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Space programs in Taiwan

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Abstract

Taiwan's current and future space programs are briefly introduced in this paper. The National Space Organization (NSPO) in Taiwan has successfully carried out three satellite programs (FORMOSAT-1, 2, &3) since its establishment in 1991. FORMOSAT-1 is a scientific satellite performing three scientific experiments for measuring the density, velocity and temperature of ionospheric plasmas, taking the ocean color image, and conducting Ka-band communication experiments. Equipped with a 2m ground resolution remote sensing instrument, FORMOSAT-2 operates in a sun-synchronous orbit with revisit time equal to one day. This unique feature of the daily revisit capability is significantly useful for post disaster assessment and environmental monitoring. FORMOSAT-2 also carries a scientific payload "Imager of Sprites and Upper Atmospheric Lightning (ISUAL)". ISUAL provides the world's first long-term satellite observations on the lighting phenomenon in the earth's upper atmosphere. FORMOSAT-3 is a constellation of six micro-satellites to collect atmospheric and ionospheric data for weather prediction and for climate, ionosphere, and geodesy research. FORMOSAT-3 has demonstrated the ability to significantly increase the accuracy of weather forecasting by utilizing the GPS Radio Occultation (GPS-RO) technique. Currently, NSPO is pursuing the follow-on space missions of FORMOSAT-5 and FORMOSAT-7. FORMOSAT-5 will be the first to utilize a CMOS detector on a high-resolution earth-observation camera. FORMOSAT-7 is a joint mission of Taiwan/US to deploy a 12-satellite constellation operational system to provide dense and timely GNSS RO data to the global communities for real-time weather forecast as well as space science research.

Keywords: ISUAL, GPS RO, CMOS image sensor, FORMOSAT-5, FORMOSAT-7

1. Introdcution

Established in 1991, the National Space Organization (NSPO) is acting as a space agency in Taiwan in charge of the national space program execution and space technology development. The NSPO's mission is to build up the indigenous space science and technology in Taiwan as well as to integrate domestic resources that would make Taiwan become a significant contributor in the global space community.

In past two decades, NSPO has built a competitive infrastructure and fostered human resource by successfully carrying out three major satellite programs, named FORMOSAT-1, 2, and 3. These programs have made great achievements in missions of advanced space science, remote sensing, and meterology respectively. In particular, FORMOSAT-2, a 2-meter ground resolution remote sensing satellite,

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has been well known to the international community for its unique feature of daily revisit that can quickly access to the disaster areas and provide continuous monitoring information useful for rescue planning. FORMOSAT-3, a constellation of six micro-satellites, are providing the GPS Radio Occultation (GPS-RO) data in atmosphere and ionosphere which have being widely used by worldwide major weather agencies for weather prediction and by the international scientific community for the climate, ionosphere, and geodesy researches.

With these achievements, NSPO is continuously pursuing two primary missions: Earth Observation (EO) and GPS-RO. The FORMOSAT-5 program will serve as a follow-on mission of FORMOSAT-2 to continuously provide remote sensing imagery for users worldwide. FORMOSAT-5 will carry a domestically made electro-optical Remote Sensing Instrument (RSI) to perform earth observation mission. FORMOSAT-5 is also considered as a big leap in demonstration of self-reliant space technology in Taiwan. The FORMOSAT-7/COSMIC-2 Mission is intended to provide continuity of GPS-RO data as well as to provide the next generation of Global Navigation Satellite Systems-RO (GNSS-RO) data to the global users. The FORMOSAT-7/COSMIC-2 is a joint Taiwan-US cooperative program between NSPO of Taiwan and National Oceanic and Atmospheric Administration (NOAA) of US. The goal of this program is to deploy a 12 micro-satellite constellation to provide the dense and timely GPS-RO data to the global communities for real-time weather forecast as well as for space science researches.

In past two decades, NSPO has built up its comprehensive infrastructure necessary to carry out the space missions. Three major facilities, including satellite I&T facility, mission operation and control center, and image processing center, along with over 10 spacecraft R&D laboratories have constituted a competitive infrastructure in support of NSPO's satellite programs. The NSPO's core competences and technologies include system engineering, spacecraft, EO-type remote sensing instrument, satellite operations, and satellite image processing. By utilizing these core technologies, NSPO's satellite programs are then implemented via teaming up with domestic partners or collaborating with international partners. In addition, NSPO also provides services to the domestic and international users or customers for technology enhancement and product development. The NSPO's operation model is depicted in Fig. 1.

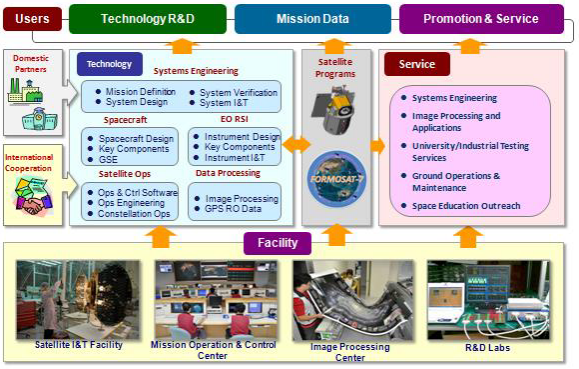

Fig. 1. The operation model of NSPO is constituted of facilities, technologies, partners, satellite programs, services, and users from which the outcomes of Taiwan's space program are evaluated.

2. FORMOSAT-1

FORMOSAT-1 is a low-earth-orbit scientific experimental satellite. After launched into an altitude of 600 km with 35 degree inclination, it circulates around the Earth every 97 minutes, transmitting collected data to Taiwan's receiving stations approximately six times a day. The major mission of FORMOSAT-1 includes three scientific experiments for measuring the effects of ionospheric plasma and electrodynamics, taking the ocean color image and conducting Ka-band communication experiment. The daily collected payload data are distributed to domestic science groups and to the domestic and international research organizations for scientific experiments. For the research on characteristics of ionospheric layers, the purpose is to understand the ionospheric layer structure in the space above Taiwan and its surroundings, in order to provide important information that influences wireless communication. Ocean color research is to provide experimental data in ocean related fields as a basis for practical and theoretical researches in areas ranging from environment, fishery, industrial, commercial areas, and ocean biology. The Ka-band communication experiment is to conduct low and high data rate and rain attenuation communication experiments and to further carry out secure communication experiment to strengthen the ability of Taiwan's communication system.

The IPEI science team at National Central University has been examining the FORMOSAT-1 observations of equatorial anomaly and plasma bubbles over Taiwan and global equatorial region. The science team also used the IPEI measurements to study mid-latitude ionospheric density irregularities during