CHAPTER I

INTRODUCTION

1.1. Background

Indonesia, a maritime country and one of the biggest archipelagic countries globally, has complex issues regarding the distribution of broadband access throughout their regions. Indonesia should be able to fulfill the needs of bandwidth and connectivity throughout their region[1]. However, the geographical challenges posed by its numerous islands and remote locations make it difficult to provide consistent and widespread broadband coverage using traditional terrestrial infrastructure. Indonesia has primarily used geostationary orbit (GSO) satellites to deliver communication services[2].

Recently, the emergence of non-GSO satellite constellations, such as Starlink, has presented a new opportunity to enhance connectivity in underserved and remote areas. Starlink's high-speed, low-latency Internet service has the potential to significantly improve broadband access across the archipelago[3]. Nevertheless, the incoming of non-GSO satellites caused the potential for interference with existing GSO satellites[4].

The International Telecommunication Union (ITU) addressed this issue in Radio Regulations. These rules require new non-GSO systems to protect existing GSO satellites from harmful interference. The goal is to ensure that both GSO and non-GSO satellites can operate together without affecting the quality and reliability of communication services.

The co-frequency interference between the large non-GSO constellation and the GSO system was analyzed by Wang et al. They used Visualized Professional to analyze the interference between One web and Sinosat-5. The results show that there is severe interference between the non-GSO and GSO systems and the aggregate interference level is affected by the locations of GSO earth station. When the GSO earth station moves from 30◦N to the equator, the interference received by the GSO system becomes worse. Wang et al. also analyzed the effect of the exclusive angle on the equivalent power flux density (EPFD) for the downlink scenario where the non-GSO system interferes with the GSO satellite system at the Ka band frequency[5].

Investigated interference between non-GSO and GSO systems at Ku band frequencies Simulated downlink interference scenarios based on TLE orbital elements found that higher GSO receiver latitudes reduce EPFD interference events beyond the interference limits recommended by ITU-R[6]. The previous two studies did not examine the impact of interference on the economic aspect and did not provide regulatory policy recommendations for Indonesia.

This thesis research aims to conduct a technical, economic, and regulatory analysis of Telkom-3S as a GSO satellite and Starlink as a non-GSO satellite in Indonesia, specifically focusing on the downlink Ku-Band frequency. The study will assess interference between Telkom-3S and Starlink by analyzing parameters such as C/N, C/I, C/N+I, and the impact of interference on capacity reduction. In this research, we provide an overview of the latest regulations published by ITU-R, with a focus on the evaluation of non-GSO compliance with ITU-R. Next, we present the results of epfd the calculation for the downlink evaluation, considering we use Starlink, and Telkom 3S. To reduce the high of harmful interference we adapt the avoidance angle. We focus on the evaluation of the interference level of epfd towards the Telkom 3S's earth station.

1.2. Problem Identification

Indonesia has Telkom 3S as GSO satellites to provide communication services. But now, there is Starlink as non-GSO satellites present an opportunity to improve connectivity. However, these new satellites might cause problems by interfering with the ones Indonesia already uses which can cause a reduction in the capacity of GSO satellites. To mitigate this risk, the ITU has rectified regulations that new non-GSO satellites shall not cause unacceptable interference to and, and cannot claim protection from GSO satellites and as the existing ones. The regulation also addresses the limits of interference caused by non-GSO on GSO. There is potential interference from Starlink affecting Telkom 3S in the Ku-band downlink frequency. Therefore, it is necessary to conduct an in-depth study to assess and mitigate this level of interference, considering technical, economic, and regulatory aspects in compliance with the Radio Regulations.

1.3. Objective

Based on the background and problem identifications that underlies this thesis research, the objectives can be described as follows.

1. Conducts the technical aspect analysis of Starlink Ku-Band and Telkom-3S Ku-Band frequency band as proposed frequency downlink at 12.28 GHz with the demand in Bogor, Indonesia.
2. Studies economic impact due to potential interference which can have an effect on the capacity of a satellite Telkom-3S.
3. The regulatory studies the calculation results of downlink epfd to determine whether the results exceed the limits set by the ITU.

1.4. Scope of Work

To focus the thesis research, some limitations of the problem will be applied. Below are the limitations and assumptions of the research scope.

1. Starlink satellite that covers only in the area at ES receiver of Telkom 3S which is in Bogor and Telkom-3S has been launched and operational.
2. Technical analysis for determining the interference & emission power from Starlink to Telkom-3S at the downlink.
3. Economic analysis decreases the capacity caused by interference.
4. Regulatory analysis with a focus on the evaluation of non-GSO compliance with ITU-R based on the calculation of downlink epfd at the Radio Regulation article 22.

1.5. Hypothesis

We suspect the interference between non-GSO and GSO systems in the downlink. The one that suffered a lot of losses was the Telkom-3S satellite because it was based on the altitude where the GSO satellite was located at an altitude of 35,678 km and the non-GSO satellite was located at an altitude of 550 km, the impact of the interference resulted in a reduction in capacity on the Telkom 3S satellite we observed that the epfd would exceed the interference limit recommended by ITU-R article 22.

1.6. Research Methodology

Below are the methods used in this thesis research.

1. Literature Study
   This process studies the theories needed to understand and support the research regarding the implementation of. The resources of related theories are obtained from books, conference proceedings, research journals, etc.
2. Data Collection
   Data are collected from related research journals, satellite operators, manufacturers, and other parties that related to the satellite's operation and related to the implementation of Starlink and Telkom-3S.
3. Technical Analysis
   Identifies the technical need of interference and epfd parameters satellites can provide to take into consideration for implementing both satellites in real-world conditions.
4. Economy Analysis
   Based on the result of technical analysis that can be used as a reference to calculate the potential losses of capacity affecting Telkom 3S satellite caused by harmful interference.
5. Regulatory Analysis
   Analysis is conducted based on the result of technical analysis that can be used as a reference for the compliance of Starlink based on Radio Regulation ITU article 22.

1.7. Methodology

This methodology of compiling this thesis will be divided in several chapters as follows:

1. CHAPTER I – INTRODUCTION
   In this chapter, will includes the introduction, research background, problem identification, objectives, scope of work, hypothesis, research methodology, and writing systematics.
2. CHAPTER II – LITERATURE REVIEW
   In this chapter, presents theoretical studies that will support and underpin this research. The theory that will be conducted is about satellite communications

systems, satellite service, satellite orbit, two line elements, frequency spectrum, GSO, non-GSO, technical aspects, interference, capacity analysis, cumulative distribution function, equivalent power flux density, economic value of GSO and non-GSO satellite, regulatory of GSO and non-GSO satellite.

3. CHAPTER III – RESEARCH METHODOLOGY

   In this chapter will discuss the research scheme that will be carried out the process of data collection and analysis.

4. CHAPTER IV – RESULT AND DISCUSSION

   In this chapter will give the result of the technical, economic, and regulatory calculation and analysis is presented.

5. CHAPTER V – CONCLUSION, RECOMMENDATION & FUTURE WORKS

   In this chapter describes the conclusion of technical, economic, and regulatory analysis. It will then draw conclusions, recommendations and future research.