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# ITS Design Priority at Large Bus Terminal in Indonesia in Supporting Sustainable Transportation

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***Abstract*— Intelligent Transportation Systems (ITS) is an important part of sustainable transportation. Implementation of ITS at large bus terminal is needed in order to increase the service quality to the passenger and encourage people to use public transportation. Unfortunately, not all of large bus terminal in large cities in Indonesia have implemented ITS yet. The aim of this study is to identify availability of ITS implementation at the large bus terminal, to evaluate whether the ITS system has fulfil the ITS standard in Indonesia, and to recommend ITS design to be implemented based on the needs, priority, and local condition at the large bus terminal. Implementation of ITS is compulsory but priority is also important based on limited support of financial, officer's capability, and commitment of the authority are the challenges. Case study is carried out at Cicaheum large bus terminal type-A in Bandung, Indonesia. Standard used is regulation of Ministry of in Indonesia, and number 132 year 2015 regarding information technology standard, including safety aspect, security aspect, reliability aspect, convenience aspect, easily aspect, and equality aspect of ITS implementation. Data collection used is direct observation of ITS implementation at Cicaheum large bus terminal in Bandung, Indonesia, questionnaire and interview with the bus terminal authority regarding the ITS implementation. Analysis method is Simple Additive Weighting. Result indicated that ITS design priority is CCTV application, topping bus ticket, automatic door bar at terminal gate, availability of facility of disable person, digital facility sign, traffic sign development, on time bus schedule, passenger information in the terminal regarding bus delay, and online/ mobile ticketing. Since these part of ITS is implemented, then based on existing condition of the large bus terminal, other part of ITS can also be implemented in the future.**

***Index Terms*— ITS design priority, large bus terminal, large city, sustainable transportation, Indonesia.**

## I. Introduction

Sustainable transportation is the transportation system that provides road facilities with many transportation modes lead to minimum using of non renewable resources and limited using of renewable resources including using Intelligent Transportation Systems (ITS) so that the future generation will not bear new problems [1, 2].

ITS is the system of advance technology to enhance efficiency and capacity of existing road infrastructure, increase road safety, improve convenience and ease of travel, and then will reduce traffic congestion [3, 4]. ITS implementation at large bus terminal in large city in Indonesia is important. This condition will encourage people to come to bus terminal, use public transportation, and then will reduce traffic congestion. Large bus terminal is chosen because this terminal is the terminal with most ready to implement advance technology like ITS. Since ITS systems consist of so many parts that cannot be implemented all soon in one time, priority of implementation of part of ITS at the large bus terminal is needed.

Cicaheum bus terminal is one of large bus terminals in Indonesia. This is a type-A (large bus terminal) in the third largest city in Indonesia named Bandung. Nevertheless, the implementation of ITS at this large bus terminal to has better serve to passenger is minim and only in the beginning level. Therefore, ITS with priority implementation because of existing condition of large bus terminal is crucial to do.

The aim of this study is to identify availability of ITS implementation at large bus terminal, to evaluate whether the ITS system has fulfil the ITS standard in Indonesia, and to recommend ITS design to be implemented based on the priority, the needs, and existing condition at the large bus terminal. It is hoped that in the future, the recommended ITS design can also be implemented at other bus terminals in Indonesia, by taking into account of their existing condition.

## II. ITS at Large Bus Terminal in Indonesia

Bus terminal is the pool location that used to manage arriving and departing bus public transportation to serve passenger, goods, and transit mode, and minimize delay time. In order to minimize delay time, therefore bus schedule, ticketing, and passenger information have to be provided integrated [5-8].

There are three types of bus terminal in Indonesia. They are type-A bus terminal (large bus terminal), type-B bus terminal, and type-C bus terminal as presented in Table 1.

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## III. METHODOLOGY

Research methodology used in this study to provide ITS design priority at large bus terminal in Indonesia in supporting sustainable transportation. The method used in analysis is Simple Additive Weighting Method.

TABLE I
TYPES OF BUS TERMINAL IN INDONESIA [5,9,10,11]

| Terminal type | Number of terminal | Serving activity | Terminal authority |
|---|---|---|---|
| A | 143 | Trip between cities, provinces, countries | Land Transport Management Agency – Province Level |
| B | 325 | Trip between cities in the same provinces | |
| C | 355 | Trip in the city or village | |

Simple Additive Weighting Method is a common multi-attribute decision making method with a number alternatives wherein each alternative has many criteria. Multi-attribute decision making method is a process of determining the decision criteria, congruence of alternatives in each criteria, and normalization of the matrix, in order to determine sequence of the alternatives based on preference value.

The process is presented in equation (1) up to equation (5). Normalization is needed to make each alternative free of uncertainly or fuzzy. Sequence of the alternatives is presented from alternative with the highest value to alternative with the lowest value. Alternative with the highest value is represents the most relevant alternative to be implemented based on the existing condition.

TABLE II
EXISTING FACILITIES AT CICAHEUM LARGE BUS TERMINAL IN BANDUNG, INDONESIA

| Aspects | Availability (√) and information |
|---|---|
| Safety aspects | |
| Pedestrian way | √ for one person |
| Safety furniture | √ sign, marking, lighting |
| Evacuation sign | --- |
| Fire extinguisher | √ 2 fire extinguisher |
| Health post | √ |
| Bus checking facility | --- |
| Bus minor repair facility | --- |
| Security aspect | |
| Security complain facility | --- |
| Security post | √ |
| CCTV | --- |
| Security officer | √ 12 persons |
| Reliability aspect | |
| Arriving / departing schedule and bus tariff | √ only for DAMRI bus |
| Next bus schedule | --- |
| Ticketing counter | √ |
| Control room | √ to manage and control buses at terminal |
| Checking post | √ 2 post at enter and exit terminal gate |
| Convenience aspect | |
| Waiting room | √ room condition need to be improved |
| Praying room | √ good room condition |
| Smoking room | √ |
| Reading room | --- |
| Hot spot | √ |
| Toilet | √ 2 ladies room and 2 gents room |
| Restaurant | √ |
| Janitor | √ |
| Drainage | √ ditch and septic tank |
| Easily aspect | |
| Location of bus arriving and departing | √ |
| Passenger information about bus schedule | √ |
| Mobile charging facility | √ limited access |
| Aboard and alight facility to the bus | √ |
| Parking Area | √ only for bus and motorcycle |
| Equality aspect | |
| Disable facility | --- |


Fig. 1. Existing condition of facilities at Cicaheum large bus terminal in Bandung, Indonesia

While preference value is determined based on the opinion of decision maker, in this study, is bus terminal authority. This is the benefit of Simple Additive Weighting Method that has capability to determine preference value from highest value to lowest value and make decision maker easy to choose alternatives with priority to be implemented [12-14].

$$A = \{A_i | \, i = 1,2, \dots, n\} \quad (1)$$

$$C = \{C_j | \, i = 1,2, \dots, n\} \quad (2)$$

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (3)$$

with:
$A$: a number of alternatives
$C$: criteria of each alternative
$X_{ij}$: performance appraisal of alternative i with criteria j [12]

$$r_{ij} = \begin{cases} \frac{x_{ij}}{\max(x_{ij})} \text{ if } x_{ij} \text{ is importance criteria} \\ \frac{\min(x_{ij})}{(x_{ij})} \text{ if } x_{ij} \text{ is needs criteria} \end{cases} \quad (4)$$

$$V_i = \sum_{j=1}^{n} w_j r_{ij} \quad (5)$$

with:
$r_{ij}$: normalized appraisal of alternative $A_i$ for criteria $C_j$
$V_i$: preference value
$W_j$: weigh factor

## IV. Field Data and Analysis

Field Data was collected in April 2017 and May 2017. Primary data is existing facilities of Cicaheum Bus Terminal, questionnaire and interview with the terminal authority. Questionnaire is regarding ITS implementation according to regulations in Indonesia. Secondary data is regarding Cicaheum Bus Terminal status.

The Cicaheum Bus Terminal is a type-A terminal/ large bus terminal at large city Bandung, Indonesia. It located on Ahmad Yani road, Kiaracondong, Bandung with area of 11,000 m$^2$. Figure 2 presents the terminal and bus circulation at the terminal. The detail development of the terminal since year 1974 up to year 2017 is presented in Table 3.

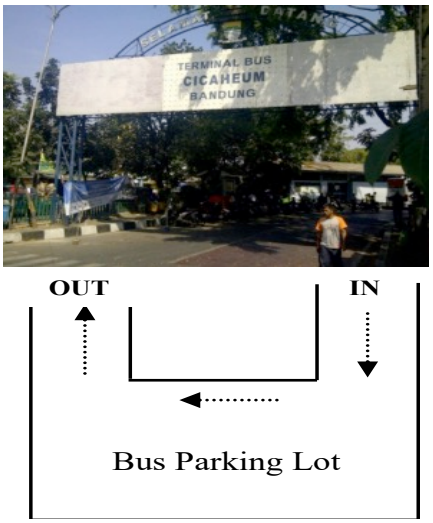


Fig. 2. Cicaheum bus terminal and bus circulation at the terminal, Bandung, Indonesia.

The existing facilities at Cicaheum large bus terminal in Bandung regarding the 6 aspects of ITS implementation have been presented earlier in Table 1. This condition is only the beginning of ITS implementation at the large bus terminal.

Furthermore, results of questionnaire to the terminal authority of Cicaheum large bus terminal in Bandung, Indonesia regarding level of importance and level of needs of ITS based on regulations in Indonesia is presented in Table 4. Likert scale from value 1 (the lowest value) to value 5 (the highest value) is used to describe the importance and the needs of ITS implementation.

ITS importance rate and ITS needs rate are use because ITS implementation in the large bus terminal is minim and at the beginning level, so that level of satisfaction as appraisal cannot be used in this study. Moreover, interview result with the terminal authority is the challenges in implementing ITS at the terminal i.e. limited support of financial, officer's capability, and commitment of the authority.

Result of questionnaire and interview with the terminal authority is presented in Table 4. Then the results are analysed using descriptive statistics and Simple Additive Weighting method. Analysis process using 5 questions in Simple Additive Weighting method is presented in Table 5. Analysis results of ITS needs to be implemented at Cicaheum large bus terminal in Bandung, Indonesia using Simple Additive Weighting method is presented in Table 6. Moreover, the analysis results are used in developing ITS design priority at large bus terminal in Indonesia in supporting sustainable transportation.

TABLE III
DEVELOPMENT OF CICAHEUM LARGE BUS TERMINAL 1974- 2017.

| Year | Development of Cicaheum bus terminal |
|---|---|
| 1974 | Building construction of Cicaheum bus terminal begin. |
| 1975 | Operation of Cicaheum bus terminal begins with capacity of 70 buses. |
| 1975-1986 | Cicaheum bus terminal serves bus route between provinces and between cities in the same province. |
| 1986 | Rehabilitation of Cicaheum bus terminal so that it has capacity of 300 buses. |
| 2017 | Cicaheum bus terminal serves 13 bus routes between provinces and between cities in the same province, and also serves 1 bus route in Bandung city (DAMRI Trans Metro Bandung / TMB). Cicaheum bus terminal capacity: 98 buses operates between provinces, 165 buses operates in the same province, and 45 buses operates in Bandung city (DAMRI and TMB). |

TABLE IV
DEVELOPMENT OF CICAHEUM BUS TERMINAL 1974- 2017.

| No | ITS Alternative at Cicaheum large bus terminal based on Indonesia regulation | Value of ITS Importance Rate | Value of ITS Needs Rate |
|---|---|---|---|
| 1 | Website development | 5 | 3 |
| 2 | Traffic sign development | 5 | 4 |
| 3 | Digital facility sign | 3 | 5 |
| 4 | Online complain facility | 4 | 5 |
| 5 | CCTV | 5 | 5 |
| 6 | Digital passenger information | 5 | 3 |
| 7 | Real time video of arriving and departing bus | 5 | 3 |
| 8 | Bus schedule and bus route in internet | 3 | 3 |
| 9 | On time bus schedule | 5 | 4 |
| 10 | Passenger information regarding bus delay time at terminal | 5 | 4 |
| 11 | Passenger information regarding bus delay time using sms | 4 | 3 |
| 12 | Online / mobile ticketing | 5 | 4 |
| 13 | Topping of TMB bus ticket | 5 | 5 |
| 14 | Automatic door bar at terminal gate | 5 | 5 |
| 15 | Availability of hot spot | 4 | 4 |
| 16 | Availability of facility of disable person | 5 | 5 |

TABLE V
ANALYSIS PROCESS USING 5 QUESTIONS IN SIMPLE ADDITIVE WEIGHTING METHOD

| ITS Alternative ($A_1$ … $A_{16}$) With $C_1$=importance rate=1.00 and $C_2$=needs rate=1.50 | | Performance Appraisal | | | | Performance Value ($V_i$) |
|---|---|---|---|---|---|---|
| | | Before Normalization | | After Normalization | | |
| | | $r_1$ | $r_2$ | $r_1$ | $R_2$ | |
| $A_1$ | Website development | 5.00 | 3.00 | 1.00 | 0.60 | 3.08 |
| $A_2$ | Traffic sign development | 5.00 | 4.00 | 1.00 | 0.80 | 3.64 |
| $A_3$ | Digital facility sign | 3.00 | 5.00 | 0.60 | 1.00 | 3.64 |
| $A_4$ | Online complain facility | 5.00 | 5.00 | 0.80 | 0.80 | 3.36 |
| $A_5$ | CCTV | 5.00 | 5.00 | 1.00 | 1.00 | 4.20 |
| $A_6$ | Digital passenger information | 5.00 | 3.00 | 1.00 | 0.60 | 3.08 |
| $A_7$ | Real time video of arriving and departing bus | 5.00 | 3.00 | 1.00 | 0.60 | 3.08 |
| $A_8$ | Bus schedule and bus route in internet | 3.00 | 3.00 | 0.60 | 0.60 | 2.52 |
| $A_9$ | On time bus schedule | 5.00 | 4.00 | 1.00 | 0.80 | 3.64 |
| $A_{10}$ | Passenger information regarding bus delay time at terminal | 4.00 | 3.00 | 1.00 | 0.80 | 3.64 |
| $A_{11}$ | Passenger information regarding bus delay time using sms | 4.00 | 3.00 | 0.80 | 0.60 | 2.80 |
| $A_{12}$ | Online / mobile ticketing | 5.00 | 4.00 | 1.00 | 0.80 | 3.64 |
| $A_{13}$ | Topping of TMB bus ticket | 5.00 | 5.00 | 1.00 | 1.00 | 4.20 |
| $A_{14}$ | Automatic door bar at terminal gate | 5.00 | 5.00 | 1.00 | 1.00 | 4.20 |
| $A_{15}$ | Availability of hot spot | 4.00 | 4.00 | 0.80 | 0.80 | 3.36 |
| $A_{16}$ | Availability of facility of disable person | 5.00 | 5.00 | 1.00 | 1.00 | 4.20 |

## V. ITS Design Priority at Large Bus Terminal in Indonesia

Analysis results of ITS implementation needs at Cicaheum large bus terminal in Bandung, Indonesia using Simple Additive Weighting method as presented in Table 6 then use to develop ITS design priority at large bus terminal in Indonesia in supporting sustainable transportation.

Implementation of ITS is compulsory but priority is also important based on limited support of financial, officer's capability, and commitment of the authority. These are the challenges. ITS facilities can be located inside or outside the terminal and will be controlled in the bus terminal management control. The ITS design priority is presented in Figure 5.

Table VI
Analysis Result Regarding of ITS Need to be Implemented at Cicaheum Large Bus Terminal in Bandung, Indonesia Using Simple Additive Weighting Method (SAWM)

| Alternative | Result of SAWM | Priority Category |
|---|---|---|
| CCTV application | 4.20 | I |
| Topping of TMB bus ticket | 4.20 | |
| Automatic door bar at terminal gate | 4.20 | |
| Availability of facility of disable person | 4.20 | |
| Digital facility sign | 3.64 | II |
| Traffic sign development | 3.64 | |
| On time bus schedule | 3.64 | |
| Passenger information regarding bus delay time at terminal | 3.64 | |
| Online / mobile ticketing | 3.64 | |
| Online Complain facility | 3.36 | III |
| Availability of hotspot | 3.36 | |
| Website development | 3.08 | IV |
| Digital passenger information | 3.08 | |
| Real time video of arriving and departing bus | 3.08 | |
| Passenger information regarding bus delay time using sms | 2.80 | V |
| Bus schedule and bus route in internet | 2.52 | VI |

It can be seen in Table 6 that CCTV application, topping of TMB bus ticket, automatic door bar at terminal gate, and availability of facility of disable person are ITS alternatives that have the first priority to be implemented. The reason is because these indicators have to be fulfilled according to the regulation. In more detail, CCTV and automatic door bar at terminal gate have been applied earlier, but they are nor working at this time. Whereas bus schedule and bus route information through internet is the ITS alternative with the lowest priority because most of the passengers are at the middle and low income level and it is easier for them to get information direct from the bus terminal as usual.

ITS design priority in Figure 5 is developed with consideration of availability, condition, service standard, regulation, and priority of ITS implementation at bus terminal. Moreover, detail explanation regarding implementation of ITS design priority at the bus terminal is presented in Table 7. Since these part of ITS is implemented, then based on local condition of the large bus terminal, other part of ITS can also be implemented in the future.

## VI. Conclusion

Large bus terminal in large cities in Indonesia needs ITS to increase passenger service quality and encourage people to use public transportation in supporting sustainable transportation. Since ITS cannot be implemented soon and in one time, priority is needed according to existing challenges condition at large bus terminal i.e. limited support of financial, officer's capability, commitment of the authority and existing ITS implementation condition that only in the beginning level. ITS design priority is developed based on observation, questionnaire, and interview results with the terminal authority using Simple Additive Weighting method. The ITS design provided in this study is not advanced ITS, because the bus terminal existing conditions have not fulfilled the aspects required by regulation in Indonesia yet, but can be implemented soon. After implemented the simple ITS at large bus terminal, the next priority of ITS implementation can be applied at the future, in large bus terminal and at the other type bus terminal.

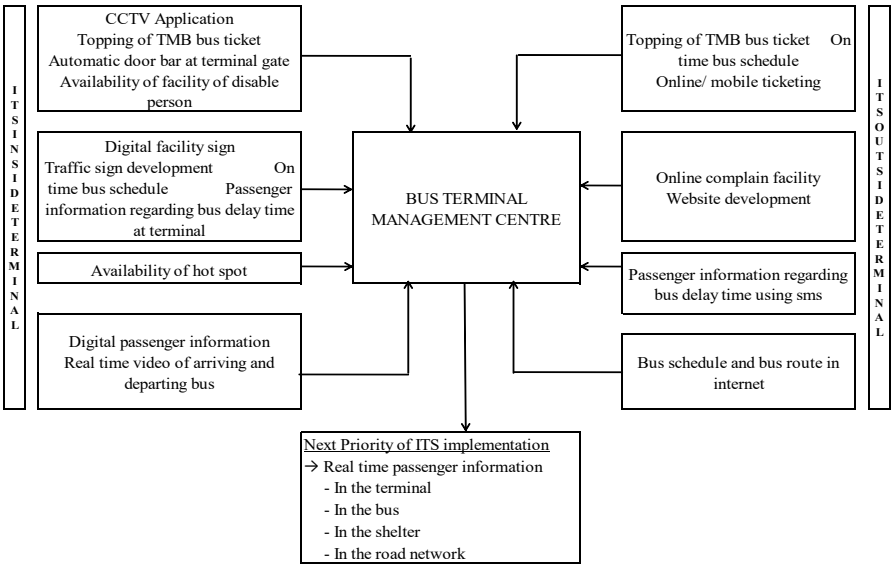


Fig. 5. ITS design priority at large bus terminal in Indonesia in supporting sustainable transportation

TABLE VII.
EXPLANATION REGARDING IMPLEMENTATION OF ITS DESIGN PRIORITY AT THE BUS TERMINAL

| Alternative | Priority Category | Aspects | Location Inside (I) / Outside (O) terminal | Explanation |
|---|---|---|---|---|
| CCTV application | I | Security | I | CCTV installed in waiting room at enter and exit gate. |
| Topping of TMB bus ticket | | Easily | I / O | |
| Automatic door bar at terminal gate | | Security | I | Automatic door bar at enter and exit gate. |
| Availability of facility of disable person | | Equality | I | Facility for disable including bus portable ramp. |
| Digital facility sign | II | Reliability | I | Digital and traffic sign to manage traffic bus circulation. |
| Traffic sign development | | Safety | I | |
| On time bus schedule | | Reliability | I / O | On bus time and on Time bus schedule to give certainty to the passengers. |
| Passenger information regarding bus delay time at terminal | | Reliability | I | |
| Online / mobile ticketing | | Easily | O | Online / mobile ticketing can use mobile application. |
| Online Complain facility | III | Reliability | O | Online complain can use mobile application. |
| Availability of hotspot | | Convenience | I | Hot spot needs to cover entire terminal area. |
| Website development | IV | Easily | O | Website to inform passenger. |
| Digital passenger information | | Reliability | I | Digital passenger information and the real time video installed in waiting room. |
| Real time video of arriving and departing bus | | Reliability | I | |
| Passenger information regarding bus delay time using sms | V | Reliability | O | Bus delay time information to give certainty to the passengers. |
| Bus schedule and bus route in internet | VI | Easily | O | The information to make passenger easy. |

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