CHAPTER I
INTRODUCTION

This chapter will explain the research background, problem identification, research objectives and contributions, research scope, hypothesis, research methodology, research plan, and writing systematics.

1.1 Background

One mode of inter-regional transportation that many people choose in Indonesia is the high-speed railway (HSR) because travel costs are affordable and passengers can continue carrying out activities during the trip. Based on Perkeretaapian Dalam Angka 2022, Direktorat Jenderal Perkeretaapian, the number of railway passengers in Indonesia is around 259,900,644 passengers [1], an increase of around 19.25% compared to two years ago (years 2020 and 2021). Fig. 1.1 shows a graph of the increase in railway passengers in Indonesia. This number has increased since the pandemic ended (year 2019). One of the HSR travel routes in Indonesia is the route that connects the cities of Jakarta and Surabaya. The railway travel time is relatively short; however, passengers can use it to increase productivity, especially regarding internet use, such as online conferencing, entertainment, or simply browsing the web with a mobile device.

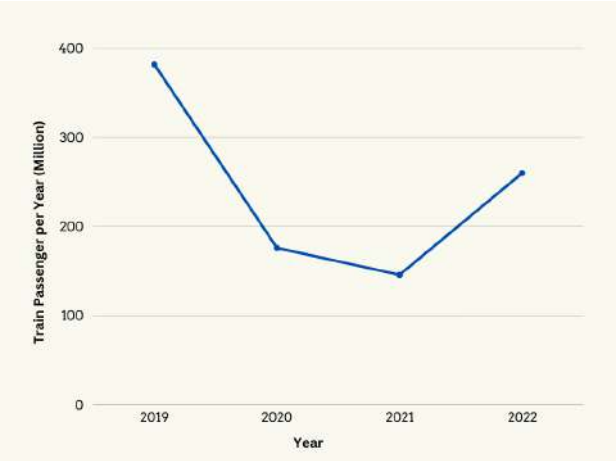

Fig 1.1 Number of Train Passengers in Indonesia.

One communication service technology that can meet the needs of railway passengers is Long-Term Evolution (LTE) technology. The railway passengers are

provided with WLAN for internet access needs, as an access point is provided during the journey. The WLAN on a railway is more or less the same as the WLAN indoors, but its characteristics must be reliable considering the fast movement of the railway and obstacles in the form of steel material as the railway's constituent material, and of course, affordable and easy to install [2].

Apart from that, the application of LTE technology also supports internet service communication along railway lines, which can enable real-time dynamic communication even though railway movements are very fast, namely in the study by [3] using the case of a 360 Km/h HSR. This research uses LTE for railway technology with mobile relay, which functions to increase communication throughput in railways, from initially 0.85 Mbps to 1.32 Mbps. The use of MIMO technology in [4], namely MIMO 2×2 and 2×4, can improve the LTE service performance, namely efficiency, reliability, and real-time communication on HSR.

Fast and ever-changing movements cause problems in the handover process between ENodeB cells, such as the signal exchange between cells that is too fast, too slow, or even the wrong cell target [5]. According to research by [6], a scheme that can improve handover performance on LTE HSR communications is the H2 scheme. This scheme is a development of the X2 handover scheme, which is commonly used in HSR communications. This scheme is specifically intended for HSR with conditions that tend to change quickly. A supporting antenna system model is also needed to improve communication on HSR. In research by [7], an LTE communication system that uses a distributed antenna system (DAS) can improve handover performance effectively compared to [8], which uses a traditional seamless dual link scheme, even though the handover performance is good already.

In the case of the Jakarta-Surabaya HSR, problems often occur in the communication process on board carriage. These problems often occur due to the diverse topography of the areas that the railway passes through. As long as the railway passes through urban areas, communication problems are not found, but after passing through areas such as suburbs, rural areas, forests, hills, tunnels, and near the sea, the stability of the internet signal is disrupted or even disappears. So, passengers onboard cannot use the internet seamlessly.

The term "seamless" describes the target condition of LTE network communication in train passenger communication, where there is no disruption or disconnection even in high mobility conditions such as on fast train trips. This term emphasizes the importance of stable and continuous communication quality during the trip to improve the user experience. Typical passengers on railways usually use the internet for video conferencing, video streaming, browsing, and messaging, which

require high throughput and low latency. Based on the standards set by internet service providers, the Key Performance Indicators (KPI) for a good throughput value for communication is at least 7.2 Mbps.

Based on the problems previously mentioned, to improve the performance and quality of LTE services for communication between passengers on the Jakarta-Surabaya HSR, it is necessary to carry out optimization activities using appropriate methods. Optimization methods that can be used are the physical tuning method and mobility robustness optimization (MRO), which are expected to improve the performance and quality of LTE services on HSR. In the [9] research, optimization was carried out by changing the tilting and re-azimuth of the antenna on the ENodeB to improve signal quality and throughput, so that it could meet the KPIs standardized by the network provider, namely the Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), and network throughput values. In the [10] research, which was carried out on changes in the movement of user equipment in the speed range of 400 Km/h to 600 Km/h.The results show that the X2-based predictive handover method is able to increase the handover success rate by up to 30% compared to the conventional method, and remains stable up to a speed of 600 km/h. However, its performance decreases at speeds above 600 km/h, so further optimization is needed.

Based on previous research and the problems with LTE communication on the Jakarta-Surabaya HSR that were mentioned previously, this research will focus on optimizing the LTE communication network for HSR passengers by paying attention to RSRP, RSRQ, network throughput, and latency values to increase performance and service quality for seamless passenger communication. Apart from technical optimization for LTE services, an economic feasibility study was also carried out to see the impact of optimization on economic aspects for passengers, HSR service providers, and internet service providers.

1.2 Problem Identification

The stability of the communication network onboard is crucial to support passenger needs, which are increasing yearly. However, fast movement causes frequent delays in communication performance and problems during signal handover, especially on the Jakarta-Surabaya HSR line, which passes through dense urban areas to rural areas, causing slow internet speeds and even loss of signal when the passenger wants to communicate. Therefore, it is necessary to optimize the network along the railway line using appropriate methods, namely the physical tuning method and

mobility robustness optimization, to increase the receive power level and reduce network latency to support seamless passenger communication onboard. This will also have an economic impact on HSR service providers and internet service providers.

1.3 Objective and Contributions

This research aims to optimize the LTE passenger communication on Jakarta-Surabaya HSR to increase the receive power level and reduce latency so that the network performance and service quality could be better, as well as analyzing it from the perspective of economic feasibility for HSR service providers and internet service providers. From this research, it is also hoped that the results could become practical recommendations for HSR service providers and internet service providers to improve the quality of communication, service, and user experience of the Jakarta-Surabaya HSR.

1.4 Scope of Work

This research will only discuss related issues and is limited to the following:

1. The research will be carried out for the Jakarta-Surabaya HSR at up to 160 Km/h.
2. The network and access point technology that will be used are LTE and WLAN.
3. Direct field measurement will be carried out, but only in simple and small-scale testing by performing real-time network measurements inside train cars and only along the train track. The network provider that will be used is Telkomsel.
4. The aspects that are optimized are the receive power level and latency of the LTE passenger communication onboard the HSR.
5. This research was conducted without considering the redundancy and survivability aspects of the network, to focus on basic performance calculations.
6. The economic feasibility aspects carried out are on the operational and infrastructure sides, as well as investment and impacts obtained by related parties (HSR provider and internet service provider).

1.5 Hypothesis

The following statements are several hypotheses related to the research conducted:

1. The optimization carried out on the LTE network for passenger communications on the Jakarta-Surabaya HSR can provide seamless connectivity for users on board the carriage.

2. The optimization carried out on the LTE network for passenger communications on the Jakarta-Surabaya HSR can improve the overall user experience, especially in terms of internet usage experience, especially for streaming, browsing, and conferencing.

3. The optimization carried out on the LTE network for passenger communications on the Jakarta-Surabaya HSR can improve the economic side for related parties, such as train service providers and internet service providers.

1.6 Research Methodology

This research used several methods as well in its preparation, including:

1. WP1: Literature and Desktop Study
   Provides appropriate theoretical concepts for the research, systems, and analysis that will be done from books, journals, and articles. As well as enriching sources and references for research-related data, this can be through annual reports or existing data from companies or institutions related to research through a desktop study.

2. WP 2: Drive Test Measurements
   Carried out using simple and small-scale network testing tools on the network along the high-speed train track and within the Jakarta-Surabaya HSR. Direct field measurements refer to the collection of empirical data in the actual operating environment of high-speed trains.

3. WP 3: LTE Network System Simulation and Optimization Analysis
   The system simulation aspect involves creating a virtual environment that mirrors the real-world scenarios of LTE communication within HSR. Optimization pertains to the strategic and technical efforts made to enhance LTE network coverage, capacity, and performance.

4. WP 4: Techno-Economic Analysis for The System
   It involves assessing the economic viability of the network enhancements, taking into account factors such as investment costs, operational expenses, and the potential revenue generation from offering seamless LTE passenger communication on the HSR.

Fig 1.2 Research Work Breakdown Structure

This thesis project involves a comprehensive work breakdown structure that encompasses multiple key phases as shown in Figure 1.2, including project initiation, literature review, data collection, methodology development, LTE network analysis, optimization, simulation, and testing, result analysis, economic feasibility analysis, conclusion, and future work. Each of these phases plays a vital role in the successful execution of the study, contributing to the ultimate goal of achieving seamless LTE passenger communication on the Jakarta-Surabaya high-speed railway.

1.7 Research Schedule

This thesis will be prepared according to the plan shown in the chart in Figure 1.3 below:

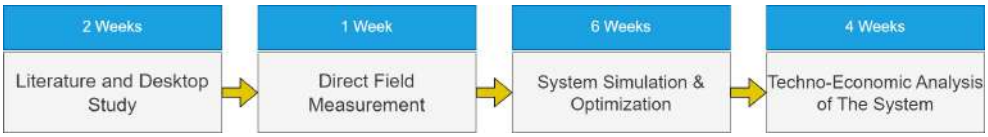

Fig 1.3 Research Plan.

1.8 Writing Systematic

The system of writing this final assignment is as follows:

1. CHAPTER II THEORETICAL BASIS
   This chapter discusses the theoretical basis related to the topic of discussion in this research.

2. CHAPTER III NETWORK DESIGN
   This chapter discusses the network design steps that will be carried out in this research.

3. CHAPTER IV ANALYSIS OF SYSTEM DESIGN SIMULATION RESULTS
   This chapter discusses the analysis carried out based on calculations carried out in the simulation.

4. CHAPTER V CLOSING
   This chapter discusses the conclusions of the network design analysis results, which have been done.