The 5th East Asian Meeting
of Astronomy

Space Program in Taiwan

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Executive Yuan, ROC

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Outline

- National Space Program Office (NSPO)
  - Program Overview and Goals
  - Organization, Schedule, and Staffing
  - Satellite Integration & Test Facility and Laboratories
  - ROCSAT Ground Segment

- ROCSAT Programs
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  - ROCSAT-2
  - ROCSAT-3

- Future Plan and Goal
Overview on Space Program of ROC

- A long-term space program of Republic of China (First Stage 15 year, 1991-2006), consisting of establishing necessary domestic infrastructure and carrying out three satellite programs (ROCSAT-1, ROCSAT-2 and ROCSAT-3), is to acquire the following goals:

  - To build up national system engineering capability of developing large-scale, high-quality, and high tech integrated systems via carrying out the space program
  - To establish the organizational and technical infrastructure necessary for executing a national space program
  - To enhance the human resources and capabilities necessary to support the space program
  - To promote the space science research of domestic universities and to upgrade the technology base of local industry
  - To position the ROC as an active and contributory member in the international space community via participating in the international cooperative projects
National Space Program Office (NSPO), established in 1991, is a governmental agency to execute the space program of Republic of China

- Location: Hsin-Chu Science-Based Park, Hsin-Chu City, Taiwan, ROC
## Program Schedule

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Satellite Integration & Test Facility and Laboratories

- Construction started in Sep. 1994 and completed in July 1997
- The I&T facility is the first large, high space-standard, high cleanliness facility in Taiwan
- In addition to conduct the I&T tasks for ROCSAT programs, this facility provides services not only to local industry and R&D organizations for space environmental tests, but also to the international space community via cooperative program

2-Story Building with High Bay
- Office Area: ~2000 m²
- Laboratories & Control Rooms: ~3000 m²
- High Bay Area: ~3000 m²
Layout of I&T Facility

- Airlock Room
- Integration Highbay
- Ground Support Equipment
- EMI/EMC Anechoic Chamber
- Acoustic Chamber
- Tool & Machine Room
- Mass Property Measurement
- Laboratory
- Vibration Test Area
- Mechanical highbay
- Control & Instrumentation
- Thermal Vacuum Chamber
Major Testing Equipment/Facility

EMI/EMC Anechoic Chamber

Acoustic Chamber

Vibration Test Facility

Thermal Vacuum Chamber

Mass Property Measurement Facility
Laboratory Capabilities

Structure Laboratory
- Mechanical Design Integration
- Structure and Mechanism Design
- MGSE Design
- Dynamic and Stress Analysis
- Coupled Loads Analysis
- Structure Dynamic Test Validation

Thermal Laboratory
- Satellite Thermal Control Design and Analysis
- Thermal Control Components Hardware Development
- Thermal Hardware Installation
- Perform Thermal Vacuum and Thermal Balance Tests and Test Analysis.

Mechanical Design Integration
- Static Analysis
- Dynamic Analysis
- Structure/Mechanism Design
- Couple Load Analysis

Structure Lab.
- Manufacture, Assembly
- Structure Dynamic Validation
- Pro-E, Adams, CATIA

PATRAN, MSC/NASTRAN
**Laboratory Capabilities**

**Electro-Optic Laboratory**
The objective of the EO Lab is to develop technology of space EO system analysis and integration.

**ADCS Test Lab.**
- Processor-in-The-Loop
- Vehicle Dynamic Software
- Real-Time Control

**System Simulation Laboratory**
System Simulation Lab is responsible for the overall space system analysis, simulation, and verification, including mission analysis and simulation, I&T support, and mission operations support.
ROCSAT Ground System (RGS)

- The main facilities of RGS consists of the Mission Center (Hsin-Chu), southern TT&C station (Tainan), and northern TT&C station (Chung-Li).
- RGS is currently operating the ROCSAT-1 satellite and being upgraded and expended to Multi-Mission Center (MMC) to support the follow-on ROCSAT programs.
Mission Center

- Monitor the SOH of satellite
- Uplink satellite commands
- Satellite and payloads activities planning and scheduling
- Detecting and resolving the conflict of satellite activities
- Science instrument operations planning, science data processing, archive and data distribution
- Satellite orbit and attitude determination
- Orbit and attitude maneuver planning
The TT&C station provides the RF links between the RGS and satellites via S-Band.

Two TT&C stations are remotely controlled by Mission Operations Center (MOC) located at NSPO via the T-1 lines:

- North site located in National Central University (Chungli)
- South site located in National Cheng Kung University (Tainan)
RGS Future View

ROCSAT-3

S/L-Band TT&C Station

ROCSAT-1

S-Band TT&C Station (north)

ROCSAT-2

S-Band TT&C Station (south)

Other Satellite

X-Band Antenna System

Multi-Mission Center

Image Processing System

SDDC for R-1

SDDC for R-2

CDAAC/TACC for R-3

RSDDC for R-2
ROCSAT-1 Program

- Category: Scientific experimental satellite
- Weight: 402kg (with payloads and propellant)
- Dimensions: Hexahedron, 2.1m(H) x 1.1m (7.2m in width with solar array deployed)
- Orbit: Circular earth orbit with altitude of 600km and inclination of 35º
- Period: 96.7 min.
- Communications: S-band, Uplink=2kbps, Downlink=1.4 Mbps
- Data Storage: 2Gbits EOL
- Attitude Control: 3-axis stabilized
- Pointing Accuracy: 0.5 deg each axis
- Mission Life: 2 years min. (design life 4 years)
- Payloads: OCI, IPEI, and ECP
- Launch Vehicle: Athena I
- Launch Date: January 27, 1999
Three scientific payloads on-board:

- **Ocean Color Imager (OCI)**: Collect data on visible and near-infrared radiance for mapping pigment distribution in the low-latitude oceans.
- **Ionosphere Plasma and Electrodynamics Instrument (IPEI)**: Measure the ionization of the earth’s upper atmosphere in low and middle latitude.
- **Ka-band Experimental Communication Payload (ECP)**: Conduct various Ka-band telecommunication experiments to build-up the capability on Ka-band communication technology inside the country.
Ion Holes observed during July 15-16, 2000
Magnetic storm
ROCSAT-2 Program

Remote Sensing Mission
- Acquire and monitor the terrestrial & marine environment and resource of Taiwan in near real time

Applications are mainly focused on agriculture and forestry, land use, natural disaster assessment, environmental monitoring, as well as academic researches and public education

Science Mission
- ISUAL (Imager of Sprite Upper Atmospheric Lightning)
- ISUAL is to observe the natural upward lightning discharge phenomenon toward the ionosphere on the top of the tropopause
- ISUAL is a joint research program by NSPO, University of California, Berkeley, National Cheng Kung University, and Tohoku University
ROCSAT-2 Spacecraft

- Weight: around 700kg
- Dimensions: Hexahedron, 2.4m (H) x 1.6m (solar array folded)
- Orbit: Sun Sync. with altitude of 891 km daily revisit Taiwan twice
- Remote Sensing Instrument: Pan + 4 MS
- GSD @ ndir: 2m (PAN) and 8m (MSI)
- Swath @ ndir = 24 km; @ 45 deg = 62 km
- Agility: Body Rotation with ± 45 deg Roll & Pitch
- RSI Duty Cycle > 8% per orbit
- Point Accuracy < 0.7 km
- Point Knowledge < 450 m without GCP
- Position Knowledge < 70 m
- X-band Imaging Data Rate: 120 Mbps
- Remote Sensing Data Storage = 40 Gbits
- Mission Life: 5 years
- Launch Date: Mid. of 2003
Stereo Imaging

8 Minutes Above 20 deg Elevation

11 Minutes Above 10 deg Elevation

Look Forward 1 Minutes

Pitch Maneuver

Look Backward 1 Minutes

Groundtrack
Image Tasking Simulation

Swath Width: 24 km
Imaging Time: 1 min
Maneuver Time: 1 min
ISUAL Mission

- To obtain a global survey of upper atmospheric optical flash transients.
- This will be the first experiment to observe upper atmospheric lighting from the satellite.
- To identify the global distribution of red sprites;
- To identify the spatio-temporal dynamics of red sprites;
- To explore and identify the UV band content in the activity of red sprites;
- To identify the degree of the ionization in the sprite emission region.
Red Sprites

Taken from A-Li Mountain
by ROCSAT-2/ISUAL Science Team on May 1, 2001
Red Sprites

Sprites are transient optical flashes observed at an altitude of 30-90km, which are associated with electric discharges above thunderstorm systems. The sprite events in this poster were recorded on May 1 and June 7, 2001 from Ali Mountain Weather Station and the campus of National Cheng Kung University (NCKU). The thunderstorms producing these sprites were located in the eastern Guandong Province, China and the western edge of Pacific Ocean near Taiwan.

ISUAL Project, ROCSAT-2, National Space Program Office, Taiwan
http://sprite.phys.ncku.edu.tw/
NCKU/UC-Berkeley/Tohoku Univ/NSPO
The ROCSAT-3/COSMIC system is a constellation of 6 low-earth-orbit (LEO) micro-satellites. Each micro-satellite is cylindrical with weight 70 Kg, diameter 120 cm, height 43 cm, and two 110-cm diameter solar panels deploying 90 and 53 degrees, respectively.

Satellite parking orbit is 400~500Km with 72-degree inclination. The individual micro-satellite will perform orbital raising maneuvers to get into 3 separate orbital planes. The mission orbit is 800-Km circular.

Mission life: 2 years (design life: 5 years)

Expected Launch Date: Early 2005

An international cooperation program between NSPO and UCAR (University Corporation for Atmospheric Research), USA.
ROCSAT-3 Missions

- The ROCSAT-3/COSMIC program is to launch and operate a constellation of 6 LEO micro-satellites comprised of an integrated spacecraft platform and three payloads:
  - GPS occultation receiver
  - Tiny Ionospheric Photometer
  - Tri-Band Beacon.

- These micro-satellites collect a large amount of atmospheric data for meteorological, climatic, ionospheric, and geodetic research as well as for weather forecasting and space weather monitoring.
To obtain the temperature, pressure, and water vapor pressure from refractivity of the GPS signals to provide global weather forecasting (< 3 hrs latency)

To provide space weather information, e.g. electron density profiles, horizontal & vertical TEC and CIT, scintillation, and communication outage maps (<2 hrs latency)
Red dots are current radiosonde sites. Green dots are COSMIC soundings in a day.
Array system promises global atmospheric monitoring

David Cyranoski, Tokyo

A Taiwan-US collaboration is hoping that its constellation of microsatellites equipped with Global Positioning System (GPS) receivers will provide a valuable new approach to meteorology, climatology and research into 'space weather'.

Most weather forecasting currently relies on balloons that take readings such as temperature and humidity on their way up from some 300 locales worldwide. But these points are restricted to land, ruling out truly global weather models. Weather satellites give wider coverage, but they gather data by looking straight down to Earth, yielding little information about what is happening at various different altitudes.

But the Taiwan-led Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) could change that by using an array of microsatellites and a novel technique to improve the coverage and accuracy of data collection.

The six COSMIC microsatellites, scheduled to be launched in mid-2005, will pick up radio signals from 28 existing GPS satellites as they pass through the Earth's atmosphere. The microsatellites will observe the refraction (or bending) of the signals, and infer information about atmospheric density from it, at all altitudes. From the density data, researchers will be able to deduce the pattern of pressure and temperature.

"We can also calculate atmospheric moisture near the surface, construct pressure contours, and derive wind fields and other critical quantities," says Ion Yunck of NASA's Jet Propulsion Lab (JPL), which did much of the early work on the technique.

The most important advantage is coverage. "The microsatellite constellation will measure some 4,000 points spread uniformly around the globe, with high accuracy," says Chao-Han Liu, president of Taiwan's National Central University.

Researchers on 'space weather' are also excited about the project, says Liu. In the ionosphere, at altitudes of about 80 km, electron density can be measured in a similar fashion to the atmospheric density. This will provide valuable information for predicting magnetic storms, which can affect the operations of satellites and power grids.

The COSMIC system has the potential to significantly improve climatological measurements, says Alan Thomas, director of the Global Climate Observing System secretariat. However, he warns that it will probably take time to develop a reliable system that produces measurements for climate-change applications, and another 20 years or so after that to obtain a meaningful long-term climate dataset.

The agreement to build the system, signed on 3 May, involves Taiwan's National Space Program Office (NSPO), JPL, the US University Corporation for Atmospheric Research in Boulder, Colorado, and several US universities.

Taiwan will pay US$80 million of the estimated US$100 million total project cost and will build the satellites with the help of Orbital Sciences Corporation of Dulles, Virginia, which made a prototype version of the satellite in 1995 for a 'proof-of-concept' experiment. Taiwan will also operate the mission.

"This is a chance to get people really interested in space science," enthuses Luo Chang Lee, director of NSPO.
A second phase fifteen-year follow-on plan is being planned to continue the current Space Program in ROC with focusing on the following direction:

- **National Need**: Ka-Band Communication Satellite, High-resolution Remote Sensing Satellite, etc.
- **Scientific Research**: International Cooperation, COSMIC-II, etc.
- **Commercial Applications**: Multi-purpose Micro-Satellite, etc.

NSPO will evolve from the governmental agency into a non-profit institution to accommodate the future challenge and step into the space business area.

With all the available resources, Taiwan will be an active member in the space community for years to come.
NSPO is currently planning its missions for the next 15 years (2003-2018). NSPO plans to launch satellites for frontier science missions and participate in international satellite projects.

NSPO solicits mission concepts with frontier research using advanced technology.

NSPO invites the active participation of universities and research institutes to plan and execute the missions together.

NSPO will consider space-related fields including astrophysics, solar physics, space physics, atmospheric physics, oceanography, geodesy, and other disciplines.
NSPO current proposals

1. HELIX proposal (MIDEX Proposal)
   - *Exploring the evolution of solar wind and coronal mass ejection in the heliosphere*
   - *X-ray Imager*
   - *Solar wind plasma instrument*
   - *Some spacecraft subsystems*

2. OHMIC proposal (MIDEX Proposal)
   - *Observatory of heteroscale magnetosphere-ionosphere coupling*
   - *High Resolution Visible Imager for aurora*
   - *Some spacecraft hardware*

3. Lightning Map Sensor proposal
   - *Investigation of global distribution of lightning and its relations with storm weather*
The red arrows point to the HELIX spacecraft (H1 to H4). The inserts show X-ray images of a solar flare with a loop-top source as seen form the different spacecraft and the time profiles in X-rays and electron flux. For spacecraft H4, the footpoints are occulted and only the weak loop-top source is visible.

**Key Measurements:**
- X-ray imaging from multiple directions
- Electron velocity dispersion
- Direction finding of type III emission
- Neutrons and γ-Rays from flare

As the EIT wave moves in time, different spacecraft are connected to the different locations of electron acceleration.

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1 day  
2 days
LMS Requirements

Mass: 35 kg
Power required: 135 W
IFOV: ± 5.30° E/W,
± 3.62° N/S
(each of 2 lens assy)

Pointing
Accuracy: 0.1°
Stability: 35 μrad
Knowledge: 112 urad

Downlink rate: 200 kbits/sec LVDS PCM
Commanding: 5 Kbits/sec, max
Timing knowledge: ± 1 millisecond of UTC