CHAPTER I
INTRODUCTION

1.1 Background

The biggest obstacle in the integration of telecommunication networks in Indonesia is that 62% of Indonesia's territory is water and vulnerable to natural disasters. Indonesia is one of the countries dubbed as "*Ring of Fire Country*" which has part of the area surrounded by active volcanoes and tectonic plates that can be active at any time. [1], [2]. Therefore, Indonesia has several areas with geographical contours consisting of waters, mountains, and valleys, which are difficult to reach by wired telecommunications network infrastructure that has a large channel capacity and low latency and is a challenge for telecommunications service providers in Indonesia. [3]. In expanding and developing mobile infrastructure, Indonesia also needs backup telecommunication services that can be accessed by various regions and a broadband access network that can be accessed by various multimedia devices and non-dedicated connections to deliver fast information during disasters or emergencies. Therefore, satellite is a reliable telecommunication tool in dealing with this problem [4]. The development of telecommunications technology has led to an increase and development of needs. Therefore, through the KOMINFO program, the Indonesian government is developing telecommunications network infrastructure in Indonesia through the BAKTI program [5].

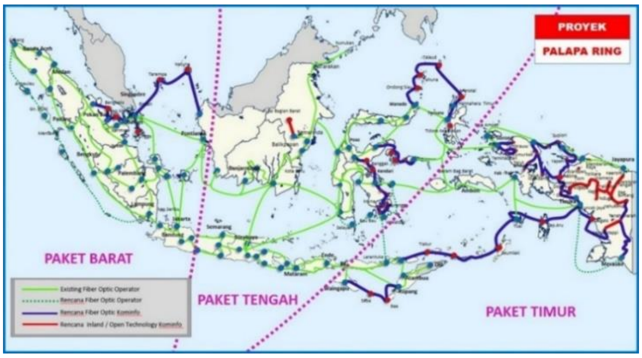

Figure 1.1 Palapa Ring Development Map[6]

Through the BAKTI program from KOMINFO, the government strives for equitable distribution of telecommunications networks in Indonesia, which uses underwater cable media (optical fiber), cellular networks, and geostationary satellite gateways so that telecommunications networks in Indonesia can be integrated through sea and air routes. One of the airways developments uses geostationary High Throughput Satellite (HTS) which aims to serve 3T areas that are difficult to access by land or sea optical cable networks but can be covered by airways, which is more efficient for installation investment costs, as has been written in PERPRES No. 131/2015 on the Determination of Disadvantaged Areas for 2015-2019 [6]. Through the BAKTI KOMINFO program, the Indonesian government opened the opportunity to tender to companies providing Indonesian satellite telecommunications networks to incur significant investment costs in efforts to telecommunications networks in Indonesia by air, namely by using Geostationary HTS satellites with a value of Rp.20.7 trillion [7], [8].

In general, satellites are a disadvantaged medium for broadband access network communications due to their conventional technology, limited throughput and capacity, and short operational time [9]. However, with the development of digital information technology and telecommunication methods, there is an increasing need for broadband access networks that can cover remote areas, difficult terrain, and prone to natural disasters. Geostationary HTS satellites have a very large throughput capacity and a wide coverage area and can operate for a long period of time. The launch of HTS satellites by the government is also an effort to maintain slot filling orbits so that they are not used by other countries registered with the ITU. Therefore, Indonesia already operates GEO and LEO satellites, namely [10]:

Table 1.1 Some List of Indonesian Satellites that Have Operated [12]

Satellite Name	Satellite Mission	Slot Orbit	End of Year Operational
TELKOM-3S	Fix Satellite Services	118° E	2032
TELKOM-4 (Merah Putih)	Fix Satellite Services	108° E	2034
BRI-Sat	Fix Satellite Services & Banking	150.5° E	2031
NUSANTARA-1	Fix Satellite Services HTS	146° E	2034
NUSANTARA-3 (SATRIA)	Fix Satellite Services VHTS	146° E	2038
Merah Putih-2	Fix Satellite Services HTS	113° E	2039
LAPAN-TUBSAT	Space & Earth Science Research	NGSO 98°	-
LAPAN-A2/ORARI	Space & Earth Science Research	NGSO 6°	-
LAPAN-A3/IPB	Space & Earth Science Research	NGSO 97.5°	-

The use of GEO satellites is one of the solutions in integrating telecommunication networks in Indonesia, which can support backhaul networks for cellular or backend systems. However, GEO satellites have the disadvantage of high latency and delay due to the high orbit of the satellite. In addition to the technical issues of using GEO satellites for the backend, large antenna dimensions are required to obtain strong signal directional power to overcome significant propagation attenuation values.

Figure 1.2 Indonesian Satellite Service Orbit Slots [13]

Some satellite companies in developed countries are starting to look at and develop low orbit satellite technology with non-fixed orbit (Non-Geostationary Satellite Orbit) based on broadband access network communications which can be a solution to overcome the problems found on GEO satellites to obtain good connectivity latency values and optimal propagation delay in order to increase the value of greater channel capacity. In addition, low satellite orbit can dimension devices in terms of users and ground stations that are smaller, practical, and lightweight and use the latest technology, namely a beamforming-based antenna alignment system that changes the radiation pattern and polarization of the antenna electromagnetically which can make hardware designs that are easy to use in a mobile manner In addition, along with the growth of several overseas companies that have begun to look at developing broadband access networks on low orbit (LEO) satellites for massive use are Starlink, OneWeb and Kuiper (Amazon). In addition, along with the growth of several overseas companies that have begun to look at developing broadband access networks on low orbit (LEO) satellites for massive use are Starlink, OneWeb and Kuiper (Amazon) [14], [15].

The company is looking to invest in the development of a broadband access network based on low orbit (LEO) satellites which has great opportunities for massive use for broadband access network connectivity businesses in areas that are isolated from internet connection networks. However, for the LEO broadband access network internet service operation license, the Indonesian government only imposes a mooring rights license that is used as a *backhaul* network on partnering local telecommunications networks.

Table 1.2 Concert LEO satellites with broadband access network services [17]

Satellite Name and company	Slot Orbit NGSO			Total of Satellite	Latency	Status
	Altitude	Inclination	Earth Orbit Period			
Starlink (SpaceX)	530km 540km 550km 560km 570km	43° 53.2° 53° 97.6° 70°	90 minutes	4487 Satellites	<25ms	Operational
OneWeb (Eutelsat)	1100km (Gen 1) 1200km (Gen 2)	87.9°	109 minutes	648 Satellites	<70ms	Operational
Kuiper (Amazon) [13]	Initial Launch Plan Q4 2024			3236 Satellites Phase 1 738 satellites	N/A	Development

Table 1.2 describes the large companies that are conducting the NGSO satellite development stage in LEO orbit for broadband access networks which have low orbits to produce optimal latency values. In addition, satellite orbits are designed to have altitude and inclination variations which can divide the capacity of satellite service users where LEO orbit satellites are starting to be looked at because of the development of new technologies that have been implemented.

In June 2024, through the 10th World Water Forum June 2024 Summit held in Bali, the CEO of SpaceX together with the Coordinating Minister for Maritime Affairs and Investment inaugurated a Low Orbit (LEO) Satellite-based broadband access network service, Starlink, which is used for health services which then becomes the starting point for Starlink to obtain an operating and business license in Indonesia for massive use and the general public on an end-user basis [14]. This is the beginning of the equalization of air-based broadband access network telecommunications networks that can cover 3T areas in Indonesia evenly. However, the presence of the Starlink satellite in Indonesia can be a threat that subverts the services and business of the telecommunications industry in Indonesia that has been going on for years. [15]. The opportunity for Starlink to circulate in Indonesia can be a threat to data sovereignty where user traffic data in Indonesia will be processed on foreign servers which have an impact on data security in the form of sensitive information such as government and company data. Therefore, the Indonesian government requires guarantees for broadband access network services in Indonesia for the implementation of Law No.27 of 2022 concerning personal data protection, Law No.19 of 2019 concerning ITE, and PP No.71 of 2019 concerning the implementation of Electronic Systems and Transactions can be implemented and enforced [16].

From the results of the above study, it can be concluded that Indonesia has a great opportunity to develop broadband access network services on the NGSO satellite for state sovereignty and have an independent telecommunications network that has a major impact on Indonesia with the aim of not relying on foreign services where the benefits of these services will be obtained by foreign companies. In addition, the impact of the LEO satellite broadband access network service has an impact on the growth of internet users in Indonesia, which has grown by almost 78% [17].

Therefore, the discussion of this thesis research will discuss the planning of broadband access network implementation through Non-Geostationary Satellite Orbit (NGSO) Orbit using low earth orbit (LEO) with equatorial line inclination through technical analysis methods that aim to design satellite orbits and coverage, as well as economic analysis which aims to find the value of investment and operational prices with the main objective of analyzing satellite modeling of broadband access networks in LEO orbit in the hope of providing a space for opinion in the NGSO satellite investment described above for the integration of telecommunications networks in Indonesia so that it can be fully sovereign for the resilience and unity of the Unitary Republic of Indonesia.

1.2 Problem Identification

In the case experienced by GEO satellites, which have very large latency values due to the influence of propagation delays where GEO satellites have a high orbital distance from the earth, which has an impact on the quality of service possessed by previous generation satellites against poor latency values [18]. In addition, the development of Non-Geostationary Orbit (NGSO) Satellite technology in low earth orbit (LEO) is starting to be looked at by the satellite telecommunications industry outside Indonesia, which has the potential and can develop into a simple and low-power device that can improve energy efficiency because low orbit satellites have a lower budget link value compared to GEO satellites [19]. Therefore, this thesis will discuss how to design a Non-Geostationary Orbit (NGSO) Satellite model on the implementation of low earth orbit (LEO) satellites with equatorial inclination to generate high throughput capacity and lower investment cost.

1.3 Objective

The objective taken in this thesis is the design of the Non-Geostationary Satellite Orbit (NGSO) network implementation using the LEO satellite with an equatorial tilt orbit using the Broadband Access Network system so that it can be as follows:

1. Modeling the implementation of a Non-Geostationary Satellite Orbit (NGSO) satellite orbit in low orbit (LEO) placed at an optimal and efficient equatorial inclination variant for regional coverage in Indonesia.
2. Calculating the number and minimum orbit requirements on Non-Geostationary Satellite Orbit (NGSO) satellites for broadband access network needs.
3. Calculate the estimated investment cost and operational cost to implement NGSO on equatorial lines for broadband access network in Indonesia.

The results of the above objectives can be used to conduct studies used for the design of Non-Geostationary Satellite Orbit (NGSO) satellite orbits in low orbit (LEO) with an equatorial inclination angle that can be used for Broadband access networks in Indonesia.

1.4 Problem Limitation

The problem limitations in this thesis topic use a technical and economic approach, where there are limitations to the discussion and limitations to the actual information. However, this can be drawn from several scientific publications, journals and data from developers. Therefore, the problem limitations on this topic are as follows:

1. Frequency band frequency allocation using only Ka-Band.
2. Discussion The satellite orbit area only covers the equatorial line and the territory of Indonesia.
3. The technical analysis only considered the two-way communication between the end-user (EU), NGSO satellite, and satellite gateway and did not address the direct-to-cellular system.
4. This topic does not explain detailed concepts for constellation communication systems (Inter-Satellite-Link) and latency in satellite systems is ignored.
5. Does not explain in detail the principles and working concepts of beamforming antennas to users or gateways.
6. Did not explain the principles and concepts of frequency Doppler and frequency handover/hopping.
7. Economic assumptions are based on the estimated values obtained from the survey, such as CAPEX, OPEX, and other supporting assumptions which can then become a model for analyzing the feasibility of NGSO satellite investment in the Equatorial Line.
8. Does not discuss advanced investment analysis such as modeling investment capital lending or bank creditors.

1.5 Hypothesis

Implementation of Non-Geostationary Satellite Orbit (NGSO) satellites in low orbit (LEO) is costly compared to GEO satellites because many orbital satellites are required to cover the entire surface of the Earth.[20]. However, the results of the implementation of LEO satellite broadband access network services have the advantage of great impact.

Therefore, the development of Non-Geostationary Satellite Orbit (NGSO) satellites placed in low orbit (LEO) at the inclination of the equatorial line region can reduce investment costs in the development of broadband access network satellites required and can increase channel capacity and good connection latency values to cover the territory of Indonesia.

1.6 Research Methodology

The methodology used in this thesis to discuss Non-Geostationary Satellite Orbit (NGSO) in low orbit (LEO) at equatorial inclination angles is:

1. Literature Study

   Describes the basic theory needed to support knowledge in implementing the NGSO satellite orbit at LEO Equatorial line for broadband access network needs. This includes technical analysis, economic analysis, and regulatory sources, as well as investment feasibility obtained from books, journals, and papers, as well as reliable internet sources.
2. Data Collection.

   Information was collected through several publications, journals, news, and papers related to the communications services sector, including manufacturers, operators, and Regulations related to implementation. In addition, data was also collected from satellite component manufacturers and developers.
3. Technical Analysis.

   Identify satellite coverage, capacity, and orbits on non-geostationary satellites. Low orbit (LEO) satellites orbit at the equator and carry payloads that support Broadband Access Networks, which can then be applied to field conditions.
4. Economic Analysis.

   The economic analysis aims to calculate the estimated value of the technical analysis in implementing a Non-Geostationary Satellite Orbit (NGSO) satellite with low orbit (LEO) at an equatorial inclination angle, the results of which can be used as an estimate of the value of investment, operation and business feasibility.

5. Investment Feasibility Analysis.

   The results of Technical Analysis and Economic Analysis can be combined as reference material in calculating the feasibility of investment for a period of less than 10 years.

6. Conclusions and Suggestions.

   From the results of the conclusion can be an answer to the formulation of the problem that can be a recommendation and proposal for the development of Non-Geostationary Satellite Orbit (NGSO) regulations in low orbit inclination angle equatorial line by carrying the payload of Broadband access network.