CONTINUOUS SIMULATION ON THE NUMBER OF TRAFFIC ACCIDENTS IN INDONESIA

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ABSTRACT

Traffic accidents are a serious problem in Indonesia, according to data from Central Statistics Agency of Indonesia from 2014 to 2021, on average each year there was an increase in the number of accidents by 1.40% with 218,446 deaths, 131,002 people seriously injured and 958,935 people with minor injuries, taking into account the negative impacts caused, efforts to reduce the number of traffic accidents are very necessary. Traffic accidents do not suddenly appear but rather through a series of events per unit of time in which there are two or more interaction variables, namely human error, facilities/modes, infrastructure and environmental where the severity of the losses that occur are greatly influenced by how strong is the intervention carried out on variables in order to prevent it. The research method uses modeling with continuous simulation which is validated using mean comparisons and amplitude variations for modeling in the form of a Stock Flow Diagram whose model formulation is obtained through literature studies. From the results of simulations on the model carried out in the period 2021 to 2029, it was found that increasing knowledge of safety in traffic and improving road infrastructure was able to reduce the number of accidents by 13.428% or 8,868 incidents per year if the two solutions were implemented simultaneously.

Keywords: continuous simulation; modeling; traffic accident

INTRODUCTION

Traffic accidents are a serious problem in Indonesia, according to data from the Indonesian Central Statistics Agency from 2014 to 2021 on average every year there was an increase in the number of accidents by 1.40% with 218,446 deaths, 131,002 serious injuries and 958,935 minor injuries, this figure shows that traffic accidents are still a serious problem and require proper handling. If we consider that the adverse impact caused by the traffic accident is very necessary, but the achievement of this goal will not succeed well if these efforts are carried out sporadically without knowing the actual event in the event itself, by knowing the mechanism of the actual system, the formulation of solutions to reduce it can be more targeted, One way to be able to represent a story so that it is easy to understand can be done by modeling. With the model, we can carry out experimental investigations at a relatively low cost and save time when compared to conducting experiments on real systems (Forrester, 1968). In addition, by using the model, we do not need to be afraid of the impact of risk on the actual system when conducting experiments with various purposes, of course (Suryani, 2006).

Traffic accident events do not immediately arise but through a series of events in a period of time in which there are two or more variable interactions based on so that in modeling accident events use dynamic system modeling because Dynamic Systems have feedback or feedback structures that are interrelated and towards balance (Sterman, 2000). According to William (1968) every accident is usually caused by several variables, namely human variables, facilities/modes, infrastructure and environmental variables where the severity or lightness of the losses that occur is greatly influenced by how strong the intervention is carried out on the

variables in order to prevent traffic accidents, for example based on the 2011 KNKT investigation report on traffic accidents in the form of collisions between buses PO. Sinar Jaya with license plate number B-7166-TGA with a Toyota Avanza passenger car with license plate number F-1884-HD which resulted in the death of 8 people due to the bus car suddenly changing lanes due to avoiding a truck parked on the left side of the road so that it hit an Avanza car driving from the opposite direction, this was caused by the bus driver not being able to see clearly the presence of the truck due to the absence of lighting and the lack of signs.
To formulate the best solution in reducing the incidence of traffic accidents, it is necessary to carry out simulations, according to Suryani (2006) simulations can estimate system performance under certain conditions and provide the best design alternatives according to the desired specifications. By looking at the variables that cause traffic accidents which are always changing with time, the right type of simulation to use is continuous simulation.

METHOD

Modeling uses the form of *Stock Flow Diagram (SFD)* on the event of an increase in the number of traffic accidents in Indonesia from 2014 to 2021 which is simulated using continuous simulation. The data in this study is secondary data obtained through literature studies in the form of data on the number of traffic accidents from 2014 to 2021 taken from Republic of Indonesia State Police Traffic Corps (Korlantas Polri) data and data on the causes of traffic accidents in the same year period obtained from the KNKT Investigation Report of the Ministry of Transportation from 2014 to 2021.

The object of this research is the occurrence of land traffic accidents on motor vehicles in 2014 to 2021 in Indonesia. The stages of this study include model formation, model validation and formulation of improvement scenarios where in describing the number of accidents in the early stages of the event is modeled in the form of a caustic diagram because the rate of increase in the number of traffic accidents and the number of traffic accidents itself has a causal relationship which is influenced by 4 variables, namely human variables, facilities/modes, infrastructure and environmental variables. To find out whether the model formed is representative in reflecting real events, validation is carried out on the model, model validation is the main consideration in evaluating whether the model is representative to the real state. Model testing can be done by testing the structure and behavior of the model (Schreckengost, 1985). According to Barlas (1996), there are two types of validation processes, namely using an average comparison and a comparison of amplitude variations between the value of the simulation results and the actual data value of the model with the following formula.

For the average comparison formula

$$E1 = \frac{|S-A|}{A} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

with
S : simulation average score
A : Average value of data
Model is considered valid when E1 ≤ 5%

For the amplitude variation comparison formula

$$E2 = \frac{|Ss-Sa|}{Sa} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

with
Ss : standard deviation of the model
Sa : standard deviation of data
Model is considered valid when E2 ≤ 30%

The improvement scenario is carried out on a valid model structure with the aim of reducing the number of traffic accidents where the formulation is carried out based on the results of the literature study.

RESULT AND DISCUSSION

For data on the number of accidents in Indonesia obtained from the Indonesian Central Statistics Agency for the period 2014 to 2021, it can be seen that on average the number of traffic accidents in that period increased by 1.40%, which is influenced by several causal variables.

Table 1
Number of Lakalantas Incidents in the Period 2014 to 2021

Year	Number of Accident
2014	95.906
2015	96.233
2016	106.644
2017	104.327
2018	109.215
2019	116.411
2020	100.028
2014	95.906
2015	96.233
2016	106.644
2017	104.327
2018	109.215
2019	116.411
2020	100.028
2021	103.645

From the National Transportation Safety Committee (KNKT) Traffic Accident Investigation Report, there are 4 variables that cause traffic accidents in the period 2014 to 2021 with the largest percentage, namely the human variable of 44.33% due to reckless drivers, fatigue while driving, incompetent, not vigilant and not mastering the terrain, followed by vehicle variables of 32.99% as a result of brake system failure, ODOL, poor condition of vehicle superstructure, infrastructure variables with a portion of 19.59% due to invisible traffic signs, potholes, roadside plants blocking the view, lack of equipment and road lighting and the fourth variable is an environmental variable of 3.09% caused by weather conditions such as rain and fog.

Table 2
Variables Causing Lakalantas Incidents in the Period 2014 to 2021

Year	Causative Variables			
	Human Variable	Vehicle Variable	Infrastructure Variable	Environment Variable
2014	4	1	3	0
2015	5	4	5	0
2016	5	5	3	0
2017	5	6	2	1
2018	6	4	3	0
2019	5	5	1	1
2020	6	4	1	0
2021	7	3	1	1

The number of traffic accidents is increasing by the percentage increase in the number of accidents where the number of accidents itself is influenced by 4 causal variables, namely driver/human error variables, good and bad variables of road conditions, good and bad variables of environmental conditions and good and bad variables of vehicle conditions, where each of these variables has a proportional contribution to the number of accidents that occur which according to the caustic diagram model can be seen in figure 1.

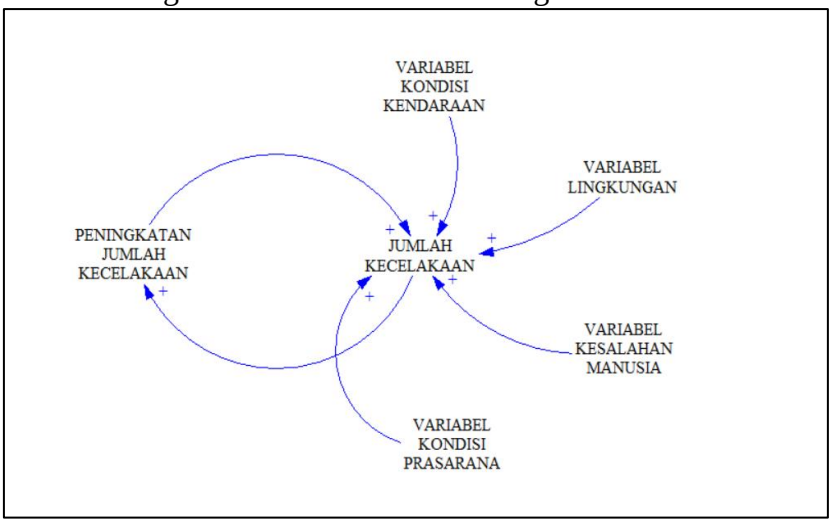


Figure 1. Casutaic Diagram of Lakalantas Incident

From the form of causal relationships and quantitative values of secondary data collection, a base model *stock flow* diagram of the increase in the number of accidents from 2014 to 2021 can be formed which can be seen in figure 2.

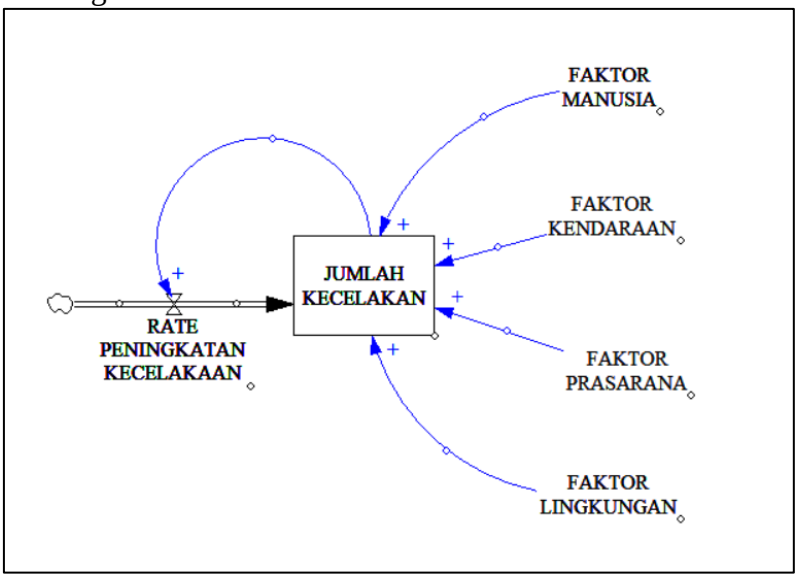
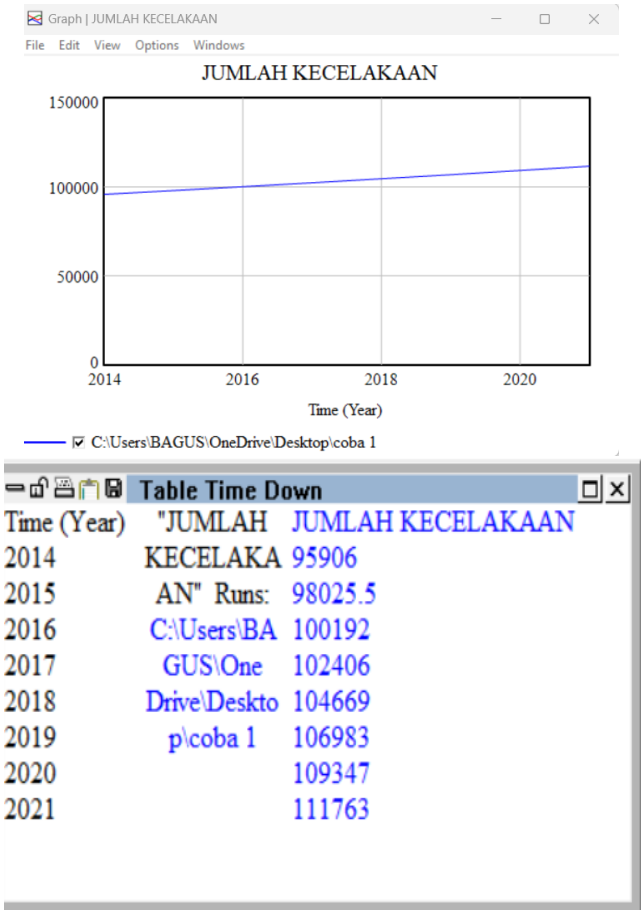


Figure 2. Stock Flow Diagram of Traffic Accident Events

As a model level, the number of accidents influenced by human, facility, infrastructure and environmental variables as an auxiliary to the level where the influence of these factors is seen from the large percentage portion of the total number of traffic accidents that occurred from 2014 to 2021, the increase in the number of accidents is influenced by the rate of increase in accidents which has a causal relationship to the number of traffic accidents itself, Where from 2014 to 2021 on average per year there was an increase in the number of accidents by 1.40%.

The simulation was carried out using the Stock Flow Diagram base model which was processed using the help of *VENSIM* Software with a period of 8 years with an initial time in 2014 and a final time in 2021 with the results as can be seen in figure 3.



From the average comparison test and the comparison of amplitude variations, the E1 value was obtained of 0.375% where the model was considered valid if E1 ≤ 5% and E2 was 19.19% where the model was considered valid if E2 ≤ 30%, meaning that the base model stock flow diagram was considered reliable to represent the actual system of increasing the number of accidents that occurred in Indonesia. To reduce the number of traffic accidents, a scenario was carried out by changing the parameter values and structure on the model that was simulated for 8 years starting from 2021 to 2029.

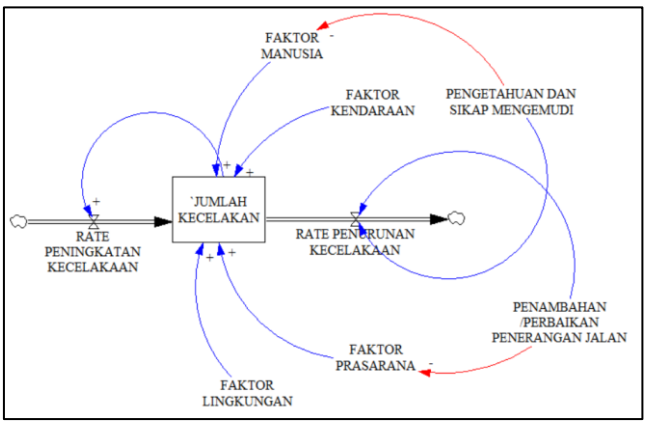


Figure 4. Structure Scenario Stock Flow Diagram

In the base model, an accident reduction rate structure is added which has a causal relationship to the number of traffic accidents, meaning that the greater the rate of decline, the lower the number of traffic accidents, which the lower the number of accidents, it will affect the rate of reduction in the number of accidents itself, where the rate itself is the sum of *the auxiliary* Driver safety knowledge and repair/addition of street lighting directly also reduces the proportion of traffic accidents that are influenced by *auxiliary* human variables and infrastructure variables with the following simulation results

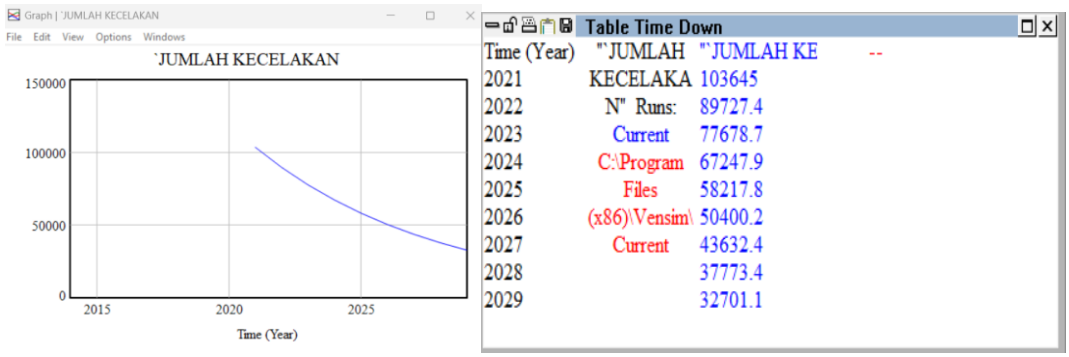


Figure 5. Data on Traffic Accident Simulation Results in the Period 2021 to 2029

From the results of the simulation of the number of accidents with model scenarioization, the results were obtained by adding factors of orderly behavior and the improvement/addition of lighting and traffic signs were able to reduce the number of accidents by an average of 13.428% or by 8,868 incidents per year.

From the results of data collection and analysis, it was obtained that the average number of accidents in Indonesia from 2014 to 2021 per year increased by 1.40%, of which the causative factors were influenced by 4 triggering factors, namely the human factor of 44.33%, the vehicle factor of 32.99%, the road infrastructure factor of 19.59% and the environmental factor of 3.09%. For the human factor as the largest contributor to the increase in the number of accidents, most of the accidents that occur are due to vehicle drivers who are not capable of driving their vehicles, as in one case in 2020 based on the KNKT Investigation Report, there were consecutive collisions located in Tanah Datar, West Sumatra, caused by the driver braking using the main brake many times, without starting the engine braking and exhaust brake techniques on the road The descent and engine rotation speed at 2500 RPM is considered over speed as a result of the air supply in the tank is depleted and the fluid that pushes the master cylinder is not optimal which results in the brakes not working eventually causing the vehicle to experience a collision event, another example of a case is the incident of a bus overturning in the Way Kanan Lampung area caused by the Inter-City Inter-Province (AKAP) bus driver could not anticipate what would happen by using the fifth gear (speed above 70 km/h) in the geometric road turned to the left and uphill as a result after passing the Way Capang bridge in Way Tuba, the AKAP bus failed at the bend and rolled over, causing the roof of the AKAP bus to hit a Crude Palm Oil (CPO) tanker truck coming from the opposite direction.
Meanwhile, in the infrastructure factor, one of the causes of the increase in the number of accidents is the lack of lighting and the invisibility of traffic signs, as in the example of an accident case in 2016 based on the KNKT Investigation Report located in Labuhanbatu, North Sumatra, there was a collision between a bus and a CPO Tanki Car parked on the shoulder of the road, this was caused by the lack of adequate street lighting, both for areas with limited visibility and intersection in the form of access in and out of/to CPO processing companies.

In a study conducted by Notoiswoyo (2014) stated that knowledge and attitude in driving have an influence of 3% on traffic accident prevention efforts, one form of effort to increase knowledge for drivers is by holding Defensive Driving Training (DDT) training every year, the more knowledge obtained, the more positive the behavior will be carried out (Arianto et al, 2021). Meanwhile, according to Ruktiningsih (2017), in the state of California, the installation and repair of street lighting lights can reduce the number of accidents there by 15%, which in this study if the two efforts are applied and simulated on a model simultaneously for 8 years from 2021 to 2029, the result of a reduction in the number of accidents is obtained by 13.428% or 8,868 incidents per year.

CONCLUSION

In traffic accidents from 2014 to 2021, there was a causal relationship between the rate of increase in traffic accidents and the number of traffic accidents, where the rate of increase was 2.21% of the number of accidents and the number of accidents increased every year following the rate of increase of the accidents, while the number of traffic accidents itself was influenced by human factors by 44.33% and vehicle factors by 32.99% infrastructure factors 19.59% and environmental factors 3.09%. By increasing traffic safety knowledge and repairing/adding street lighting lights at vulnerable points from the model simulation, a decrease in the number of accidents was obtained by 13.428% or 8,868 incidents per year from 2021 to 2029 if the two solutions were applied jointly and simultaneously.

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