THE DEVELOPMENT OF TRAFFIC INFORMATION SYTEM AND ELECTRONIC TOLL COLLECTION IN JABOTABEK TOLL ROAD NETWORK

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Abstract: Intensive expansions of the toll road network, however, had never covered the rapid growth of traffic demands on the network. Traffic congestion was and remains a regular occurrence, and the traffic accidents are in the upward trend. The situation becomes worse since unavailability of information along the Jakarta intra urban toll road then choosing the toll road is no longer become solution to avoid traffic congestion. Traffic accident in the toll road automatically generates traffic congestion since there is very limited traffic management system. Traffic Information System (TIS) and Electronic Toll Collection System (ETC) as part of the toll road control and management system are significantly required in Jabotabek toll road.

The paper report the review result which consist of conceptual framework formulation in design the requirement of TIS and ETC system for Jabotabek toll road network, including investment feasibility which is required for further development in the future.

Key Words: TIS, ETC, toll road, Jabotabek

1. BACKGROUND

The total length of the toll road network for Jakarta and its surrounding area (JABOTABEK), including its extensions down to Cikampek, and to Merak, was about 340 km before the economic crisis hit this country in 1997, and it will reach about 390 km within a few years with completion of ongoing and programmed constructions of remaining sections in the Jakarta Outer Ring Road.

Intensive expansions of the toll road network, however, had never covered the rapid growth of traffic demands on the network prior to 1997, resulting in near or over capacity utilization on several road sections. Traffic congestion was and remains a regular occurrence, and the traffic accidents are in the upward trend.

Since 1988, Government of Indonesia employed the Build Operate Transfer (BOT) concept in toll road development. To date, over 100 km of toll road has been developed under BOT. Consequently, several different parties comprising PT. Jasa Marga, as a single state owned cooperation, and concession companies operate the resultant network. Tolls are collected using either the "open" or "closed" system.

Operational problems arise because of independent toll collection functions by Jasa Marga and individual concession companies on most of the toll sections. The results are a proliferation of tollbooths, unnecessary delays, restricted capacity and reduced safety. As the network nears completion, this means of revenue collection and operation is proving to be impractical and leads to operational and economic inefficiencies. The present toll collection system is labor intensive and may have a certain degree of revenue leakage; as such, it is fraught with problems of accountability. It also impairs the quality of services for the toll road users.

To address these issues, the GOI wishes to implement an Operational & Management System comprising traffic information, surveillance and electronic toll collection capabilities. The proposed system is intended to play a pivotal role in reducing economic inefficiencies through the introduction of operational improvements and by providing the ability to identify the causation and significance of other operational inadequacies.

The GOI intends that no governmental funds are utilized for the design and construction of the system and that no subsidy is expected for operation. The benefits arising from the implementation of the system in term of cost saving and leakage reduction alone are expected to enable the scheme to be "self-financing", albeit that contractual and regulatory requirements can be met.

2. EXISTING CONDITION OF JABOTABEK TOLL ROAD NETWORK

2.1. Average Annual Daily Traffic (AADT) and Traffic Growth

Traffic demands on the toll road have increased steadily until 1997 since its first introduction in 1978. The toll road network was estimated to carry about a total of 1.1 billion vehicle-km of traffic for the first quarter of 1996. The heavy traffic demand on the Jabotabek region has loaded both toll roads and the non-toll arterial to a condition that some sections of the toll roads are experiencing near capacity or overcrowded during the peak periods. As an illustration, Figure 1 depicts the network of Jabotabek toll roads. Meanwhile, Figure 2 depicts the existing toll collection system. Both open and closed systems are applied in the collection of toll tariff.

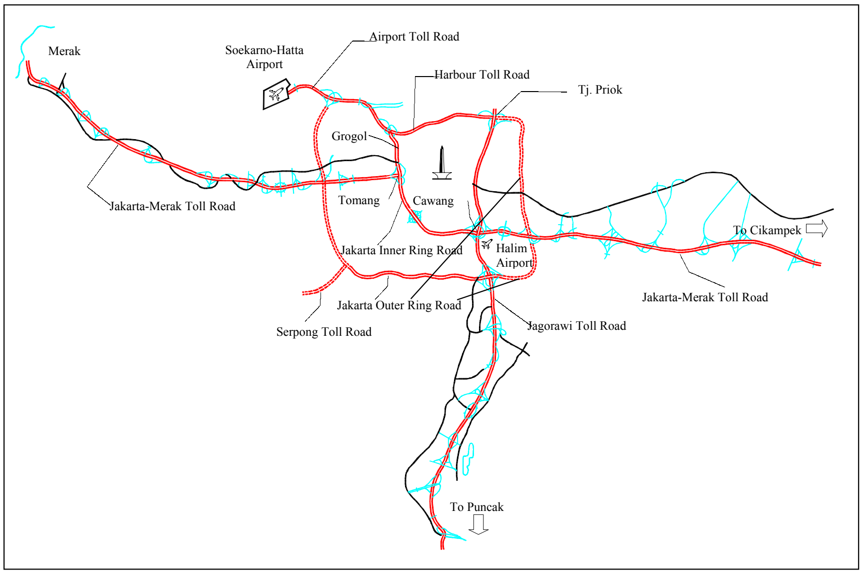

Figure 1 Network of Jabotabek Toll Roads

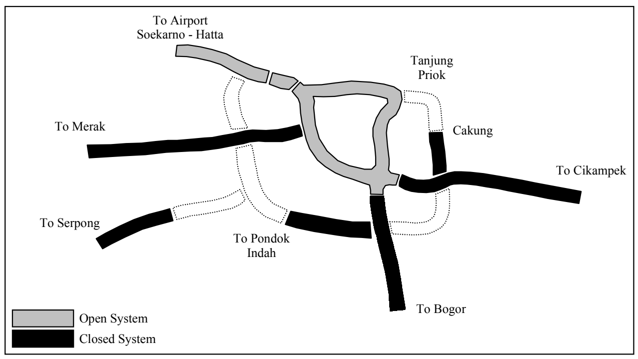

Figure 2 Existing Toll Collection System

Figure 3 show AADT on Jabotabek toll roads during 5 years period, starting 1996 to 2000 (November). Jakarta Inner Ring Road was recorded to be the busiest toll road section, then after that follows Jakarta-Cikampek, Jagorawi and Jakarta-Tangerang.

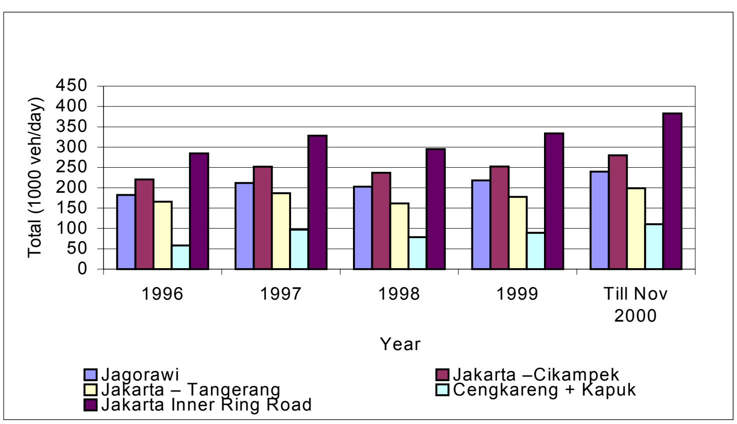

Figure 3 Average Daily Traffic at Jabotabek Toll Roads

Figure 4 depicts the average growth rate for the period 1996 to 2000. Since the toll roads operated AADT growth on Jabotabek toll roads had been increasing very rapidly every year until 1996, and started to decline in 1997 when Asian financial crises occurred. The Jagorawi Toll Road, for example, recorded an average annual growth rate of 15.2% during 1990 to 1995 and decreased to 7.35% during 1996 to 2000. Over the same period Jakarta-Tangerang decreased from 24.7% to 5.27%, from 25.2% to 6.46 % on Jakarta-Cikampek, 15.8% 8.26% on JIRR section and increasing from 11.3% to 21.01% on Cengkareng Airport Access Road.

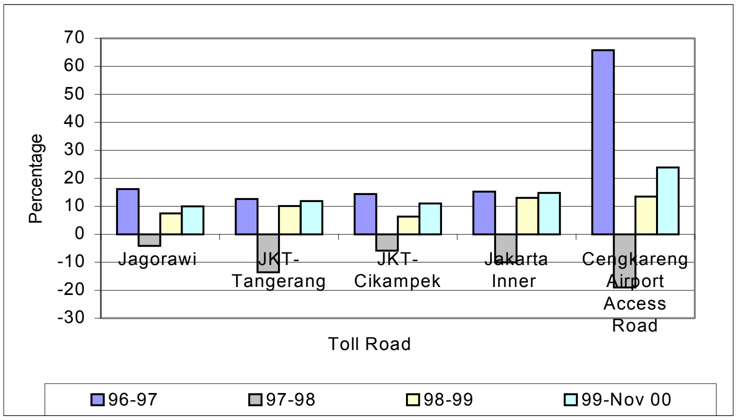

Figure 4 Annual Traffic Growth Rate at Jabotabek Toll Roads

Figure 5 also depicts the traffic composition profile for the year 2000. Vehicles Class I, light vehicles including passenger car, dominates the share of traffic composition.

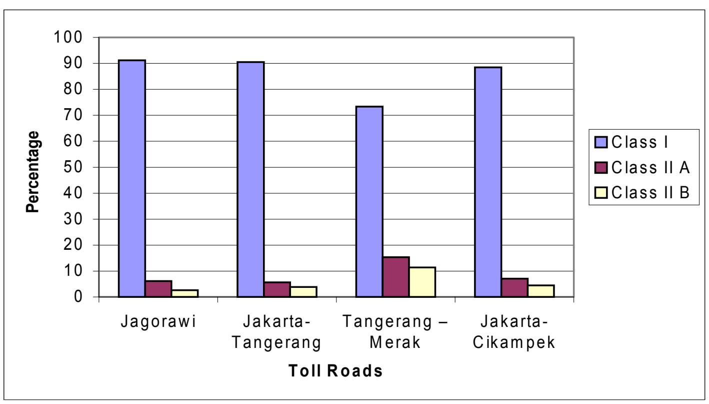

Figure 5 Traffic Compositions at Jabotabek Toll Roads

2.2. Problems Found

Operational problems found include existence of permanent congestion locations, considerable locations of which are in approaches to the tollbooths, either for entrance or exit. The problems caused from this arrangement to the toll road operators are:

- Increases in construction, operation and maintenance costs for toll collection facilities,
- Possibility of a certain revenue leakage,
- Possibility of reduction of toll revenue,

The problems to the toll road users are;

- Increasing journey times,
- Restricting capacity,
- Increasing driver frustration and inconvenience,
- Creating an abundance of conflict points associated with merging maneuvers at exits of the toll plazas,

Briefly, the existing traffic management inadequacies and problems can be listed as follows:
(1) Lack of a comprehensive traffic surveillance and management system
(2) Very high and rapidly growing traffic demand (The JIRR and sections of the radial toll roads close to the city carry more than 150,000 vehicles/day)
(3) Very high proportion of heavy vehicle traffic (The proportion is as high as 33% on some sections, but on the average about 22% on the JKT-Merak, JKT-Cikampek Toll Roads and 14% on Jagorawi Toll Road)
(4) Lack of consistent installation standards
(5) Broken equipment, Poor Parking/rest areas and Dangerous driving habits by users

2.3. The Needs for Traffic Information System and Electronic Toll Collection

Traffic Information System (TIS) as part of toll road control and management system aims at improving on one or more of the following aspects:
- safety
- throughput
- energy consumption
- pollution of the environment, and
- travel time predictability

The relative importance of those aspects depends upon which of the aspects become of public and of political interest or problems. In the current state of Jabotabek toll road, if one may place priorities, travel time predictability and throughput are of the most important concern at the moment, then follow safety, energy consumption (or efficiency) and environmental concern. Such priorities may shift with time, however the basic control systems and measures do not necessarily change. The way TIS deliver information to toll road users and subsequently achieve a particular target of improvement may vary from particular aspect to another.

According to a recent market survey on toll road user profile conducted by Marketing Research Indonesia (MRI, 2000), amongst the reasons given by road users when they are asked reasons in using the toll roads, it was reported that 53% responded that it was due to matters of time efficiency, 21% claimed smoother traffic and 17% stated to avoid traffic congestion. As road congestion increases and spreads over the Jabotabek road network, travel times within the region during the peak hour periods are already unpredictable at the moment. Another technique to handle over saturation is to dampen the shock waves, which can be implemented by introducing advised speeds, normally 15% to 25% below the maximum allowable speeds.

Traffic accidents sometimes occurred on the existing Jabotabek toll road network. On the southwest section of the Jakarta Inner Ring Road from Cawang to Grogol, for example, it was reported that sections of Cawang-Tebet and Semanggi-Slipi have a high accident rate of over an average of 40 accidents yearly. Other accident-prone sections are between Grogol-Cengkareng and Tebet-Kuningan with an average of more than 30 accidents annually. When accidents occur traffic may be hold up, and congestion spreads. Such congestion can also be prevented from getting worse and controlled via rerouting and alternative routes. This is particularly the case for recurrent congestion. The precondition for this particular control measure is the availability of alternative routes within the toll road network.

With respect to Electronic Toll Collection, the system is expected to improve the performance of toll tariff payment or transaction at the tollbooths. In the case for the Jabotabek toll road, ETC will enable various operators and toll road sections to be integrated in the processing of toll collection. It is expected that toll road users can reduce unnecessary delay time for transacting toll tariff every time they enter a different toll road section operated by a different operator, while for operators costs for a proliferation of toll plazas to handle the growing traffic can be minimized.

Suffice it to say that all techniques that can be introduced to improve toll road traffic performance by implementing the TIS and or ETC system have the advantages that lie not only in the increased throughput and reduced accident risk, but also in the reduction of pollution and the improvement of travel time prediction.

3. SYSTEM CONCEPT OF TIS AND ETC

3.1. Conceptual System of TIS

ITS can be defined as transportation systems that apply information and control technologies to help their operations with improved efficiency, safety and comfortableness, and therefore ITS is in this broad definition an umbrella that covers a wide range of transportation systems. Practical technologies applied to ITS include the latest in computer hardware and software, electronics, communications, sensors, and safe systems. Generally, various sub systems developed on a country's ITS program are to be so designed as to share information databases, communication facilities and components standards within the ITS architecture of the country.

The overarching objective of ITS is to improve transportation system operation which more practically is to support the transportation objectives of increasing efficiency, safety, productivity, energy savings and environmental quality. These objectives are common to all regions around the world even though their relative priority may vary from one to another.

The conceptual system of TIS as delivered by The Feasibility Study of A Traffic Information System for Jabotabek (1997) by PT. Jasa Marga (Persero), are as follow:

A. System Functions
- Traffic surveillance
- Incident detection
- Information dissemination
- Countermeasure implementation
- Data logging

B. System Components
- Vehicle detection system
- Closed circuit television system
- Emergency telephone system

- Driver information system
- Highway radio system
- Central computer system
- Transmission system
- Radio communication system
- Man-machine interface system

C. Coverage Area

The average annual average daily traffic volume of 60,000 vehicles a day was set as the guideline to determine which sections should be covered by TIS, without an elaborating basis of the selection of 60,000. This is based on arguments that sections carrying higher volumes should present higher total amount of benefits that would be received by the road users and that the adverse consequence of an accident would be more severe at the section with a heavy traffic. Other factors considered in determining the coverage area are: road alignment, accident rate, future traffic demand forecast, etc.

3.1.1. Network Configuration Alternatives

Most applicable network configuration outlines, including transmission redundancy and employment of a SONET/SDH ring with standby ring are illustrated in Figure 6 to Figure 8.

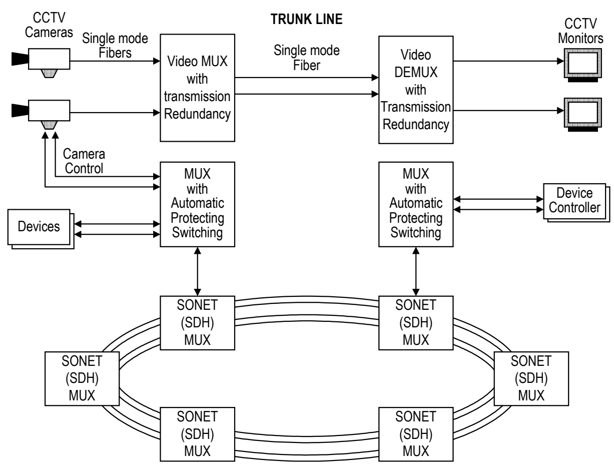

Figure 6. CCTV and SONET

Figure 6 shows separate point-to-point CCTV network with a fault-tolerant transport for voice/data on a SONET backbone (trunk) network. Low-speed communication devices feed into T1 channel banks and are integrated DS-1 signals before being fed into the SONET equipment. The SONET network ensures self-heading and redundancy by the dual bi-directional fiber rinks; one is for use and another for standby. To provide further redundancy for the multiplexed signals, alternative pass can be established between the multiplexer (data node) and the SONET equipment that is installed in the different station. Transmission redundancy is usually built into the video communication equipment.

This configuration maintains broadcast quality video images and redundant network passes. However, with the increase in the number of cameras, additional video multiplexers, and in turn additional use of fibers will be required.

Figure 7 shows a complete digital solution to transport of video, voice and data on the network. It facilitates interoperability of information transportation with the deployed networks of other agencies.

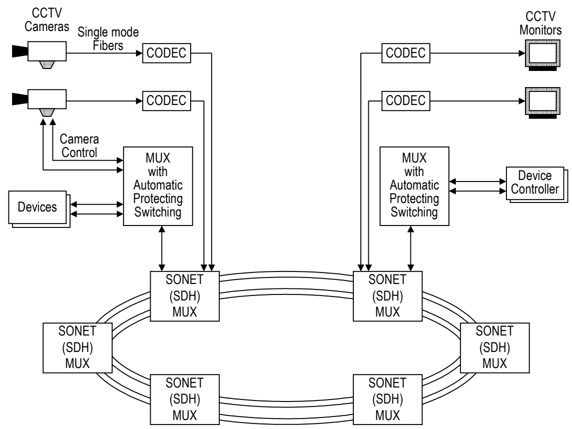

Figure 7. Digital Video over SONET

However, unlike voice which is digitized for uncompressed 64 Kbps, an uncompressed digital video requires about 135 Mbps in band width which may monopolize the communication bandwidth in an all-digital network. Therefore, digital video signals are usually compressed before being transmitted. Compression results in degradation of video signal. There are many video compression technologies, each of which has advantages and disadvantages.

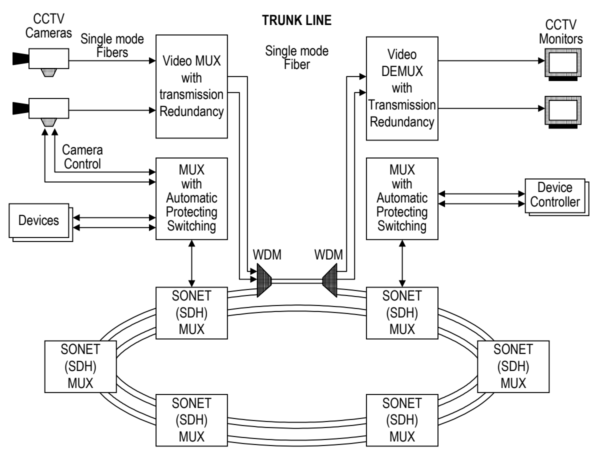

Figure 8. Hybrid CCTV and SONET

For lower quality full-motion video, a minimum DS-1 data rate per video signal using H.261 CODECs has been considered cost-effective. These signals however would occupy most bandwidth of a popular OC-3 network in case the number of cameras is increased to 100, still offering lower quality than required for a video-site-surveillance during nighttime and under bad weather. In some applications, compressed digital images of 3 Mbps are transmitted to the center for a backup of a failure of the analogue CCTV network.

Hybrid solution is another alternative to an integrated network design (as shown in Figure 8), which draws advantages of both previous configurations.

These advantages are;
- SONET data/voice backbone with high fault-tolerance, efficient fibre usage, interoperability with other SONET-based deployments, and ability of integration of compressed video signals.
- CCTV video transmissions for high quality, full-motion and low-cost video.

Optical integration of the CCTV video and SONET signals is performed through Wavelength Division Multiplexing (WDM) technology, which allows the integration of two distinct optical signals, each operating at different wavelengths, for transport over a single single-mode optical fiber.

3.1.2. Incident Detection System

As such, since the 1960s a great deal of efforts have been made in developing field operational systems with less detection time, high detection rate, and low false alarm which perform in heavy, medium and light traffic.

Possible actions following rapid incident detection, and verification, includes
- Fast dispatch of rescue team and arrangement related to saving lives of injured
- Fast arrangement for clearance of incidents to reduce congestion/delay
- Dissemination of information to advise route diversions
- Fast countermeasures to prevent secondary accident

Most commonly used vehicle detection devices are inductive loop detectors. CCTV systems are widely deployed together with incident detection systems and contribute in detection verification, and some initial detection through manual observation by operators at the center.

CCTV based automatic incident detection technologies have been tested for a long time, and some systems are successfully deployed, mainly in European countries. Images on CCTV contain much information. Most CCTV (fixed cameras) based systems directly detect slow or stopped vehicles on the detection zones or lines imaginary set on the monitor scopes, with simpler algorithms. No example system was found, in which the CCTV cameras that were frequently moved remotely by traffic operators in traffic observation, were utilized for an automatic incident detection system.

3.2. Conceptual System Configuration of ETC

A system configuration should illustrate all key functions and basic functional or physical components arrangements the system should have thus the final system configuration can only be produced within works for a system master plan development. The system configuration created here in Figure 9, therefore, was prepared to illustrate system's accommodations of main conceptual requirements described in the previous section and key information flows.

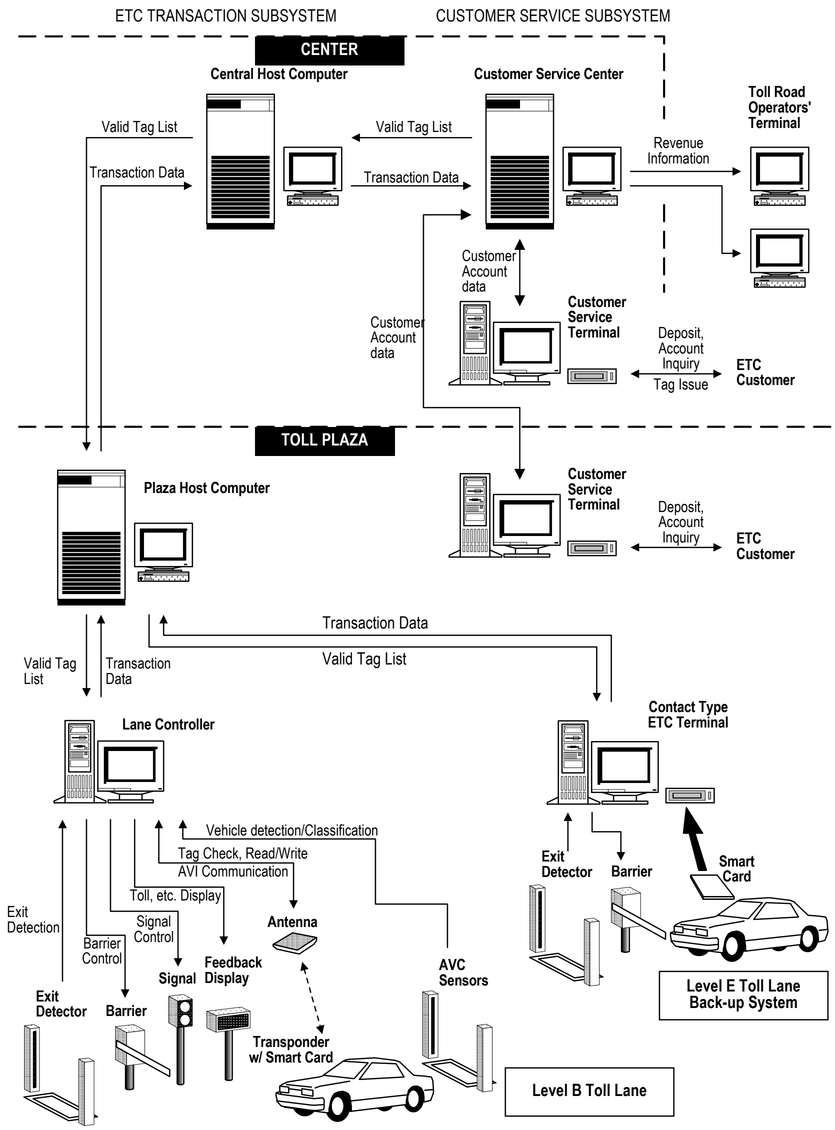

Figure 9. Conceptual System Configuration and Information Flow

The configuration intentionally sidesteps the relationship with manual toll collections that must remain. Technically, automated centralization of transaction data from all toll plazas could be implemented utilizing the communication facilities of the ETC system. By providing another administration computer and on-line facility, data files from ETC and manual transactions could be put together, and compiled data files and reports would be produced. The implementation depends on political decisions rather than technical aspects.

The system includes manual ETC terminals for transition stages and locations with a few ETC transactions.

The system functionally consists of two main subsystems, the ETC transaction subsystem and the customer service subsystem. Both subsystems operate closely for some functions such as tag validation and transaction data collection. The former subsystem consists of in-lane systems, toll plaza systems and a central computer system and the latter consists of customer service terminals and a central computer system. The level of most customer services can be designed independently from the former, but some services such as feedback information to the customer in the toll lanes are restricted by the functions of the former subsystem.

The transponders and customer cards are not required to be issued by the system operator (toll road operator or system concessionaires), but the system operator will activate and register the transponders and cards upon the customer-ship contracts. Activations with giving unique IDs to individual transponders and customer cards can be undertaken by a third organization that provides this service over all interoperable systems when multiple system operators use multiple interoperable systems.

When concessionaires operate the system, the toll road operators will be provided with terminals connected (permanently or on demands) to a terminal of the customer service center that always provides revenue related information. The revenue will be shared by the concessionaires and the toll road operators in accordance with predetermined formulas. Individual shares will be calculated by a separate computer, but the toll road operators are ensured audit ability through this arrangement. The customer will receive a receipt of prepayment or additional payment to charge his/her account, or transaction records, at a customer service counter in case that a prepaid system is adopted. He/she will receive a billing statement (monthly) with transaction records in case of a postpaid system.

4. ECONOMIC EVALUATION OF TIS

The estimation on annual benefits of TIS for Jabotabek Toll Road Networks are taken from *The Feasibility Study of A Traffic Information System for Jabotabek Toll Roads, June 1997* by PT Jasa Marga (Persero), as shown in Table 1.

Table 1 Estimated Annual Benefits for Jabotabek Toll Road Networks

No	Toll Road	Relative Accident Indices	Estimated Annual Benefits (Rp.)
1	Jakarta Inner Ring Road (Cawang – Grogol)	1.0	19,326,593,005
2	Jakarta Inner Ring Road (other sections)	0.5	9,663,296,503
3	Jagorawi Toll Road (Cawang – Cibubur)	0.6	11,595,955,803
4	Jakarta – Cikampek Toll Road (Cawang – Bekasi Timur)	2.0	38,653,186,011
5	Jakarta – Merak Toll Road (Tomang – Karawaci)	1.6	30,922,548,809
6	Cengkareng Airpor Road	0.2	3,865,318,601
7	Jakarta Outer Ring Road	0.3	5,797,977,902
8	Jakarta – Serpong Toll Road	0.3	5,797,977,902
9	Kalimalang – Bekasi Toll Road	1.5	28,989,889,508
Total Benefits for Phase I Project			114,026,898,732
Total Benefits for Phase II Project			154,612,744,044

Source: The Feasibility Study of A Traffic Information System for Jabotabek Toll Roads (1997)

The study first attempted to calculate the saving due to reduction of delay and vehicle operating cost for Cawang-Grogol section of Jakarta Inner Ring Road with and without SIL. The saving estimation for the other sections of JIRR and other toll roads in Jabotabek was calculated using a relative accident rate factor, which is the relative accident occurrences between the other toll road sections with that of Cawang-Grogol section of the Inner Ring Road for the same time period.

The total benefit for Phase I project, which covers the first six toll roads, consists of savings in vehicle operating cost, and travel time cost. The total benefit for Phase I is estimated around Rp.114.0 billion annually and Rp.154.6 billion for Phase II.

The Feasibility Study of A Traffic Information System for Jabotabek Toll Roads estimated the system construction cost to be US$ 72.80 million for Phase I and US$ 50 million for Phase II. The system maintenance and operating costs were also computed as US$ 3.56 million for Phase I and US$ 5.60 million for Phases I and II, which were about 5% of system construction cost. The other cost items to be considered for the analysis are listed in Table 2.

Using the estimated benefits and the cost items estimation, the yearly streams of costs and benefits are computed for 15 years after completion of the Phase I project. There were additional assumptions that were also used in calculating the economic parameters, those are:

- Engineering service for detail design of Phase I costs US$ 3.9 million for two years distributed at 50% (1998) and 50% (1999)
- Engineering service for detail design of Phase II costs US$ 2.8 million in year 2000 (75%) and 2001 (25%)
- Project supervision cost estimated at 75% of detailed design cost
- Construction cost at US$ 72.480 million for Phase II distributed by 50% : 50% ratio in (2000 – 2001) for Phase I and 10% : 60% : 30% in (2000 – 2002) for Phase II
- Benefits to increase at 10% a year due to increase in traffic demand
- Maintenance cost of system at US$ 3.562 million a year for Phase I and II
- Phase I system operational by 2001 and total system by 2002

Table 2. System Construction Cost, Maintenance and Operational Cost, and Other Cost Items for the Proposed Traffic Information System

No	Category	Phase I (million US$)	Phase II (million US$)	Total (million US$)
1	Construction Cost	72.80	50.74	123.54
2	Engineering Service :			
	a. Detailed design	3.90	2.80	6.70
	b. Tendering (10% of a.)	0.39	0.28	0.67
	c. Construction supervision (75% of a.)	2.93	2.10	5.03
3	Annual Operation and Maintenance Cost (5% of 1.)	3.56	2.04	5.60

The discounted yearly benefits and costs are the sum up for the computation of economic indicators. Assuming 1 US $ = Rp. 2400 at the time when the feasibility study was carried out, the economic analysis results an estimation of Benefit – Cost ratio (BCR) of 3.02, a Net Present Value (NPV) of Rp. 502 billion, and the Internal Rate of Return (IRR) is 22.7%.

5. THE FINANCIAL EVALUATION ON ETC

5.1. Estimation of Financial Benefits on ETC

A. Benefit from Reduced Toll Booth Construction

Capacity of an ETC booth can reach 1200 vehicle per hour (Takanashi, 1999), while, based on field survey, the capacity of a manual one is only 350 vehicles per hour. Thus, by implementing ETC the need for constructing more toll booths may be reduced, even eliminated. It is fully understandable that the costs for constructing and installing an ETC booth are more expensive than that for a manual one, but the operational cost for ETC booth is cheaper than that for a manual booth.

The savings can be calculated from the difference between construction cost of newly manual toll booth (included space and structure) and construction cost of ETC in existing booths (minimum 2 entry booths and 2 exit booths per plaza). The addition of new booth is limited up to 6 booths per toll plaza. The construction cost of a newly manual toll booth is assumed to be US$ 58,000, and the cost for land acquisition is assumed to be US$ 132,000 (space of 240 m^2 per toll booth, US$ 550 per m^2 at currency rate 1 US$ = Rp. 9000).

B. Benefit from Toll Tariff Increase

In this study, the rate the increase is assumed to be 2.5% from total toll tariff. The basic data is obtained from Toll Revenue Data from PT Jasa Marga, November 2000. The annual increase of traffic is predicted to be 10%, and toll tariff increase 25% three-yearly. This results a benefit of US$ 79,067,797 in 2023.

5.2. Estimation of Financial Costs on ETC

The construction costs of ETC consist of installation of the ETC central system, the customer service system, the communication system, and the unit cost per toll booth/toll lane. The system installation cost for Jabotabek Toll Road Network is estimated to be US$ 17.500.000 and the unit cost per toll booth to be US$ 65.000. Basic assumptions used in the financial feasibility of ETC are :

1. Base year = 2001
2. System installation and construction of ETC Phase I (Jakarta Inner Ring Road) finish at 2002
3. ETC Construction for other toll road finish at 2003
4. Life time is assumed to be 20 years
5. Operational and maintenance costs are 10% from construction cost
6. Currency rate : Rp. 9000 per 1 US$

The results of economic feasibility evaluation are shown in Table 3.

Table 3 Financial Evaluation of ETC

Financial Evalution Indicators	Discount Rate			
	10%	15%	20%	25%
NPV (million US$)	86,522	37,611	14,869	3,628
BCR	2.78	1.93	1.43	1.12
FIRR (%)	25.66			

6. ECONOMIC EVALUATION OF ETC

6.1. Estimation of Economic Benefits on ETC

A. Benefits from Vehicle Time Cost Savings

By taking average vehicle time cost of US$ 0.958 per hour (as a result of *Study on Value of Time*, PT Jasa Marga, 2000) at currency rate Rp. 9000 per 1 US$, annual vehicle time savings can be calculated as shown in Table 5 according to number of customers who subscribe to ETC.

B. Benefits from Fuel Consumption Savings

The benefits in the form of saving in fuel consumption due to increase in vehicle speed at toll plaza are listed on Table 6. The savings are calculated by assuming the speed at manual toll booth 8 km/hour and the speed at fully ETC toll booth 50 km/hour. Fuel consumption at 8 km/hour is 119 litres/1000 km and at 50 km/hour is 59.5 km/hour. The composition of traffic is assumed to be 80% of class I vehicles (gazoline fuel), 10% of class IIA vehicles (diesel fuel) and the rest for class IIB vehicles (diesel fuel). Table 7 gives annual savings on fuel consumption according to the number of customers who subscribe to ETC.

Table 5 Benefits from Annual Vehicle Time Cost Savings by Customer Penetration Level

No	Number of Customer (in % of total)	Total Vehicle Time (Hours)		Total Vehicle Time Cost (Rupiahs)		Annual Vehicle Time Cost Savings (in US$)
		without ETC	with ETC	without ETC	with ETC	
1	10%	5,489,246	5,023,502	5,258,698	4,812,514	446,183
2	20%	5,489,246	4,557,757	5,258,698	4,366,331	892,367
3	30%	5,489,246	4,092,012	5,258,698	3,920,148	1,338,550
4	40%	5,489,246	3,626,267	5,258,698	3,473,964	1,784,734
5	50%	5,489,246	3,160,522	5,258,698	3,027,781	2,230,917
6	60%	5,489,246	2,694,778	5,258,698	2,581,597	2,677,101
7	70%	5,489,246	2,229,033	5,258,698	2,135,414	3,123,284
8	80%	5,489,246	1,763,288	5,258,698	1,689,230	3,569,468
9	90%	5,489,246	1,297,543	5,258,698	1,243,047	4,015,651
10	100%	5,489,246	831,799	5,258,698	796,863	4,461,835

Table 6 Benefits from Annual Savings on Fuel Consumption

No	Toll Section	Fuel Consumption without ETC (in litres)	Fuel Consumption with ETC (in litres)	Annual Savings (in US$)
1	Jagorawi	1,259,412	629,706	629,706
2	Cawang - Tomang - Cengkareng	1,979,529	989,765	989,765
3	Jakarta - Tangerang	1,051,373	525,686	525,686
4	Jakarta - Cikampek	1,478,111	739,056	739,056
Total		5,768,425	2,884,212	2,884,212

Table 7 Annual Savings on Fuel Consumption by Customer Penetration Level

No	Number of Customer (in % of total)	Fuel Consumption (litres)		Annual Savings (US$)
		without ETC	with ETC	
1	10%	5,768,425	5,480,003	288,421
2	20%	5,768,425	5,191,582	576,842
3	30%	5,768,425	4,903,161	865,264
4	40%	5,768,425	4,614,740	1,153,685
5	50%	5,768,425	4,326,318	1,442,106
6	60%	5,768,425	4,037,897	1,730,527
7	70%	5,768,425	3,749,476	2,018,949
8	80%	5,768,425	3,461,055	2,307,370
9	90%	5,768,425	3,172,634	2,595,791
10	100%	5,768,425	2,884,212	2,884,212

6.2. Estimation of Economic Cost on ETC

The construction costs of ETC consist of installation of the ETC central system, the customer service system, the communication system, and the unit cost per toll booth/toll lane. The system installation cost for Jabotabek Toll Road Network is estimated to be US$ 17.500.000 and the unit cost per toll booth to be US$ 65.000.

Basic assumptions used in the economic feasibility of ETC are:

1. Base year = 2001
2. System installation and construction of ETC Phase I (Jakarta Inner Ring Road) finish at 2002
3. ETC Construction for other toll road finish at 2003 and with 20 years life time
4. Operational and maintenance costs are 10% from construction cost
5. The evaluations are made for annual growth of traffic 10%, 15%, and 20%
6. Currency rate: Rp. 9000 per 1 US$
7. ETC subscriber is assumed to be 10% at year 1, 20% at year 2, 30% at year 3, 40% at year 4, up to maximum 50% for consecutive years.
8. Number of booths to be applied ETC per toll plaza are minimum 2 for entry booth and 2 for exit booth per toll plaza. If a toll plaza consists of more than 10 toll booths, then the number or ETC booth to be applied is one every 4 toll booths. This results the number of ETC booths to be applied are :
    - 50 ETC booths for Jagorawi Toll Section
    - 46 ETC booths for Cawang – Tomang – Cengkareng Toll Section
    - 35 ETC booths for Jakarta – Tangerang Toll Section
    - 55 ETC booths for Jakarta – Cikampek Toll Section

The results of economic feasibility evaluation are:

Table 8 Economic Evaluation of ETC (Traffic Growth 10%)

Economic Evaluation Indicators	Discount Rate			
	10%	15%	20%	25%
NPV (million US$)	-5,021	-14,714	-18,625	-20,024
BCR	0.90	0.63	0.47	0.35
EIRR (%)	7.02%			

Table 9 Economic Evaluation of ETC (Traffic Growth 15%)

Economic Evaluation Indicators	Discount Rate			
	10%	15%	20%	25%
NPV (million US$)	15,302	-4,982	-13,640	-17,304
BCR	1.13	0.88	0.61	0.44
EIRR (%)	12.04%			

Table 10 Economic Evaluation of ETC (Traffic Growth 20%)

Economic Evaluation Indicators	Discount Rate			
	10%	15%	20%	25%
NPV (million US$)	48,821	10,569	-5,943	-13,249
BCR	2.00	1.26	0.83	0.57
EIRR (%)	17.80%			

7. CONCLUSIONS

The conceptual system of TIS and ETC as delivered by The Feasibility Study of A Traffic Information System for Jabotabek (1997) by PT Jasa Marga (Persero) have been economically and financially feasible. However, there are still several basic operational problems that require further review. The problems arise due to independent toll collection functions by Jasa Marga and individual concession companies on most of the toll sections. The condition creates problem defining the appropriate mechanism to calculate users fee for services for different toll road operators. The limited capacity of toll road network in Jabotabek also comes up with another problem to be solved.

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