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Development of ROCSAT-1 Program

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ABSTRACT

The long-term plan for National Space Technology Development has its primary goal of establishing the infrastructure and system engineering capabilities required to developing Republic of China's space technology. It envisions a gradual development of technical capabilities for satellite as well as ground systems. The National Space Program Office (NSPO) was formally established in October 1991 as the implementing agency for the country's space program. ROCSAT-1 is the first satellite program executed by the NSPO. This paper provides a summary description of the ROCSAT-1 program development and accomplishment. Major elements of the program are introduced. Goals of the Republic of China space program are also briefly described.

(Key words: ROC Space Program, ROCSAT-1 Program)

1. INTRODUCTION

A nation's decision to embark on a space technology development program, apart from satisfying national needs, generally is a reflection that its overall technological, economic and industrial capabilities have reached a level of maturity to support such an undertaking. This type of high technology, high quality and high reliability system development involves the joint, multi-disciplinary application of system engineering, electronics, mechanical engineering, material science, telecommunications, remote-measuring, navigation, propulsion, control, information and other cutting-edge technologies. The development of space technology bears a strong and positive impact on the advancement of a nation's civilian as well as defense industries. Satellite-based space R&D and applications are extremely useful for upgrading the industrial technologies, and nurturing the skills for the integration, manufacturing and management of large-scale systems. They also generate long-term economic benefits and improve a country's education, notably in science and technology.

Based on "The Fifteen Year Plan for National Space Technology Development Plan" approved by the Executive Yuan, the National Space Program Office (NSPO) was established

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in October of 1991 under the supervision of the National Science Council (NSC) as the implementing agency of the country's Fifteen-Year Space Program. Among its goals is to utilize the development of the infrastructure and the real capability of integrating large-scale high-tech systems as a solid foundation for the Republic of China's space technology development. Another one of the goals of the space program is to create needed resources for competition in the international market place for space technology and related industries in the future.

Research projects on satellites and satillite application technology make up the bulk of the Fifteen-Year Plan. During the past seven years, the NSPO has been dedicated to conducting satellite-based research, satellite integration and test capabilities, technical transfer of satellite components, and international co-operations. The NSPO believes that these are the best way to exploit the benefits of satellites for the nation and to promote related applications. Up to now, in addition to the ROCSAT-1, the other two programs, ROCSAT-2 and ROCSAT-3 are also under development. These two programs will concentrate on missions emphasizing the areas of remote sensing, meteorology, communications and scientific experiments.

2. THE ROCSAT-1 PROGRAM

The ROCSAT-1 Program consists of several main elements, i.e. Spacecraft (includes ROC manufactured components), Payload, Integration and Test, Ground Segment, and Launch Ser-

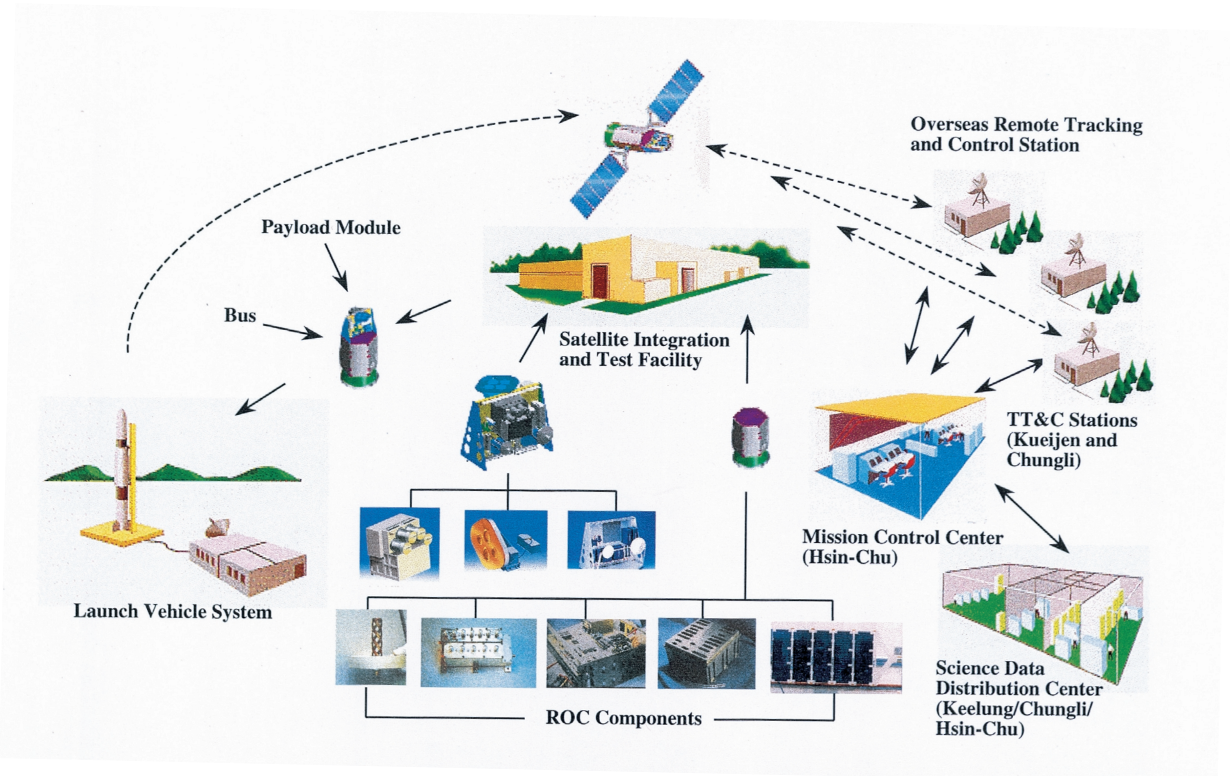

Fig. 1. The system architecture of the ROCSAT-1.

vices. Figure 1 shows the system architecture of the ROCSAT-1 system. The ground systems and the integration and test facilities established benefit not only the ROCSAT-1 program but also other ROC small satellite programs in the future.

The integration and test facility is located in the Hsinchu Science-Based Industrial Park. Construction of the building, which started in September 1994, was completed in May 1996. The facility includes an EMI/EMC Anechoic Chamber, a Thermal Vacuum Chamber, an Acoustic Chamber, and a Vibration and Mass Property Measurement Facility.

The ROCSAT Ground Segment (RGS) has two major goals: building the basic infrastructure of the ground segment, and assuring mission success. It consists of the Tracking, Telemetry and Command Stations, the Ground Communication Network, the Mission Operations Center, the Mission Control Center, the Science Control Center, and the Flight Dynamics Facility. The RGS contract was awarded to the Allied Signal Technical Services Cooperation (ATSC) of the USA. Through a contractual arrangement, four domestic subcontractors, i.e., Tatung, SysCom, TTNS, and CTCI, were selected by ATSC to participate in the development of the system. Also included in the contract was the training of an Operations and Maintenance team, made up of personnel from NSPO and domestic industries.

ROCSAT-1 is the Republic of China's first satellite. The mission objective is to successfully develop, launch, and operate a low earth orbit scientific satellite, and to conduct three scientific and technology experiments in the areas of ocean color imaging, space telecommunication, and solar-terrestrial physics.

The ROCSAT-1 spacecraft was developed jointly by TRW of the USA with an jointed team of TRW and NSPO engineers. The contract was awarded to TRW in June 1994.

NSPO dispatched 28 engineers to join the development effort at TRW to ensure the success of the satellite mission and development of spacecraft design, manufacturing, assembly and test capabilities. For the purpose of establishing the foundation of the ROC space industry, five of the spacecraft components were domestically manufactured, including the Onboard Computer, the Remote Interface Unit, the Filter/Diplexer, the Antennae, and the Solar Array Panel Assembly. In addition to these five flight components, a flight quality Structure Test Model was also manufactured by Taiwan Aerospace and ITRI as a pathfinder for ROCSAT-1 integration and test activities and to serve as a touchstone for demonstrating ROC capability in manufacturing and assembling the structure subsystem of space vehicles.

The three on-board payload instruments are the Ocean Color Imager (OCI), the Experimental Communication Payload (ECP), and the Ionosphere Plasma and Electrodynamics Instrument (IPEI). The payload data received daily will be distributed to research institutions, domestic and foreign, to conduct scientific experiments. Details of these three payload instruments and their scientific experiments will be described in detail below in the other articles. This paper will concentrate on the description of the spacecraft.

There are three ROCSAT-1 operational phases. Phase I includes all operations from launch through insertion and checkout in the final operational orbit. It is anticipated that this phase can be completed in the middle of March 1999. Phase II will be devoted to the conduct of payload experiments and collection of scientific data. This phase will end two years after the launch date. Phase III starts after the completion of phase II and continues until the satellite is decommissioned. Toward the end of Phase II, NSPO will review results from all three experiments and plan new experiments using the same on-board equipment for Phase III.

3. ROCSAT-1 SPACECRAFT

ROCSAT-1 is a low-earth orbit science experimental satellite (Figure 2). After lunch, the satellite will orbit the Earth at an altitude of 600 Kilometers with an inclination of 35 degrees and an orbital period of 97 minutes. ROCSAT-1 weights 402 kg. It is a hexahedron in shape, measuring 2.1 m (Height)*1.1m (Width). The extended width is 7.2 m with solar array deployed. The mission life is 2 years minimum with a design life of 4 years. Reliability for the spacecraft is 0.9 at the end of its 4-year design life.

The spacecraft consists of a payload adapter and the Bus. The payload adapter serves as a mounting platform for the payload instruments and associated electronics. It also provides the interface between the spacecraft bus and the instruments. The spacecraft Bus can be described in terms of its six subsystems: Structures and Mechanisms Subsystem (SMS), Electrical Power Subsystem (EPS), Thermal Control Subsystem (TCS), Attitude Determination and Control Subsystem (ADCS). Reaction Control Subsystem (RCS), and Communication and Data Handling/Telemetry, Tracking and Command Subsystem (C&DH/TT&C).

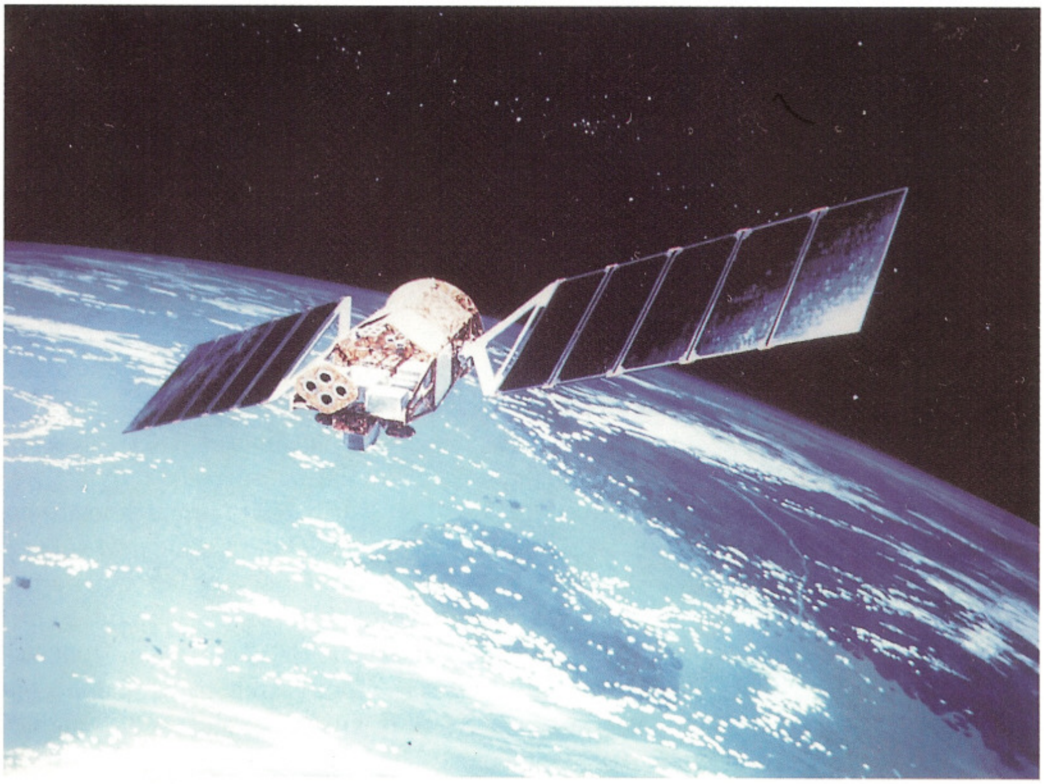

Fig. 2. ROCSAT-1.

3.1 Structures and Mechanism Subsystem (SMS)

The Structures and Mechanism Subsystem provides the structural support, alignment, and stiffness required by the spacecraft bus, its subsystems, components, and the instruments. It also provides for assembly of the launch vehicle for launch and separation; and deployment mechanisms for the arrays.

Module design was adopted for easy assembly and integration. The spacecraft consists of launch adapter for launch vehicle interface, propulsion module for housing propellant tank and associated hardware, core module for electronic components, and payload adapter for three instrument payloads. Major structure elements consist of longeron as load carrying members and platforms for component mounting. Aluminum and aluminum honeycomb material are used except for the solar array panels where graphite honeycomb is used.

3.2 Electrical Power Subsystem (EPS)

The Electrical power subsystem generates, stores, regulates and distributes the electrical energy necessary for the spacecraft and the instruments. The total power for the satellite will be 450 W at the end of its 4-year design life.

A silicon solar cell with efficiency greater than 14.6% is used on the five panels in each wing of the solar array assembly. A 21 AH NiCd battery cell is used to provide power during the eclipse period.

3.3 Thermal Control Subsystem (TCS)

The spacecraft thermal control subsystem ensures the proper thermal environment for the spacecraft and thermal interface control with the instruments. This is achieved through passive elements such a Multi-Layer Insulation. Semi-passive elements, such as heaters, are used for the spacecraft when necessary to meet system requirements.

Thermal control of payload instruments is accomplished through thermal interface requirements. In addition, OCI has its own thermal control system.

3.4 Attitude Determination and Control Subsystem (ADCS)

The ADCS provides real-time attitude and orbit information, maintains proper spacecraft attitude and payload pointing states during all phases of the spacecraft orbital life. The pointing accuracy of the spacecraft is better than 0.5 degree per axis. The post facto, i.e., after ground processing, spacecraft pointing knowledge uncertainty is better than 0.1 degree per axis.

The major components of the ADCS subsystem consist of 2 Scan Wheel Assembly, 2 Reaction Wheel Assembly, 3 Gyro Reference Assembly, 3 Magnetic Torque Rod, 4 Fine Sun Sensors and all the associated electronics.

3.5 Reaction Control Subsystem (RCS)

The RCS provides the required impulse for spacecraft attitude control during orbit insertion and contingency operations. Major components include one propellant tank and 4 pairs of 1 LB thrusters. 72 Kg NiH2 propellant is carried on board.

3.6 Communication and Data Handling/Telemetry, Tracking and Command Subsystem (C&DH/TT&C)

The C&DH/TT&C subsystem provides processing of command and telemetry; communication with ground network, data storage, and spacecraft data processing. The telemetry data rate is 2.048 Kcps for real time telemetry and 1.4 MBPS for real time plus stored data playback. The format is CCSDS compatible.

The major RF components of the C&DH/TT&C subsystem consist of S Band Omni Directional Antennae, Switch/ Hybrid Assembly, RF Assembly and Transponders. The C&DH equipment consists of On Board Computers, Remote Interface Units, GPS Equipment, Transponder Interface Electronics, and Solid State Recorder.

4. LAUNCH INTO THE FUTURE

In May of 1997 the ROCSAT-1 spacecraft was sent back to the Integration and Test Facility building in NSPO. The system integration and testing of the satellite as well as the end-to-end test with the ground system was completed by NSPO them of engineers and technicians at the end of September 1998. On December 9, 1998, ROCSAT-1 and its ground support equipment were shipped to Cape Canaveral for launch preparation. On January 26, 1999 ROCSAT-1 was launched using the Athena I launch vehicle built by Lockheed Martin Astronautics.

The successful launch and operation of the ROCSAT-1 satellite has accomplished two major mission goals of the ROCSAT-1 program, i.e., to develop infrastructure for future satellite development and to launch and operate a low-earth orbit satellite for scientific experiment. In addition, the success of ROCSAT-1 program will not only deliver the three payload instruments into space but also carry its wishes and hopes of the ROC space program along with it.