GISTDA SMALL TRACKING ANTENNA DEVELOPMENT PROJECT PHASE 2

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KEYWORDS: Small Antenna development, project management, tracking system, Intelligent ground system

ABSTRACT: The first Earth observation satellite owned by Thailand was Thailand Earth Observation Satellite (THEOS) with the mission was observing our country using Earth imagery applications. In 2008, THEOS is operated by Geo-Informatics and Space Technology Development Agency (GISTDA) and the Control Ground Station (CGS) was initialized and operated by Thai engineers. The communication system between the ground station and the satellite pay the main important part for the system. GISTDA's engineers have gained their skills and experience in satellite technology through the in-house projects to improve the performance of the operation system. Due to there are significant increase to use the satellite data worldwide. The new technology advances especially in small satellite technology, their performance has increased and they are cheaper to develop. Accordingly, there are more communication satellites operating in Low Earth Orbit. Consequence, the automatic tracking antenna is important for Low Earth Orbit satellite.
It is important to ensure that GISTDA and Thailand remains competitive in space technology. Space technology skill and knowledge are essential to support our country in the near future. Training activities can increase capacity building for both people and the organization. This paper presents the hands-on capacity building of GISTDA's engineers to develop a small automatic tracking antenna phase 2. The prototype has been continuing to develop in this phase and integrated to the GISTDA Ground Intelligent Network system. Moreover, in this phase the testing has been performed. The results are that the prototype can operate automatically according to the satellite location and display the status of the system correctly. Furthermore, Furthermore, the FINN system now be able to connect with the GISTDA's Ground Intelligent Network system if request.

1. INTRODUCTION

Currently, demanding of using the internet is incredibly increasing among the population around the world. Traditionally, GEO satellites are the communication satellite to operate for the applications like broadcasting and communication, where a constant connection is important. The GEO satellites are positioned at a high altitude above the Earth's equator. It appears to remain stationary relative to a fixed point on the Earth's surface [Vatalaro,1995]. They are normally used for communication, weather observation, and other purposes that benefit from continuous coverage of a specific area. The advantages of GEO satellites are such as stable coverage, large footprint, and simple ground equipment as demonstrated in Figure 1. Therefore, the higher altitude of the GEO satellite leads to higher signal propagation delays and is more expensive due to the larger and requires the larger rocket.

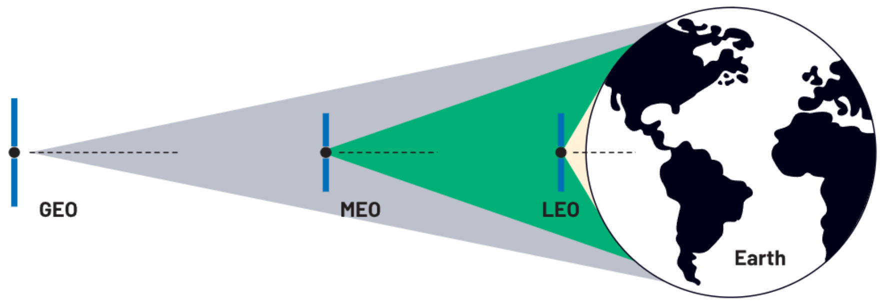

Figure 1. Earth coverage and distance from GEO, MEO, and LEO to the Earth's surface[Ryan, 2023].

On the other hand, LEO satellites are located at lower altitudes and move at much higher speeds relative to the Earth's surface [Gaur et al., 2020]. LEO satellites are often used for global communication networks, Earth observation, and various scientific and research purposes as demonstrated by the deferent position of GEO and LEO satellites in Figure 1. This picture shows that the satellite at the GEO orbit position is very far from the earth's surface if compare to the satellite in the LEO but the coverage is larger for the GEO satellite [Gaur et al., 2020]. The advantage of the satellite in the Low Earth Orbit is lower signal propagation delays making them suitable for real-time application. LEO satellites are easier and cheaper to launch, allowing for faster deployment and easier replacement of individual satellites [Jianwei et al., 2022].

LEO satellite constellations can provide higher data throughput and capacity, making them well-suited for broadband internet and global communication networks. Therefore, there are coverage gaps due to the shorter visibility window over any given location. To solve this problem the constellation satellite can cover gaps. Ground-based systems must automatically track and communicate with moving LEO satellites [Vatalaro et al, 1995]. This means the system requires more complex automatic tracking equipment. Accordingly, several big companies develop communication satellites operating in Low Earth Orbit such as Starlink, Telesat, OneWeb, and Amazon [Hayder et al., 2023]. Consequently, the automatic tracking antenna is essential for the ground system.

GISTDA's engineers have increased more in the operation and maintenance of ground station technology since THAICHOTE was launched into orbit [Plaidoung et al., 2015]. Many internal projects improve the operation system to be more accurate, have less human risk, and work automatically. [Channumsin, et al., 2019; Vongsantivanich et al., 2014]. Therefore, it is crucial to engage continually our human resources to be able to catch up with the new trend of communication LEO satellites and automatic tracking antenna. Accordingly, this project was initiated. This paper describes the component of the First InterNational AnteNa (FINN) System, which is the small automatic tracking antenna. The result of the prototype testing and the study of interfacing of FINN with the Ground Intelligent Network System (GINs) is described in this paper.

The rest of the paper is organized as follows: Section II describes GISTDA's ground station. Part III explains the project development plan. Part III explains the FINN prototype character. The next part describes the interfacing with the GINs system. The final section gives the conclusion and future work.

2. GISTDA'S GROUND STATION

Normally, Space-based earth observation system can be separated into three parts, firstly, the space segment which is the THAICHOTE earth observation satellites. Secondly, the ground segment which includes the ground control station, which controls the satellite and thirdly, the image ground station, which processes the images/data acquired from space into standard satellite images. This paper focuses on the development of GISTDA's control ground segment, which is located at Siracha Chonburi Thailand.

Figure 2 shows the GISTDA Satellite Ground Control Station overview [Vongsantivanich et al., 2014], which consist of (1) S-band station, (2) Satellite control center with the function to be an interface between the control ground station and the satellite, which includes telecommand (TC)/mission plan transmission and telemetry (TM) reception, (3) Orbital Analysis sector is calculation and prediction the accuracy of the satellite orbit for the system. (4) Mission planning section is planning the mission for the satellite to operate every day according to the user requests.

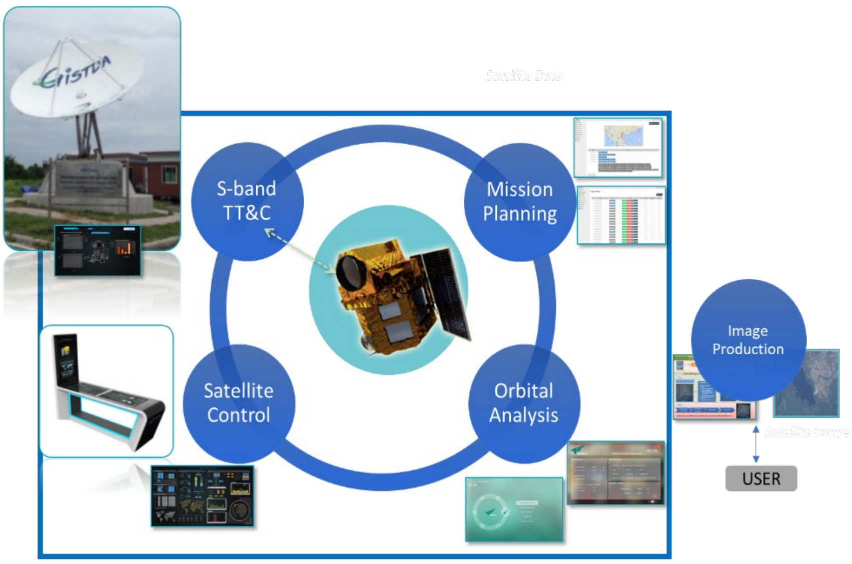

Figure 2. GISTDA Satellite Ground Control Station [Vongsantivanich et al., 2014].

GISTDA's engineers have significantly increased their skill and knowledge of ground station technology from many previous different projects [Vongsantivanich et al., 2014; Warinthorn et al., 2021]. For instance, the project was initiated as named WATER (Wise Antenna for Transmission Execution and Receiving System). It succeeded in developing and implementing. It operates to replace the original system for the THAICHOTE ground station and supports other satellites. This project will develop the small antenna system, which is a very important part in the S-band station.

3. PROJECT DEVELOPMENT PLAN

A Project Development Plan is an essential component of project management that outlines the overall approach, scope, timeline, resources, and objectives of a project. It is crucial for ensuring the successful initiation, execution, and completion of a project. It provides a structured framework that guides the project team, helping them work together toward achieving the project's objectives while effectively managing risks and resources.

Our project development methodology shows in Figure 3. FINN system starts with collecting all the requirement of the project before moving to the second step which is system design, which includes creating a detailed system, specifications, and hardware layout. The next step is implantation, all the components such as Software and Hardware will integrate and operate together and move to the Testing section.

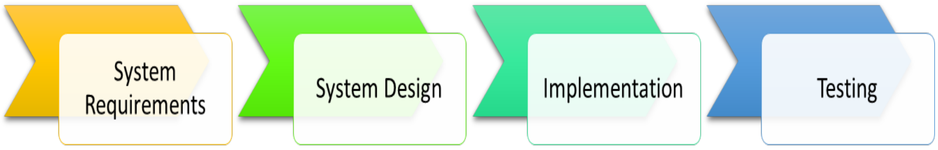

Figure 3. FINN system project development Plan.

4. FINN PROTOTYPE DEVELOPMENT

4.1 FINN system

The small automatic tracking antenna name FINN system consists of three main important parts to develop as shown in Figure 4. There is a Tracking system, Monitoring &Control, and RF components. The concept of the FINN system is to contact the LEO satellite by using a small antenna that can track the satellite accurately by using TLE data. After FINN receives the signal the RF component will perform its function to manage the satellite signal. Finally, the Signal will demonstrate the status and information on the monitoring and control section for the operation to investigate the signal later on.

The tracking system comprises the antenna dish, the structure to support the antenna, and the motor system. The control system's function offers the motor motion command by using the satellite location from TLE file. The control system of the structure has been designed to be able to control the movement of the receiver arm in many axes according to the position, speed, and sequence of operation. The M&C software can demonstrate the tracking status with the satellite position data automatically and can display various monitoring data of the antenna in real-time. Moreover, the system can operate manually.

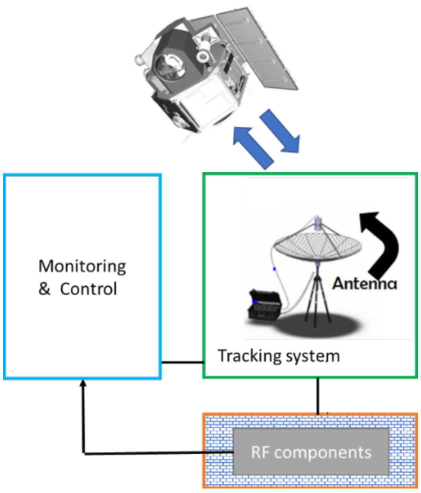

Figure 4. Finn Tracking system overview.

4.2 FINN Testing

The FINN system prototype has been developed successfully with 2 main parts, the tracking system, and the monitoring and control software. Both parts have had function tests performed by using the Two-Line Element (TLE) data to generate the satellite location.

Figure 5 shows the FINN system prototype phase 2 during testing the function test. Perform a signal measurement test using a Spectrum Analyzer. The results are that the prototype can operate automatically according to the satellite location and display the status of the system correctly.

Figure 5. Finn system during testing.

5. FINN AND GINS INTERFACING

5.1 GINs System

The Ground Intelligent Network System (GINs) is responsible for managing GISTDA's ground station facilities to be able to more efficient, and flexible and optimize the antenna's dish service. GINS is under development by THEOS-2 and GINs must be capable of multi-mission operations as demonstrated in Figure 6. In the display of system information, it is divided into 7 subtopics as follows: Summary, Satellite plan, Antenna Plan, Antenna Usage management, Antenna Status, Antenna Equipment, and Ticket Management.

Figure 6. GINs Graphic User Interface unit [GISTDA, 2021].

The GINs system was developed to support the operation of the satellites THEOS, THEOS-2 MainSAT, THEOS-2 SmallSAT, and other satellites. The GINs system is now over 70% complete.

5.2 The Study of FINN Integrated with GINS

This section is the preparation of the FINN system to be able to include in the GINs system. The connection between GINs and FINNs will provide FINN with the satellite reception schedule. There is an API set up for connecting to other systems via Ethernet TCP protocol, which can replace all manual operations through the GUI (Graphic User Interface) and can receive satellite reception schedule information. From this study, FINN can interface with GINs by adding to the system in the future.

6. CONCLUSION AND FUTURE WORK

This paper has described the FINN prototype project development plan and the testing result for the function test. FINN is operating as expected according to the satellite location data. Moreover, the study is focusing on the interface between FINN and GINs to be ready to work together in the future has been done.

The project manager and engineers in the team have amplified their knowledge and skills in project management and control ground station technology. GISTDA's engineers have more confidence to continue the develop the future project. The success of the project is not only the FINN phase 2 prototype but also Thailand 's ability to remain competitive with new space technology for communication satellites, especially the current constellation with an automatic tracking antenna.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude towards GISTDA for providing the equipment and resource for development and support. The collaborative spirit and dedication of the entire GISTDA team were truly inspiring. This paper benefited greatly from the wealth of knowledge and resources they provided. We are honored to have had the opportunity to work alongside such a forward-thinking and supportive organization. Thank you once again to GISTDA for their incredible partnership and contributions.

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