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## TOTAL SOLUTION FOR SMART TRAFFIC AND TOLL ROADS MANAGEMENT IN INDONESIA

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### ABSTRACT

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The Ministry of Public Works and Public Housing has the task of carrying out government affairs in the field of public works and public housing to assist the President in administering the state government. One of the mandated functions in carrying out this task is to formulate and implement policies in the field of road administration in accordance with the provisions of laws and regulations, including the regulation of toll roads in Indonesia in accordance with Government Regulation No. 15 of 2005 concerning Toll Roads. The toll road is one of the vital means needed to increase efficiency in public services, logistics and industry which leads to economic efficiency. According to data released by the World Bank in 2019, losses due to traffic jams in Indonesia amounted to USD 4 billion, equivalent to an estimated IDR 56 trillion, more than that due to queuing at toll gates there is potential for losses for all business entities. To overcome this problem, Indonesia is preparing to implement a non-stop (touchless) toll payment system on the Multi Lane Free Flow (MLFF) system using RFIDbased ETC (Electronic Toll Collection) Total Solution technology and the transaction process is carried out through a special application that can be accessed from the Internet. Integrate all departments with an IoT (Internet of thing) system. This payment system can eliminate the GTO function of toll entry and exit gates. In addition, the MLFF system using RFID-based ETC will recognize and identify vehicles and users. In addition to the RFID-based ETC system to increase the productivity and effectiveness of traffic management on toll roads, maintenance of toll roads and bridges is also very vital, therefore detecting road surface damage directly using sensors, CCTV cameras and UAV unmanned aerial vehicles. (Unmanned Aerial Vehicle) which has the advantages of high.

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### INTRODUCTION

Transportation can be defined as the movement of both people, goods and objects from one place of origin to another. So transportation is defined as the transfer of goods and people from the place of origin to the destination. According to Morlok, E, K. In this connection there are 3 (three) important things, namely There is a load being transported and Available vehicles as a means of transportation 3. Roads that can be passed by vehicles.

In general, big cities in Indonesia experience the same thing in the field of transportation, namely traffic jams on highways, for example DKI until the latest information has not received the right solution in terms of overcoming congestion. The application of private vehicles that pass on the highway at least 3 passengers in a vehicle with the term three in one. Reducing private vehicles that pass on the highway by about 50% by enforcing a vehicle plate that passes on alternating odd-even numbers is still a discourse. Making a Busway for Trans Jakarta bus vehicles to be able to carry a lot of passengers in a safe, comfortable and affordable way. Congestion results in economic and immaterial losses such as causing stress due to frustration not being on time at the destination. Congestion is caused by a variety of interrelated lives, for example to lack of discipline, weak low-enforcement, the growth of vehicles that cannot be matched by the growth of road infrastructure. The current level of congestion spread has

even entered the freeway (toll roads) in several big cities. And the factors that contribute to congestion on toll roads are:

Payment queues at toll gates, damage to roads and bridges on certain sections, a fairly high accident rate, uneven distribution of vehicles because vehicles can move quickly in one place and will accumulate in certain distribution lines. Article 43 of Law No. 38 of 2004 concerning Roads states that toll roads are operated with the following objectives:

1. Streamlining traffic in developed areas
2. Improving the usability and efficiency of goods and services distribution services to support increased economic growth
3. Easing the burden of government funds through the participation of road users
4. Increase the distribution of development results and justice.

When a country's economy relies on land transportation, of course, transportation facilities in the form of roads, especially toll roads will encourage the creation of economic efficiency in it. In Indonesia, the toll road section that has been operating is 1,868.62 kilometers long (Toll Road Management Agency, Ministry of PUPR 2020). And according to existing plans that by 2025 it will reach 6,000 kilometers. The benefits of toll road construction itself are influencing regional development, facilitating traffic, facilitating the distribution of goods and services, and increasing the economy (Sumaryoto, 2010). Besides that, it will get benefits in the form of savings in Vehicle Operating Costs (BOK) and time compared to passing through non-toll roads. With the number of vehicles in Indonesia increasing significantly where in 2008 there were only 61,685,063 vehicles but in 2018 the number of vehicles became 146,858,759 vehicles (Central Bureau of Statistics, 2019). The construction of toll roads is a solution provided by the Central Government to overcome the high level of congestion that occurs in a number of big cities such as on the islands of Java, Sumatra, Kalimantan and Sulawesi while opening up connectivity between provinces, regencies and municipalities.

Toll roads are paid roads, so the infrastructure and services on toll roads must be different from non-toll public roads. Thus, the toll road regulators are not only looking for profit but also prioritize the safety and smoothness of traffic because these two are the main business of toll roads. In relation to economic development and efficiency, toll roads, which are a form of road infrastructure that have an important role in smoothing the flow of the economy and supporting economic growth and industrial efficiency, need to upgrade technology according to current developments. Thus, the use of RFID technology in the payment system as an effort to minimize queues at toll gates as well as the use of UAV technology, sensors, application modifications and software on the monitoring and handling system of roads and bridges is urgent and must be implemented immediately

## METHOD RESEARCH

The research was conducted within 3 months, starting from September 2021 to December 2021 and was carried out in the form of cooperation between three countries, namely Indonesia, Taiwan and America. This research was conducted by PT. AITEK (Asia Intellectual Technology). This study uses a qualitative method.

## RESULT AND DISCUSSION

### Comparison of Provision of Toll Road Facilities Abroad

The implementation of non-cash transactions and the implementation of road inspections on toll roads using the technology described above, has been carried out by several countries in the world, including:

#### 1. United States of America



Picture 1. Highways in the United States.

Several toll roads built around the world have become famous thanks to their very long distances. One of the longest in the world is the Pan American Highway. The Pan American Highway runs from Alaska in the north of America through Mexico and ends in southern Chile and Argentina. No less than 15 countries, including Latin American countries, are traversed by toll roads whose total length reaches this 47,516 km. To optimize the toll payment system in the United States, use E-mail.

Z Pass. This E-Z Pass has the same function as a prepaid card, in this tool there is already a nominal value of money that can be used to make payments when passing through toll roads bearing the E-Z Pass logo. This card will work according to its function when passing toll gates that have been specially designed with advanced technology. The way this tool works when it enters the E-Z Pass special lane is:

- a. The E-Z pass attached to the windshield will be censored by the antenna located in front of the toll gate
- b. When the car passes, the E-Z pass account is automatically deducted according to the toll rate
- c. Digital signage will tell motorists whether or not to pass through the toll gate. The digital board is located not far from there, besides that the digital board will also tell you about the nominal money in the passenger card that must be refilled if the money inside is not enough.

If the car does not have an E-Z pass or the E-Z pass funds are empty and still force to pass through the toll gate, the passenger is categorized as a violator and this will be recorded by the camera installed in the toll area for further processing. The ticket card will be received by the driver who is sent by post according to the data recorded by the detection camera. Here is a picture of how the E-Z pass system works. The E-Z pass system is also equipped with RIFD or Radio Frequency Identification technology, which is a technology that uses radio waves to identify humans or objects automatically. The most frequently used method is to store a serial number indicating the identity of a person or object, on a microchip attached to the antenna (the chip and antenna are an RFID transponder or an RFID tag). The antenna enables the chip to transmit identification information to the reader. Then the reader converts the reflected radio waves from the RFID tag into digital information that can be passed on to the computer that will use it. The advantage of using RFID technology is that the EZ Pass system is able to reduce data entry errors and reduce manual business transaction processes, provide data automatically, overcome problems in the supply chain, for example inventory that is inaccurate, fast and cost-effective and will be expanded to include: increase

sales, increase security, reduce crime and improve customer service.

#### 2. Taiwan (R.O.C)

Taiwan was the first country to implement from manual toll roads to all- electronic, multi-lane highways on all of its highways (Multi Line Free Flow).

#### a. Use of e-Tags for Toll Payments

Taiwan was the first country to switch from a fixed-fare toll station to a distance-based pay-as-you-go toll system on all of its expressways. The Taiwan Highway Electronic Toll Collection System (ETC; Chinese: ; pinyin: Gāosù Gōnglù Diànzǐ Shōufèi Xitǒng) is used to collect tolls electronically on national highways in Taiwan. All tolls are collected electronically by multi-lane free-flow overhead gantries instead of traditional toll gates. Taiwan was the first country to switch from manual tolls to all-electronic multi-lane freeway tolls on all of its expressways. To simulate the previous model, in which vehicles would not pass through toll collection via short distance travel, each vehicle received 20 kilometers per diem of free travel and thereafter billed NT\$1.2 per kilometer. Buses and trailers are subject to a heavy vehicle surcharge. Highway administrations may change fares (e.g. clear per diem) during peak travel seasons to facilitate distribution of congestion until midnight.

The toll gate divides the highway into segments, each of which has a price value determined by the distance to the next gate (intersection). The daily gate count is calculated at midnight, and the total cost is deducted within 48 hours. Each vehicle receives a further discount after the first 200 kilometers, and eTag customers with prepaid accounts get a further 10% reduction. Non-customers are billed with license plate recognition and mailing reports, or can make payment at the convenience store on the third day after the vehicle trip, because ETC subscription is not mandated by law.



Picture 2. Installing e-Tags on Vehicles in Taiwan.

The number of cars that have an eTag, an electronic tape attached to the windshield, already exceeds 6 million – equal to 94% of registered vehicles. Drivers whose cars are equipped with RFID eTag no longer have to slow down to pay tolls at the toll gantry. Instead, a total of 319 electronic gantries have used RFID (radio frequency identification) technology to track vehicle progress along the freeway, automatically.



Picture 3. Installation of e-Tag Readers and CCTV Readers at Toll Gates in Taiwan.

Vehicle owners can add money to their e-Tag account at 11,000 outlets across the area, including convenience store chains or can make payments via mobile fintech, bank transfer and included with phone bills. Despite heavy freeway traffic an average of 14 million trips daily. The fully automated system has achieved an accuracy rate of 99.9998%, Taiwan's transportation department uses this system to make fare differentials for passenger cars, buses and trucks, as well as fare adjustments during busy times or in congested areas.

Implementation of Non-formal Education at the Education and Culture Office of Mamasa Regency, it was concluded that several things were needed by customers in Mamasa Regency such as advanced courses for Non-formal Education alumni, infrastructure for supporting services for Non-formal Education and improving the quality of teaching staff in the Non-formal Education unit, which was very much needed by work partners. In the field of Non-formal Education in Mamasa Regency, the strategy for the quality of Non- Formal Education services at the Mamasa District Education and Culture Office, it is necessary to understand the strategy in service delivery



so that customers feel satisfied and feel valued when providing services, besides that it is necessary to apply SOPs as standards in service delivery. especially in the field of Non-formal Education, as well as support and commitment from all apparatus at the Mamasa District Education and Culture Office and Non-formal Education partners regarding understanding and behavior that must be changed in m providing services and equipping infrastructure to support services in the field of non-formal education so that the services provided can be maximized and the information submitted by internal and external informants on services in the field of non-formal education in general can be said to be good, but there are still things that need to be improved and perfected by the work unit of the Mamasa District Education and Culture Office, especially in the field of Non-formal Education regarding the quality of services that will be provided to customers so that they feel satisfied and feel valued in receiving services.



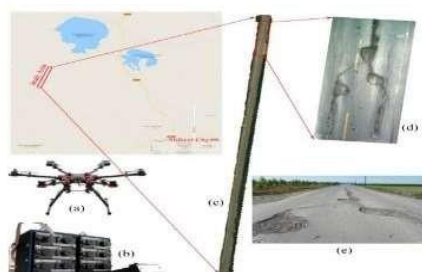
Picture 4. Radar and CCTV Working Mechanisms on Toll Roads.

- The ETC network covers 1,050 kilometers of expressways, making it the largest system in the world of its kind. Since its introduction, the eTag has slashed ride times from five to 30 minutes for most riders, resulting in substantial fuel savings. Combined with the elimination of printed toll tickets, the total savings from the introduction of this new system are calculated to be approximately NT\$2 billion (US\$66 million) per year.

#### Road Maintenance by MOTC (Ministry of Transportation and Communications)

There are about 20,000 kilometers of highway network in Taiwan, mainly covering three north-south national highways (No. 1, 3 and 5), as well as five east-west expressways (No. 2, 4, 6, 8 and 10), which spans a total length of 1,050 kilometers of the toll collection system electronics has been fully applicable on highways since late 2013. In addition, there are 98 provincial highways in Taiwan, including 12 east-west expressways.

In order to provide convenient and comfortable transportation services and increase the desire to use public transportation, Taiwan's Ministry of Transportation (MOTC) continues to work to facilitate movement between various modes of transportation, improve safety, and build "smart" technology and electronic ticketing systems. Furthermore, MOTC has implemented road inspection using photogeometric UAV technology, capturing data and analyzing it to improve road maintenance effectively, efficiently and accurately. In addition, it helps the safety of transportation for the community by reducing the number of accidents and injuries due to traffic accidents.



Picture 5. (a) Multirotor UAV. (b) MCA snap12 camera. (c) MCA image results. (d) Example of a cracked road drawing. (e) Photo of damaged road spot MCA : Multiple Camera Array system.

The Taiwanese government has saved time and money on road inspections with drone data. The team chief engineer in administration and field is responsible for flying the drone once or twice a week. Smaller projects only take 15 minutes, while larger ones can take some time up to two hours. When comparing this with traditional survey methods and UAVs, the time cut from traditional methods, using a road survey UAV covering approximately 5 km (3.1 miles) requires three UAV units, each lasting between 18 and 22 minutes. This adds up to about an hour of flight time. In flight at an altitude of 100-120 m (328- 394 ft) and using a government base station to correct for accuracy to about 2 cm (0.8 in) accuracy. The administration department primarily looks at the volume of damage and potholes with the tightest possible tracking across the entire project. One of the main ways drone accuracy proves to be cost-effective is its ability to help contractor work progress. The government hires contractors to build roads, with drone data, it's easier, faster and more accurate to compare estimated work to what's actually happening on the ground.



Picture 6. Road Inspection Method by UAV.

The devices and protocols used in conducting road inspections are as follows:

#### 1. IoT devices

System inspection involves the cooperation or synchronization of many components in the control architecture. To complement UAV inspection with capabilities network and data processing, Broadband IoT installed, respectively including: processor and microcontroller as with processor, IoT based devices can connect to network wifi as well as process recipient data via Linux or Android operating system. The microcontroller allows other hardware devices to be integrated into an Internet Protocol (IP) based network.

#### 2. Communication Protocol

Along with IoT hardware, communication protocols play an important role in ensuring the security and efficiency of the distributed data. The communication protocols that can be used for IoT are Transmission Control Protocol (TCP), User Datagram Protocol (UDP), and Real-Time Transport Protocol (RTP). While TCP was originally designed for reliable static data transmission over low bandwidth (LoRA WAN), managing the error rate on the network while operating, UDP can send datagrams from device to device (D2D device to device) as quickly as possible regardless of network

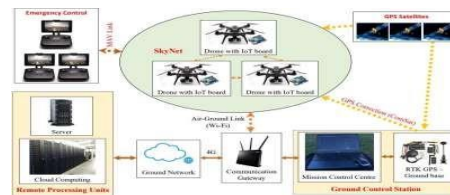
conditions. . To provide real-time multimedia data, RTP can facilitate network delay differences and detection of non- consecutive data.



Picture 7. Inspection Camera.

One of the main benefits of using IoT is its ability to perform computing and data processing at various layers of the system, namely with devices by broadband IoT, control layer by the built-in UAV computer and application layer by network server computers or cloud computing services, depending on the amount of data being transferred. will be processed and the real-time requirements needed. In the system to MOTC, broadband IoT is used to process communication data between UAVs such as position, speed, and other status information to minimize computational latency. The active control

algorithm on the other hand is handled by the UAV's built-in computer to increase its reliability. The information and other photogeometric data are processed by the server to cope with the high demand computing and energy consumption connected to the UAV itself.



Picture 8. UAV Work Structure to Data Center.

### Use of UAV Technology for Bridge Damage Monitoring

Taiwan has more than 30,000 bridges across the region with a total bridge length of 2,070 km and nearly 1.8 times the coastline of the entire island. The density of such a distribution is much greater than in most developed countries (about 0.4 for Japan and about 0.1 for the US). To make it easier for bridge management agencies to carry out inspections quickly, safely and effectively, the Ministry of Transportation and Communications (Institution of Transportation) has developed an Unmanned Aerial Vehicle (UAV) autonomous flight inspection module with the slogan "Bridge inspection at your fingertips".

With climate and environmental changes, bridges often age and deteriorate gradually over time requiring regular inspections and sufficient budget for repairs of these bridges.



Picture 9. The Transportation Research Institute of the Ministry of Transport has developed an unmanned aerial vehicle (UAV) to replace manual inspection vehicles to inspect bridges. (Provided by Operation Research Institute).

To make it easier for bridge management agencies to carry out bridge inspections, the Department of Transportation has integrated various communication equipment and technologies, including: UAV, global positioning system, obstacle detection and avoidance, inspection cameras and tablet computers, etc. The successful development of the "UVA Autonomous Flight Inspection

Module" allows bridge inspection personnel to use tablet computers to quickly and easily route flight routes. In addition, control of the UAV with autonomous flight in close proximity to the bridge will make it easier to take photos of the current condition of all parts of the bridge according to the requirements. to the specified route.



Picture 10. Photographs of Balin Bridge and Neiwan Bridge taken during UVA Autonomous Flight Inspection.

The flight inspection route can also be used over and over again. This set costs about NT\$ 150,000 dollars (Rp 7 million), which is much cheaper than the cost of buying a bridge inspection vehicle which is estimated at 1.5 million Taiwan dollars and does not require a road permit or traffic control during operation, therefore the module is indeed "a great value." very good for C/P value". To further improve

the required technology, the Transportation Agency is currently developing the use of image stitching process technology to generate 3D models, and is also conducting research on a new risk control function of fixed spot hovering for interrupted communication where the UAV will immediately return to its original place if it loses contacts and parachutes for stall devices to increase the application value of UAVs and reduce flight risks.

In addition to using UAVs for inspection, Taiwan has used BHMS (Bridge Health Monitoring System). Structural Health Monitoring enables rapid assessment of bridge health, and this approach is recognized as one of the best available means to improve general safety and optimize bridge operations and maintenance. The high cost of traditional HMS is a major challenge in transitioning traditional HMS techniques from R&D to field implementation to BHMS for the whole process.



Picture 11. UAV Ground Control Program Operation Screen.

The BHMS developed by the Department of Transportation is a new solution that is more affordable and practical because:

- One Sensor, three functions: vibration, gyroscope and magnetometer;
- Natural Frequency (3axis) + 3 axis deflection data using Gy and Mg;
- Can be connected with WiFi and Cloud;
- 100s of BHMS sensors can be installed on the Bridge in a few hours;
- Data collection and analysis can be performed within minutes after installation;
- Alarm/SMS can be shared to multiple authorities automatically – Police.



Picture 12. Sensor Under The Bridge.

## CONCLUSION

The toll road is one of the vital means needed to improve the industrial efficiency of an economy. When a country's economy relies on land transportation, of course, transportation facilities in the form of roads, especially toll roads will encourage the creation of economic efficiency in it. To achieve this, it is necessary to make continuous improvements to the technology as well as toll road supporting facilities and infrastructure. Thus, the application of technology RFID-based ETC (Electronic Toll Collection) is a solution developed to modify the existing cashless payment system with the aim of reducing carbon dioxide (CO<sub>2</sub>) emissions by 32.4%, reducing costs for externals by 60.1% and can eliminate congestion due to the accumulation of vehicles at the gate at the time of entering and exiting toll lanes; Inspection Road with UAV (Unmanned Aerial Vehicle) photogrammetry technology and the use of CCTV cameras, sensors, application modifications and software updates on the monitoring and handling system of road and bridge damage on toll roads is urgent and must be implemented



immediately so that it will save human labor to monitor and contribute to high productivity and on target.

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