) has introduced several traffic schemes to alleviate the worsening traffic conditions. However, there are limitations like social and geographical restrictions and limited government budget that hinders construction of sufficient road networks or road widening and improvements to accommodate large volume of traffic. It is therefore necessary to effectively and efficiently utilize road resources to overcome this congestion problem.

Since the use of ITS is being introduced as an approach to address congestion problem, the following review on ITS framework and ITS practices around the world are needed to establish fundamental knowledge on ITS. Then, this paper seeks to present potential solution as well as feasible ITS approach to address congestion problems through in depth discussion and citation of related studies.

## 2. ITS EXPERIENCE IN THE PHILIPPINES

There are two ITS deployments in the Philippines. These are traffic responsive signal system and the Metro Manila electronic toll collection (ETC) system. (Sigua, 2008) Some ITS technologies are also used for traffic and road management purposes.

### 2.1 Traffic Responsive Signal System

The signaling project for Metro Manila which was undertaken by Department of Public Works and Highways (DPWH) is called State-of-the-Art Metro Manila Adaptive Responsive Traffic (SMART) system. This utilizes the Sydney Coordinated Adaptive Traffic System (SCATS) technology. The same technology was also introduced and successfully installed in Cebu City. A dynamic demand-responsive traffic is achieved through SCATS since signal timings would depend on the detected traffic demand.

Initial assessments pointed out some issues on unwanted practices like uncontrolled loading and unloading of passengers by PUVs and illegal parking that hinder traffic flow along roads and as a result, optimum potential benefits from SCATS were not realized. However, pre and post evaluation of the project which covers twenty-five intersections along four corridors estimated an overall reduction of 30.39 and 35.98 percent for queue lengths during the morning and afternoon peak respectively. (Sigua, 2008)

Nowadays, the installed SCATS technology is not fully operated in Metro Manila since U-turn scheme has been introduced to a number of major roads like Quezon Avenue, EDSA, E. Rodriguez Avenue and Marcos Highway.

### 2.2 Metro Manila ETC System

The ETC system, also known as E-PASS, was implemented in August 2000 along South Luzon Expressway (SLEX) and the skyway. Table 1 shows the recent update of ETC system currently in place. The existing system consists of dedicated or mixed manual and ETC lanes for payment of toll collection fees. The system uses tags placed inside the windshield of vehicles which are electronically read at the entry or exit of E-PASS toll lanes.

Initial study revealed that the dedicated E-PASS lane has an average tollbooth transaction time of 1.5 seconds per vehicle while 15.0 seconds per vehicle for the manual scheme, and 5.9 seconds per vehicle for mixed-mode lanes. This faster transaction time thus, helped reduce queue lengths in toll booths. Sigua (2008) further mentioned a number of vehicle inconveniencies and technical flaw associated with the simplified system introduced at SLEX.

Similarly, the North Luzon Expressway (NLEX) has dedicated or mixed manual and ETC lanes for toll collection payment scheme. The ETC system in NLEX is known as EC-Tag and it uses transponders and swipe card system for faster transactions. No assessment with regard to the EC-Tag was available.

**Table 1. The Metro Manila ETC System (taken from Sigua, 2009)**

| | SLEX | NLEX |
|---|---|---|
| Length, km. | 48 | 84 |
| Start of Operation | Aug. 2000 | Early 2005 |
| Technology<br>DSRC 5.8 Ghz | US-based<br>Transcore | Egis Projects S.A. of<br>France |
| Daily Volume | 270,000 | 200,000 |
| % ETC Users | 20 | 6.5 |

### 2.3 Other ITS Technologies

There are also other ITS technologies such as fiber optics, closed circuit television (CCTV) and variable message signs (VMS) that have been used for traffic management, and guidance of motorists through display of real-time traffic information. The new NLEX, for example, has developed into an intelligent and modern facility which uses technologies mentioned above. (TMC, 2006) These technologies alongside rehabilitated, expanded and well paved roads enhance safe and secure monitoring of traffic flow.

## 3. ITS AROUND THE WORLD

ITS have been defined by World Bank (ITS Toolkit) as the application of information technologies such as computers, sensors, wired and wireless communications to the problems of surface transport. ITS is becoming popular in the world as an effective means to address worsening traffic problems. The US, Japan and Europe are the leading countries that started ITS researches and programs in the 1990's. These developed countries have attained advances in realizing the benefits of ITS in terms of safety, efficiency and improved transportation systems. (Shibata, 1998) Thus, potential benefits of ITS have already attracted most developing countries to follow and adopt ITS deployments of developed countries. Recently, World Bank published the ITS Toolkit and ITS Technical Notes based on an extensive study of the ITS situation in east Asia, eastern Europe, and Latin America and contain appendixes that include 130 examined cases of ITS deployment. These documents actually aim to provide guidance to countries with developing and transitional economies toward successful introduction of ITS.

Yokota *et al.* (2005) identified the basic reasons for introducing ITS, which are similar around the world whether the country is developed or developing. The reasons include a) enhancing mobility for people and freight, b) reducing traffic-related deaths and injuries, c) reducing traffic congestion, d) lessen environmental impact of automobiles by reducing vehicle consumption and emissions, and e) managing the infrastructure more effectively and economically.

Table 2 shows regional comparison of ITS applications. This reveals both common characteristics and individual characteristics of the regions. Notably, Figure 2 illustrates that developing countries can possibly leapfrog directly to an ITS-enabled transportation infrastructure more rapidly and less expensively than developed countries. This is so because of several advantages mentioned by Yokota (2004). Among those advantages is the fact that developing countries can take advantage of ITS products and applications that have been tested and deployed in developed countries that are now mature, stable, and less expensive to acquire and operate. This is further enabled by the four innovative approaches discussed in section 4. However, Yokota *et al.* (2005) further explained that developing countries should not simply follow in the footsteps of developed countries because there are actually significant local variations in the characteristics of ITS deployment as shown in Table 2. This is further emphasized by Sigua (2008) in the discussion on conditions for acceptable deployment or implementation of ITS in Metro Manila.

**Table 2. ITS Applications Introduced in Each Region (taken from ITS Toolkit, p. 21-22)**

<table>
<tr><td></td><td></td><td>East Asia</td><td>Eastern Europe</td><td>Latin America</td></tr>
<tr><td rowspan="6">Common Applications</td><td>Traveler Information</td><td colspan="3">- Traffic information systems using roadside variable message signs</td></tr>
<tr><td>Traffic Management</td><td colspan="3">- Traffic signal systems<br>- Traffic surveillance systems using CCTV</td></tr>
<tr><td>Electronic Toll Collection</td><td colspan="3">- ETC</td></tr>
<tr><td>Commercial Vehicle Operation</td><td colspan="3">- Commercial vehicle tracking systems</td></tr>
<tr><td>Public Transport Management</td><td></td><td colspan="2">- Bus operation management systems</td></tr>
<tr><td></td><td>- IC card systems<br>- Electronic ticketing</td><td></td><td>- IC card systems<br>- Electronic ticketing</td></tr>
<tr><td colspan="2">Region-Specific Applications</td><td>- Traffic information services utilizing multiple media</td><td>- Road management systems to identify road surface conditions<br>- “Empty cargo space” trading systems to improve transportation efficiency</td><td>- Border crossing systems</td></tr>
</table>

There are two kinds of incentives for and benefits of ITS deployment according to Yokota *et al.* (2005) The first refers to the society wide benefits (e.g. reduced traffic deaths and injuries, overall levels of congestion, and emissions) which positively affect society as a whole, but the direct benefit to particular individuals is often intangible and not clearly immediate. The second refers to reliability-oriented benefits (e.g. greater reliability and less uncertainty in travel, greater efficiency in operating and using the transportation system and travel that is more comfortable, more productive and secure) that road users, and transport administrators can see, understand and appreciate. The second type of ITS is easier than the first type to deploy since public and political support come readily from the benefits that it can provide. In contrast, the higher costs of ITS deployment for society-oriented ITS may be justified with the society-wide benefits that it will deliver. It was further stated that these two kinds of benefits are not mutually exclusive but usually, the introduction of ITS will deliver both.

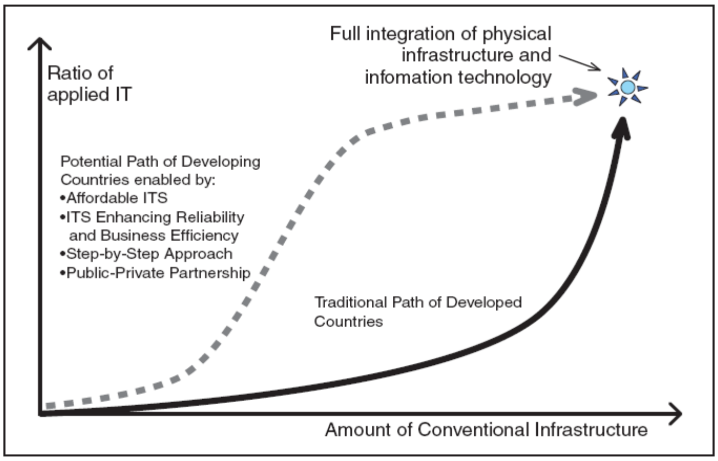



**Figure 2. Leapfrogging to ITS (taken from ITS Technical Note 3, p. 4)**

**Table 3. Traffic Problems in Cities in Studied Countries (taken from ITS Toolkit, p. 29)**

| Traffic Problem | Vietnam | Indonesia | Philippines | Thailand | China | Malaysia | Czech | Poland | Romania | Hungary | Brazil | Argentina | Chile | Mexico | Colombia |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Traffic congestion | ++ | ++ | ++ | ++ | ++ | ++ | ++ | + | + | ++ | ++ | ++ | ++ | ++ | + |
| 2. Traffic accidents | ++ | + | + | + | ++ | ++ | + | ++ | ++ | + | ++ | ++ | ++ | ++ | + |
| 3. Air pollution and global environmental problems | + | ++ | ++ | ++ | + | + | | | + | | ++ | + | ++ | ++ | + |
| 4. Traffic rule violations and uncivil driving | ++ | ++ | ++ | + | | + | | + | + | | ++ | ++ | ++ | ++ | + |
| 5. Inadequate public transport services such as railways and buses | ++ | + | + | + | + | ++ | | | + | | ++ | + | ++ | ++ | |
| 6. Inadequate logistics services | + | ++ | ++ | + | | | ++ | + | + | + | ++ | ++ | ++ | ++ | + |
| 7.Inadequate road management | + | ++ | ++ | | | | | ++ | + | | + | + | ++ | + | |
| 8. Transport access problems for the elderly and disabled | + | | | + | | + | + | | | | + | + | + | + | + |

++: Locally recognized as serious  +: Emerging  Blank: Not viewed as an issue locally

Qualitative impressions, based on interviews with key ITS contacts in each country

Moreover, introduction of ITS should have sound rationale. Based on the World Bank study shown in Table 3, ITS is introduced because of the perceived worsening traffic problems and limit of infrastructure construction in developing countries. Similarly, Sigua (2009) particularly identified the traffic issues in the Philippines that ITS seeks to address. This includes effects of Metro Manila's urbanization which lead to inadequate transportation services and traffic congestion. Traffic congestion in turn, results to wastage of time and energy due to delays incurred in congested roadways, environmental degradation due to increased vehicle exhausts, and losses due to traffic accidents. Thus, introduction of ITS becomes even more feasible to address these traffic issues since ITS has been proven to deliver desired benefits such as shorter travel times, increased capacity and throughput, improved safety, reduced fuel consumption and emissions, improved efficiency of public transport and several others toward better road environment. (ITS Toolkit) According to Federal Highways Administration's ITS Benefits: 2001 Update, as mentioned in the ITS Toolkit, on-board navigation experiment for one year showed delay reduction of 8.1% and fuel consumption decrease of 3%. Reduced travel time obviously reduces travel costs and therefore, positively contributes to congestion relief.

## 4. APPROACHES FOR INTRODUCING ITS

According to the Metro Manila Urban Transportation Integration Study (1997) about 70% of the trip makers in Metro Manila rely on public transport. Thus, it would be most appropriate to focus on specific ITS applications that would benefit the commuters rather than car users only. (Sigua, 2009) In line with this limiting condition, the following related and necessary discussions through identification of adoptable ITS application would help address traffic congestion leading to society-wide benefits in terms of less travel time and less impact to the environment.

There are recommended innovative approaches to the planning and development of ITS for developing countries as discussed by Yokota (2004). These include the concepts on affordable ITS, reliability-oriented ITS, development of a step-by-step architecture, and the use of public-private partnerships. ITS Technical Note 3 provides detailed discussion on the four concepts and cites several innovative development practices in other countries. An example for affordable ITS, for instance, is the use of Global Positioning System (GPS) for geolocation, and collection of data on traffic and road conditions.

Furthermore, a two stage selection model for ITS applications was recommended in ITS Technical Note 2. The overall process of Two-Stage Selection is shown in Figure 3. Stage 1 models the benefits-motivations of ITS and the fields of ITS while stage 2 subdivides ITS fields into individual applications and identifies the requirements for the introduction of each application.

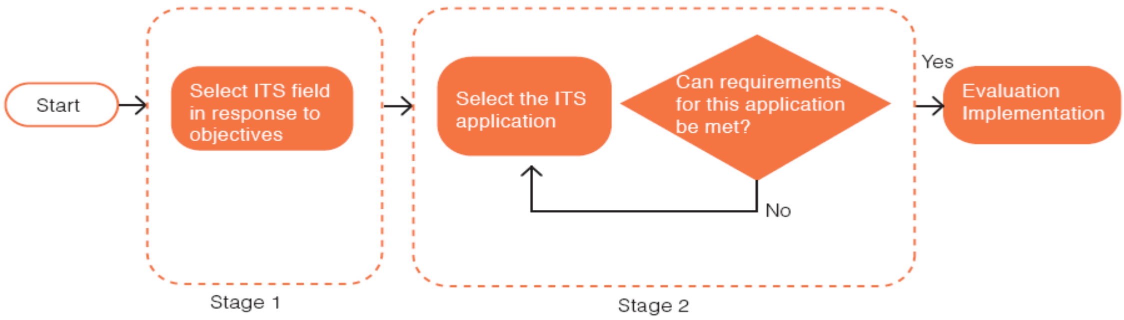



**Figure 3. The application selection process (taken from ITS Technical Note 2, p. 3)**

Table 4 which shows the relationship between the nine ITS fields and the three kinds of benefits or incentives is used in stage 1. The nine ITS fields and services are indicated in the top most cells of the last nine columns. The three kinds of benefits are the vertical grouping of one to three which refer to society-wide benefits, benefits to individuals, and additional incentives. The intended use of the table below as mentioned in ITS Technical Note 2 wherein TM stands for traffic management and DM means demand management is quoted below. (Yokota, 2004)

> *"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."*

**Table 4. Nine ITS fields and three kinds of benefits/incentives (taken from ITS Technical Note 2, pp. 5)**

| | Direct effects and issues to be solved by ITS in short term | | Traveler Infor-mation | Traffic Manage-ment | Demend Manage-ment | Road Manage-ment | Advanced Driver Assistance | Electronic Financial Transac-tions | Commercial Vehicle Manage-ment | Public Transport Manage-ment | Incident & Hazard Response |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Increased Mobility | | ☆ | ☆ | | | ☆ | ☆ | ☆ | ☆ | |
| | Congestion Relief | | | ☆ | ☆ | | | | | | |
| | Environment | | ☆ | ☆ | ☆ | | ☆ | ☆ | ☆ | ☆ | |
| | Improved Safety | | | ☆ | ☆ | | ☆ | | | | ☆ |
| | Better Highway Asset Management | | | | | ☆ | | | | | |
| 2 | Improved Security | | ★ | | | ★ | | | ★ | ★ | ★ |
| | Less Travel Uncertainty | | ★ | ★ | ★ | | | | ★ | ★ | |
| | Efficiency for Operators | | | | | ☆ | | ☆ | ☆ | ☆ | ☆ |
| | Efficiency for Users | | ★ | | | ★ | ★ | ★ | ★ | ★ | ★ |
| 3 | Regional | | ★ | | | | | ★ | ★ | | |
| | IT Industry | Automobile | ★ | | | ★ | | | | | ★ |
| | | Infrastructure | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ | ★ |

Note: ☆means that the effects are quantifiable while ★means that the effects are not readily quantifiable.

Stage 2 then involves selection of applications and identification of requirements for specific services in order to assess the feasibility of their introduction. Considering the example above and still focusing on congestion relief, stage 2 for traffic management and demand management are further examined. ITS Technical Note 2 presented each ITS field and its different applications by identifying the types of services it provides, and the requirement in terms of infrastructure, information and standards needed to deploy the application. The figure in Appendix 1 illustrates stage 2 model for traffic management.

For demand management application, there are two types of applications namely, the park and ride and the ETC. (Yokota, 2004) These services have been applied or at least tried in the local setting. First, the park and ride scheme is currently in place in Lawton area. However, this facility does not fully promote lesser use of urban road since it is located inside the city where private vehicles would still have to use urban roads to access this PUV terminal. The second service is road pricing through ETC wherein the ETC systems in expressways are already good examples. However, pricing through electronic transactions does not apply only in expressways but may also be done in urban roads as suggested by Sigua (2009). Table 5 shows potential benefits based on the initial studies on road pricing conducted by MMUTIS. Nevertheless, when the system or user requirements (e.g. on-board units, and DSRC), the prerequisite data (e.g. license plate and transponder) as well as strong regulation or institution to collect users' fee periodically, and approval of road users to such proposition are all considered, deployment of electronic road pricing (ERP) can not be done immediately. For instance, consider proposing ERP along EDSA wherein it covers several cities. Then, the deployment of ERP would necessitate high level of cooperation among local governments of the different cities, and law enforcement agencies which is not easy to attain given differences in the local government's priorities and allocation of budget.

**Table 5. Potential benefits when road pricing is implemented on major traffic corridors in Metro Manila (taken from Sigua, 2009)**

| Scheme | Alleviation of Congestion, % | Revenue US$ million/year |
|---|---|---|
| Along EDSA | 5 | 70 |
| CBD of Makati | 5-10 | 61 |
| Area bounded by EDSA | 3-10 | 174 |

For the field of traffic management as shown in Appendix 1, there are four types of services. These are traffic surveillance, traffic control, traffic regulation enforcement, and incident management. Currently, there are issues with regard to incident management due to lack of traffic accident database and emergency response system. Sigua (2008) discussed and elucidated on the state of road safety in the Philippines and traffic accident analysis, in which ongoing studies are anticipated to improve incident management strategies. Traffic control and traffic regulation enforcement have always been undertaken by MMDA and law enforcement agencies. Traffic regulation enforcement is done through manual ticketing of road traffic violators. The deployment of ITS' automatic enforcement using speed cameras and other sensors would require huge expense over lesser benefits especially in terms of its contribution to congestion relief. Meanwhile, in traffic control, the SCATS technology has been used for dynamic traffic signal timings in intersections. This technology was found effective in reducing queue lengths up to 30% during peak hours. With this technology already in place, the key endeavor for traffic engineers is to maintain and sustain its operations. The last service and often disregarded prerequisite for traffic management is the preparations which entail traffic surveillance. This pertains to a collection of traffic information or database, a fundamental input for traffic analysis, planning and other management, leading to less congestion and less impact to the environment.

Sigua (2009) has recognized that there is no sustained data collection effort because data collection is largely on a project basis (e.g. MMUTIS). The MMUTIS funded by Japan International Cooperation Agency (JICA) and published in 1997 is so far the latest source of comprehensive traffic information used by transport planners and engineers. There is no updated and historical traffic baseline information. As a result, inadequate traffic information hinders operators to exercise better traffic management.

Another important local practice to revisit is the old traffic data collection procedures that entail household surveys and manual methods which usually require huge labor and time costs, and susceptible to human errors. It is deemed necessary to do away with previous data collection technique and adopt modern traffic engineering practice which utilizes ITS technologies such as video imaging, loop detectors, or other automated procedures. Appendix 1 has particularly trimmed down the choices to on-site data collection with the use of road side unit or the mobile probe car technique. A more detailed discussion on selection between the two methods is presented in the succeeding paragraphs.

## 5. SUSTAINABLE DATA COLLECTION SYSTEM

One of the basic inputs in traffic management is real-time and historical traffic baseline information. Such record of traffic data is actually essential to come up with unbiased evaluation of present traffic condition, accurately assess the changes or improvements introduced to the transportation system as well as measure the performance of traffic management strategies.

ITS technologies have been available for more than a decade to supplement construction-based methods in improving capacity of existing transportation systems. Some examples of ITS technologies for traffic data collection include road-side sensors and instrumented test vehicles. These technologies modernized the old manual data collection methods that involve huge labor and time costs.

Road-side sensors such as inductive loop detector, video imaging detection systems, radars and lasers acquire traffic information at a fixed point and thus, gather spot data. Inductive loops are introduced in the 1960s and have become the most widespread detection system. (ITE, 1991) SCATS technology that uses inductive loops, for instance, required installation and maintenance of detectors under road pavements along the legs of major intersections. For a wide area like Metro Manila, some areas covering a number of intersections are controlled by a regional computer, which is then connected to a central management computer. Currently, some of the detectors have either failed or have not been operated since the introduction of MMDA's U-turn scheme in some major roads. This condition then, allows gathering of traffic information only in areas where the detectors are functional. Moreover, the problems encountered with inductive loops have led to the introduction of other non-intrusive devices such as video imaging, radars, and many others. Middleton *et al.* (2003) discussed the results on tests performed for each of the 14 advanced traffic detection devices wherein those that generate more accurate data are more costly while some devices still need further development.

In contrast, instrumented test vehicles like probe cars acquire traffic information using mobile equipment and specially equipped vehicles. The probe car technique is a non-intrusive data collection method since the instrumented vehicle follows the traffic stream and thus, gathers sequential traffic data. A probe car usually equipped with GPS wherein its location at certain point in time is sent through signals to a central facility will provide traffic information along the route it traversed. In order to cover much of the city roads, a number of vehicles must be instrumented to serve as active test vehicles. Probe car data has been extensively used to estimate or predict travel time (Laborczi, 2006, Hellinga *et al.*, 1999 and Miwa *et al.*, 2004). Moreover, there are several studies conducted with regard to evaluation and cost-effectiveness of PCS (Ishizaka *et al.*, 2005, Liu *et al.*, 2008). However, PCS is usually used in tandem with existing road side detectors. There is no current city yet that fully depend on PCS alone in collecting traffic information.

Considering these two alternatives for traffic surveillance, probe car technique is more feasible than the road side detectors. This is so because the benefits over costs incurred for the installation and maintenance of road side units as well as support for centralized monitoring of the system are not maximized but easily disregarded when other traffic management schemes (e.g. U-turn scheme) are introduced. Moreover, probe car system gathers sequential traffic data as compared to the spot data from road-side detectors that offer limited details. Another advantage is the capability of a probe vehicle to cover links where detectors have been defective or not activated as in the case of some closed intersections in Metro Manila. The use of probe cars actually supplements the gaps in traffic information gathered by the existing detectors. In addition, probe vehicle moves with the traffic stream thus, deployment will not interrupt traffic flow.

Furthermore, Sigua (2009) rationalized the promotion of probe car survey system to gather traffic baseline information by identifying its potential uses and applications. First, probe cars provide real-time traffic information that can be used for yearly unbiased evaluation of traffic condition (e.g. network travel speeds, delays, and bottlenecks). Second, updated and historical traffic information obtained from probe cars will provide adequate data for assessment of changes or improvements introduced to the transportation system. System or area-wide assessments include impacts of new or improved infrastructures (e.g. flyovers, bridges, pavement rehabilitation, pedestrian overpass, etc), evaluation of traffic management strategies (e.g. U-turn scheme, one-way regulation, parking regulation, etc.), post traffic impact assessment of new commercial developments, and finally, improved recognition of influence area of congestion due to road construction, pipe laying and other activities. Localized application like identification of specific problem areas such as bottleneck, and blackspots are also possible with the use of detailed traffic information.

## 6. CONCLUSION

Metro Manila experiences traffic congestion problems which include wastage of time and energy, air pollution due to increased vehicle emissions and significant losses due to traffic accidents. The key to solving these traffic issues is to effectively and efficiently manage existing road resources than rely only on road infrastructure developments or improvements to accommodate larger volume of traffic. ITS has been explored and presented as viable approach and potential solution to the perceived issues.

Through detailed review of ITS framework, the identified ITS application that can be used to relieve congestion is traffic surveillance or a sustainable data collection system. Moreover, the probe car system is recommended for this purpose. The real-time and historical traffic data which can be obtained from probe cars will in turn be used to effectively respond and manage congestion problems and utilize accurate information in planning and assessments.

## 7. FURTHER WORK

PCS consists of a probe vehicle, mobile sensors, Geographical Positioning System (GPS), and other additional components like digital camera. Considering the components of a probe car system, the costs of setting up such technology could be expensive. Thus, the primary step before deployments and the recommended future work is to develop a cheap and replicable PCS and to establish a methodology for testing the system.

## REFERENCES

Hellinga, B., P.E., Fu, L. (1999) Assessing Expected Accuracy of Probe Vehicle Travel Time Reports. **Journal of Transportation Engineering, Nov/Dec 1999**, 525- 530.

**ITS Introduction Guide**: Draft (2006) Road Bureau, Ministry of Land, Infrastructure and Transport, Japan, 2006.

**ITS Toolkit** for Road Transport in Countries with Developing and Transitional Economies, World Bank, Washington, DC, www.developingits.org/itstoolkit/report/itsdevelop.pdf.

Ishizaka, T., Fukuda, A. Narupiti, S. (2005) Evaluation of Probe Vehicle System by Using Micro Simulation Model and Cost Analysis. **Journal of the Eastern Asia Society for Transportation Studies, Vol.6**, 2502-2514.

Laborczi, P. (2006) Travel Time Estimation Based on Incomplete Probe Car Information. **13th World Congress on ITS**, 8-12 October 2006, London.

Liu, K., Yamamoto, T., Morikawa, T. (2008) Study on the Cost-Effectiveness of a Probe Vehicle System at Lower Polling Frequencies. **International Journal of ITS Research, Vol. 6, No.1**, 2008.

Metro Manila Urban Transportation Integration Study (1997) Transportation demand characteristics based on person trip survey. **MMUTIS Technical Report No. 4,** Manila, Philippines.

Middleton, D., Gopalakrishna, D., Raman, M., (2003) **Advances in Traffic Data Collection and Management**. US Federal Highway Administration, Washington, DC.

Miwa, T., Sakai, T., Morikawa, T. (2004) Route Identification and Travel Time Prediction Using Probe-Car Data. **International Journal of ITS Research, Vol. 2, No. 1.**

Shibata, J. (1998) General Trends of ITS in the World: Key Technology to Improve Traffic Safety. **Journal of International Association of Traffic and Safety Sciences, Vol. 22**, 7-22.

Sigua, R. (2008) **Fundamentals of Traffic Engineering**. University of the Philippines Press, Quezon City.

Sigua, R. (2009) ITS Experience in the Philippines. Seminar on Intelligent Transport Systems (ITS) Applications in the Philippines. Ortigas Center, Mandaluyong City, February 13, 2009.

**Traffic Detector Handbook** (1991) Institute of Transportation Engineers, Washington D.C.

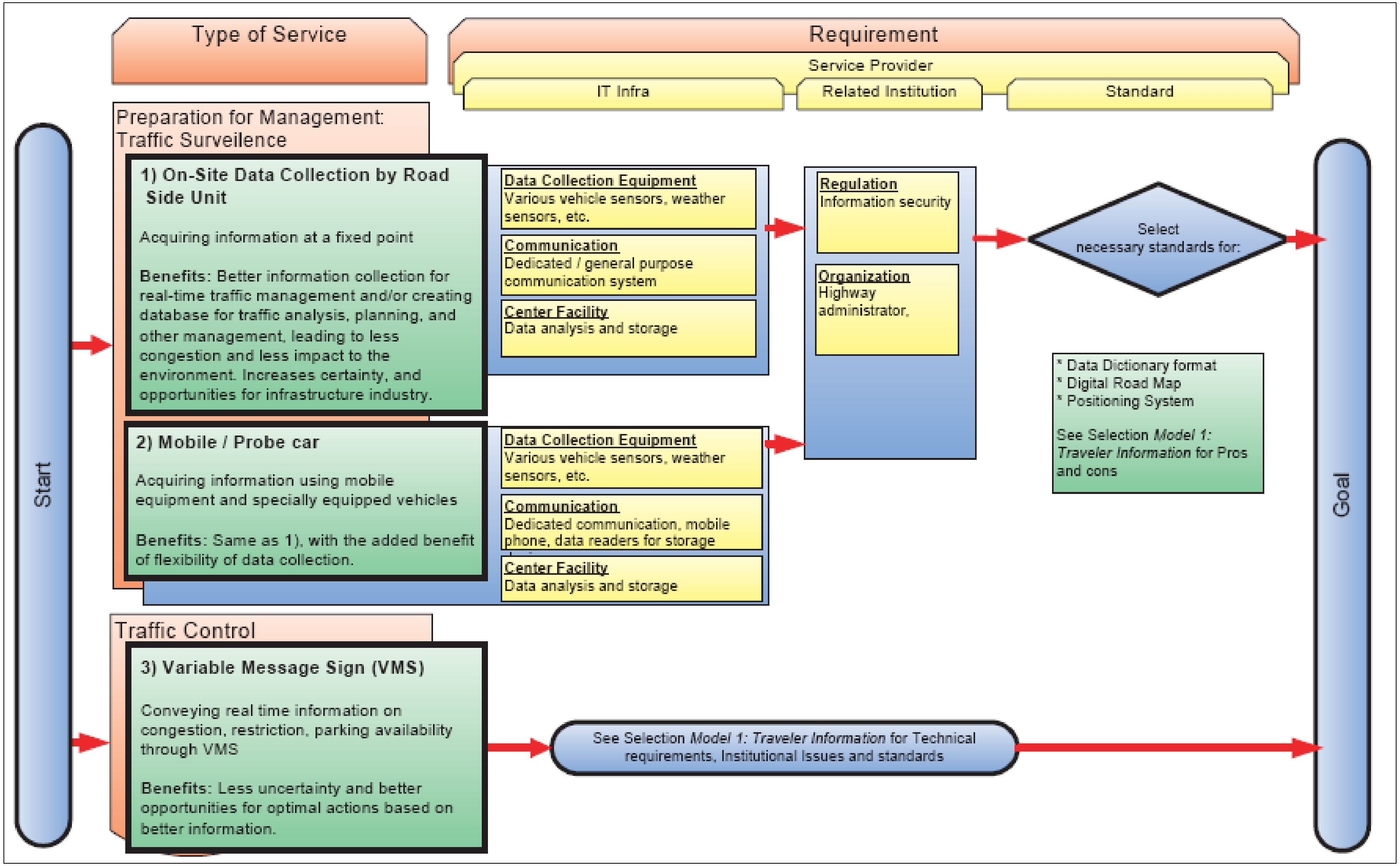
TMC (2006) **The Motorist's Handbook**. The Tollways Management Corporation publication, Caloocan City.

Yokota, T. (2004) **ITS for Developing Countries**, Technical Note 1. World Bank, Washington, DC, http://siteresources.worldbank.org/EXTROADSHIGHWAYS/Resources/ITSNote1.pdf.

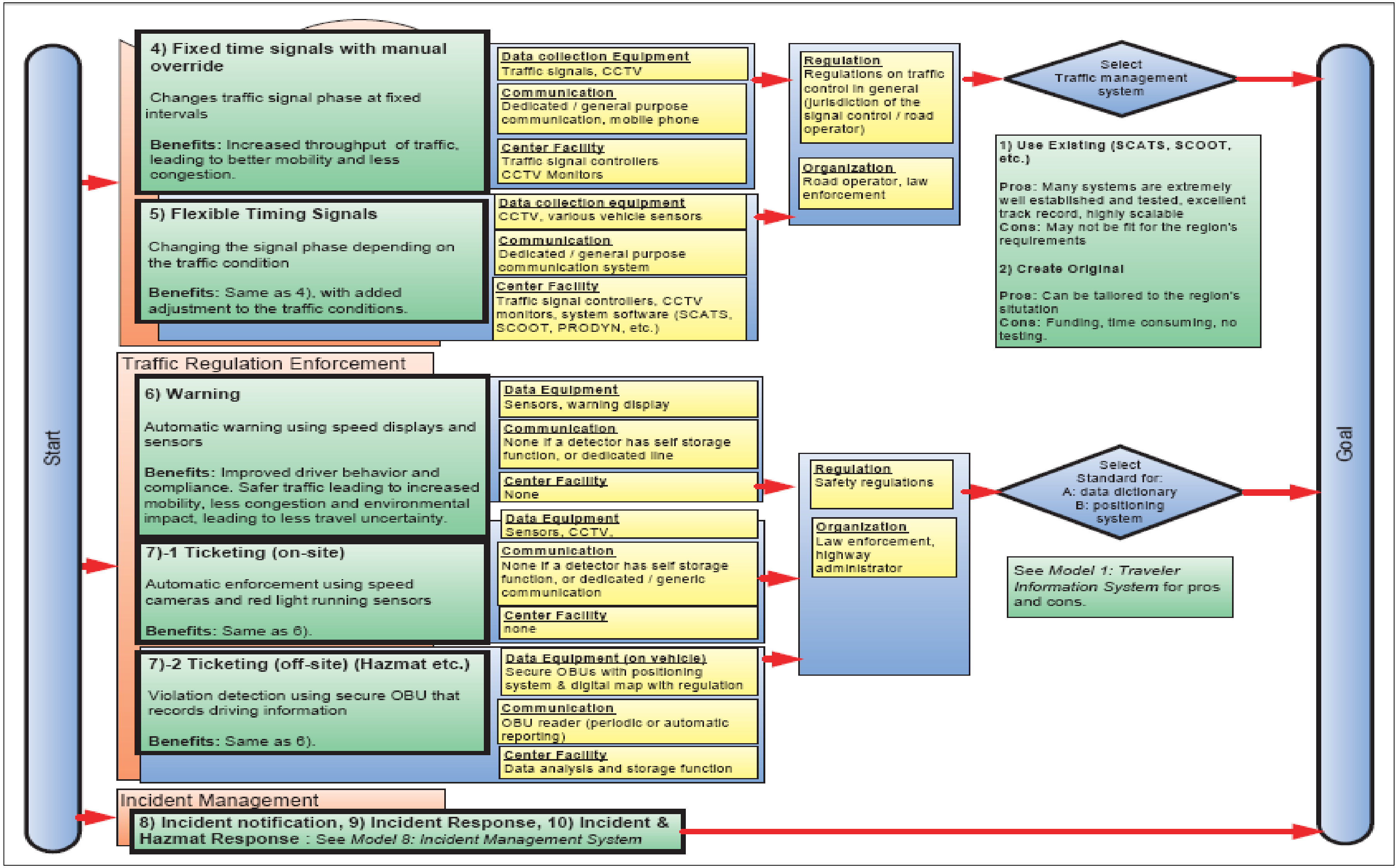
Yokota, T. (2004) **Two Stage Selection Model for ITS Applications**, Technical Note 2. World Bank, Washington, DC, http://siteresources.worldbank.org/EXTROADSHIGHWAYS/Resources/ITSNote2.pdf

Yokota, T. (2004) **Innovative Approaches to the Application of ITS in Developing Countries**, Technical Note 3. World Bank, Washington, DC, http://siteresources.worldbank.org/EXTROADSHIGHWAYS/Resources/ITSNote3.pdf.

Yokota, T., Weiland, R., Yamagata, H. (2005), Approaches for Introducing Intelligent Transportation Systems into Developing Countries, **Transportation Research Record: Journal of the Transportation Research Board, No. 1910**, pp. 72-81.




Appendix 1. Sample of Stage 2 selection model of ITS applications: Traffic Management (taken from ITS Technical Note 2, p. 11




Appendix 1. (Continuation) Sample of Stage 2 selection model of ITS applications: Traffic Management (taken from ITS Technical Note 2, p. 12