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Design of Driver Monitoring System for Logistics Truck with Design Thinking Approach

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Abstract

The main cause of traffic accidents is risky driving behavior. Risky driving usually happens with professional drivers (logistics vehicle) and non-professional drivers (private vehicle). Professional drivers such as truck drivers with experience a higher accident rate than non-professional drivers because they have more driving hour and has a track record of high driving distances. In addition, driver working conditions are stressful because they are demanded to be on-time delivery and fatigue due to congestion, road usage limitation time from government, long administration waiting times, and if the driver has exhausted, the unlicensed assistant would take over the driving. This behavior was one of the factors causing road traffic accidents. In this study, researchers focused on the process of designing prototypes and the feasibility of solutions obtained from the performance problems of logistics truck drivers, where researchers can reduce logistical truck driver accidents and improve driver safety. The process of designing an IoT prototype uses a design thinking method that is focused on the process of investigating and creating solutions that focus on the human center using personas. The design thinking approach is used in this research to design a driver monitoring system that has the design results according to the needs and desires of management and driver. Started from the empathy phase with interviewing management and driver to obtained driver journey map. The defined phase obtained that the main problem of aggressive driving. Furthermore, the ideation phase providing solutions to problems that occur from the define phase, in this study generating ideas and creating a driver monitoring system according to the needs of the management in the form of a web dashboard and IoT devices implemented in logistics truck. The final stage is the testing phase. There are four objects of the focus of this study, that is operational during driving, vehicles, driving environment, and management which is analyzed analytically which will become a comprehensive driver monitoring system framework from the main research areas and explore their interactions. Well-designed Driver Monitoring System with a design thinking approach that can provide real-time reports during driving to prevent accidents, monitor truck operations, remote control, and historical reports.

CCS CONCEPTS • **Social and professional topics** • **User characteristics** • **Logistics Truck Driver**
Additional Keywords and Phrases:Design Thinking, Aggressive Driving, Drowsiness, Logistics Truck, Driver Monitoring System. **ACM Reference Format:Rezayanti Novia Putrika Dewi, Amalia Suzianti, and Maya Arlini Puspasari. 2021. Design of Driver Monitoring System for Logistics Truck with Design Thinking Approach.**

1 INTRODUCTION

1.1 Road Safety State

Traffic accidents are a very important safety issues either among developed or developing countries. Approximately 1.35 million people worldwide die from traffic accidents and around 20-50 million people are injured or disabled [1]. The most important cause of traffic accidents is risky driving behavior [2]. Risky driving behavior is divided into two categories, which are non-professional drivers (private cars) [3] and professional drivers who aim to be a job, such as truck drivers [4]. There is a difference between a professional driver and a non-professional driver. In the category of professional drivers are drivers who are related to their work and aiming as their profession to drive a vehicle for work purposes [5]. A professional driver aims to carry out his job as a driver, while a non-professional driver has driving objectives such as trips to work, shopping, vacations. Non-professional drivers have shorter driving times and mileage per year than drivers [6]. Professional drivers have a demanding job with driving hours of at least 50 hours per week, very common among professional drivers due to stressful conditions and fatigue while driving [7]. That professional drivers are involved in more accidents than non-professional drivers [8]. The main cause of traffic accidents is aggressive driving behavior [9]. Driving aggressively has a detrimental effect including a higher risk of collision, this is due to impatient drivers, road distraction, disputes, and shortened driving time. [10]. In Indonesia, according to official statistics from Badan Pusat Statistik report in 2018 where more than 7.5 million truck accidents occurred on roads in 2018 and increased from the previous year by 5.58%. Based on data collected from the Badan Pusat Statistik, losses caused by land transportation accidents in 2018 amounted to 272,3 billion.

1.2 Analysis of Driving Behavior

In Indonesia, based on data from the Indonesian Police, there are 3 factors that cause traffic accidents. Vehicle factors such as compliance with road engineering requirements by 9%, environmental factors by 30% and human factors causing traffic accidents by 61% related to the ability and character of the driver. Fatigue can affect driving behavior, which can lead to drowsiness or visual, cognitive, hearing, and manual impairment [11]. Driver behavior analysis has been established to improve the safety of road users and is an important part of preventing road accidents. It is determined that three main factors cause road accidents, namely human factors (driver/road user behavior), environmental / road design errors, and vehicle errors. The cause of accidents on the road is determined to be driver behavior which accounts for 95% of the total road accidents [12]. The driver monitoring system is used to monitor the driving status of the driver and to maintain driver safety [13]. Driver Monitoring system provides accurate driver's state information and alert the driver in real time when any mistake occurs from driver side [14].

Research on the Driver Monitoring System has received attention, majority of this research looks at the driver side. There is a need for research on driver monitoring systems that see from two sides, the driver and management side, where management can monitor drivers while they are operational, besides functioning as accident prevention, remote control, and historical reports. In aviation safety, design thinking is proven to provide more useful, effective and acceptable interventions. Because in design thinking, human behavior is actively used as the core of product and system development for designing interventions [15]. By using a design thinking approach in this research aims to design and produce a prototype to monitor and control the driver's operational processes during driving operations.

2 LITERATURE REVIEW

2.1 Driver Monitoring System

Driver Monitoring Systems (DMS) is a system that can observe driver information to assess his driving ability to drive safely [16] .The Driver Monitoring System is used to detect driver drowsiness the real-time system based on facial image processing of the driver to identify the driver's physical and mental state, identification is made based on eye movements which include closed eyelid movements, eye blinking, the direction of the eye gaze, which can also be detected by yawning and head movements [17]. The performance of the driver monitoring system by giving warnings on high alert conditions such as drowsiness, fatigue, and distraction This monitoring system is divided into two categories. In the first category, the detection of driver fatigue and distraction is only by processing the eye area because it is the first symptom that appears when the driver is experiencing fatigue and disturbance occurs in the driver's eye [18]. The deep neural connection between the brain and the eye is useful for detection using eye behavior [19]. Besides, other reasons when processing the eye area from the total face area have less computational complexity. In the second category, it is detected from the face and head, not limited to eye activity [18].

2.2 Digital Dashboard

The digital dashboard website is an interface used to present data by displaying several reports, diagrams, warning mechanisms, and visual indicators that are displayed in a dynamic and relevant information platform [20]. The digital dashboard website will combine and organize information on one screen by displaying the most important information so that it can be monitored quickly. An operational dashboard is a dashboard that functions to provide information directly for interests that must respond quickly, focus on monitoring with constantly changing activities. The presentation of the pieces of information is equipped with alerts and is dynamic and real-time [21]. Dashboards are used quite a lot in a variety of areas, from information about the stock market to showing air traffic. There are many reasons the dashboard is a good medium for presenting data. A well-designed dashboard should show the user all relevant information at glance and should be easy to understand [22].

2.3 Internet of Things System

The ability of a device to exchange information using an internet network is often called IoT (Internet of Things). By using IoT, control, communication and collaboration between devices can be done using the internet. Internet of Things (IoT) is when connecting things not operated by humans with the internet [23]. The data used by IoT devices refers to everyday objects and is equipped with artificial intelligence. Integrating each object with the embedded system will increase the presence of the internet [24].

2.4 Real-time Database

A database that can handle the data it carries over time is a real-time database [25]. In the design process, there is a need for interoperable integration with the core IT system, which serves to increase the complexity of the design and the technological capabilities required not only for design and production but also for sustainable functions [26].

2.5 Design Thinking Approach

Design Thinking is a user-focused problem-solving method. Design thinking is basically how designers can understand the complex ecosystem in which the product operated. Design thinking takes this concept a step further, urging designers to describe the system but put a human at the center. Design thinking is a methodology that inculcates the full spectrum of innovation activity with a human-centered design ethos. More specifically, design thinking is a discipline that uses design sensibilities and methods to match people's needs with what is technologically feasible and what a viable business strategy can transform into customer value and market opportunities. As such, it combines technical feasibility, human desirability, and economic viability into a holistic team-based approach. Design thinking consists of five stages is empathized, define, ideate, prototype, and testing [27].

3 RESEARCH METHODOLOGY

In the process of finding an IoT solution, a designing process is needed to identify the user category of the IoT solution to be designed, by making various design decisions to focus on what is important. In design thinking, researchers refer to these user categories as personas. Building Design Thinking personas are powerful and well-established tools for designing user experiences. Apart from the user experience (UX), personas can also be used to design systems and solution architectures. This makes this design thinking tool useful not only for UX / UI designers but also for architects and developers.

The research object is management and driver personnel who are related to the process of delivery goods carried out by a driver, which means that humans are learned as system users on the computer. In this study, there are two types of respondents according to their role in the operational process of delivery of goods, that is:

a. Management: Personnel who assign tasks to a driver to -send goods to customers, arrange delivery schedules, and provide instructions related to delivery.
b. Driver: Personnel in charge of delivering goods to the customer in accordance with a work order from management.

This study was conducted in five stages. There are 5 steps in design thinking. The first step starts from empathize is the process of understanding and empathizing with users. In process of empathy is related to direct interaction with users, there are several methods used. This study used primary data collection procedures through semi-structured interviews. An interview is a meeting two people who exchange information and ideas through inquiries and responses, resulting in communication and construction of meaning about the topic under study. Retrieval of data in this study using a semi-structured interview method. This method is used in order to retrieve data in depth compared to structured interviews. The purpose of semi-structured interviews is to find problems more openly and freely in which the interviewed informants asked for their opinions or feedback along with their ideas. In the define stage, the researcher disassembles and synthesizes findings from the empathy stage and provides insight into ones meaningful to the point of view that comes from the user. Researchers describe the management and driver needs were found and see their view. At the Ideate stage, researchers form ideas in the design process, where the focus is on idea generation then the idea can be formed as many as possible, then selected. In this study, prototyping uses a minimum viable product, which is Solidwork software to design hardware and Figma applications to design dashboards and design images. The

researcher looks at the management and driver reaction to the product description and confirms whether the description is suitable to be a solution. The last stage is testing, which is done with a clickable mockup by the management. In this study, a monitoring system driver has been developed that has never been used by manufacturing industry stakeholders as a solution to the problems that occur, and the solution is according to user needs. The prototype will be re-evaluated by personnel at the end of the study as a way of assessing the usefulness of the final solution.

4 RESULT

4.1 Target

In this study, the research was carried out in the warehouse expedition section of a manufacturing company in Tangerang. The interviewed personnel consisted of one warehouse manager, one HSE manager, and 6 drivers. Data was collected using a mixed approach of interviews, field observations and internal documentation. That activity begins with storytelling and sharing observations to frame the challenge, and then moves on field observations. Immediately after each point of data collection, the researcher wrote a summary of ‘facts’ and reflection in the notes. Data collection with warehouse and HSE managers was carried out through online meetings, for interviews with drivers divided into 2 where 1 driver was interviewed online, and 5 drivers were directly interview.

4.2 Empathize Phase

The researcher conducted interviews with warehouse managers, HSE managers, and drivers to understand more deeply the workflow of the driver when delivering goods. Interviews were conducted with six drivers. Interview a driver by online conference, while five drivers interview face to face. The researcher also conducted interviews with a warehouse manager and a HSE manager in an online conference. The researcher created a Customer Journey Map based on the results of interview to map the pain points experienced by drivers on delivery routes. Figure 1 shows Driver Journey Map.

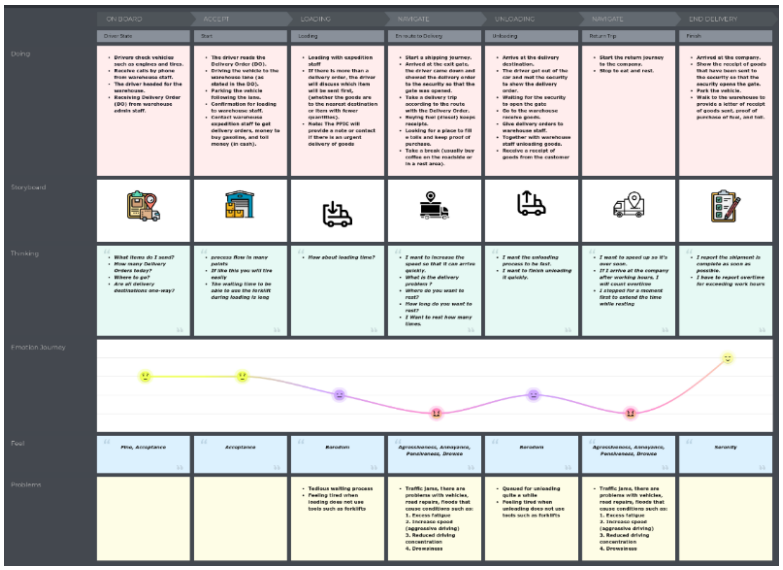


Figure 1: The Driver Journey Map

4.3 Define Phase

Through the empathy stage, the researcher defines the pain and gain of stakeholders. It is the goal of knowing the pain and final desire of all personas. The results of the pain point, the researcher tries to define the real problem experienced by the driver. Researchers also formulated the problems experienced by the Warehouse Manager and HSE Manager regarding the delivery of goods carried out by drivers. There are three personas in this research which developed based on the role of the driver's monitoring system internal personnel, namely the Warehouse Manager, HSE Manager, and Driver. Figure 2 shows user identification information describing the three personas. In complete, the three personas explain how the driver does his job in relation to the operational process of delivering goods to customers. Researchers know how the driver's job of the three personas by knowing their respective roles through interviews and then combining the information with the problem points obtained through that persona. The researcher was able to integrate how the problem at hand increased as the personnel performed their work with the workflow defined as the driver journey map.

Figure 2: The Personas from Empathy Map

4.4 Ideate Phase

At this ideation stage, the researcher collects and assembles input ideas from stakeholders as supporters in create a product that is of value to their expectations. Stage ideation aims to create an alternative solution to the pain of each person by fulfilling the selection criteria and aspirations of the personnel set in the previous phase. According to 3 personnel from warehouse manager, HSE manager, and drivers, there are five main difficulties from the job of delivering goods to customers. At this ideate stage, a solution design process is carried out by brainstorming between a researcher, two people management, and two people experts of IoT devices to get feedback and to clarify any doubts in terms of generating ideas.

Table 1: Brainstorming Result

Personnel	Pain Point	Function that the DMS should have	Elements that can realize the function	Idea Generate
Warehouse Manager	Pay overtime to drivers without evidence of overtime work	Provide a system which warehouse manager can trust what the driver is doing	Feature-The status of each stage of delivery	Digital Interface-Digital Dashboard

Personnel	Pain Point	Function that the DMS should have	Elements that can realize the function	Idea Generate
	Drivers take long breaks on delivery trips	Provide a system to controlling operational driver	Feature-Remote control in real time	Integrated hardware device (ignition) with Digital dashboard
HSE Manager	The Driver exceeds the speed limit	Provide drivers are within the speed that has been determined as a preventive accident	Speed Limiter for vehicle	Integrated hardware device (Limit Speed) with Digital dashboard
	If there is damage to vehicle the drivers are often not responsible and blame each other	Provide a system for historical reports of drivers	Feature-Drivers Historical Report	Digital Interface-Digital Dashboard
Driver	The Driver drowsiness	Help the driver detect drowsiness and alert the driver to refocus on driving - Driver	Camera that detects winks	Integrated Hardware (Detector & alert drowsiness)

4.5 Prototyping Phase

At the prototype-making stage, the researcher made a prototype in the form of a minimum viable product (MVP) from the ideate stage. A prototype that is made in the form of a prototype is a system where hardware and software are integrated. Hardware prototyping is done by designing a 3D model (see Figure 3) and designing the placement of the hardware in the vehicle using solid work software (see Figure 4). After that, print the box packaging design with a 3D printer (see Figure 5). Then the hardware components are arranged into the box packaging and programming is carried out (see Figure 6). While the software prototyping stage in the form of a digital dashboard is done by creating a clickable digital dashboard mockup, the prototype is made in the form of a wireframe that focuses on building features. The Figma application is used in making wireframes, where at a later stage the Figma application is also used to convert wireframes into higher quality forms, namely clickable mock-ups. The next step is to integrate a hardware clickable wireframe so that the results will be visible with real-time data on the digital dashboard interface. The image from the prototype cannot be displayed in its entirety due to space limitations.

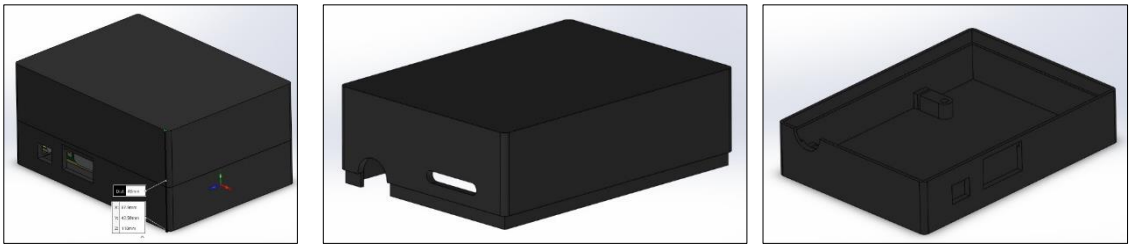


Figure 3: 3D Design of Hardware

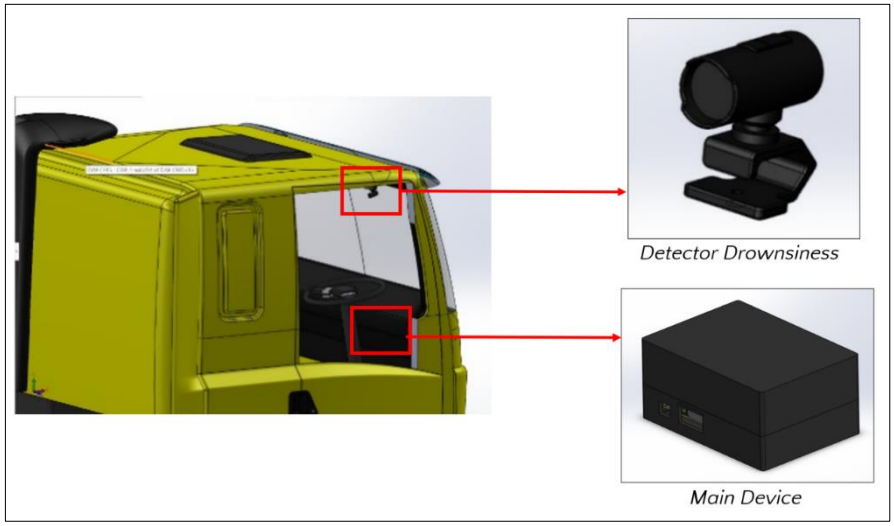


Figure 4: Placement of Hardware

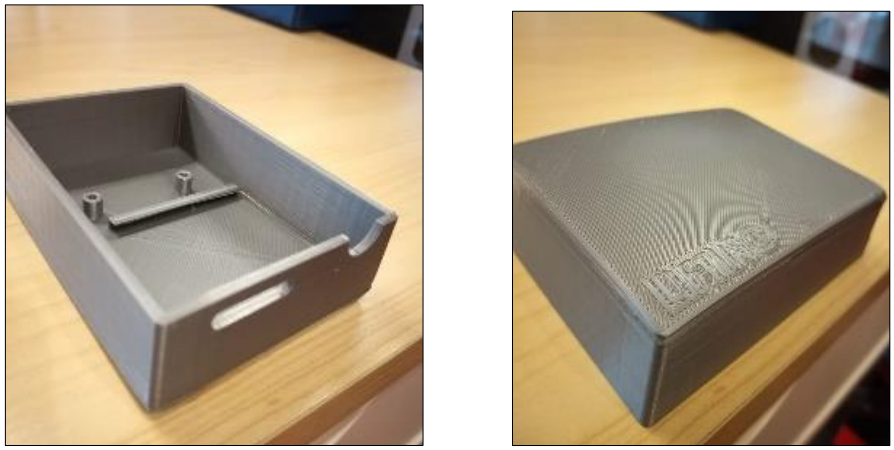


Figure 5: 3D Printer Print Results

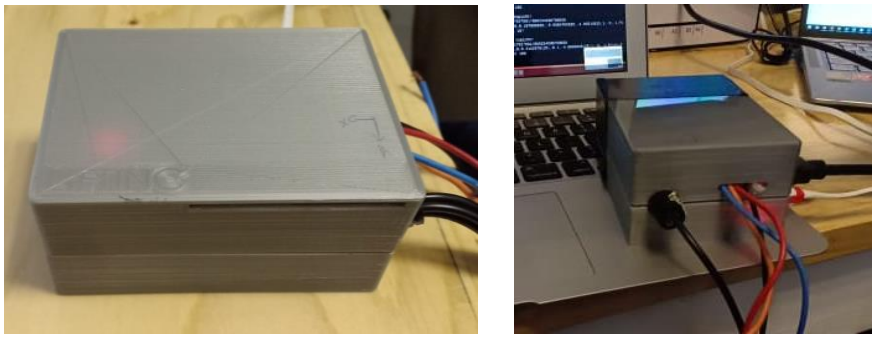
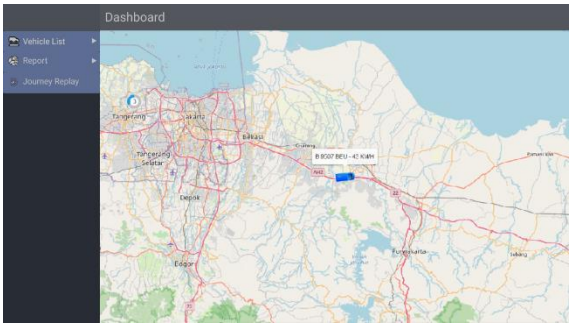
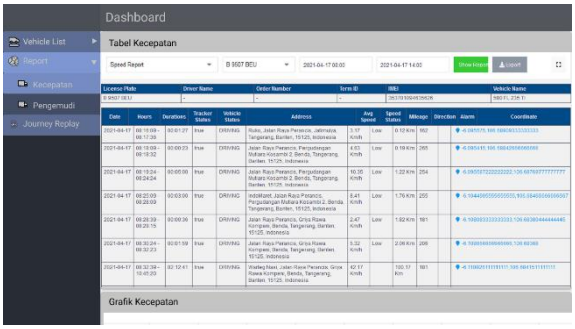
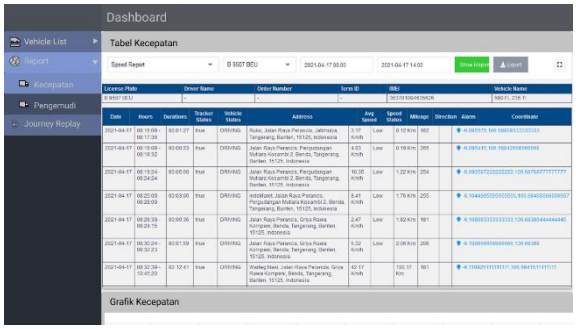


Figure 6: Hardware Component Assembly and Programming







5. CONCLUSION

Based on the stages of the design thinking process that has been carried out and analyzed, it can be concluded that this research has resulted a system that functions as a monitoring and control driver during working hours. In this study, researchers designed a design thinking approach functions as accident prevention, monitoring, remote-control and driver history reports and has been validated by stakeholders. The driver monitoring system in a feature to provide driver drowsiness uses a driver face monitoring system, which in this paper is to design a driver monitoring system in which there are a driver drowsiness detection and warning system. The drowsiness detection system is designed to prevent accidents due to driver fatigue and drowsiness. The system consists of a blinking eye sensor that parameters the eye status (open or closed) per minute. When the parameter value is more than the set limit, there will be a sound like a horn that sounds to warn the driver. Thus, accidents due to drowsiness can be minimized with this system. This driver monitoring system in this study was made to be able to provide real time reports on vehicle location data and can be accessed quickly by management, where warehouse management and HSE management are accurate when needed. This can be achieved from the use of a real time database that is integrated with a monitoring system. On the management side, the digital dashboard of operational drivers can be presented in a visual interface which makes it easier for management to be able to monitor and control drivers during operational delivery.

The following are suggestions that can be implemented in further research, including the addition of an automatic braking system aims to control when the vehicle operates at a speed that exceeds a predetermined limit. serves to reduce the speed of the vehicle slowly. If the driver is sleepy, a pressure sensor with an automatic braking system is used, which can automatically adjust to changing conditions.

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