

MAPPING IDEA & LITERATURE FORMAT | RESEARCH ARTICLE

Open Innovation Electronic Toll Collection Using Soft System Methodology

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ABSTRACT

Technological developments continue to develop and expand into various fields. Indonesia began implementing non-cash payments using electronic toll technology in October 2017. This research aims to analyze the implementation of Electronic Toll Collection (ETC) on an electronic toll basis as part of technological developments in the transportation sector. Technological innovation in the form of the application of ETC has provided several criticisms and a significant influence on PT. Jasa Marga (Persero), Tbk is the market leader in Indonesia's toll road management industry. On the other hand, there are many benefits that PT can optimize. Jasa Marga (Persero), Tbk, from implementing ETC. This research shows how an organization or company can manage the impact of open innovation on profits through the right strategy. The Soft System Methodology approach analyzes the complexity of implementing ETC for PT. Jasa Marga (Persero), Tbk. This research collects data in the form of facts stored in the form of research, documents, information, and related regulations through documentation techniques. This research explains the strategy PT uses. Jasa Marga (Persero), Tbk, is dealing with the implementation of ETC, which is explained through the seven stages of SSM ETC, as a new technology obtained through open innovation. Open innovation in an organization or company can be successful if it is responded to with the right strategy. The success of an innovation is if all parties can accept the innovation.

Keywords: Electronic Toll Collection, Open Innovation, Soft System Methodology.

I. Introduction

Technological developments continue to grow and expand into various fields. Transportation is one of the fields that follows the development of technological knowledge. The transportation sector has a relationship with economic development. Transportation innovation is a supporting instrument for a country's economic welfare in achieving efficient and sustainable mobility. Transportation is the factor that most affects the productivity of private companies and even the quality of business carried out (Highway Administration, 2011). Transportation innovation dates back to the 20th century. Introducing the term "toll road" in the European Union marked an innovation in transportation. In the 21st century, innovation in transportation was driven by technological developments known as Electronic Toll Collection (ETC). This innovation was motivated by the ineffectiveness of toll tariff collection. This innovation began with the idea of the EZ Pass System, which was introduced as a toll road technology that could reduce service time, delays, and vehicle emissions (Rich, 2008)



Transportation innovation is not without obstacles and has received criticism from various parties. Roth (1998) criticized the practice of developing innovative toll road systems in various countries. Four weaknesses are conveyed, namely, the first system developed only increases the operational costs of vehicles. Second, the cost of community income is also reduced because the distribution costs are increasingly expensive. Third, vehicles passing through toll roads are not different from ordinary roads. Fourth, the security of the toll road system is still worrying. In Indonesia, this transportation innovation is also happening. As a country with a large area and many people, of course, it also makes the mobility of its people high. The growth in the number of vehicles continues to increase yearly. Transportation is necessary due to economic, social, and other activities.

One of the transportation facilities in Indonesia is a toll road. Law No. 2 of 2022 concerning roads states that road development aims to provide basic infrastructure in public services and use economic resources as part of the national transportation system through a regional development approach to achieve connectivity. At the beginning of toll road operations in Indonesia, there was only one payment method: traditional and manual cash payments. Toll fees are collected at the toll gate based on the distance traveled and the classification of the vehicle. This payment system is considered less effective because each transaction takes 8-10 seconds. This long transaction process can cause queues of vehicles that lead to congestion. In addition to causing congestion, this system has other obstacles, such as transaction control, that cannot be carried out optimally by the Toll Road Business Entity. The manual system allows miscalculations and fraudulent practices by toll collectors. With these problems, technology updates are needed in the toll road payment system.

Technology updates also benefit toll road users. The use of technology can not only provide vehicle distribution trends for toll road managers and assist road users in obtaining accurate travel time prediction information (Luo et al, 2022). Technology upgrades on toll roads also allow operators to have analytical data on road users. Records of road user profiles and movements can be stored using technology. Digitization of processes allows service providers to collect digital records containing accurate descriptions of all user transactions (Borges et al., 2022). However, since this involves personal data, the technology must be designed to maintain the driver's privacy (Borges et al., 2022). Many options for toll payment technologies have been developed in various countries. Toll payment systems in different countries have various technologies, such as based on highway usage schemes, peak or non-peak, or based on travel distance (Zhou et al, 2023). For example, the technology used in India is based on Radio Frequency Identification Technology with its product, FASTTag. This system was developed in 2014, but has only become the only payment option since 2020. All vehicles must use FASTTag to pass through the toll road. However, it turns out that the penetration rate of using FASTTag is still very low, where its use is still dominated by buses, multi-axle vehicles, trailer trucks, and government vehicles (Bari et al., 2023). In other countries, for example, Taiwan, has been used since 2005 using On Board Unit technology and then switched to RFID technology in 2012. At that time, Taiwan was the first country in the world to use an all-electronic toll collection system (Lai et al., 2021). The system used is called e-tag, without the need for toll gates.

Today, the application of toll transaction technology implemented in Indonesia is electronic toll (e-toll) technology that uses electronic money cards with chips. Toll road users are required to fill out an electronic money card with a sufficient balance to be able to travel. The use of this technology was agreed upon between the Ministry of Public Works and Housing and Bank Indonesia through a Joint Agreement on Cooperation and Coordination in the Framework of Implementing the Tasks of Bank Indonesia and the Ministry of Public Works and Housing. This technology also received various criticisms from related parties. Labor unions have criticized the implementation of e-tolls for increasing unemployment. According to the labor union, five workers were laid off at each toll booth. From the user's side, it also received criticism because users need additional time to fill in electronic money on the EDC machine, and there are difficulties in adjusting the distance between the car and the payment machine, so that they often experience collisions/scuffs on their vehicles (Media, 2017).

This research studies one of the state-owned companies engaged in toll road management, namely PT. Jasa Marga (Persero), Tbk PT. Jasa Marga (Persero), Tbk (Jasa Marga) is the first and largest toll road developer and operator company in Indonesia, with a market share of 48% for the length of commercial toll roads that have been operating (JSMR, 2023). Jasa Marga, the market leader in toll road management, has fully implemented this ETC technology since 2017. Jasa Marga manages 3.5 million daily transactions and revenues of 14 trillion rupiah annually. ETC is a crucial technology and needs to be managed well by PT. Jasa Marga dramatically affects the company's overall performance.

PT. In this case, Jasa Marga uses the concept of open innovation as an approach to implementing ETC in its transaction system. Open innovation emphasizes the importance of stakeholder engagement and shared values to deliver sustainability (Gould, 2012). Open innovation provides a paradigm in modern industry where linear innovation can no longer adequately explain innovation activities, so organizations must collaborate with externals by exchanging knowledge, technology, and resources across their organizational boundaries. To be able to continue to compete, organizations cannot innovate alone but instead establish relationships with various types of partners, ranging from suppliers to customers, as well as universities, research centers and even competitors (Bigliardi & Galati, 2016) Furthermore, this study aims to analyze the application of ETC at PT. Jasa Marga uses the SSM (Soft System Methodology) method.

II. Literature Review and Hypothesis Development

2.1. Open Innovation

Open innovation was first proposed by Chesbrough (2003) and is based on the need for firms to combine internally and externally developed ideas and technologies to create business value two avenues can be taken to support the open innovation process, namely technology exploration through the acquisition of external ideas and technology exploitation through the utilization of internal technologies outside the firm's boundaries (Chesbrough & Crowther, 2006; van de Vrande et al, 2009). Many researchers suggest that innovative ideas often come from outside the organization. The internal development of a company not only allows the generation of new knowledge in general but also increases the ability to assimilate external knowledge (Cohen & Levinthal, 1990). Open innovation provides greater access to external expertise, lower technology development and improvement costs, faster market time, and better product quality. (Sieg et al, 2010). The open innovation process has several benefits such as (1) accelerating the innovation process, (2) shortening the launch time, and (3) creating new sources of revenue furthermore, it also adds (4) reducing research costs, and (5) sharing shared risks (Nambisan et al., 2018).

2.2. Electronic Toll Collection

Electronic Toll Collection is a system that enables electronic collection of toll payments, making it possible to collect tolls non-stop and enabling traffic monitoring (An et al., 2022). ETC can eliminate queues on toll roads, high occupancy vehicles on toll lanes and bridges, and toll collection without requiring cars to stop (An et al., 2022). As a technology that adopts the Internet of Things, the ETC system is designed for machine-to-machine communication only, such as car identification or traffic monitoring. The ETC system combines techniques and technologies that allow vehicles to pass through toll facilities. The toll road transaction system in Indonesia itself continues to evolve and innovate from time to time along with the growth of toll roads The government initiated a cashless transaction system on toll roads based on the Minister of Public Works and Public Housing (PUPR) Regulation Number 16/PRT/M/2017 concerning Cashless Toll Transactions on Toll Roads, as an effort to implement a fast and efficient transaction system innovation for toll road users. The big goal of this electrification policy is that toll transactions become more effective, efficient, safe, and comfortable (BPJT, 2022).

With the regulation that has been set, starting from October 31, 2017, the implementation of non-cash transactions is officially implemented on all toll roads in Indonesia. The congestion at the toll gate began to decrease because with non-cash transactions, the time required is only a maximum of 5 seconds. This transaction's payment tool uses electronic money card-based technology, e-toll.

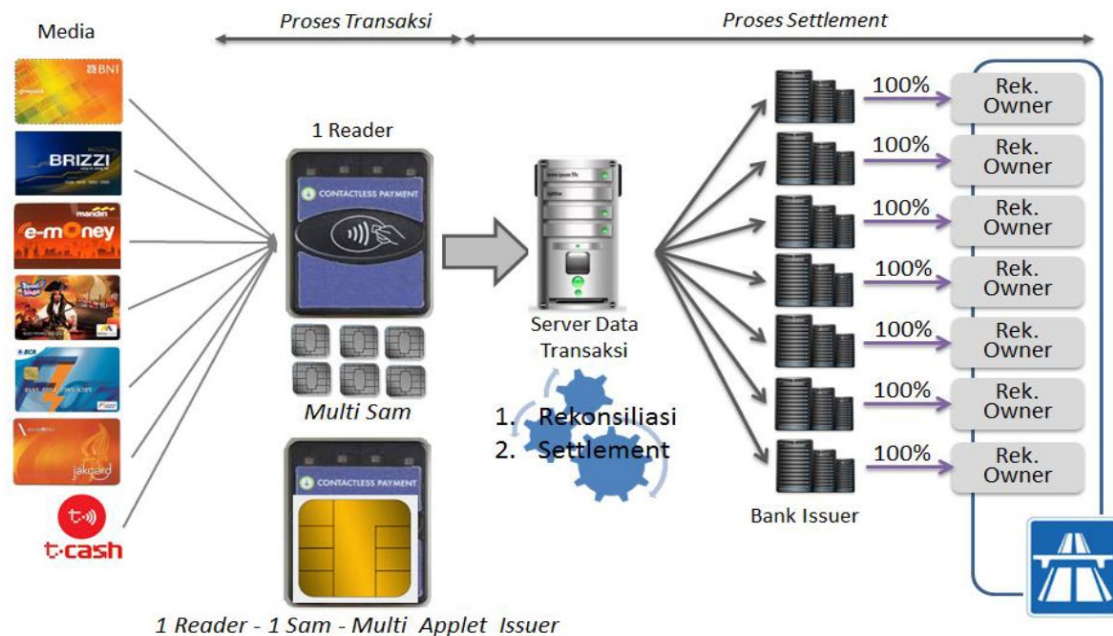


Figure 1. Configuration of the e-toll system

ETC systems require practical and quality-assured evaluation and a complex set of hardware and software (Tseng & Pilcher, 2022). ETC combines the measurement of various data, such as road usage and fares, and integrates the data (Tseng & Pilcher, 2022). These data are used for payment collection, so it is important to ensure their accuracy, quality, and security (Tseng & Pilcher, 2022).

III. Research Method

This research uses the Soft System Methodology (SSM) approach. SSM is an organized way of dealing with the perception of action-oriented (social) problem situations that organizes thinking about a particular situation so that corrective action can be taken (Budiarso et al., 2022; Devi et al., 2023; Reynolds & Holwell, 2020) (Budiarso et al., 2022; Devi et al., 2023; Reynolds & Holwell, 2020). SSM is an action-oriented process of inquiry into problematic situations where users learn by finding out about the situation to take action to improve it. Learning emerges through an organized process in which the situation is explored using a series of purposeful action models (each built to encapsulate a single worldview) as intellectual devices, or tools, to inform and structure discussion about a situation and how it can be improved (Checkland & Poulter, 2010). LUMAS stands for Learning for a User by a Methodology-informed Approach to a situation. The model starts with U (User) understanding a problem called S (situation), who appreciates a methodology called M (Methodology) to come up with a specific approach called A (Approach) to be used in a particular situation. This process results in a better situation and learning called L (Learning).

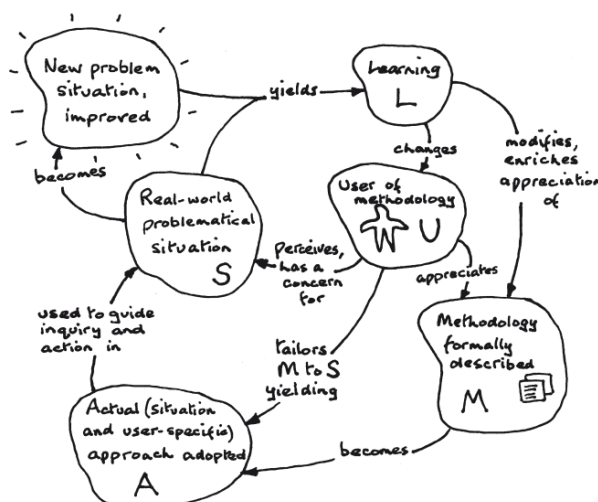


Figure 2. LUMAS

There are seven stages in SSM, the first of which is mapping the problem in an unstructured manner. The Second is that the problem situation is disclosed. Third is developing the root definition. Fourth, creating a conceptual model—Fifth, the conceptual model is compared with the real world (model comparison with the real world). Sixth, systematically and culturally, can be done, and sixth, defining/actions to improve the situation/problem.

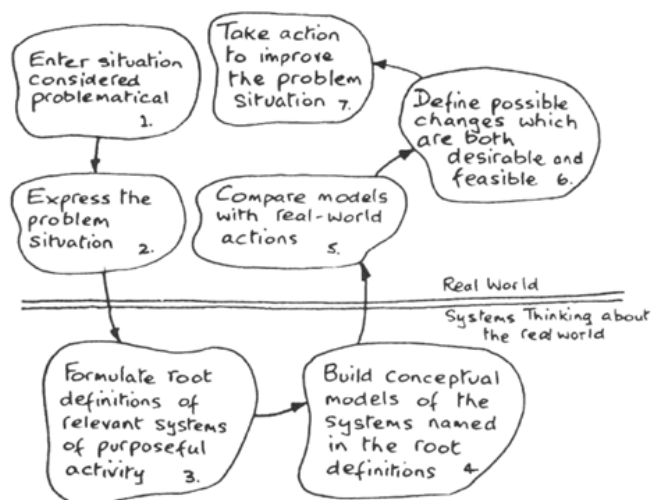


Figure 3. Stages of SSM

IV. Results and Discussion

To better understand how SSM provides exploratory learning of problem solving, this paper will discuss the context of the problem using the stages of SSM.

4.1. First Stage: The Problem Situation in Unstructured

At the beginning of toll road operations in Indonesia, only one way of payment was recognized, namely by using traditional and manual payments using cash. PT. Jasa Marga uses the same payment method as a toll road operator. In 2008, Jasa Marga innovated transactions on toll roads using electronic money issued by Bank Mandiri. Jasa Marga established special cooperation with Bank Mandiri to use electronic money.

However, the use of electronic money is limited only to a few toll booths, and the penetration of its use is also low.

Toll payments using cash require slower transaction times, resulting in queues that create congestion on toll roads. Congestion on toll roads can cause losses for road users and managers. Time loss and excess fuel consumption are some losses experienced by toll road users. As for toll road operators, congestion on toll roads decreases the number of vehicles entering the toll road due to obstructed traffic distribution. Payment made in cash also results in losses for toll operators in the form of difficulty controlling toll roads. There is a potential for fraud or error in collecting toll money that is collected manually. Toll operators also have difficulty matching the number of vehicles passing by with the toll revenue received. Toll transaction innovation in various countries has grown rapidly. As a country with toll roads since 1978, Indonesia must keep up with technological developments. Digitalizing processes in various fields has been going on for a long time, but unfortunately, the process has not been carried out on toll roads. Electronic Toll Collection is a system that enables electronic collection of toll payments, making it possible for toll collection to be done non-stop and enabling traffic monitoring (An et al., 2022).

4.2. Phase Two: Problem Situation expressed

At this stage, the researcher compiled a picture that could provide a visual picture of thoughts related to situation analysis, ranging from the primary problem relationship to the organizational context, through preparing the Rich Picture. Rich Picture is a tool to analyze the actors, structures, viewpoints related to the problem situation, and ongoing processes, as well as identify obstacles and potential problems that may occur (Checkland & Poulter, 2010). Describing a chaotic or disorganized situation using words is difficult. To provide a picture that can illustrate a diagram or a picture that can explain the relationship between elements in the system. The picture can be seen in the Rich Picture. Based on the results described in the Rich Picture, it is necessary to implement Electronic Toll Collection on toll roads as described in Figure 4.



Figure 4. Electronic Toll Collection

Source: Author, 2024

4.3. Stage Three: Develop root definition or relevant systems

The third stage of SSM is conceptualizing the purpose of the activity model in systems thinking. To do that, we need a statement that describes the activity system to be modeled. Such a description is known in SSM as a Root Definition (RD). The RD is a relevant system related to the research problem (Checkland & Poulter, 2010). In analyzing RD, the PQR formula is used, namely Do P, by Q, to achieve R, where PQR is used to answer What, How, and Why questions. The PQR formula is a tool used to conclude RD. The PQR organization in this study is the Electronic Toll Collection System run by Jasa Marga (P) based on a joint agreement between the Ministry of Public Works and Public Housing and Bank Indonesia (Q) to implement a non-cash payment system that uses Electronic Toll Chip Based technology to make toll payments more effective, efficient, safe and convenient (R).

The researcher compiled the CATWOE elements to analyze the transformation process in analyzing RD. This research uses indicators of efficacy, efficiency, and effectiveness (3E) for system performance. First, we will explain the beneficiaries of the system or transformation process. These parties are Toll Road Operator Companies, Toll Road Users, the Indonesian Toll Association, and electronic money issuing banks. Second is the party that issues regulations and SOPs, namely the Toll Road Regulatory Agency and Bank Indonesia. Third is the party authorized to evaluate the implementation of Electronic Toll Collection, namely the Ministry of PUPR, Bank Indonesia, OMBUDSMAN, the Ministry of Industry, and the Ministry of Communication and Information.

4.4. Stage Four: Creating Conceptual Models

After formulating the Root Definition, the next step is to form a conceptual model. The model is prepared by describing the system's activities to be formed and then compared with existing models in the real world. The comparison is carried out to conclude whether the model can be applied and accepted by the prevailing culture and system so that transformation can occur (Checkland & Poulter, 2010). The conceptual model in this study can be seen in Figure 5.

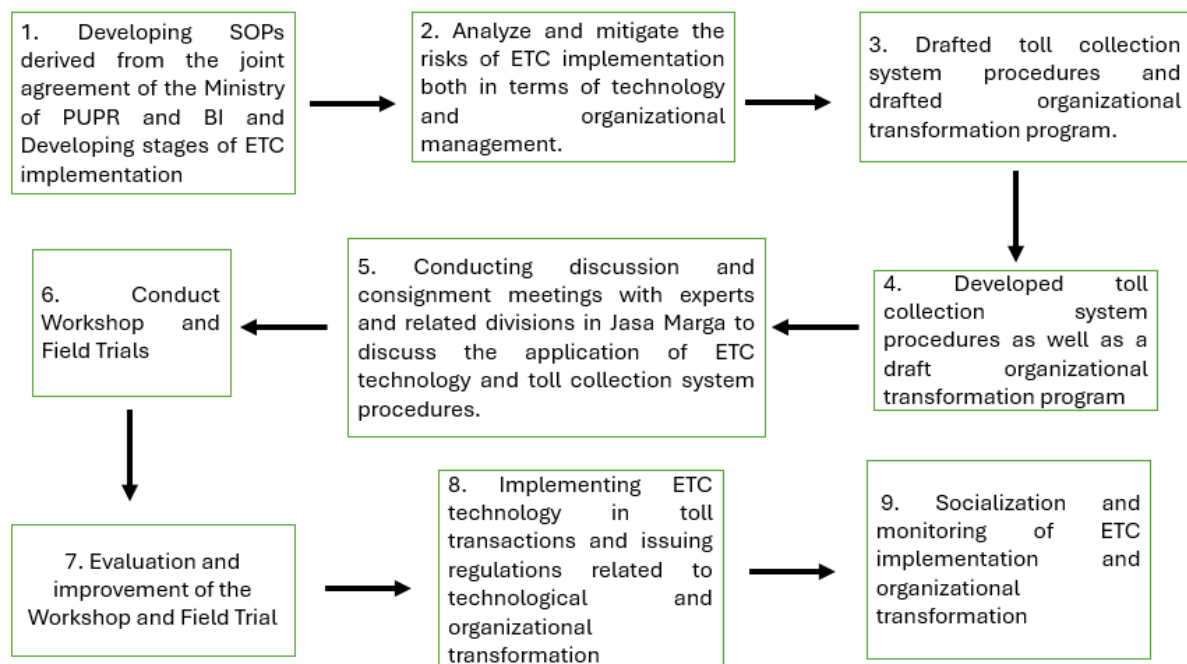


Figure 5. Conceptual Models

4.5. Fifth Stage: Conduct comparison of conceptual models with the real world (comparison of models and real world)

This stage compares the conceptual model with the real world, hoping the new model can improve the situation (Checkland & Poulter, 2010). Electronic Toll Collection, as the focus of this research, comes as an innovation in the field of transportation that was born from the problem of slow and non-optimal toll transactions. Electronic money-based ETC has officially been implemented on all toll roads in Indonesia since October 2017. The penetration of electronic money usage increased sharply, reaching 85% on average in Indonesia in 2017. The conception of joint innovation between the Ministry of Public Works and Housing and Bank Indonesia provides innovation in implementing ETC in Indonesia. Indonesia applies the concept of open innovation, which adopts innovations that have been done previously in other countries. Through MOUs and SOPs for implementing non-cash payment systems on toll roads, the government plays a role in this innovation process. As a market leader in the toll road industry, Jasa Marga is also affected by the implementation of this ETC technology. In terms of technology, Jasa Marga made changes to its transaction equipment to accommodate non-cash payments. On the organizational side, Jasa Marga transformed the transfer of operational employees affected by the application of technology. Through the A-life program, Jasa Marga has transformed its organization to survive the various pressures of the affected workforce and is efficient in its organizational structure.

4.6. Stage Six: Feasible and Desirable Change

Changes in the system must meet two criteria: desirable in principle and feasible to implement (Checkland & Poulter, 2010). Implementing ETC for Jasa Marga has a positive impact on the company. The implementation of the technology is regularly evaluated and monitored so that it can satisfy various stakeholders involved. SOP and procedure updates are carried out together to overcome the problems. Regarding organizational transformation, Jasa Marga resolves industrial disputes through official channels. This is done so that various parties who feel disadvantaged by applying ETC technology can accept the consequences.

4.7. Stage Seven: Action to Improve the Problem Situation

At this stage, the solution is implemented in the real world. The work in this research has not stopped, but will continue to be developed and refined. The development of ETC will continue with various new technologies. Development and refinement in SSM will restart the stage from the beginning and continue.

V. Conclusion

The concept of open innovation can be a solution in technology development in Indonesia, especially in the field of toll payment. In Indonesia, the application of ETC technology uses the same technology set by the government. This limits the concept of technology that can be adopted, so it requires open innovation to absorb innovations from the external side. SSM can be used to analyze the application of applied technology and determine further development. The seven stages of SSM can be used to analyze the innovation process so all parties can accept it. Innovation also has an impact on a company or organization. In this research, the study conducted on Jasa Marga shows that the company can control the impact and risk with various corporate transformation strategies. Therefore, open innovation can benefit significantly if the company or organization prepares a transformation strategy supporting the innovation process.

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