Thailand Earth Observation System (THEOS): A New Dimension of Thailand Remote Sensing

Chanchai Peanvijarnpong[1], Darasri Dowreang[2], Navanit Aphicholati [3],
Wientian Kodchabudthada[4] , Monchaya Piboon[5]
Geo-Informatics and Space Technology Development Agency (Public Organization)
196 Phahonyothin Rd., Lad Yao, Chatuchak, Bangkok 10900
Phone: +66-2-940-6420 to 8 Fax: +66-2-940-5670
chanchai @gistda.or.th[1], darasri @gistda.or.th[2], navanit @gistda.or.th[3],
wientian @gistda.or.th[4], mpiboon @gistda.or.th[5]

Abstract: Thailand has embarked in remote sensing activities for several decades. Over the past 20 years, the country has operated its own ground receiving station to acquire satellite imageries from various sources. The development of Thailand Earth Observation System (THEOS) Satellite brings a new dimension of remote sensing to Thailand. THEOS is a polar orbit, sun-synchronous satellite designed to provide operational remote sensing services to Thailand and worldwide. This paper describes THEOS background information and its characteristics including the satellite's bus, payload, orbit, imaging capacity and THEOS routine operation. The ground operations of THEOS including its ground control segment and image ground segment are also illustrated. Programmes associated with THEOS including capacity building, data applications promotion and international cooperation development are described.

Keywords: THEOS, Earth Observation Satellite, Space Segment, Ground Segment, Remote Sensing Programme

1. Introduction

For several decades, Thailand has actively engaged in remote sensing activities. The country has a long experience in operating ground receiving station, which acquires image data from various satellites. In July 2004, the Thailand Earth Observation System or THEOS Project has been initiated with Geo-Informatics and Space Technology Development Agency (Public Organization), Ministry of Science and Technology as the project's core operating agency and EADS Astrium as a prime contractor. The THEOS Project brings a new dimension to space technology and remote sensing development to Thailand. The project consists of satellite design and development, satellite launching and commissioning, control and image ground segment development, satellite data dissemination, satellite data applications and Thai personnel training.

THEOS is the first Earth observation satellite of Thailand, scheduled to be launched in 2007. The satellite has been design to fulfill a number of Earth observation requirements including fast access to area of interest, high revisiting capacity, routine monitoring and updating as well as local and worldwide observations. This paper aims to provide basic information about the content of the THEOS satellite, its ground segment and products as well as programmes under the umbrella of THEOS project. It also provides information about the services that THEOS offers to Thailand and to the international community.

2. Thailand Earth Observation System:THEOS

2.1 The THEOS Satellite

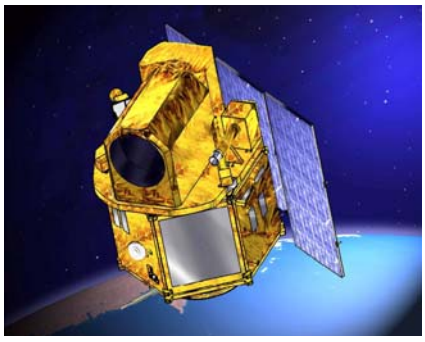

Figure 1: THEOS (Thailand Earth Observation System) Satellite

1) Payload and Bus

THEOS is a medium-sized satellite, that will be launched into a polar, sun-synchronous orbit with an altitude of 822 kilometres from the Earth. The satellite's main mission is to provide Thailand and international community with worldwide geo-referenced image products for various applications related to natural resources, the environment and security issues. The satellite may be divided into 2 main parts; payload and bus. The THEOS payload feature high resolution imaging capacity with a panchromatic camera and a wide swath capacity with a multispectral camera. The payload also contains a redunded electronic unit, which gathers the video, numerical conversion, compression and formatting function.

The THEOS bus is in charge of providing all necessary service functions. These functions include: onboard data handling; power generation and distribution (solar array and battery); attitude and orbit control subsystem (with stellar sensors, gyroscopes, GPS and reaction wheel); thermal control; propulsion (thrusters and tank); mechanical interface with launch vehicle and communications with Ground Segment (S-band and X-band stations).

The characteristics of THEOS satellite are summarized in Table 1

THEOS Characteristics	
Total mass	750 kg
Dimension	2.1x 2.1x 2.4 m
Payload	PAN and MS cameras
Orbit	Sun-synchronous (14+5/26 orbits per day)
Inclination	98.7 °
Altitude	822 km
Repeat cycle	26 Days
Period	101.4 minute
Mean local crossing time	10:00 am (descending)
Satellite point velocity	6.6 km/second
Onboard memory	51 GB
Onboard image processing	2.8 or 3.7 compression ratio (DCT)
Image telemetry	X-band link (120 Mbit/s)
Telemetry, Telecommand &Control	S-band link
Attitude Orbit Control and Orbit Determination	Three-axis stabilized, Star Tracker, Gyro, GPS, Magnetic Torque, Sun Sensor
Solar array	800 W
Hydrazine	80 kg
Nominal lifetime	At least 5 years

Table 1: Summation of THEOS characteristics

2) Technical Details of THEOS Instruments

As mentioned above, the instruments of THEOS include a high resolution panchromatic camera and a multispectral camera with wide field of view. The PAN camera has a resolution of 2 metre and a spectral range of 0.45-0.90 μm. The resolution of multispectral camera is 15 metre with the following spectral bands:

Band 1 (Blue): 0.45-0.52 μm ;
Band 2 (Green): 0.53-0.60 μm ;
Band 3 (Red): 0.62-0.69 μm ;
Band 4 (Near Infrared):0.77-0.90 μm .

The structure of panchromatic camera is made from Silicon Carbide, securing good stability and light weight. The multispectral instrument is a dioptic camera with 4 filters. For both PAN and MS instruments, linear arrays of Charge Couple Devices (CCD) are located at their focal planes of high precision optics and transform electromagnetic radiance into electronic signal. Both cameras perform their imaging function with pushbroom scanning principle, where each line of image is electronically scanned and successive lines are imaged utilizing the motion of the satellite.

2.2 THEOS Ground Segment

The THEOS satellite is accompanied by Control Ground Segment (CGS) for operating and controlling the satellite directly from Thailand and Image Ground Segment (IGS) facilities for image receiving, processing, exploiting and archiving. Figure 2 illustrates concept of CGS and IGS in relation to the THEOS satellite.

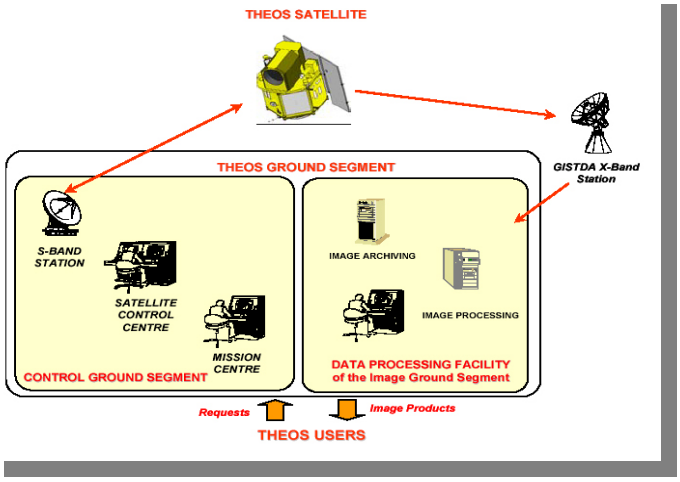

Figure 2: A conceptual diagram of THEOS satellite and its CGS and IGS

2.3 THEOS In Operations

1) THEOS Orbit

THEOS will be placed into the orbit similar to SPOT satellites with local crossing time at 10:00 am on a descending node. The satellite is designed to have a 26-day cycle and to make 14 + 5/26 revolutions per day with a revolution period of 101 minutes. With such selected orbit, THEOS can take images of the entire World in less than 35 days with the MS camera and within 130 days with the PAN camera. In addition, THEOS roll and pitch ability can increase the satellite's coverage capacity significantly. It is estimated that about 90 % of the Earth can be imaged within 1 day, with less than 50 degree rolling.

2) THEOS Agility and Repeat Viewing Capacity

As already mentioned, THEOS takes a scene of image with a width of 22 km for PAN scene and 90 km for MS scene. THEOS can take images of various length, up to about 4000 km. THEOS also features agility ability, it can take image by rolling up to 50 degree off-nadir. Performances are normally granted if the satellite roll is less than 30 degree. With the satellite's viewing capacity, the viewing frequency of a given area can be increased. It is approximated that THEOS can take image of a particular target every 1-5 days. The satellite's roll and pitch also allow across track and along track stereo imaging.

3) THEOS Operational Cycle

The routine operational cycle of THEOS may be considered as starting from collection of users needs which later are transformed into a satellite work plan, taking into account the resources onboard satellite. The workplan is then uplinked to the satellite via S-band station during the night. At the Image Ground Segment, the imagery taken onboard satellite are downlinked during night and day visibility to free up onboard memory as much as possible. The raw imagery are then processed daily. The image data are later transferred to THEOS archive system and delivered to users. Feedbacks regarding the users requests satisfaction or needed reprogramming are sent to the Control Ground Segment upon each data delivery. Figure 3 depicts daily operational activities of THEOS.

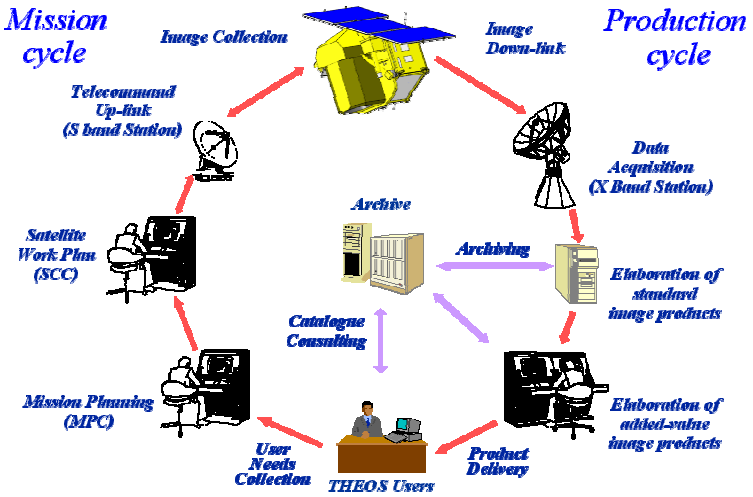

Figure 3: Operational cycle of THEOS

2.4 THEOS Products

THEOS Image Ground Segment processes THEOS image data into various product levels. The different THEOS image products available in both PAN and Multispectral formats include: level 1A products are those with radiometric correction for distortions due to non-uniformities of optical instruments; level 2A products are those with geometric correction for systematic effects such as panoramic, Earth curvature and rotation and internal distortion and are projected with a standard cartographic projection; level 2B are image products with geometric correction that come in a map projection with ground control points; and Digital Terrain Model products obtain through correlation process of THEOS stereo pairs.

To serve users more effectively, GISTDA is currently implementing a plan of producing different kinds of value-added products from THEOS imagery.

3. Programmes Associated with THEOS

3.1 Trainings and Capacity Building

Capacity building is a crucial part of the THEOS Project. Thai engineers are actively involved in THEOS satellite and ground segment development. The engineers attend intensive satellite engineering courses and obtain on-the-job training as well as participate in THEOS development throughout its design, procurement,development and AIT (Assembly, Integration and Test) phase. Thai personnel will also obtain an intensive operational training, in order to effectively operate both Control Ground Segment and Image Ground Segment, and serve THEOS users. In addition, the THEOS Operational Training Programme (TOTP) has been implemented. The Programme offers short term and long term trainings to staff from various Thai agencies in satellite engineering and satellite data applications, in both Thailand and France for the period of 10 years. Seminars are held each year to educate Thai staff and the public. Under TOTP, scholarships are also given to Thai students for pursuing their studies in the field of space technology and applications at Bachelor's, Master's and PhD levels. Such trainings and capacity building ensure Thailand's long term space technology and remote sensing development.

3.2 Applications Development Programme

It is crucial that THEOS data users can apply the data to serve their needs effectively. As part of the THEOS programme, GISTDA earned the right to receive data from SPOT-2,4 and 5, which have many features similar to THEOS. One approach to prepare users for THEOS data applications is by supplying Thai organizations with SPOT satellite data prior to THEOS launching, GISTDA is implementing programmes such as SPOT Enhancement Programme and other THEOS preparatory projects aiming to promote the use of THEOS data and strengthen capability of Thai users community.

3.3 THEOS International Business and Cooperation

THEOS is capable of providing high and medium resolution imagery globally. It will serve Earth observation needs of Thailand and nations worldwide. Images from THEOS can be applied in various areas such as cartography, forestry, agriculture, water resources, coastal monitoring, urban planning, security, environmental monitoring and natural disaster mitigation. GISTDA is currently developing a plan of disseminating THEOS images to serve the needs of international communities.

4. Current Status of THEOS Project

The Radiocommunications Bureau of the International Telecommunications Union (ITU) had accepted THEOS's filing of Advanced Publication Information (API) for THEOS satellite system registration since May 2005 and published THEOS API in the ITU Special Section. At present, THEOS system registration is in the process of international coordination and is planned to be finalized in October 2005.

The THEOS satellite and its associated ground segment have been progressing well according to the planned schedule. Preliminary Design Review of the satellite, the system and ground segment have been completed. The Critical Design Review is in progress. Parts of the satellite have been procured and manufactured. After intensive review, Rockot has been selected as the launcher of THEOS. GISTDA has worked extensively on preparing ground infrastructre for THEOS. A new Ground Control Station has been designed and will be located in Sriracha, Chonburi, Thailand.

Pilot projects aimed to address the applications of THEOS in key areas have already started. A scheme for international THEOS data dissemination has been initiated and shall be completed in 2006.

5. Conclusion

The first Earth observation satellite of Thailand, Thailand Earth Observation System or THEOS shall bring a new dimension to remote sensing and space technology development of Thailand. In this paper, overview of THEOS satellite, its space segment and ground segment, its capacity and operational scheme have been discussed. Capacity building under the umbrella of the THEOS Satellite project is crucial to Thailand's long term development in the filed of space technology. Programmes to prepare users for THEOS data applications have been established. As THEOS has capacity to provide imagery worldwide, a plan to disseminate THEOS data internationally has been initiated. As for current status, the development of THEOS satellite and associated systems and ground segments has progressed well. THEOS satellite shall be ready to provide imaging services to Thai and worldwide users upon its launch in 2007.

References

[1] GISTDA and EADS Astrium, 2004. *THEOS User Handbook*, Bangkok, Thailand.
[2] Peanvijarnpong, C., 2005. *The THEOS Satellite Project*, Presented at the Seminar on THEOS Satellite, Khon Kaen and Chiang Mai, Thailand.
[3] Geo-Informatics and Space Technology Development Agency (Public Organization), 2005. *Potential Benefits of THEOS Satellite* [in Thai], Bangkok, Thailand.
[4] URL: THEOS website on http:// www .gistda.or.th .