Towards International Cooperation and Capacity Building between Space Agencies: A Case of GISTDA and NSPO

Pirada Techavijit* and Ravit Sachasiri
Geo-Informatics and Space Technology Development Agency
6th Floor, 120 Government Complex Building B,
Chaeng Wattana road, Lak Si, Bangkok-10210. Thailand

E-mail: ptechavi@eoc.gistda.or.th, ravit@eoc.gistda.or.th

* Author to whom correspondence should be addressed; Tel.: +66-86-783-2220

Abstract:

Geo-Informatics and Space Technology Development Agency (GISTDA) firmly believes in the synergy of international cooperation and capacity building and is always on a quest to build global knowledge partners. Keeping in mind the growing trend of international cooperation, GISTDA and the National Space Organization (NSPO) of Taiwan will enter into a cooperation agreement that will develop space system engineering in Thailand. The cooperation aims to promote technical activities, human resources development as well as infrastructure development in both countries. Several cooperative activities had already been initiated according to the work plan and an In-flight Systems Engineering Technical Assistance (SETA) has also been drawn up and agreed upon by both the agencies. The SETA encompasses the area of satellite operation, satellite and ground maintenance, anomaly handling, instrument calibration and satellite life extension assessment. The execution procedure and budget planning has been taken into consideration and the allotment of resources, both time and money, are planned for. GISTDA has also proposed the timeframe for personnel exchanges and training program to NSPO and the work plan will be put into action as soon as the areas are mutually agreed upon.

The paper shall discuss the entire project plans divided into phases with major concentration on the e-aspect of the cooperation. Online training, remote system management and satellite data transfer over the Research and Education Network (REN) for emergency and educational purposes are but a few of the strategic areas covered in this cooperation. Mutual cooperation between the two agencies will help facilitate mission-critical agendas with no visible shortcoming. The paper shall also set precedent for future cooperation between international...
agencies and discuss how cost saving is achieved with the application of communication technologies.

**Keywords:** international cooperation, REN, knowledge transfer, GISTDA.

1. **Introduction**

Individual country may find it very difficult to conquer space or just to finance space projects. Therefore, International cooperative project is a simple answer to solve this problem. Nations may cooperate in the development of space technology to development of missions to the operation of the space missions. It is always more beneficial to share resources among the different nations as it may also lead to stronger ties between the countries and this in turn may lead to other resource sharing programs. The International Space Station (ISS) is the biggest example of international collaboration in the space domain.

Thailand is still a small emerging space faring nation but they operate a few satellites in Geostationary orbit and one satellite in Low-Earth orbit. Moreover, Mahanakorn University, Thailand, have developed and launched a satellite, TMSAT-I, back in 1998, but further development in the space domain has been few and far in between.

GISTDA was established on November 3, 2000 as a public organization and assumes all responsibilities and activities for space technology and geo-informatics applications[1]. Currently, one of GISTDA’s most important mission is to operates Thaichote or THEOS (THailand Earth Observation Satellite), the first earth observation satellite of Thailand, which was launched on October 1, 2008. Today, Thaichote is fully operated by GISTDA engineers at THOES ground control station which is situated at Siracha, Chonburi. GISTDA is closest to what is Thailand’s space agency but it mainly concentrates on Earth Observation technology. Small non-commercial space agency similar to GISTDA such as small government agencies, scientific institutes or universities are usually limited in resources as they depend on external funding and are non-profit. They may also distribute the acquired images to offset cost but most of the time, images are provided at a much reduced price or sometime, free of charge. Therefore, these organizations must minimize operational cost.

The National Space Organization (NSPO) is the civilian space agency of the Taiwan. NSPO is involved in the development of space exploration, satellite construction and development as well as related technologies and infrastructure (including the FORMOSAT series of Earth observation satellites) and other research in aerospace engineering, remote sensing, astrophysics and atmospheric science. Furthermore, NSPO is currently operating a Remote Sensing satellite, Formosat-2, which shares the same bus as THEOS satellite and this provides additional reason for cooperation between the two agencies.
2. The Cooperation

The purpose of cooperation between GISTDA and NSPO is to share their core competences and resources. GISTDA studied its and NSPO’s existing infrastructures in order to implement a cooperation plan and conducted the first discussion in Tainan, Taiwan with NSPO. NSPO currently operates Formosat-2 and are developing their next earth observation satellite - Formosat-5 by themselves in Taiwan. Following the preliminary talk in Taiwan, GISTDA and NSPO planned the area of cooperation and drafted an assistance and resource sharing agreement. By sharing the resources, both the parties aim to gain knowledge of each other and augment the existing knowledge of its employees. The cooperation set up between GISTDA and NSPO is part of a multi-services framework aimed at enabling both GISTDA and NSPO to share resources, expertise and infrastructure.

GISTDA aims to extend its reach as a space agency and therefore involves itself in the synergy of international cooperation and capacity building and a quest to build knowledge partners. Different agencies may have faced different problems and have worked to solve these problems and these solutions may be very useful to the other agencies if they face a similar problem. Each agency can learn from the other’s mistakes, and solutions. Initial discussion for cooperation with NSPO includes personnel exchange, training, system and maintenance support as well as ground station support.

The project first meeting was on 28th June 2010 between Mr. Chanchai Peanvijarnpong of GISTDA and Dr. An-Ming Wu of NSPO. This led to more meetings both in Thailand and Taiwan. The second meeting took place on 16th September 2010 between Dr. Eddy Yang and Mr. Bo Chen of NSPO and Mr. Damrongrit Niammuad and Mr. Ravit Sachasiri of GISTDA in Thailand and an agreement to setup bi-directional communication between the two agencies’ ground stations was done. Further areas of cooperation were also discussed and formed the basis of the infrastructure of the cooperative relations between GISTDA and NSPO, and covers cross-support in the following areas:

- Technical Workshop/Training
- Ground station support including Bi-directional TT&C services
- Image Sharing
- Satellite/Ground Anomaly management
- Post-maneuvers evaluation
- Assistance for Special Studies
The agreement means that GISTDA and NSPO will provide each other technical support as well as space operations services. The sharing of resources is a sensible and efficient way to achieve enhanced space science value in an era of tight budgets and shall benefits both the agencies by providing back-up ground stations in case a mission's ground station is not available due to maintenance, weather or disasters, by ensuring additional station support during critical mission phases and by expanding station resources. Other than the ground station support, the area of cooperation is discussed further in the next sections.

2.1 Technical Workshop/Training

The technical workshop and training are organized to be performed both in person and distance learning. Distance learning will be done using teleconference and tele-presence feature using the high-speed TEIN-3 network with GISTDA connecting to the THAIREN network with the UniNet. For the personal workshop, the classes will be organized at both the THEOS ground station in Thailand and Hsinchu Science Park in Taiwan. This will allow exchange of personnel and ideas. Distance learning shall include e-learning, online training and remote support over secured network through the UniNet network. The training courses that shall be covered are:

2.1.1 Degradation trend and parameter adjustment for degraded equipment

GISTDA’s engineers and NSPO’s engineers have exchanged their experience to study the degradation trend and how to adjust the parameters in case of degraded equipments due to the similarity of satellite platform (THEOS and FORMOSAT-2). This workshop has improved our understanding on how to configure or how to extract information when data has been corrupt by the radiation. Moreover, the engineers can check overall of satellite status and can prepare to adjust some parameters.

2.1.2 Experience training operation on redundant equipment

The satellite is designed to have both nominal and redundant chain. The nominal chain is operated since launching and the redundant chain will be operated in case of failure of equipment. THEOS is operated properly for more than 3 years in nominal chain. FORMOSAT-2 has changed the configuration to operate some equipment in redundant chain. NSPO engineers have experience on how to configure system on satellite and ground to operate in redundant chain.

2.1.3 Experience from bug fixing on Flight Software

In the beginning of FORMOSAT-2 operation, there are bug on flight software about attitude control which is the satellite can maneuver only in limited speed. This bug has been fixing by the organization whose integrate the satellite for NSPO. From this experience, NSPO and GISTDA engineers can share their information in order to verify the operation of Flight software or verify some
parameters which have been changed while perform orbit control maneuvers or extra activity.

2.1.4 Optimization of Attitude and Orbital maneuvers
The orbit control maneuvers are the important activity to perform every year or twice to adjust attitude and position for satellite imaging. This activity need the accuracy and can be optimized for the life extension.

2.1.5 Safe mode prevention and investigation
The satellite will turn into safe mode when major anomaly occurred and engineers will know the cause of problem after investigation. In some case, the safe mode situation can be prevented by setting satellite system by ground command. For example: Avoiding moon eclipse by modifying the value of standard monitoring.

2.2 Image Sharing

The two agencies are already sharing satellite images for disaster management and assistance in the Sentinel Asia Project. The Sentinel Asia is a voluntary basis initiative led by the Asia-Pacific Regional Space Agency Forum (APRSAF) to support disaster management activity in the Asia-Pacific region by applying the WEB-GIS technology and space based technology, such as earth observation satellites data. Sentinel Asia is promoted under cooperation among the following three communities[4] : Space Community (APRSAF); International Community (UNESCAP, UNOOSA, ASEAN, AIT etc.); Disaster Reduction Community (ADRC and its member countries). In the near future, the images will be sent over the TEIN-3 network which has a much larger capacity and will therefore assist greatly in all disaster recovery operations.
2.3 Ground station support including Bi-directional TT&C services

The purpose of this project is to share ground system for controlling the satellite. The benefit of this project is increasing system reliability and implementing ground control system both GISTDA and NSPO. This project has been established after the cooperation meeting on the topic “Implementation of inter-operability between NSPO and GISTDA” on 16 September 2010.

The project includes the setup of a secure communication link (VPN) between the two ground stations over the TEIN-3 network and also setup of FTP servers to transfer important operations files between the two agencies as required for the operations of the satellite over the remote ground stations.

The following pictures show the connection for control, receive, sending and monitoring mechanisms.

*Figure 2: Bi-Directional Ground System Sharing Architecture*

2.4 Satellite/Ground Anomaly management

Due to the similarity of satellite platform between THEOS and FORMOSAT-2 and the similarity of ground systems (S-band and X-band), GISTDA and NSPO can share information and experience of operation and anomaly management.

The topic for satellite/ground anomaly managements:

- ARO reconfiguration and investigation
- Investigation for on-board equipment failure
- Workaround solution for on-board equipment failure
- Telemetry check and trend analysis
• S-band TT&C station for THEOS uplink and downlink
• s-band TT&C station maintenance
• X-band station anomaly resolution

Data sharing for the anomaly management will be done both remotely or in person and the TEIN-3 network will provide the infrastructure for the exchange of information in the near future.  

2.5 Post-maneuvers evaluation

Satellite maneuvers are performed between once to four times per year and these events are very important as fuel consumption determines the lifetime of the satellite. The information exchange between GISDA and NSPO is OCM calibration evaluation and propellant accounting evaluation pre and post an OCM. This is very vital in the study of the lifetime and the satellite and for future mission planning. Maneuver evaluation also provides data in order to study and improve the environment perturbation model.

2.6 Assistance for Special Studies

There are also several planned co-study, research and development projects between GISTDA and NSPO in the areas of:
• Space Object closed Approach Analysis.
• Collision Avoidance maneuvers assistance and consultancy
• Orbit design for joint programming to decrease time between acquisitions and better response to emergency situation.
• De-orbit study

These research and development project will form a framework of new exchange programs and also arouse the minds of the engineers to think and explore the possibilities. Special research projects are planned for each given calendar year and a single topic will be selected each year for the co-study program for each division. The output of the co-study program will be equally shared between both the parties.

3. Implementation Plan

As some of the activities have already started, activities requiring interconnections between the sites are performed over the internet. As some activities require secure connections, VPN with IPSEC/IKE encryption are used to secure the channel. The internet bandwidth currently available is a 2 Mbps Uplink and 2 Mbps Downlink Leased line and hence some of the activities are hindered due to limited bandwidth availability. In order to increase reliability and channel bandwidth for exchange of information, remote access and teleconference, UniNet which is part
of TEIN3 will be used in the near future and this will increase the available bandwidth up to 20 Mbps.

3.1 Network Backbone to Thailand Research Network (THAIREN)

At the moment, network interconnections between GISTDA and UniNet have already been established in order to encourage study and research of satellite images in Thailand. GISTDA[5] has three sites spread out on Thailand and all three sites are now connected to the UniNet through the nearest university[4]. The link has been implemented as shown on following:

- **GISTDA Headquarter at Changwattana** - is connected to KU (Kasetsart University main campus). An optical fiber connection has been established between KU and GISTDA and enable high speed connectivity from the GISTDA headquarter to Thailand’s research network.
- **Earth Observation Center at Ladkrabang** - is connected to KMITL (King Mongkut Institute of Technology Ladkrabang). An optical fiber connection has been established between KMITL and GISTDA and enable high speed connectivity from the GISTDA headquarter to Thailand’s research network.
- **THEOS Operations Center at Siracha** - is connected to KU_SRC campus (Kasetsart university Siracha campus). An optical fiber connection has been established between KU, Siracha campus and GISTDA and enable high speed connectivity from the GISTDA headquarter to Thailand’s research network.

The UniNet network is then connected to the TEIN-3 network which in turn is also connected to the GEANT network allowing the entire Asia-Pacific region to the connected to the European Educational and research network.

3.2 Network Implementation Plan

NSPO is currently in discussion to connect to the TEIN-3 network[6] through the National Chiao Tung University (NCTU). At the moment, there is no interconnection yet from the NSPO site to
the TEIN-3 network but once the interconnection is completed, an end-to-end tunnel over the TEIN-3 network can be setup. The advantage of such a tunnel will be enhanced security as well as more reliability. The completion of the link from NSPO to NCTU will allow both GISTDA and NSPO to better serve the Asia-pacific community in case of natural disasters or other emergencies.

3.3 Preliminary test results

Several tests were carried out by GISTDA[7] in order to test the capacity and capability of the TEIN-3 network from the UniNet for disaster support. Satellite data were transferred to Universiti Putra Malaysia (UPM) in Kuala Lumpur for test purposes. Three satellite images totaling 1.5 Gigabytes were sent using TEIN-3 route with UniNet server through the Singapore Node. The time taken for upload from GISTDA to UPM totaled 4 minutes 52 seconds and the average bit rate calculated was 41.01 Mbps which is a very promising figure. However, as this test was carried out from gateway to gateway and at a time with reduced bandwidth consumption, it doesn’t reflect real world figure. Still, we can safely assume that we should be able to achieve approximately 20Mbps for real-time transfer of data.
For the moment, GISTDA is also transferring THEOS data files from ESRANGE Space Station in Kiruna, Sweden to Bangkok on a daily basis. This interconnection is from UniNet to SUNET over GEANT and TEIN-3. The data volume is around 690 Megabytes to 30 Gigabytes per orbit or up to 60 Gigabytes per day. Without using the UniNet connection, GISTDA could not have fathomed to send the THEOS data files over a network but would have had to resort to sending a magnetic tape or optical disk on a daily basis. Below the graph of bandwidth usage during the FTP transfer of THEOS data from Kiruna to Bangkok.
4. Conclusion

The cooperation between GISTDA and NSPO is a very good example of mutual benefits to both the organizations. The cooperation project holds tremendous scope for expansion. With the success of the ground station support project and the agreement to extend to other areas, GISTDA aims to extend this project to more partners and even a possible consortium. This cooperation sets in motion a possibility for any new small earth observation and small scientific satellite operator to participate and contribute to group welfare by entering into such partnerships. Universities, independent student groups, research agencies may now launch a small satellite and request the assistance of such a consortium to assist in the operation of their satellites as well as have other earth observation satellite operators support their operations. They may request for assistance not only for LEOP but also for normal operations. Moreover, similar to the current situation between GISTDA and NSPO, the cooperation may extend well beyond ground station resources but also to human resources and technical partnership.

Beyond the expansion in numbers of members, lateral expansion of cooperation with NSPO can also be part of future plan. Extending the project beyond cooperation of ground station and technology workshop and training, to technology transfer project and IPR partnership can be very beneficial. Both of the parties have gained different experience from the operation of their satellite and therefore both the agencies can gain from these experiences.
REFERENCES


3. R. Sachasiri; Cooperation between Earth Observation Satellite operators - Ground Station Sharing. International Astronautical Congress (IAC) 2011, Cape Town, South Africa.


