CHAPTER I
INTRODUCTION

1.1 Background

Satellite communication is an important network infrastructure for a wide and big archipelagic country, like Indonesia, for multi-functional services in every sector, which has not been touched yet by other communication infrastructure [1]–[3]. One of Indonesia's satellite's most vital roles is to provide telecommunication access, especially in the frontier, outermost, and least developed regions (3T area), which still do not have communication access through terrestrial networks.

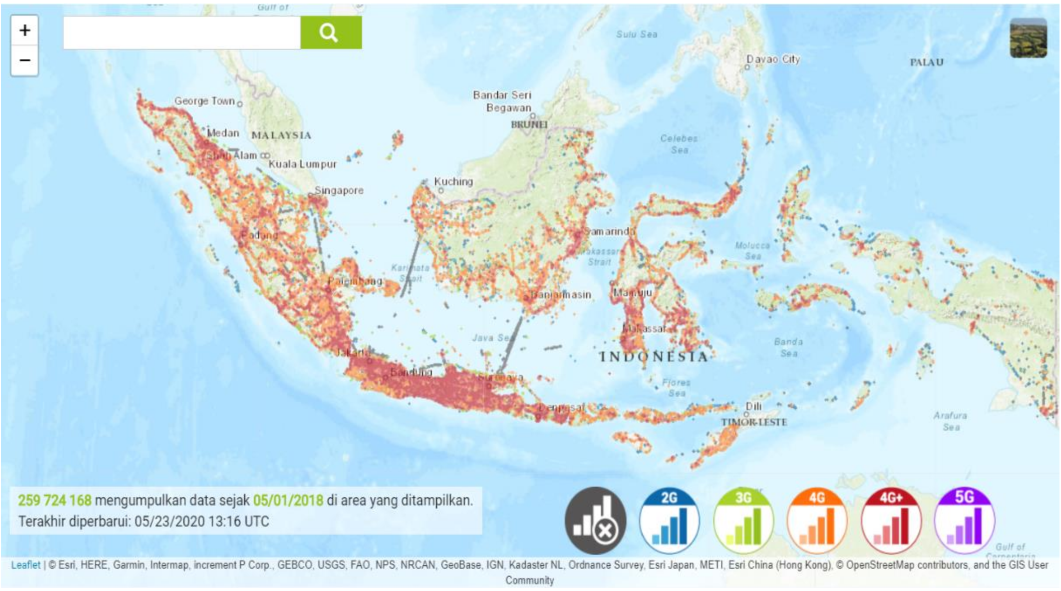

Figure 1.1 The Distribution of Cellular Communication Networks in Indonesia

Figure 1.1 shows that the distribution of network infrastructure, especially terrestrial cellular networks in the outer Java island, still does not spread equally. These will indeed be causing complicated communication access issues in the regions that become blindspot areas from signal coverage. Where most of the areas which have these issues are on the outer of java island. These problems occur because cellular network backhauling depends on optical fiber as their support network. The optical fiber network proliferation also has the same issues that it has not distributed equally across Indonesia yet. In overcoming the unequal communication access, the Indonesian Government in 2020, through

Telecommunication and Information Accessibility Agency (BAKTI), has been finishing one of the “sky highway” communication projects in the telecommunication sector, submarine cable communication. This project became the Indonesian Government's mainstay to accelerate communication needs for the outer java Island regions, as shown in Figure 1.2 [4].

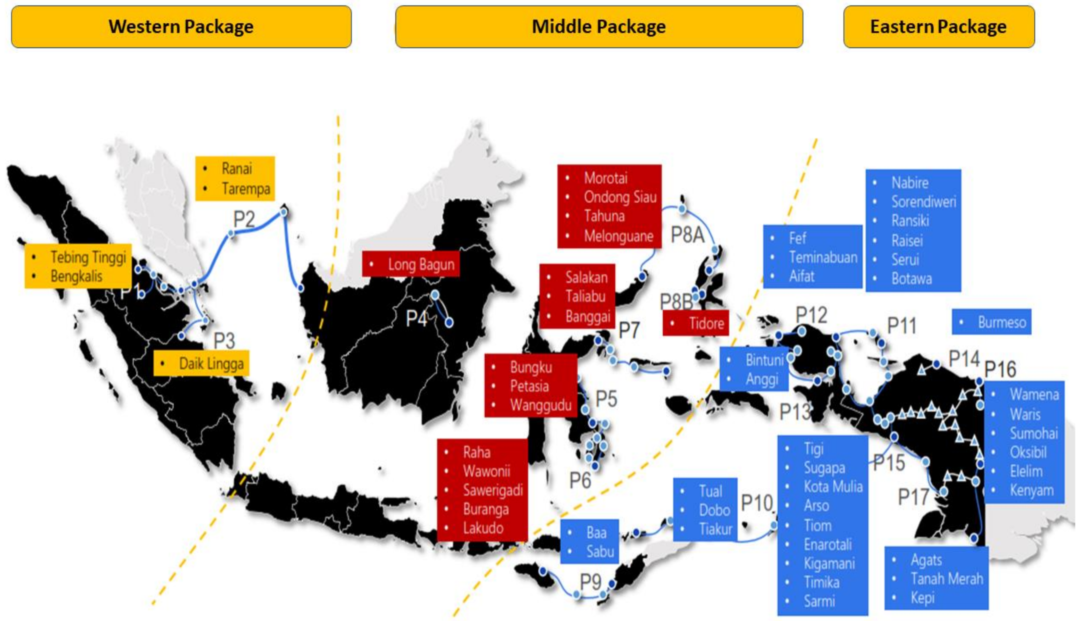

Figure 1.2 The Distribution of Palapa Ring Submarine Cable Backbone Across Indonesia

Figure 1.2 shows that the submarine cable communication project in Indonesia, also can be known as the Palapa Ring, which becomes an essential project of the Indonesian Government for equitable communication networks that have been finished by 100% achieved. However, these Palapa Ring networks still need to be connected to each internet service provider (ISP), where Core Network (CN) is usually located in a particular area. Thus, the ISP(s) still need(s) other backbones to connected their infrastructure to the Palapa Ring cable. For the other issue, suppose the bandwidth/capacity brought by submarine cable wants to distribute to either the end-user or the ISP’s core network. In that case, it still needs terrestrial optical fiber as the extension to provide broadband services. Therefore, it will take a lot of time to provide broadband service if Indonesia only depends on terrestrial network infrastructure.

On the other side, Indonesia's communication network capacity needs are growing rapidly for the Government and the people of Indonesia. The Indonesian Government needs network infrastructures for supporting their working program, also known as the Nawacita Project, that have the main objective of connecting the center of Indonesia with all of the regions across Indonesia using communication [5]. By providing reliable communication infrastructure, the Indonesian Government hopes that Indonesia's development can be carried out through the country's equitable development[6]. Therefore, it should be a certainty to provide communication networks for data access in Indonesia Regions, especially for multifunctional services, to fulfill the adequacy of capacity and extensive service coverage area aspects. One way for accommodating both aspects (enormous capacity and extensive coverage) is by implementing High Throughput Satellite (HTS) for the Indonesian Government's needs [7], [8].

The implementation of HTS is also for the Indonesian Government's effort to maintain the orbital slots owned by the Indonesian administration (INS). There are several Indonesian satellite fillings that will be or have been registered on International Telecommunication Union (ITU). The operated INS satellite network's existing condition represents INS satellite filings utilization. The number of INS satellite networks that have operated until now can be seen below [9].

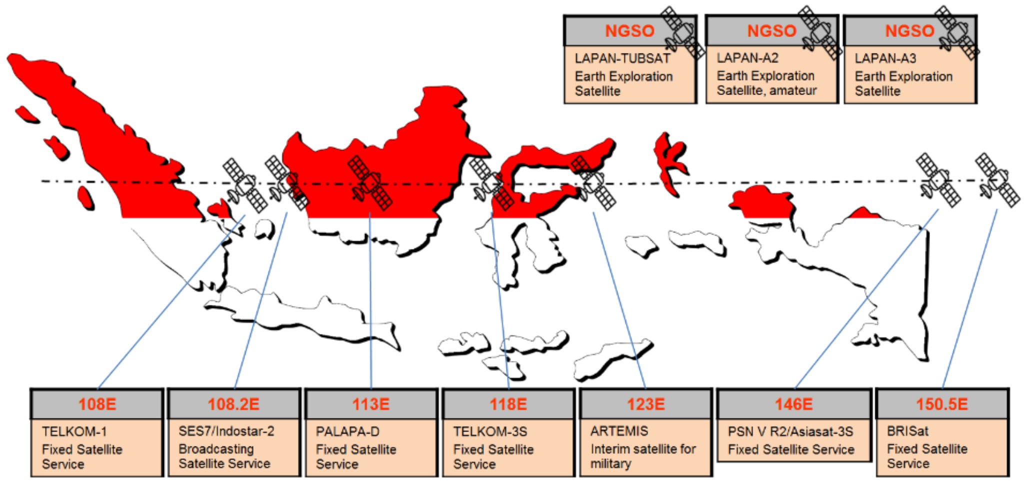

Figure 1.3 Existing Condition of INS's Orbital Slots

Figure 1.3 shows several INS satellite networks, both NGSO and GSO, representing satellite filings utilization. In the future, it is predicted will be available until 48 satellites consist of 10 existing satellites, 27 new GSO satellites, and 11 new NGSO satellites. It will also be available 13 new orbital slots if the satellite coordination with more senior satellite filings from other administrations is successfully obtained [9]. Based on the space-track database's following data, several satellites owned by the Indonesian administration are identified still operated for providing the services above Indonesia's sky.

Table 1.1 Identification of Indonesian Satellite List

Orbital Slot	Satellite Name	Notes
NGSO	LAPAN A2	The second NGSO Satellite made by Indonesia (LAPAN)
NGSO	LAPAN A3	The third NGSO Satellite mad by Indonesia (LAPAN)
NGSO	LAPAN-TUBSAT	The first NGSO Satellite made by Indonesia estimated launching around 2007
101,35E	INDOSTAR 2	Indostar 1's changer
108E	TELKOM-4	FSS
112,96E	PALAPA D	To be predicted that almost closest to the de-orbit period because it experienced several issues during launched which causes decreasing of its lifetime
118,01E	TELKOM 3S	FSS
146,01E	NUSANTARA SATU	FSS
150,51E	BRISAT	FSS, Special Comm.
157E	TELKOM 2	Almost de-orbit period

Based on the result obtained from the space-track database too, it can be known that most widely, around 10 of Indonesia's satellites are still operated. From 10 satellites that are already operating, most of them have closed to their de-orbit period. Therefore, it causes the Indonesian satellite to be far less than foreign satellites above Indonesia's sky. It can endanger the Republic of Indonesia's territorial security indirectly because the foreign satellites above Indonesia's sky are for commercial purposes and military purposes. Hence, it needs encouragement from Indonesia's satellite operator and the Indonesian regulator as the stakeholder immediately in charge of the satellite operation to increase the satellite filing utilization by launching the new satellite so that the satellite filling is not just a paper satellite. One way to increase the utilization is by implementing the HTS satellite as the new satellite technology trend for the Indonesian Government's multifunctional services.

Although the HTS implementation in Indonesia is believed can minimize those issues, the trend of HTS will use the extremely high frequency in Ku, Ka, or higher frequency band [10]–[14]. Using those frequency bands in Indonesia for the fixed satellite services (FSS) types of geosynchronous satellite (GSO) is so challenging. Considering Indonesia is located in a tropical area, means the rain attenuation that occurs in satellite signal propagation will potentially high [7], [11], [13]. Besides that, those frequencies usage in Indonesia are still rare in the satellite operator business, which providing satellite services in Indonesia. Even though several conventional satellites have used Ku-band for their business, that frequency band does not become the user's main option, whereas that band becomes one of several EHF as the HTS trends in the future. Therefore, the comprehensive analytics related to the technical and economic aspect, usually known as techno-economic analysis, is needed to give an overview of the technical and economic condition in investing the HTS if the Indonesian Government has a plan to adopt and implement that technology. Furthermore, the techno-economic analysis is addressed to examine and assess whether the HTS implementation is acceptable or not. Then, it can help the Indonesian Government to make the best decision in implementing HTS in the region.

Another problem in implementing HTS is the regulatory aspect that makes the HTS implementation in Indonesia need further study and consideration from the Indonesian Government to be ready to adopt that technology in their region. For instance, in spectrum management and coordination matters, the regulation that regulates these matters is ITU Radio Regulation [15] as an international regulatory and MCI Regulation No. 13/2018 [16] as the form of RR ratification for Indonesia. Both of them have not governed the protection through the priority services rule for the GSO FSS in the Ka-band frequency spectrum. It makes the HTS implementation in Ka-band becomes challenging, not only from a techno-economic aspect but also from a regulatory aspect. In spectrum licensing, there are also regulatory instruments from Government Regulation of the Republic of Indonesia No. 80/2015 [17], Minister of Communication and Informatics Regulation No. 24/2010 [18], Minister of Communication and Informatics Regulation No. 21/20104 [19]. From those regulatory instruments, we can figure out that the formula, variable, Constanta, and the definition stated on that regulatory have not been updated to calculate the fare of frequency spectrum usage in the HTS implementation. That's all several instances of the existing regulatory instrument's drawbacks regulation against the HTS implementation. A depth study in the regulatory analysis is also needed. There is a lot subject of regulatory analysis issues that possibly will be used to study further.

In previous related research has been explored concerning HTS implementation for Indonesia from the technical aspect [20], [21] and economic aspect [8]. In research cited [20] qualitatively discusses the important role of HTS in supporting the acceleration of broadband internet access entered the rural/ remote areas across Indonesia using technical and economic points of view. From this research, both technical and economic aspects are not clear in detail, especially about the quantitative calculation of the HTS, which the Indonesian Government needs in the future. Then from the research citation [21] discuss the comparison between the frequency band that could support HTS implementation in Indonesia using the proposal of hybrid band concept for C and Ku band satellite operation. In this research [11] discussed the technical aspect in sufficient detail, but the economic aspect is only discussed qualitatively without comprehensive quantitative calculation and studies. The other research citation in [8], discusses the comparison ability of HTS that can achieve channel capacity of about 7Gbps (C and Ku-Band satellite) and 65 Gbps (Ka-Band satellite). This research has discussed the economic aspect sufficiently, but there are still needed additional economic analyses like business feasibility studies more comprehensively. The technical aspect also did not explain in detail and still needs more improvement in this paper's technical aspect.

This thesis conducted the techno-economic analysis related to HTS implementation for Indonesian Government multifunctional services. The techno-economic analysis result was associated with the regulatory analysis for the national and international regulatory scales. The studies related to techno-economic and regulatory analysis were conducted comprehensively to determine which frequency band has a better potential for HTS implementation in Indonesia. The candidate of frequency bands that were examined using techno-economic and regulatory analysis was Ku- and Ka-Band frequency spectrum. Both frequency bands were picked up because they can easily provide more broadband frequency than C-band (existing common use), and the trend of spectrum usage is about high capacity and throughput for broadband access.

On the other hand, both frequency bands also have high attenuation and fading challenges, especially in the Indonesia region, which is needed in-depth study related to the technical aspect. The technical analysis observed the overview of the link budget analysis, capacity, and coverage analysis that was able to be provided by HTS implementation brought in this thesis research. The economic analysis study was conducted using a business feasibility study considering several parameters of the economic analysis, such as Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP), and Profitability Index (PI). The regulatory analysis study also was conducted to determine the impact of the existing regulations on the HTS implementation for Indonesian Government multifunctional services. The regulatory analysis aimed to maintain the harmonization of regulation for both national and international scales so that the HTS implementation can match those regulations. Therefore, the comprehensive analysis of techno-economic and regulatory of the HTS implementation for multifunctional services in Indonesia has an important role in helping the decision-maker in order to consider all their possibility about the HTS operation later.

1.2 Problem Identification

The problem identifications in this thesis research are shown below.

1. Indonesia has an important issue in rolling out its network infrastructure as an archipelagic country, making inequality of network infrastructure between Java island and outside Java Island.
2. On the other hand, broadband access and internet user penetration are running rapidly in Indonesia. Thus, the network infrastructure should be implemented as soon as possible to meet the broadband access availability.
3. The HTS implementation has a vital role in providing telecommunication network infrastructure. Therefore, maintaining the orbital slot allocation and frequency assigned by ITU to the Indonesia administration (INS) should get attention from the Indonesian Government.
4. The techno-economic and regulatory analysis concerning HTS implementation in Indonesia is needed to know the HTS investment's feasibility from techno-economic and regulatory perspectives. Furthermore, it is important to recognize the risk of high investment in HTS implementation and support the Indonesian Government in deciding on HTS implementation.

1.3 Objective

Based on the background and problem identification that underlies this thesis research, its objective can be described as follows.

1. Conducting the technical aspect simulation of HTS implementation for the Indonesian Government using proposed frequency plan (Ku- and Ka-Band) related to coverage and capacity provided by HTS, then it is associated with the capacity demand of Indonesian Government needs.
2. Find out how feasible the HTS implementation is as the Indonesian Government's investment for fulfilling the needs of multifunctional broadband-based services across Indonesia using economic analysis tools.

3. Analyzing and examining the existing regulations (both national and international) condition whether it is still relevant to accommodate the HTS implementation.
4. Recommends how HTS implementation should be related to the techno-economic and regulatory aspects comprehensively for supporting the Indonesian Government to make a decision.

1.4 Scope of Work

In order to avoid the spreading direction of the discussion in this study, several limitations of the problem will be given as follows.

1. The proposed frequency plan that will be given in the thesis research is about Ku- and Ka-Band separately for HTS implementation as the simulation.
2. Assume that the orbital slot of HTS is located above the Indonesian region.
3. Considering the service area of HTS is only for Indonesia territory.
4. The economic aspect study is conducted using the range of HTS operational period within 15 years as the average of satellite's end of life (EOL) period.
5. The technical analysis for examining the HTS's power management in the space segment only uses the link budget analysis.
6. The economic assumptions such as CAPEX, OPEX, and defined ARPU, and other support assumptions are based on the estimated value obtained by the trusted survey, satellite consultant, and report.

1.5 Hypothesis

Nowadays, the development of satellite technology has developed very rapidly. One of the advancements in satellite technology is the emergence of the High Throughput Satellite concept that can increase communication channel capacity's performance higher than the average of conventional satellite capacity[22]–[24]. The enhancement can be achieved because most HTS technology uses a higher frequency band like Ku- and Ka-band than the conventional satellite that mostly uses the C-Band. [25]. Suppose it is associated with the Indonesian environmental condition. In that case, theoretically, the usage of extremely high frequency like Ku-, Ka- or even V-band is not recommended considering the high attenuation and rain fading. [24], [26]. However, the HTS system architecture is believed to be able to minimize or even overcome the shortcomings of the extremely high frequency itself by applying the high gain in the HTS system as compensation because high loss occurs in signal propagation of its frequency [20]. Applying the high gain surely will have an impact on the narrower beamwidth produced by HTS. The narrower beam also will cause the coverage area of HTS to become narrower. Because of it, the multibeam and frequency reuse concept is always applied in HTS communication as their mainstay feature to overcome the limitation of coverage and capacity in conventional satellite communication in advance [21]. With the narrow beam, the HTS operational can be easier to manage and adjust their beam because the HTS has a good ability to do beamforming in a particular service area so that the operation of HTS can be more efficient and effective rather than conventional satellite [22], [23].

With two concepts brought by HTS, it can minimize the trade-off between capacity and coverage, which usually occurs in the communication system. The enormous capacity of HTS is able to give the more economical service prices of data usage (per bit/s) rather than conventional satellite service[8]. This economic aspect's advantages will be the main hypothetical result of economic analysis, providing broadband access networks for multifunctional services in the frontier, outermost, and least developed regions (3T area) in Indonesia through satellite communication [27].

1.6 Research Methodology

The methodology used in the thesis research are:

1. Literature Study

   The process to understand the theories needed for supporting this research study regarding the implementation of HTS for multifunctional services in Indonesia from technical, economic, and regulatory aspects, where the resources of those related theories are from books, research journals, white papers, etc.

2. Collecting Data

   Collect the data from related satellite research journals and the journal from the related parties in the satellite industry. Satellite parties consist of the satellite operator, regulator, manufacturer, and other additional parties that potentially affect satellite operation, especially related to the implementation of HTS specifically for Indonesian Government multifunctional services in the future.

3. Technical Analysis

   Identifying the technical need of capacity and coverage parameters that HTS can provide is linked as the consideration for implementing HTS in real conditions.

4. Economic and Regulatory Analysis

   Feasibility Study analysis is conducted based on three categories: technical, economic, and regulatory feasibility. Besides the three categories mentioned in advance, sensitivity analysis is also conducted to complete the study comprehensively.

5. Conclusion

   The result of the thesis research is concluded as the answer over problem identification explained in advance. In the future, it is expected to become the recommendation and suggestion for related parties, especially for the Indonesian Government, to implement the HTS for their multifunctional services so that it can finish well and on target.