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The Application of Intelligent Transportation System (ITS) in Urban Areas Based on Public Preferences

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***Abstract*—The application of the Intelligent Transportation System (ITS) is being widely implemented in developing cities as one of the efforts to reduce congestion in urban areas. This research aims to provide recommendations for implementing the Intelligent Transportation System (ITS) in Cirebon City based on public preferences. The method used was a questionnaire survey to find out people's preferences for the application of ITS in Cirebon City and to see its influence on the interest in travel. Data analysis technique used is linear regression analysis with 6 (six) instruments such as real-time congestion information, availability of a navigation guide system, parking capacity information, information on the availability and schedule of public transport, real-time information on congestion and accidents and real-time supervision from the government. Based on the results of the analysis, recommendations can be given for the application of the ITS system to meet public needs. This study shows that the factors that have a significant influence on people's interest in traveling are P2 and P5, which means that the application of ITS in Cirebon City need to prioritize the availability of real-time information about congestion and accidents and the availability of a navigation guide system.**

Keywords— ***intelligent transportation system (ITS), ITS application, linear regression analysis, public preferences***

I. INTRODUCTION

Congestion is a major issue that affects almost all countries, particularly in large cities [1]. Traffic congestion occurs when the number of vehicles passing through a particular point at the same time exceeds its capacity [2]. In colloquial terms, congestion refers to the inability to reach a destination within a satisfactory time due to slow or unpredictable traffic speeds [3]. Therefore, to reduce congestion, an integrated monitoring system is needed that is capable of monitoring road users and the environment as they travel.

Intelligent Transportation Systems (ITS) with new technologies, which have been increasingly developing in recent years, are used as computational systems and communication technologies for various purposes such as traffic management, route planning, vehicle and road safety, and emergency services [4]. ITS is considered a key factor in improving road safety, traffic efficiency, and driving experience [5]. It is a technology that has been developed in recent years to address traffic congestion in developing countries [6] such as India [7], Thailand [8], Vietnam [9], and Indonesia [10]. Some other developing countries have developed this system to overcome congestion and provide comfort for road users.

Intelligent Transport System (ITS) in principle is the application of advanced technology in the field of electronics, computers, and telecommunications combined with strategic management principles to improve the overall transport function. These systems provide information to drivers or passengers, enabling effective and efficient transport processes. ITS technology is becoming increasingly important for the deployment of various applications related to road safety and traffic efficiency [5]. The application of ITS is to control and manage vehicle traffic, vehicle distribution, and infrastructure to achieve a safer and more organized transport system. ITS is not only applied to solve congestion but can also be used to improve safety [11], accident monitoring [12], and improving the performance of public transport [13].

There are many previous studies on the application of ITS in addressing congestion. For instance, a study [10] conducted on the implementation of ITS in major cities in Indonesia, such as Jakarta, Bandung, Surabaya, Yogyakarta, Solo and Denpasar. In [14] which analyzed the implementation of ITS in Palangkaraya City, it was found that implementing an Area Traffic Control System (ATCS) at the signalized intersection could increase time efficiency by 1.84 hours per day or save 23% of the delay at the signalized intersection. Another research [15] analyzed how to overcome congestion in DKI Jakarta by using ITS as a factor in reducing congestion. The research resulted in several ITS applications that could be applied to overcome traffic congestion in Jakarta such as a Real-Time Traffic Information System (RTTIST), Advanced Bus Information System, Parking Space Information System, and Electronic Law Enforcement. Further research [16] provide a road map for Intelligent Transport System Development in Surabaya designed as an effort to overcome congestion. It recommends that systems that have been built i.e. ACTS ITS, CCROM and been designed i.e. fleet management systems, revenue, e-transportation integration need to be harmonized with ITS scenarios that support smart mobility. The effectiveness of the use of ITS in congestion reduction was carried out by [17] in Malang City, which resulted in the effective implementation of the RTTIC and ATCS programs, although there were some difficulties in their implementation. [18] tested the effectiveness of implementing a system to monitor vehicle traffic and provide real-time information on events occurring on the highway in Catanduva City, and found that the implementation of the system can reduce vehicle downtime by 42% and travel time by 50% at an average speed of 33 km/hour. Research conducted by [19] analyzed traveler awareness of ITS and their response to the effectiveness of the implemented system in Lahore city traffic and found that a large number of road users were aware of ITS and familiar with various ITS tools.

Cirebon City is one of the developing cities in West Java Province, Indonesia, which currently has a lot of congestion points. This is due to the high growth in the number of motorized vehicles in the Cirebon City area, which reaches more than 3% per year and private cars reach 7% per year [20]. Cirebon City Government is starting to implement an ITS system to support traffic activities by implementing an Area Traffic Control System (ATCS) at several signalized intersections with less-than-optimal implementation. To optimize the application of ITS in Cirebon City, it is necessary to conduct a comprehensive study to design an ITS development scheme in Cirebon City. This research aims to develop a plan for the application of ITS in solving congestion problems based on the perspective and needs of the community, and then provide recommendations for the development of ITS in Cirebon City.

II. METHOD

Figure 1 shows the flow of the research conducted. The first stage is preparation, which includes a literature study of previous research, looking at the application of ITS in other cities, and determining the research objectives. The second stage is data collection, which includes mobilizing surveyors, determining survey instruments and variables, determining research samples, and then conducting questionnaire surveys. The third stage involves data processing and analysis. This includes processing the survey data, testing its feasibility with a linearity test, and analyzing the data using linear regression analysis to determine the most influential variables in the application of ITS in the study area. The final stage is to provide recommendations for ITS development based on the results of the analyses that have been conducted.

Preparation
Literature Study
The study of ITS implementation in other cities

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Data Collection
Surveyor mobilisation
Determining research sample
Determining research instrument and variable
Conducting questionnaire surveys

↓

Data Processing and Analysis
Survey data processing
Data feasibility testing using linearity test
Linear regression analysis

↓

Provide recommendations for ITS development in the study area

Figure 1. Research Flow Chart

Determining Research Instruments and Variables

Data collection was conducted through a questionnaire survey of at least 100 respondents, with the dependent variable

being the value of the effect of ITS usage on interest to travel and 6 main independent variables to be analyzed, namely:
Realtime traffic information (P1)
Guided navigation system (P2)
Realtime information on parking capacity at specific locations (P3)
Realtime information on public transport availability and schedule (P4)
Realtime information on Congestion and Accident (P5)
Realtime supervision from the related government (P6)

Research Location

This research was conducted in the administrative area of Cirebon City, West Java, Indonesia. The research location can be seen in Figure 2.

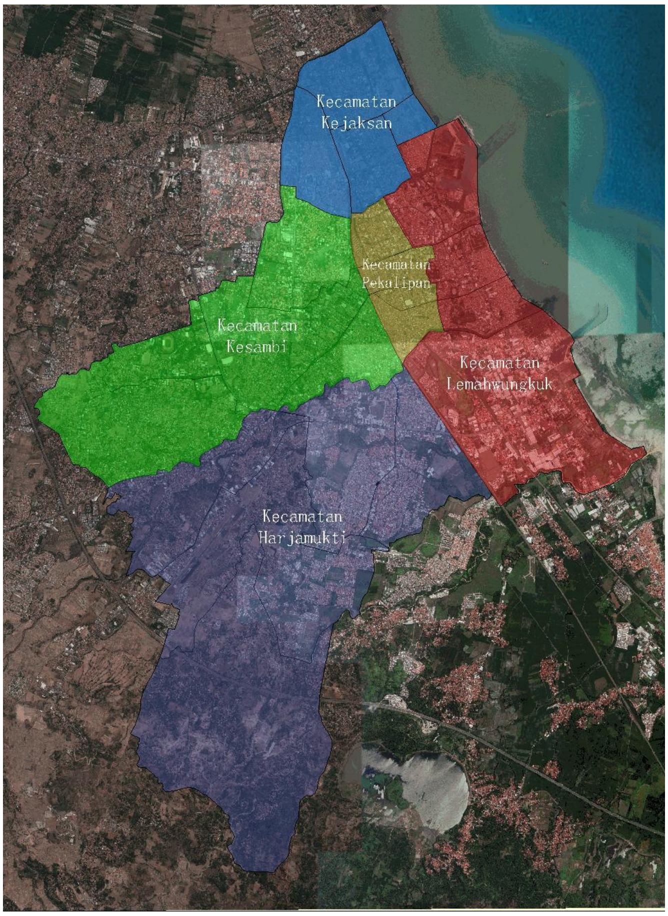

Figure 2. Research Location

Determining Research Sample

The research sample was determined using the Slovin method with a 90% confidence level (α = 0.1) and the population N is the total population in the study area (Cirebon City) in 2022 of 341,235 people with the following calculation results:

$n = N / (1+N\alpha^2)$
$= 341.235 / (1+ (341.235)(0,1)^2)$
$= 99,97$ respondents, rounded up to 100 respondents

Based on this sample determination, the minimum sample size that should be reached in this study is 100 respondents.

III. RESULTS AND DISCUSSION

Data Testing

A questionnaire survey was conducted among 171 respondents to determine respondents' perspectives on several ITS implementation variables that influence interest in travel. The questionnaire data was subjected to a linearity test to ensure the feasibility of the data so that it could later be proceeded to linear regression analysis to find out how each variable influences interest in travel.

TABLE 1. DESCRIPTIVE STATISTICAL ANALYSIS RESULTS

	X	P1	P2	P3	P4	P5	P6
N	171	171	171	171	171	171	171
Mean	4,12	4,50	3,76	4,15	4,25	4,30	4,42
Median	4,00	5,00	4,00	4,00	4,00	4,00	4,00
Mode	5	5	4	4	4	4	5
Std. Deviation	0,853	0,627	0,962	0,695	0,695	0,676	0,621

Table 1 shows that the average respondent answered “necessary” (more than 4 points) for all variables, while the average respondent answered “fairly necessary” (less than 4 points) for variable P2 or the availability of guided navigation.

This could be because there are currently many guided navigation applications available, such as Google Maps and Waze, which are already widely used to assist travel, so the provision of ITS systems in terms of navigation systems is not very necessary. However, this does not imply that the development of a guided navigation system is no longer required in future ITS development. This is because most respondents indicated that a guided navigation system is necessary (mode value = 4). Based on the mode value, most respondents answered 'necessary' and 'very necessary' for all variables asked.

TABLE 2. LINEARITY TEST RESULTS USING SPSS

No	Var	F		Ftable	Significance
1	P1	0,114	<	3,90	0,736
2	P2	0,079	<	3,05	0,924
3	P3	0,669	<	3,90	0,415

4	P4	0,012	<	3,90	0,913
5	P5	1,775	<	2,66	0,154
6	P6	3,158	<	3,90	0,077

Table 2 shows that the calculated F value for all variables (P1 - P6) has a lower value than the F table with a significance of 0.05. In addition, the significance value of the calculation results using SPSS shows a value higher than 0.05 for all variables. This means that the questionnaire data for all variables is declared feasible to proceed to the linear regression analysis process.

Linear Regression Analysis

Based on the results of the analysis using linear regression analysis, the mathematical model is as follows:

X = 1,220 + 0,158P1 + 0,195P2 + 0,109P3 + 0,139P4 + 0,222P5 – 0,123P6

The mathematical model above can be interpreted as follows:

Without the application of ITS to the transport system in the study area, the respondents' travel interest is 1,220.

The variable P1 or the availability of real-time traffic information has a positive influence on respondents' interest in traveling. This means that every 1% increase in the P1 variable will increase travel interest by 0.158.

The P2 variable or the availability of a guided navigation system has a positive influence on respondents' interest in traveling. This means that every 1% increase in the P2 variable will increase travel interest by 0.195

The P3 variable or the availability of real-time parking capacity information at certain locations has a positive influence on respondents' travel interest. This means that every 1% increase in the P3 variable will increase travel interest by 0.109.

The P4 variable or the availability of real-time public transport information and schedules has a positive influence on respondents' interest in travelling. This means that every 1% increase in the P4 variable will increase travel interest by 0.139.

The P5 variable or the availability of real-time Congestion and Accident Information has a positive influence on respondents' interest in travelling. This means that every 1% increase in variable P5 will increase travel interest by 0.222.

The P6 variable or the existence of real-time supervision from the relevant government has a negative influence on respondents' interest in traveling. This means that every 1% increase in the P6 variable will reduce travel interest by 0.123.

Based on the interpretation above, it can be concluded that the variables that have the greatest influence are variables P2 (the availability of guided navigation systems) and P5 (the availability of real-time information on congestion and accidents). This means that variables P2 and P5 need to be prioritized in the development of ITS systems in the study area. Out of the 6 variables analyzed, 1 variable has a negative influence on respondents' travel interest, which is real-time supervision from the government. This can be caused by the characteristics of respondents or people in the study area who are not ready for traffic enforcement so direct supervision by the government will reduce interest in travelling. This can be proven by the high level of traffic violations in the study area, where according to data from the Cirebon City Police, in 2021 there were 5150 cases of ticket violations and 3985 cases of violations with warnings. Meanwhile, in 2022 from January to June there were 2879 cases of ticket violations and 6284 cases of violations with warnings. However, this does not mean that direct supervision by the government should not be applied in the study area because, in terms of benefits, the application of the policy will affect improving traffic order and road safety. Therefore, the implementation of direct supervision policies from the government in the development of ITS in the study area still needs to be considered, just not as a top priority.

ITS Development Recommendations

Based on the results of the linear regression analysis that has been carried out, it can be seen which variables affect the respondents' interest in traveling. Then, the results of the analysis can be used as the basis for ITS development in the study area. ITS systems that can be developed based on the priority scale are as follows:

1st Priority: Advanced Travelers Information System (ATIS)

Advanced Travelers Information System (ATIS) is an intelligent information system for road users that provides real-time traffic information.

[16] The system is a priority for development because based on the results of the analysis, almost all variables that constitute the availability of information have a positive influence on the interest in traveling, especially in terms of the availability of guided navigation systems and real-time congestion and accident information. The form of ATIS application that can be developed is as follows:

Create a website or application dedicated to traffic information. The website or application can present actual traffic-related information to road users, such as navigation systems or directions, tourist locations or tourist routes, congestion points, accident-prone points, public transport routes and schedules, and other information.

Installing Vehicle Message Signs (VMS) at several points in the study area. For example, in locations with potential congestion, flooding, accident-prone, and others that need to be handled quickly. By installing VMS at these locations, it is expected to increase the efficiency and effectiveness of traffic and reduce the occurrence of congestion and accidents.

Real-time Parking Information to assist travelers in knowing the availability of parking at certain locations, e.g. shopping centers, etc.

2nd Priority: Advanced Transportation Management System (ATMS)

Advanced Transportation Management System (ATMS) is an intelligent transportation management system that can improve control and management of traffic that aims to improve traffic performance and make better use of available infrastructure. The forms of ATMS applications that can be developed are as follows:

Area Traffic Control System (ATCS) is an intelligent and coordinated, centralized traffic control system that aims to create optimized road network performance and achieve a safe road transport system. Currently, ATCS CCTV with announcers has been installed at 11 of the 23 signalized intersections in the study area, to appeal/alert the public directly so that the relevant authorities can monitor and control traffic from a dedicated space called the control room. So far, the function of ATCS at the study location is to monitor and appeal to people who commit traffic violations and to coordinate with the Dalops Team of the Cirebon City Transportation Agency in the event of traffic congestion. The ATCS system at the study location still has many shortcomings so its performance needs to be optimised. In addition, the ATCS system can be connected to the website or ATIS system application, where it can show live streams from ATCS CCTV videos so that users can find out the actual conditions of congestion at points that will become travel routes and can determine travel routes based on actual conditions.

Implementing an adaptive traffic signal control system, which is a type of system capable of adjusting signal timing parameters in real-time according to short-term changes and fluctuations in traffic demand, aims to improve the efficiency of traffic operations on urban road networks. This system is applied to improve the reliability of the existing ATCS, which is currently only able to control and supervise traffic in real-time so that with the application of the adaptive traffic signal control system the response to actual traffic conditions can be handled quickly to be able to unravel congestion quickly as well.

3rd Priority: Advanced Public Transportation System (APTS)

Advanced Public Transportation System (APTS) is an intelligent public transportation system that uses electronic technology to improve the operational performance and efficiency of public transportation services. The main elements supporting APTS are public transportation information and public transportation management [21]. The use of APTS, allows public transport modes to be able to report their position so that passengers can know the position of the vehicle in real-time and transport operators can monitor their assets. [16]. Dalam mengoptimalkan kinerja pelayanan Trans Cirebon sebagai moda transportasi massal di Kota Cirebon dapat didukung dengan implementasi sub system dari APTS, antara lain:

Currently, the study location already has a modern public transport system in the form of a medium bus called Trans Cirebon under the supervision of the Cirebon City Transport Agency. Trans Cirebon currently operates on two corridors, one encircling the outer ring of Cirebon City (corridor 1) and the other entering the city center (corridor 2). The optimization of the performance of Trans Cirebon services as a mode of mass transportation in Cirebon city can be supported by the implementation of the subsystem of APTS, such as:

The real-time status of fleets is a sub-system of APTS that can provide information related to the availability of transport fleets in real-time. This sub-system can help transport users to be able to know the status of the availability of transport to be used.

Automatic Vehicle Location (AVL) is an APTS sub-system capable of providing information related to the current location of the transport fleet in real-time. This sub-system can help transport users to be able to know the current location of the transport to be used so that it can minimize waiting time.

Electronic fare payment is a subsystem of APTS in the form of a non-cash transport tariff implementation. This subsystem serves to optimize the fare collection process to be easier and more controlled.

4th Priority: Archive Data User Service (ADUS)

Archive Data User Service (ADUS) is a system designed to store and use data generated by ITS systems to improve the operation of those systems. Traffic management functions cannot be performed if the government does not know what is happening on the site (actual conditions). With the development of the ITS system described above, it is possible to generate the data needed to determine and identify what is happening on the site so that the development of ADUS makes it possible to utilize ITS system data in carrying out traffic planning and management functions.

IV. CONCLUSIONS

Based on the analyses that have been conducted, the following conclusions can be drawn:

Linear regression analysis conducted on 171 respondents to determine the effect of ITS implementation (6 variables) on interest in traveling resulted in the model X = 1,220 + 0,158P1 + 0,195P2 + 0,109P3 + 0,139P4 + 0,222P5 – 0,123P6

The availability of real-time congestion and accident information and the availability of guided navigation systems are the variables that have the most influence on respondents' travel interest, while the variable of direct supervision from the government has a negative influence on travel interest.

The ITS development priorities in the study area are as follows: Advanced Travelers Information System (ATIS), Advanced Transportation Management System (ATMS), Advanced Public Transportation System (APTS) and Archive Data User Service (ADUS)

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