The 5th East Asian Meeting of Astronomy

Space Program in Taiwan

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National Science Council
Executive Yuan, ROC

November 13, 2001

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**
  - *ROCSAT-1*
  - *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

Introduction to NSPO

- **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

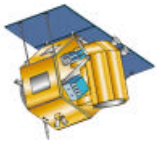
PHASE	PHASE I						PHASE II								
YEAR	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05

INFRASTRUCTURE DEVELOPMENT

- NSPO ESTABLISHED
- I&T FACILITY COMPLETED

ROCSAT-1

PLANNING → KICK-OFF | DEVELOPMENT → LAUNCH | OPERATIONS



ROCSAT-2

PLANNING → KICK-OFF | DEVELOPMENT → LAUNCH | OPERATIONS

ROCSAT-3

PLANNING → KICK-OFF | DEVELOPMENT → LAUNCH | OPERATIONS

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 cleanness 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**

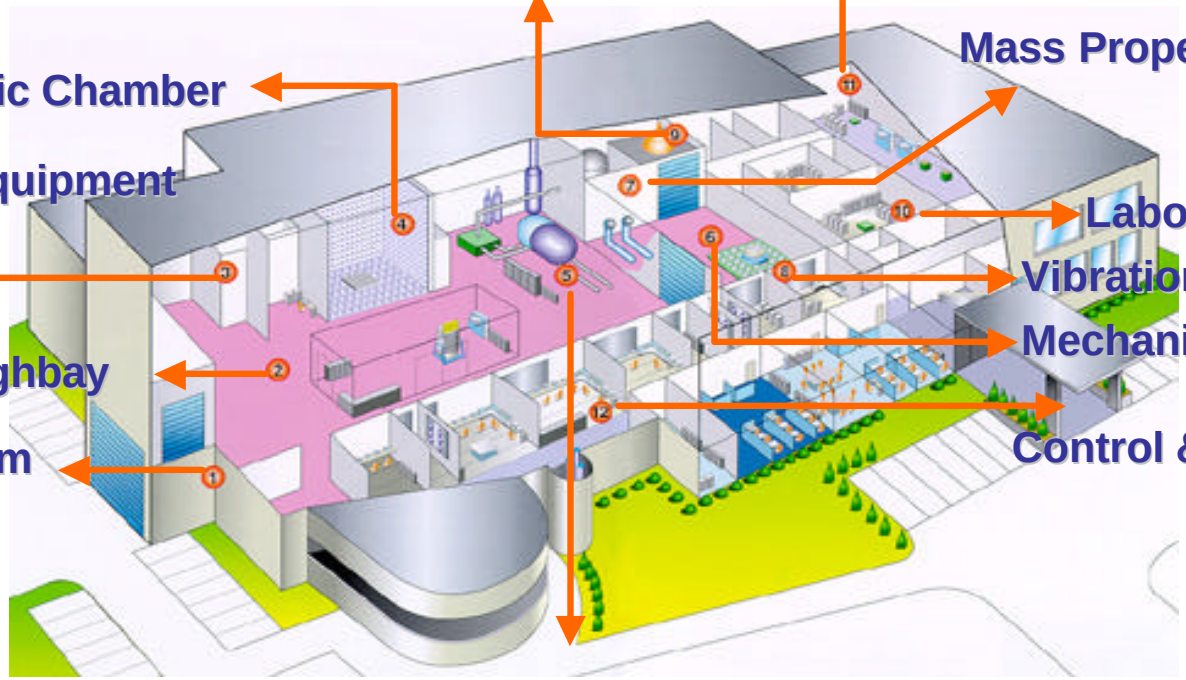
2-Story Building with High Bay

Office Area: ~2000 m^2

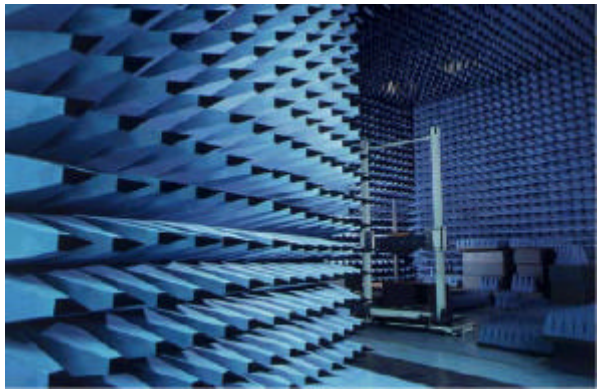
Laboratories & Control Rooms: ~3000 m^2

High Bay Area: ~3000 m^2

Layout of I&T Facility



Major Testing Equipment/Facility

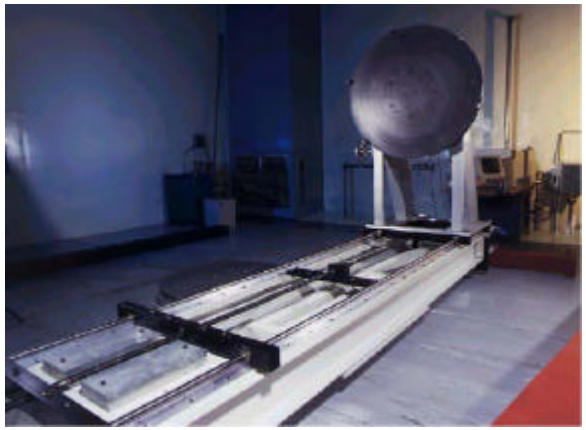


EMI/EMC Anechoic Chamber

Acoustic Chamber

Vibration Test Facility

Thermal Vacuum Chamber

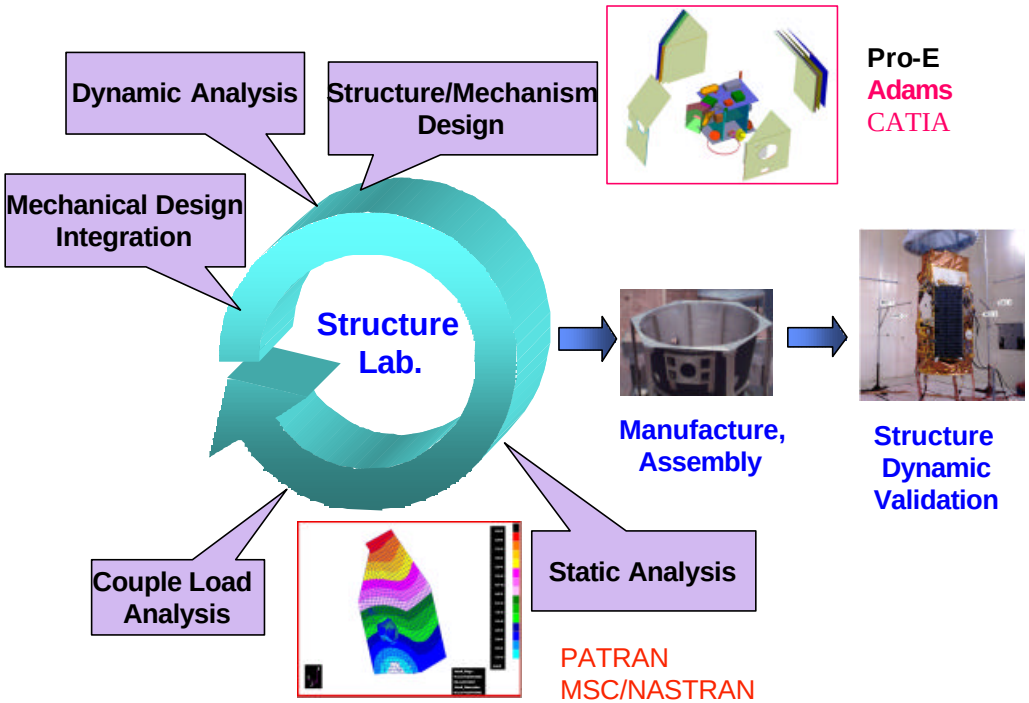


Mass Property Measurement Facility

Laboratory Capabilities

Structure Laboratory

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



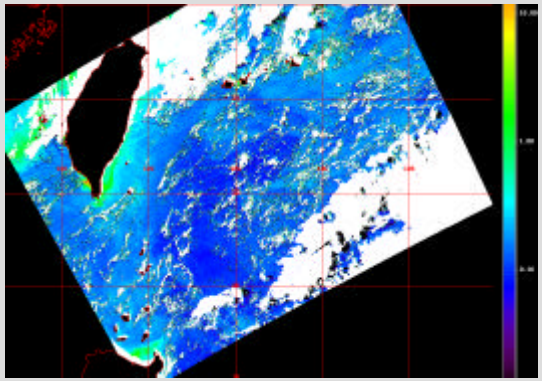
Thermal Laboratory

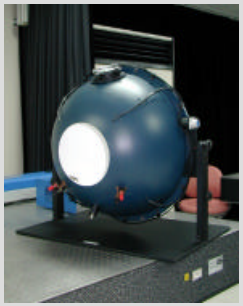
- Satellite Thermal Control Design and Analysis
- Thermal Control Components Hardware Development
- Thermal Hardware Installation
- Perform Thermal Vacuum and Thermal Balance Tests and Test Analysis.

Laboratory Capabilities

Electro-Optic Laboratory

The objective of the EO Lab is to develop technology of space EO system analysis and integration.





integrating sphere

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.

ADCS Test Lab.

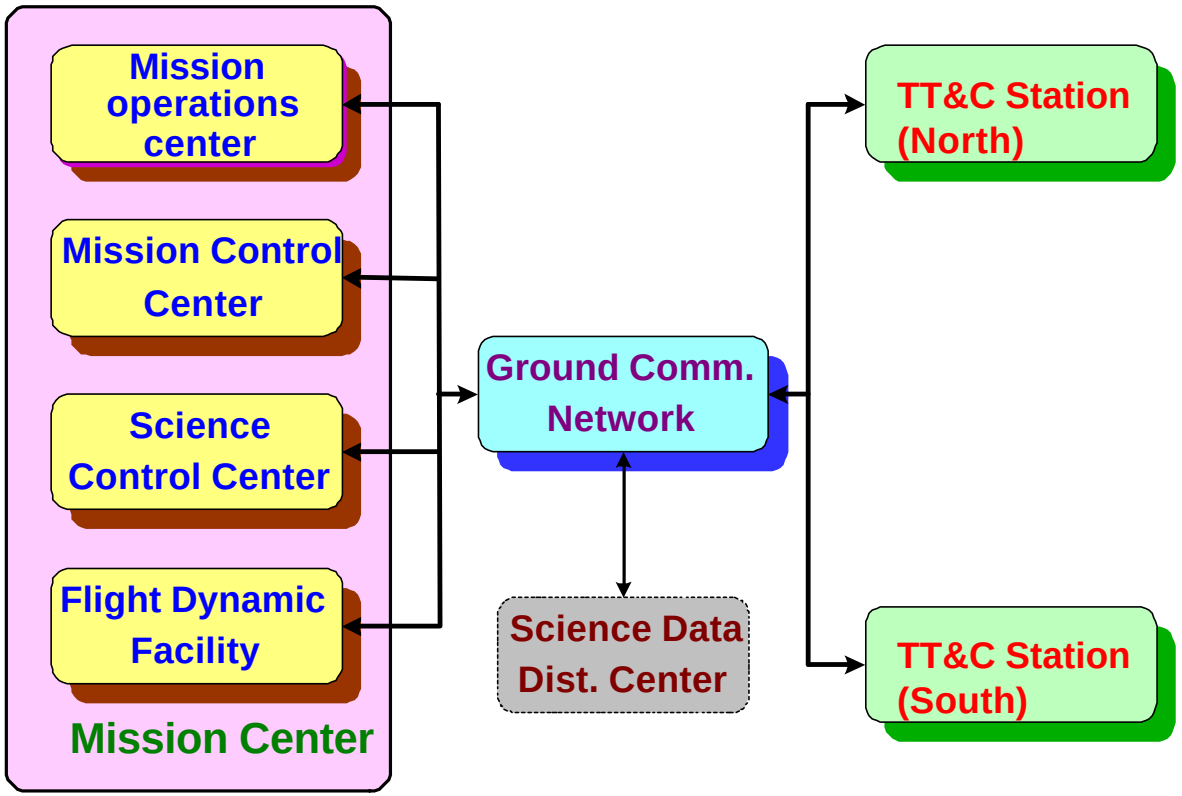
- **Processor-in-The-Loop**
- **Vehicle Dynamic Software**
- **Real-Time Control**

ADCS Test Set Host Computer

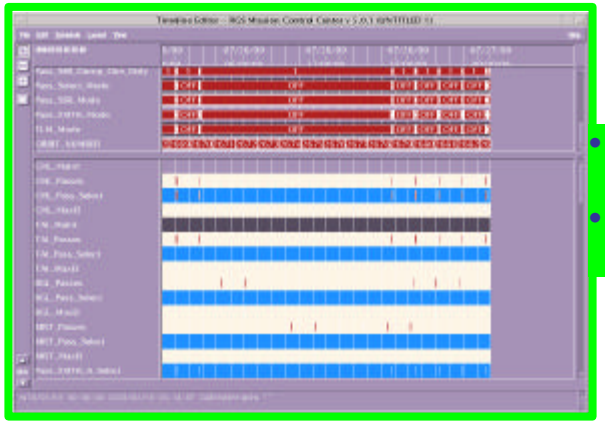
ADCS Test Set

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

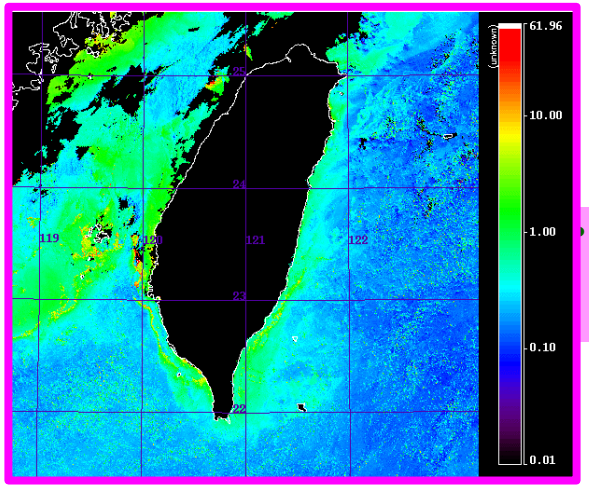


Mission Control Center

- Satellite and payloads activities planning and scheduling
- Detecting and resolving the conflict of satellite activities

- Monitor the SOH of satellite
- Uplink satellite commands

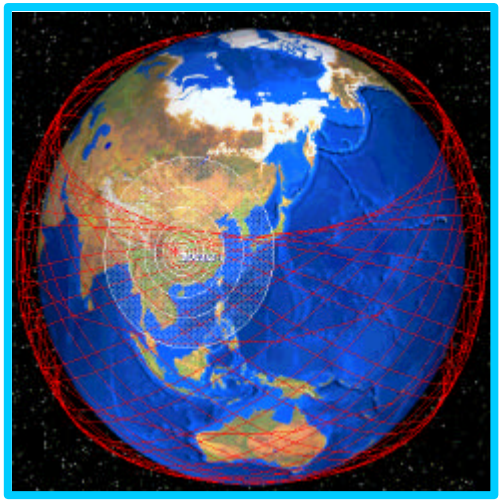
Mission Operations Center



Science Control Center

- Science instrument operations planning, science data processing, archive and data distribution

- Satellite orbit and attitude determination
- Orbit and attitude maneuver planning

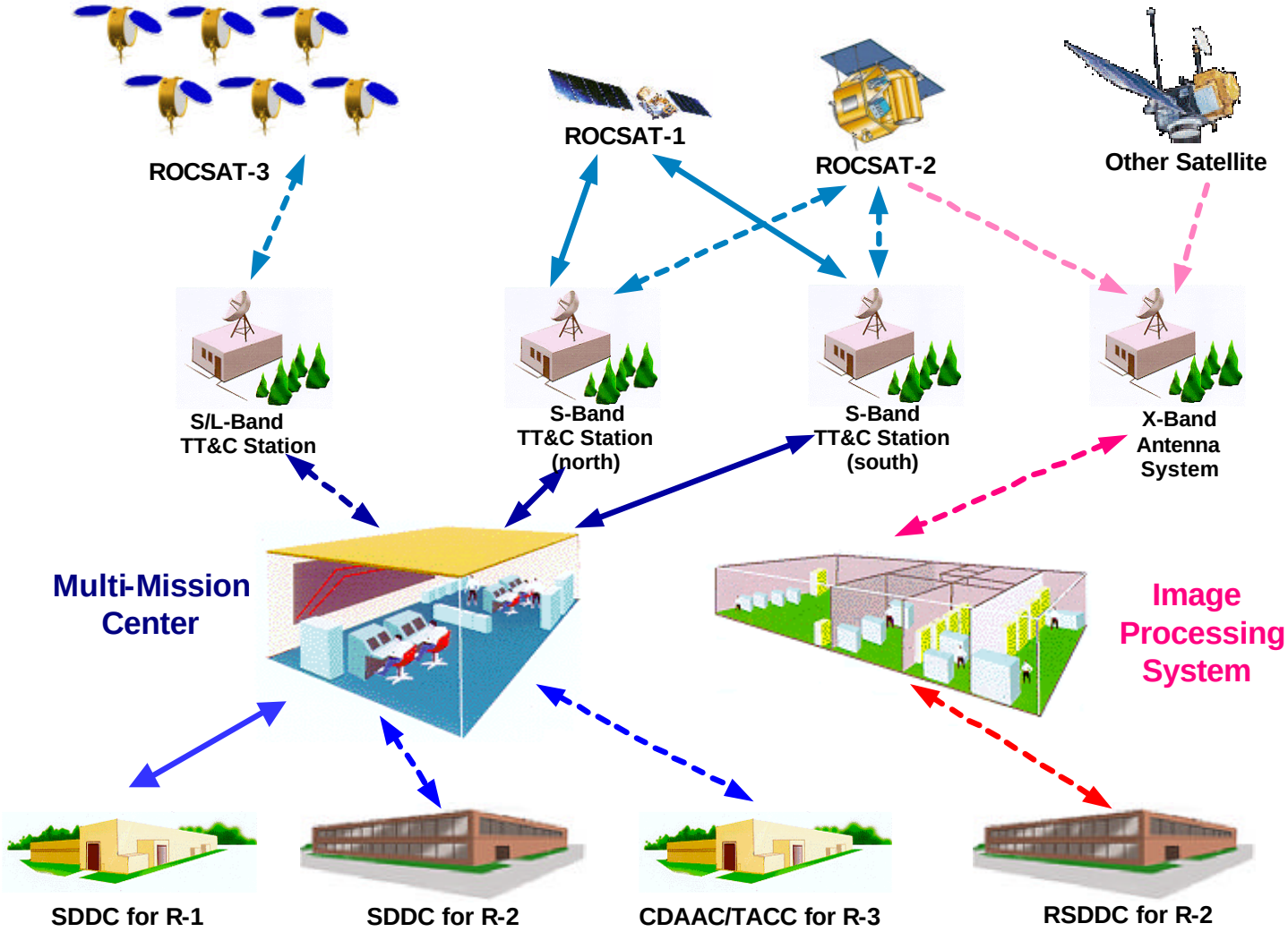


Flight Dynamics Facility

S-Band TT&C Stations

- **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

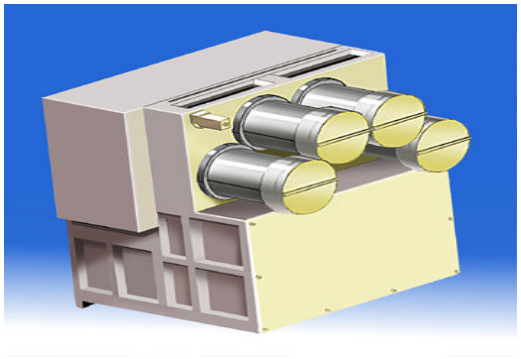


ROCSAT-1 Program

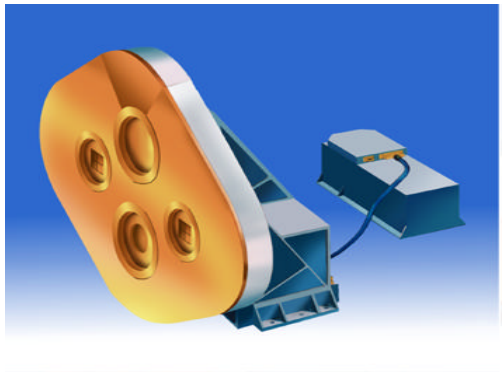
- Category: Scientific experimental satellite
- Weight：402kg (with payloads and propellant)
- Dimensions：Hexahedron, 2.1m(H) x 1.1m (7.2m in width with solar array deployed)
- Orbit：Circular earth orbit with altitude of 600km and inclination of 35º
- Period：96.7 min.
- Communications : S-band, Uplink=2kbps, 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

Scientific Missions

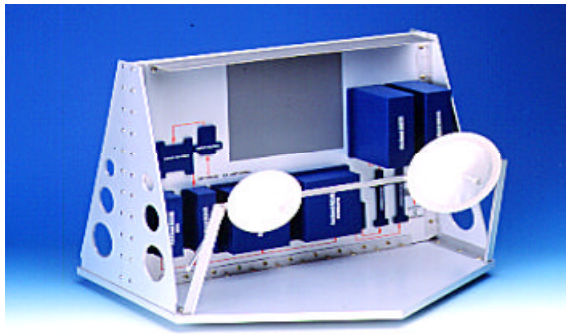
- **Three scientific payloads on-board:**
  - *Ocean Color Imager (OCI) : Collect data on visible and near-infrared radiance for mapping pigment distribution in the low-latitude oceans*
  - *Ionosphere Plasma and Electrodynamics Instrument (IPEI) : Measure the ionization of the earth's upper atmosphere 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*



Ocean Color Imager (OCI)

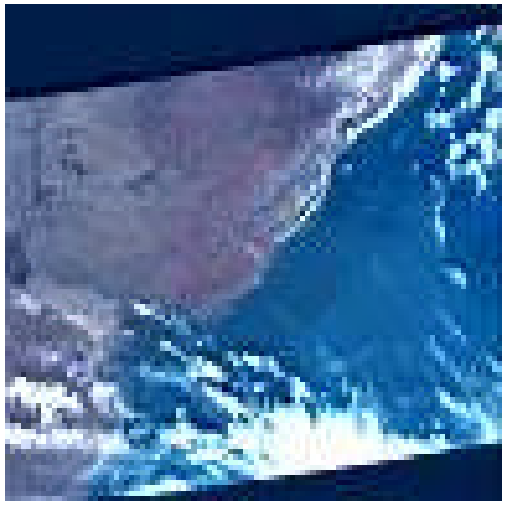


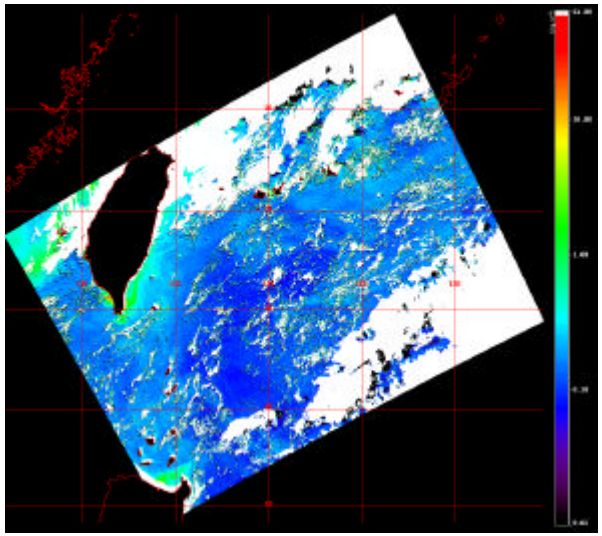
Ionospheric Plasma and Electrodynamics Instrument (IPEI)

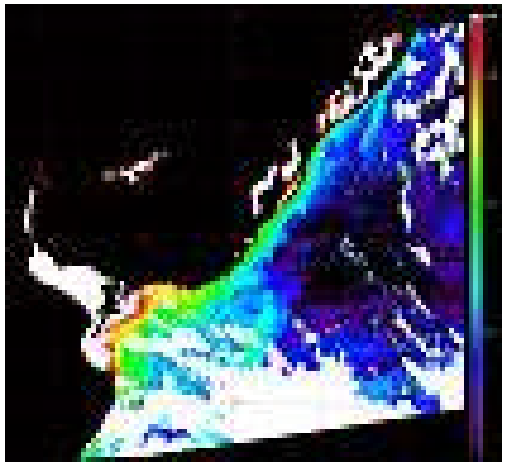


Ka-band Experimental Communication Payload (ECP)

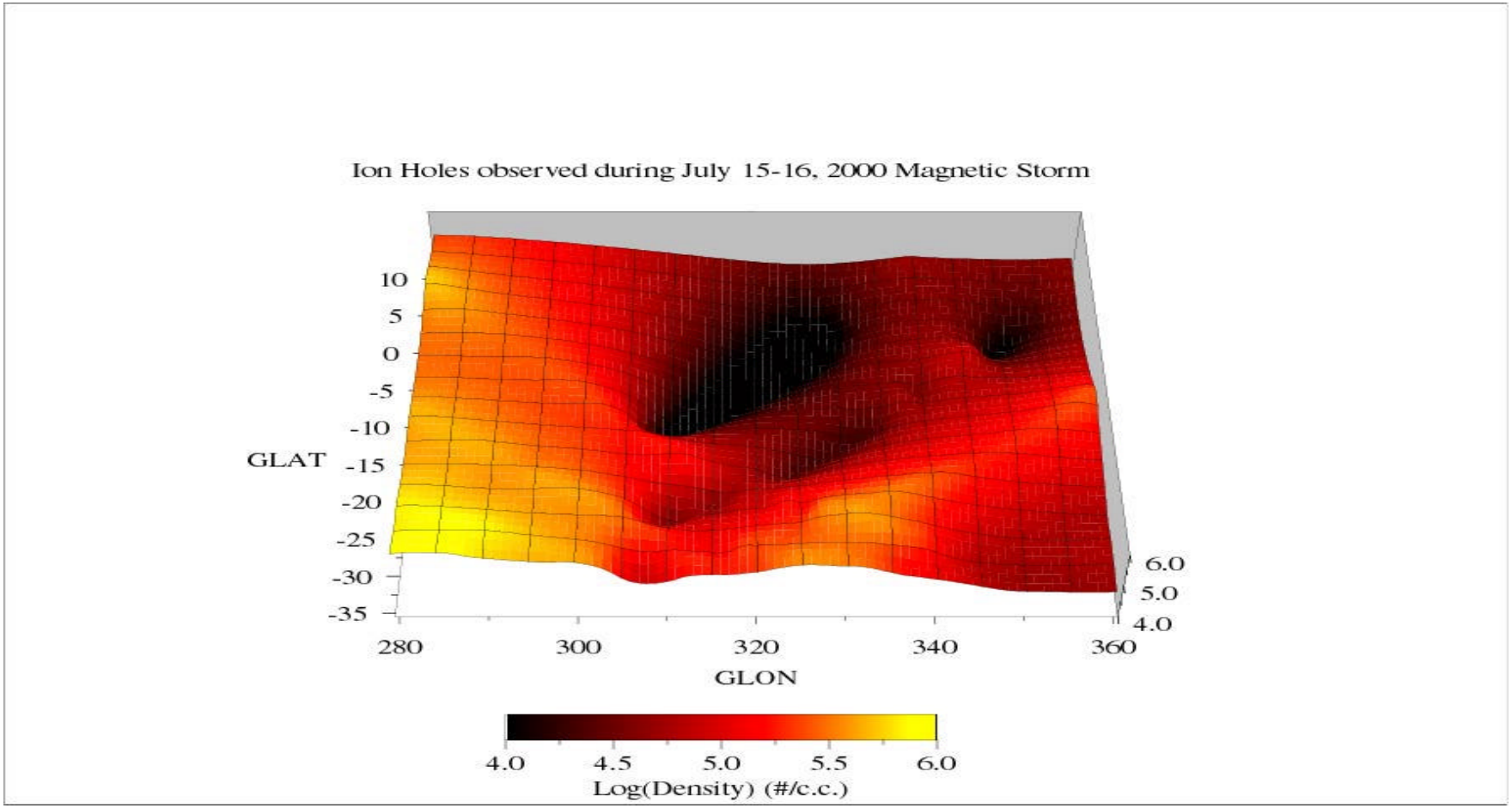
OCI Imagery and Result







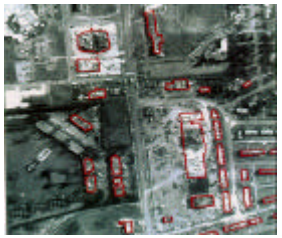
Ion Holes observed during July 15-16, 2000 Magnetic storm



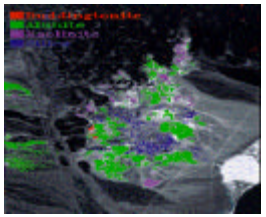
ROCSAT-2 Program

Agriculture & Forestry

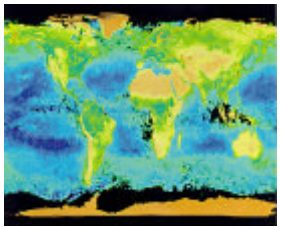
Land Use



Natural Disaster



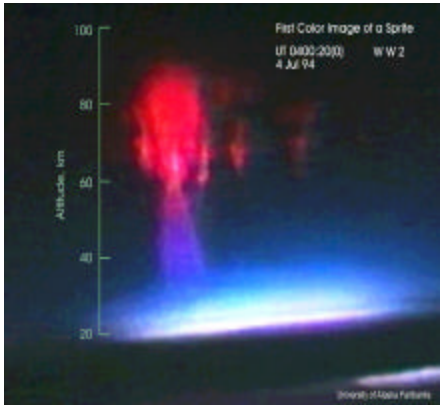
Environment Monitoring



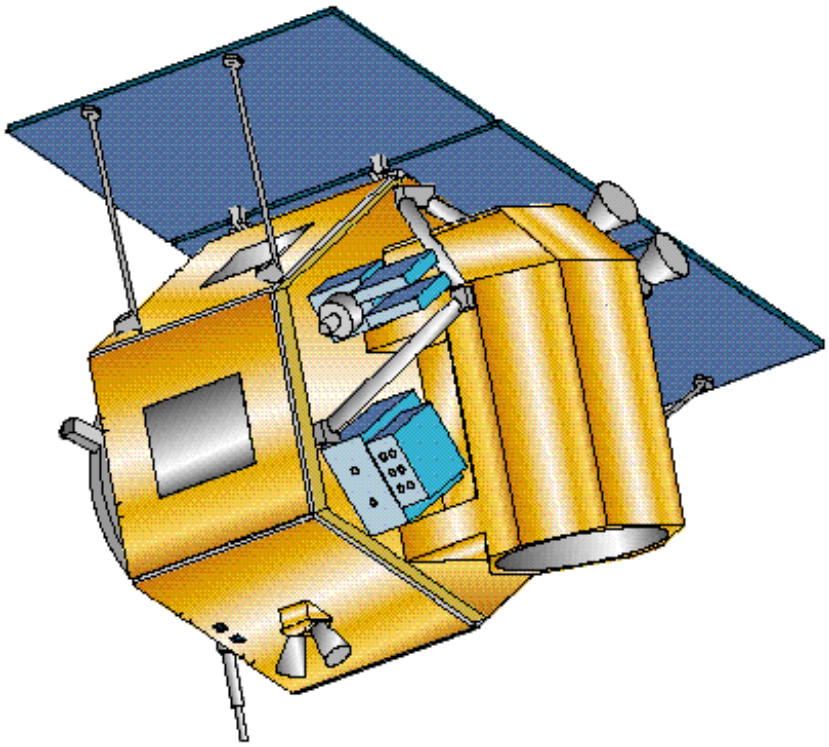
Research & Education

- **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

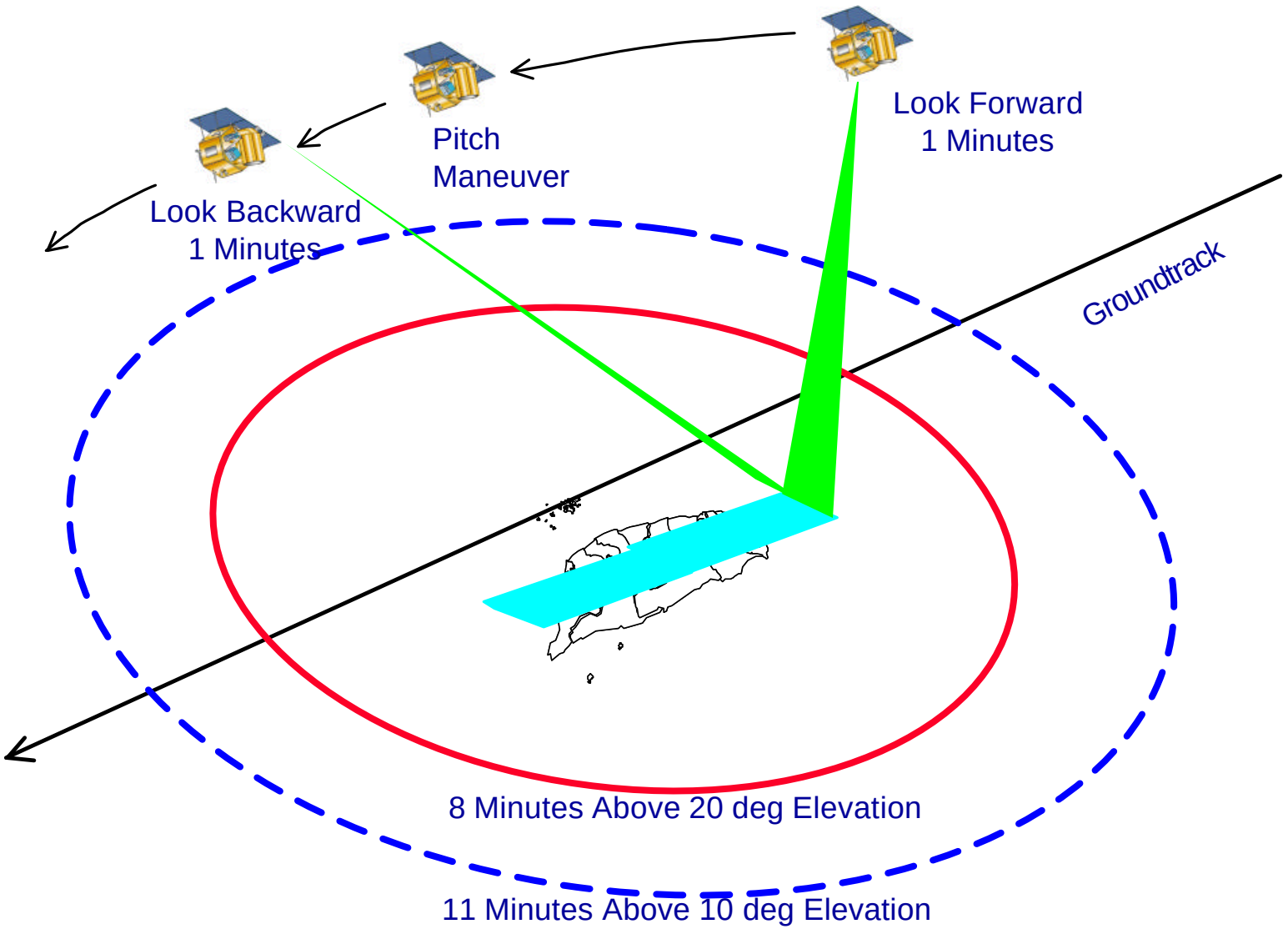
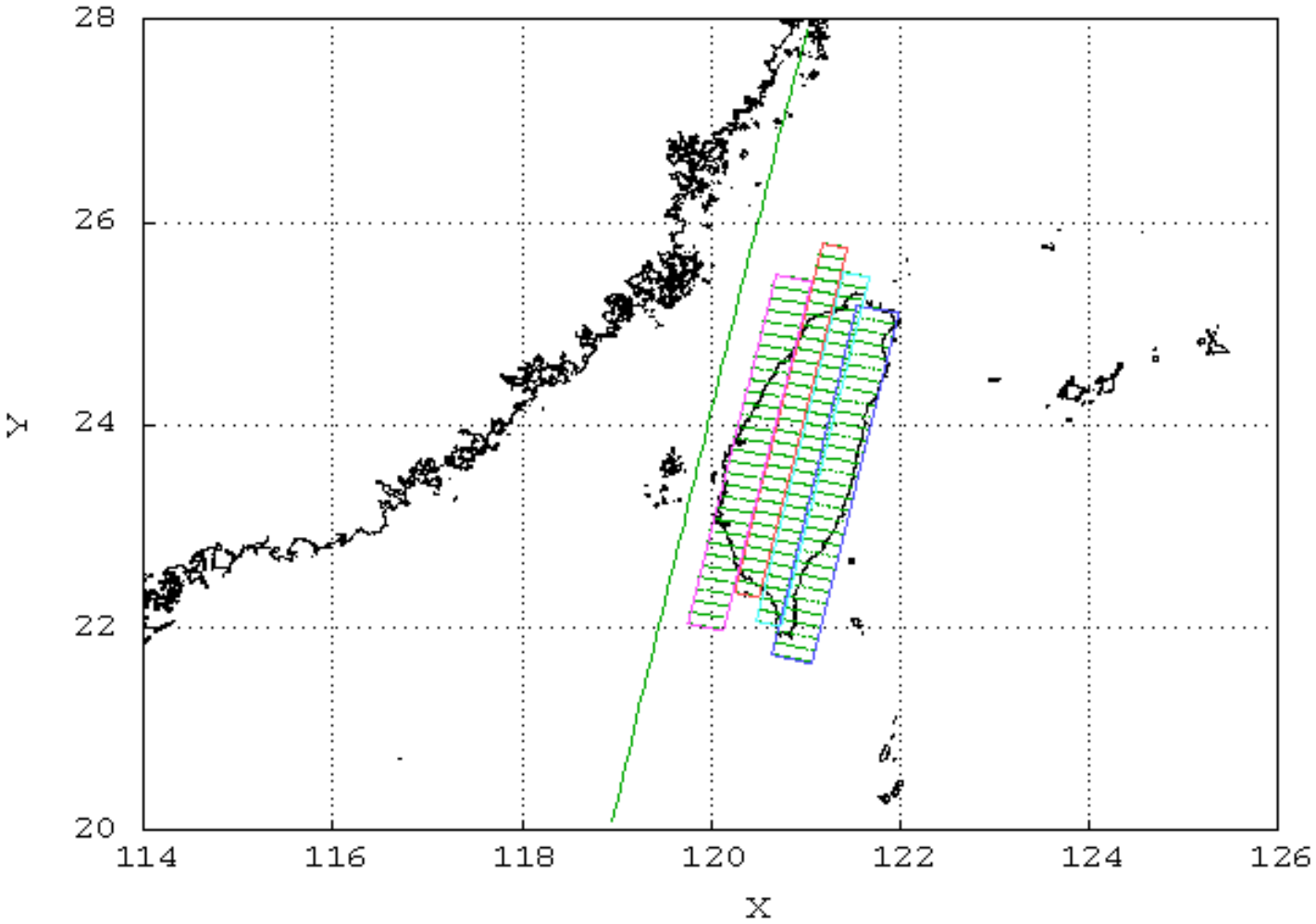


Image Tasking Simulation

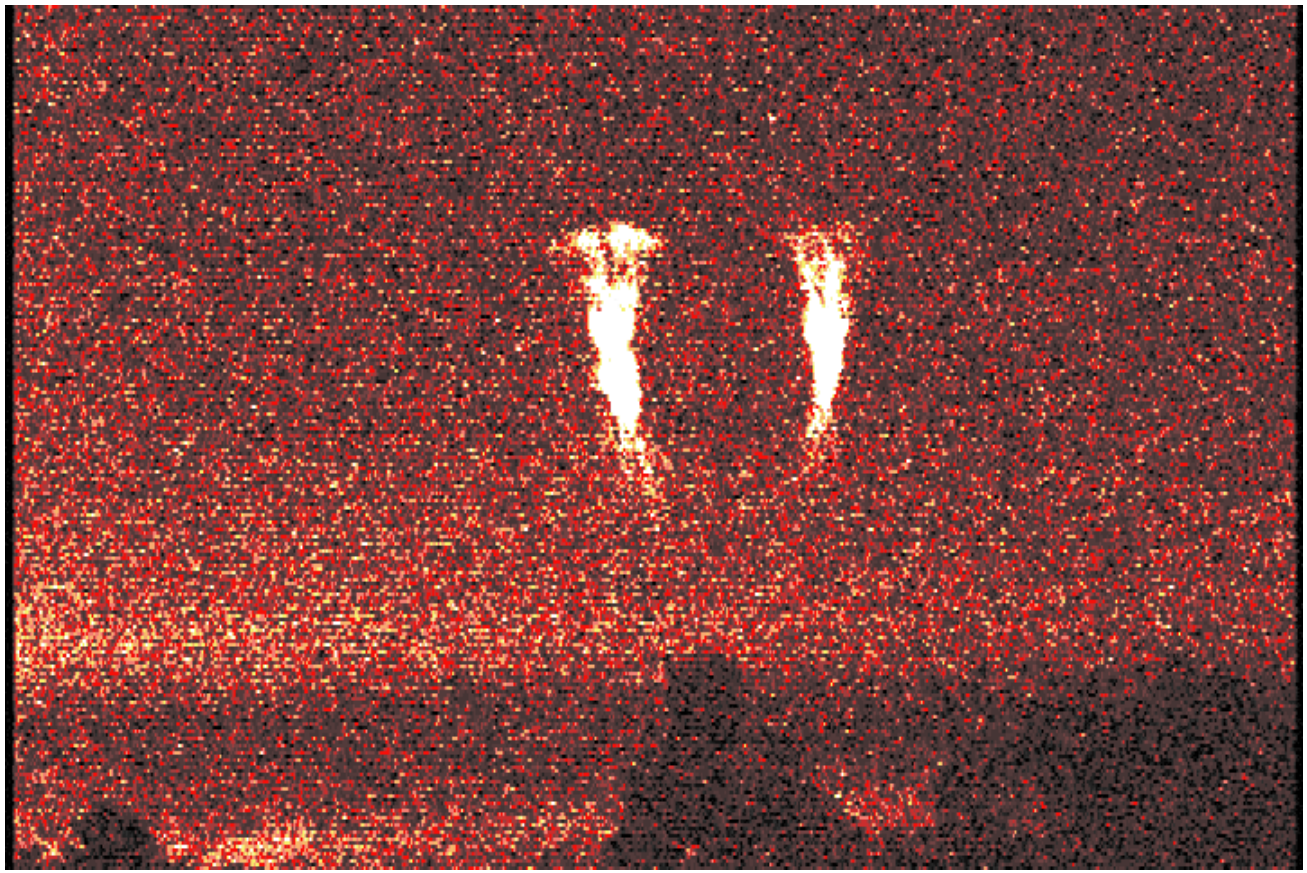
Swath Width: 24 km
Imaging Time: 1 min
Maneuver Time: 1 min



ISUAL Mission

- **To obtain a global surrey 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.**

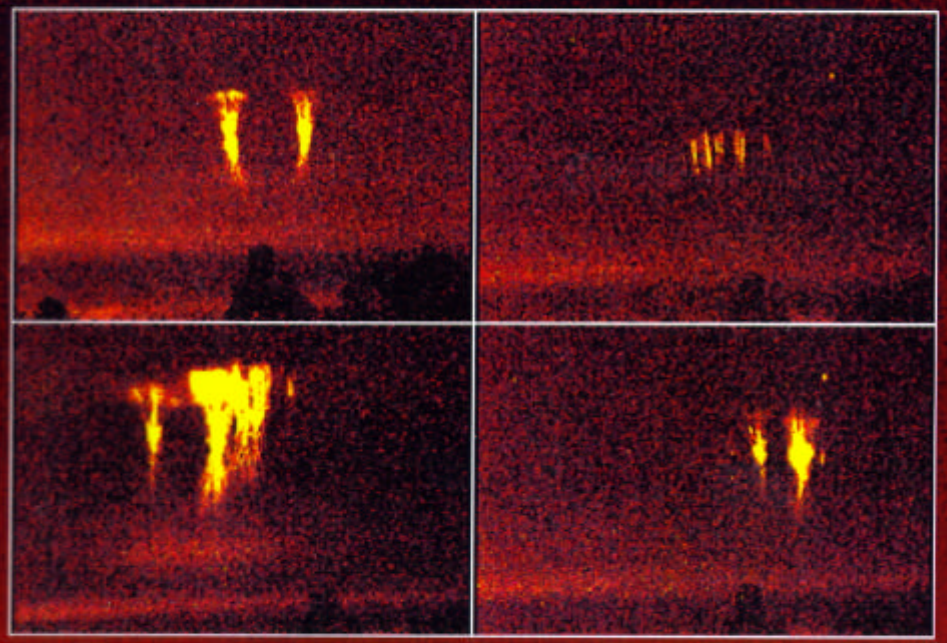
Red Sprites



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

Red Sprites

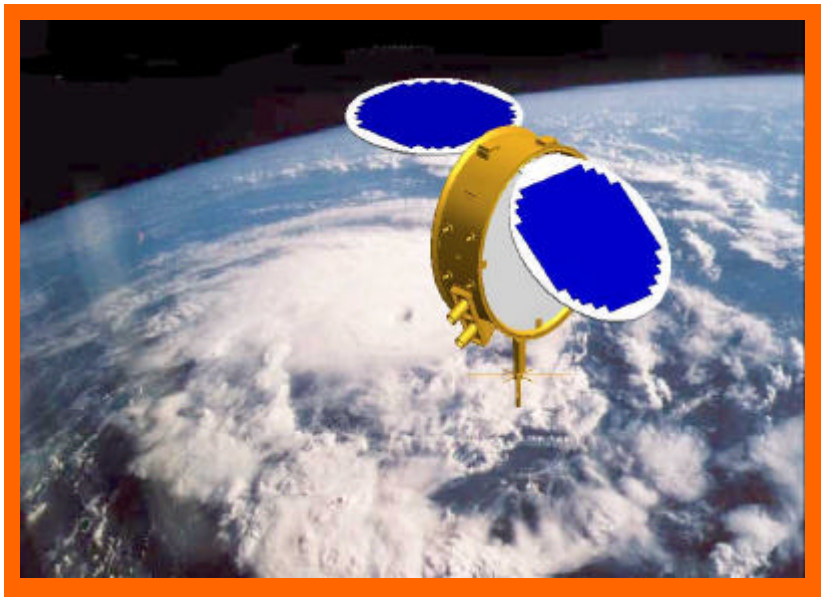
Sprites are transient optical flashes observed at an altitude of 30-90km, which are associated with electric discharges above thunderstorm systems. The sprite events in this poster were recorded on May 1 and June 7, 2001 from Ali Mountain Weather Station and the campus of National Cheng Kung University (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

ROCSAT-3 Program

An international cooperation program between NSPO and UCAR (University Corporation for Atmospheric Research), USA

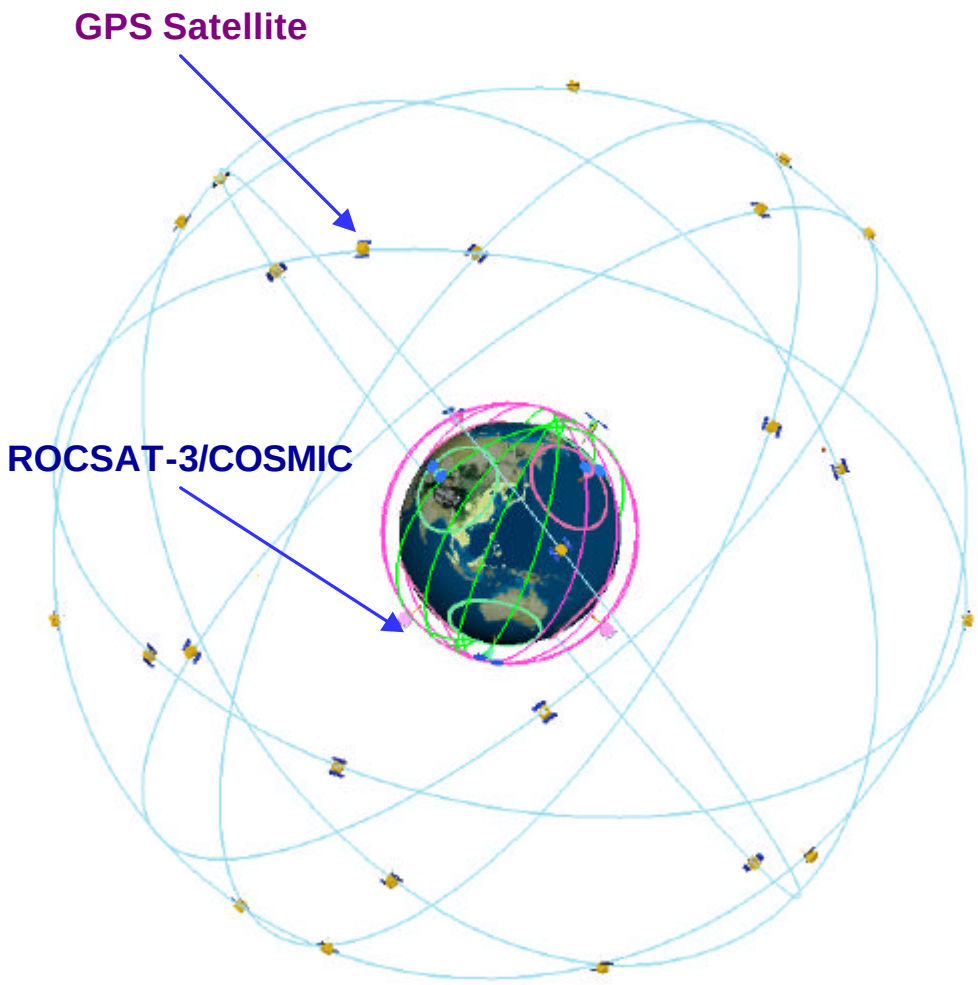


- **The ROCSAT-3/COSMIC system is a constellation of 6 low-earth-orbit (LEO) micro-satellites**
- **Each micro-satellite is cylindrical with weight 70 Kg , diameter 120 cm, height 43 cm, and two 110-cm diameter solar panels deploying 90 and 53 degrees, respectively**
- **Satellite parking orbit is 400~500Km 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**

ROCSAT-3 Missions

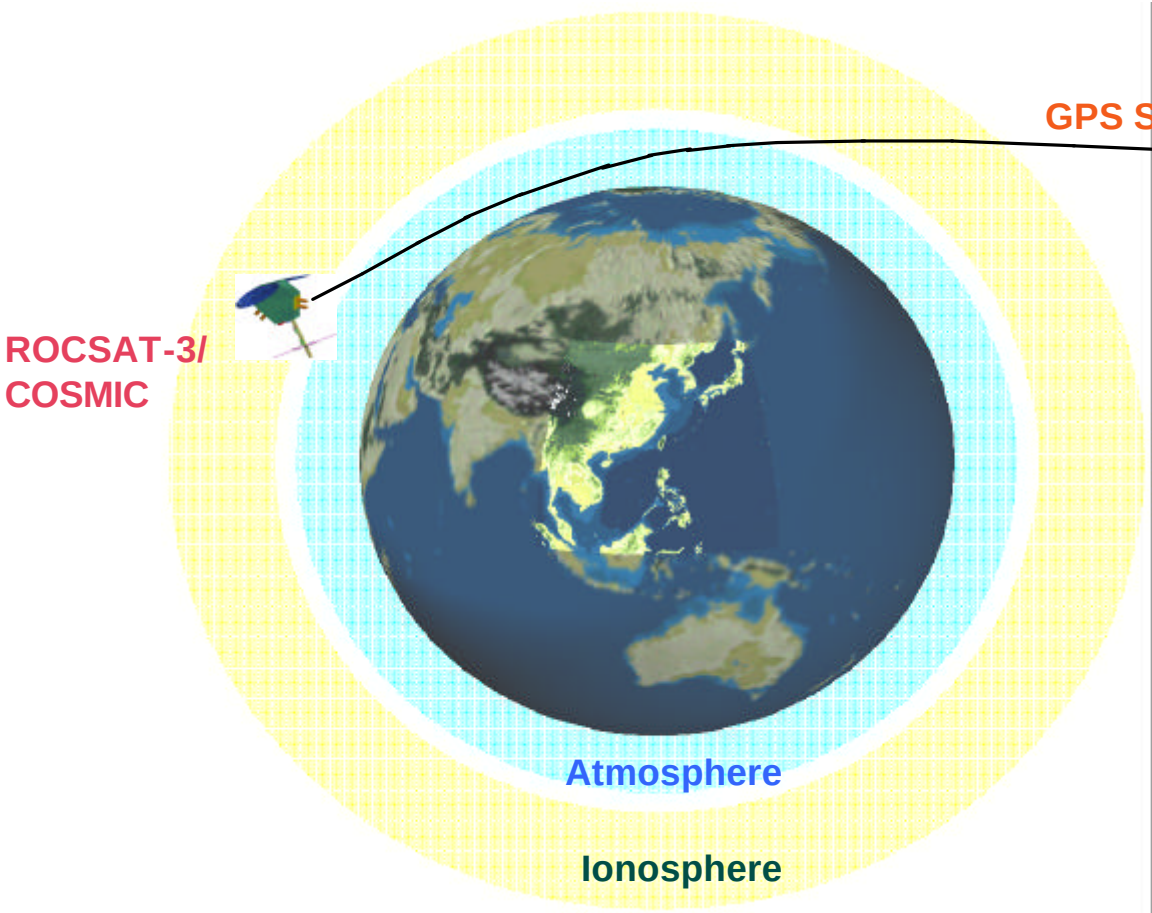
- **The ROCSAT-3/COSMIC program is to launch and operate a constellation of 6 LEO micro-satellites comprised of an integrated spacecraft platform and three payloads**
  - *GPS occultation receiver*
  - *Tiny Ionospheric Photometer*
  - *Tri-Band Beacon.*

- **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.**



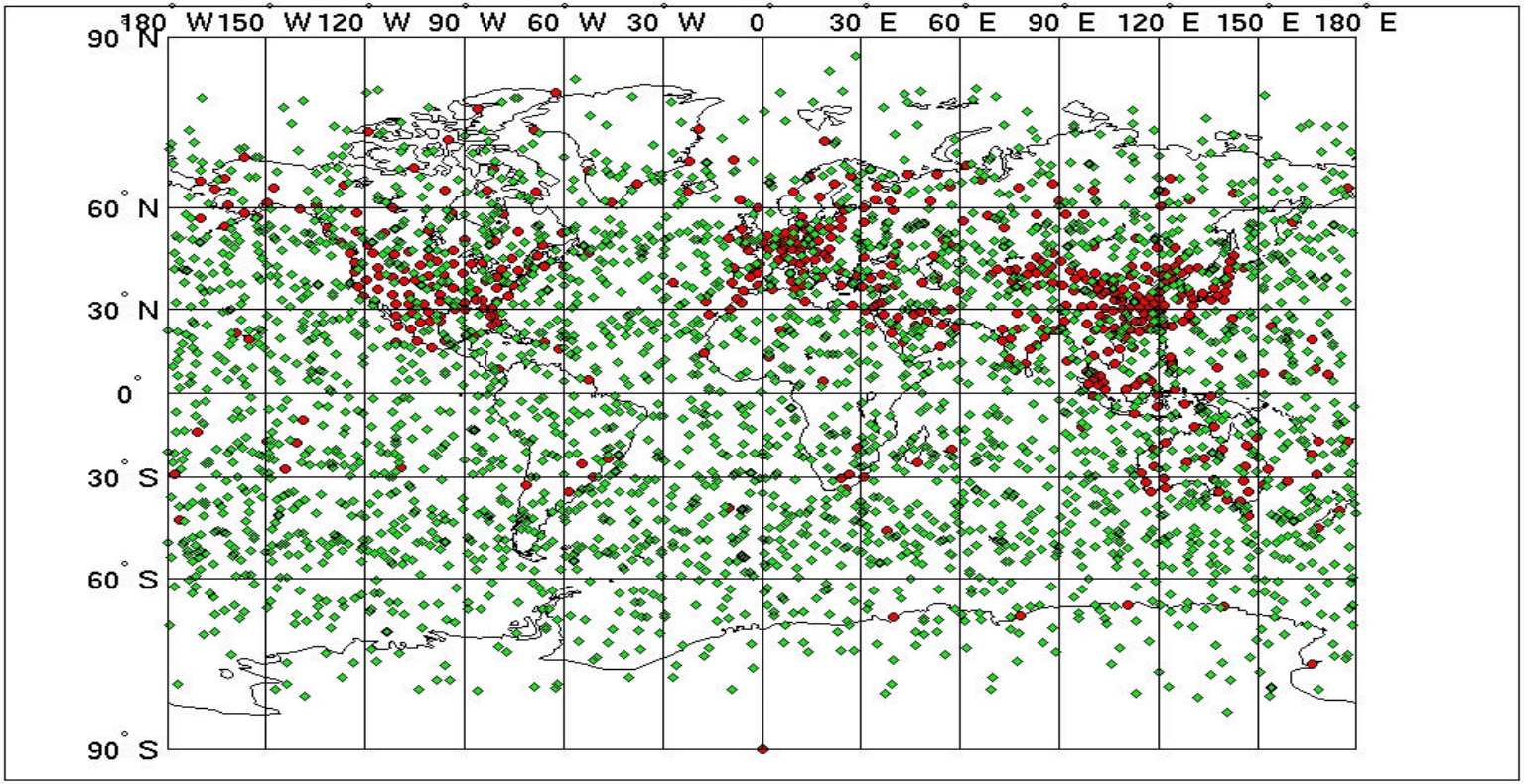
Mission Concept

COSMIC: Constellation Observing System for Meteorology, Ionosphere and Climate

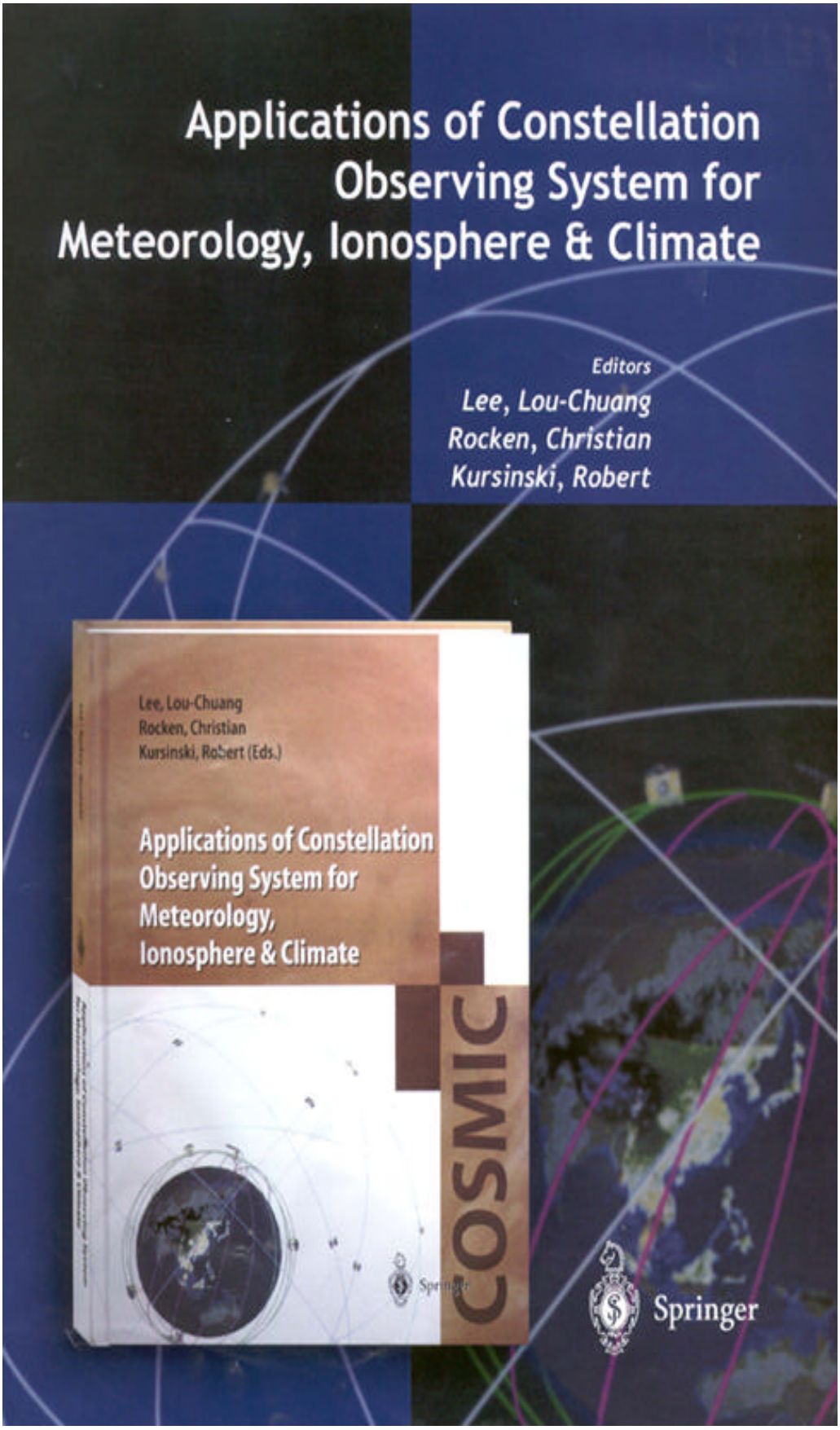


- To obtain the temperature, pressure, and water vapor pressure from refractivity of the GPS signals to provide global weather forecasting (< 3 hrs latency)
- To provide space weather information, e.g. electron density profiles, horizontal & vertical TEC and CIT, scintillation, and communication outage maps (<2 hrs latency)

COSMIC Soundings in a Day



Red dots are current radiosonde sites. Green dots are COSMIC soundings in a day.


Applications of Constellation Observing System for Meteorology, Ionosphere & Climate
Editors
Lee, Lou-Chuang
Rocken, Christian
Kursinski, Robert
Lee, Lou-Chuang
Rocken, Christian
Kursinski, Robert (Eds.)
Applications of Constellation Observing System for Meteorology, Ionosphere & Climate
COSMIC
Springer

nature

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 900 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 Tom 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.

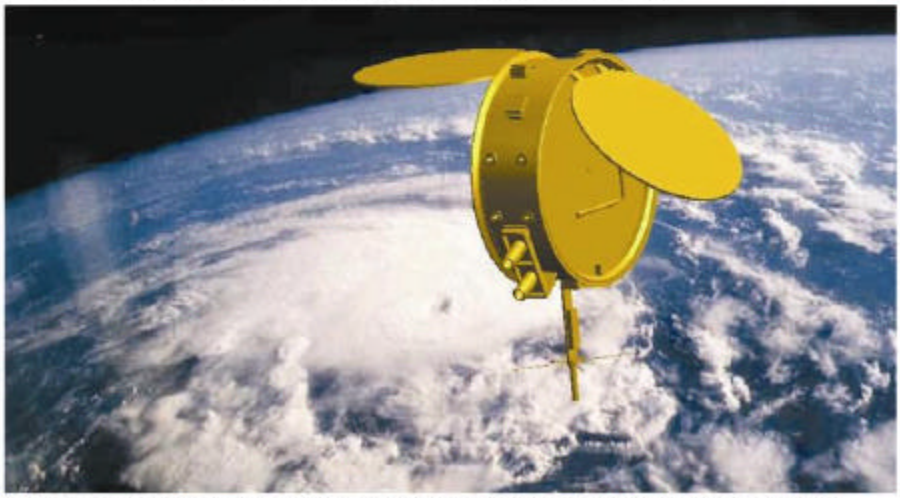
Researchers on 'space weather' are also excited about the project, says Liu. In the ionosphere, at altitudes of about 80 km, electron density can be measured in a similar fashion to the atmospheric density. This will provide valuable information for predicting magnetic storms, which can affect the operations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

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. ■



NSPO

Saturation coverage: six microsatellites will improve the coverage and accuracy of climate data.

Future Plan and Goal

- **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.**

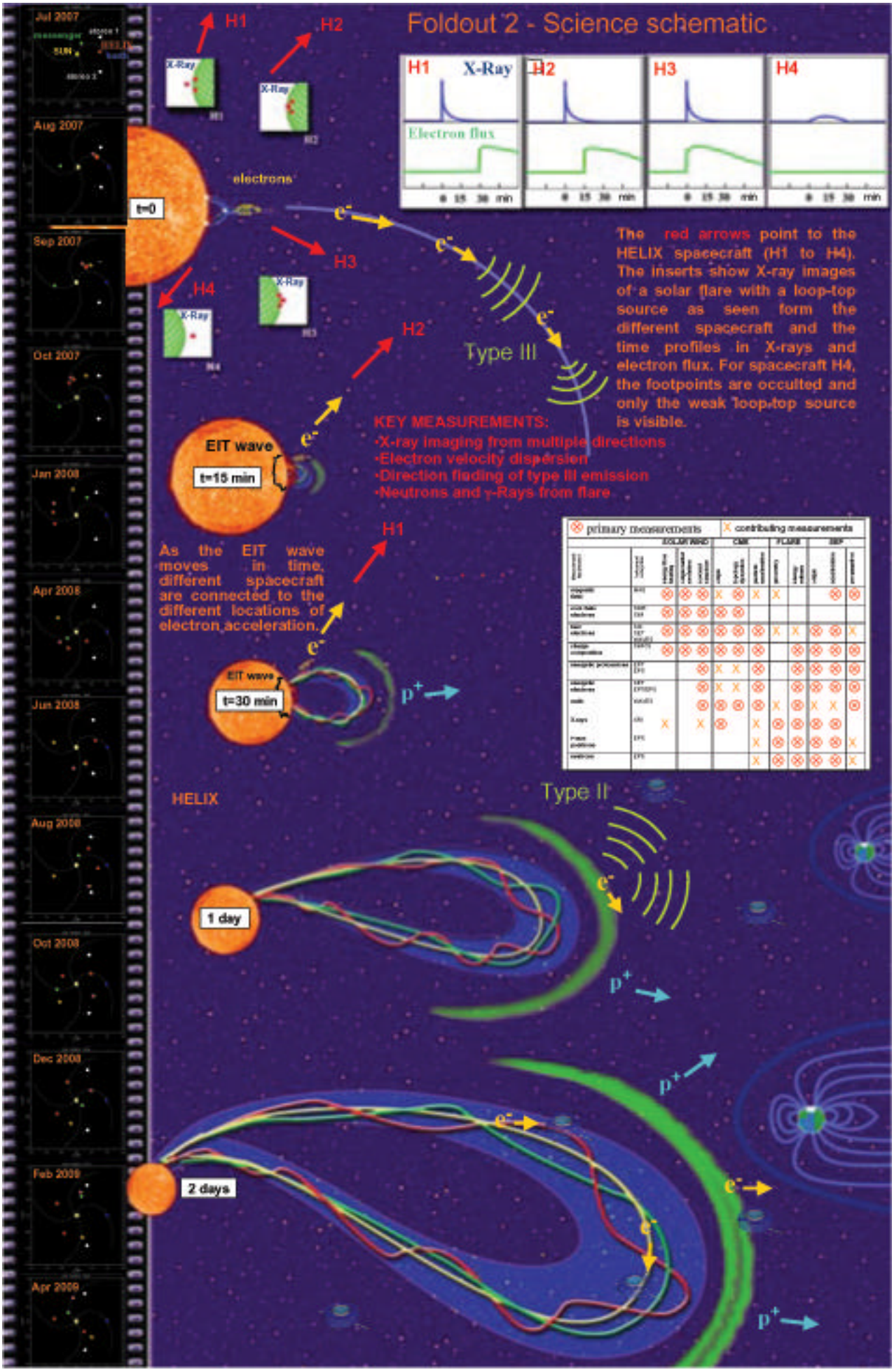
- **With all the available resources, Taiwan will be an active member in the space community for years to come.**

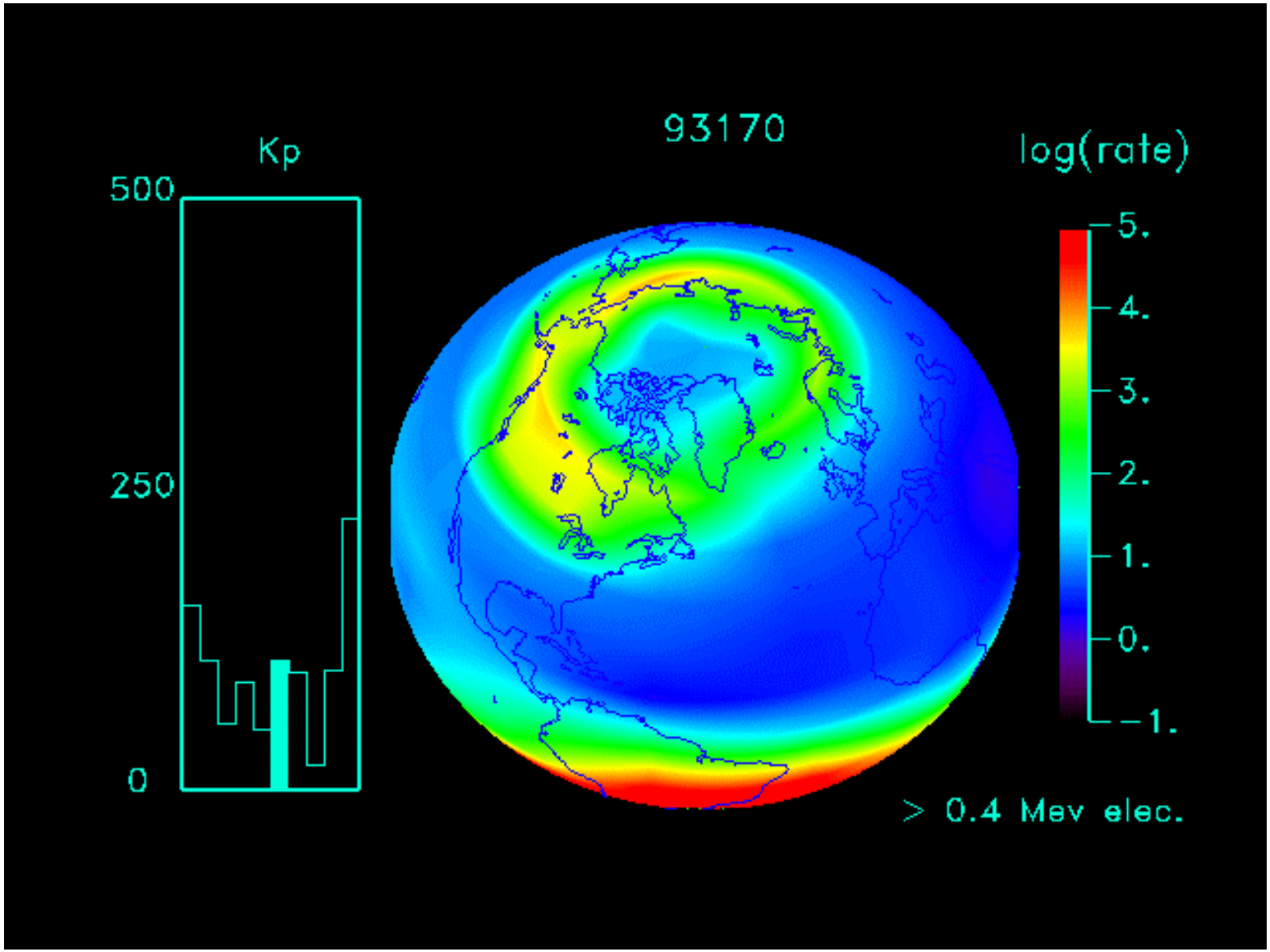
Future NSPO Satellite Projects

- **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

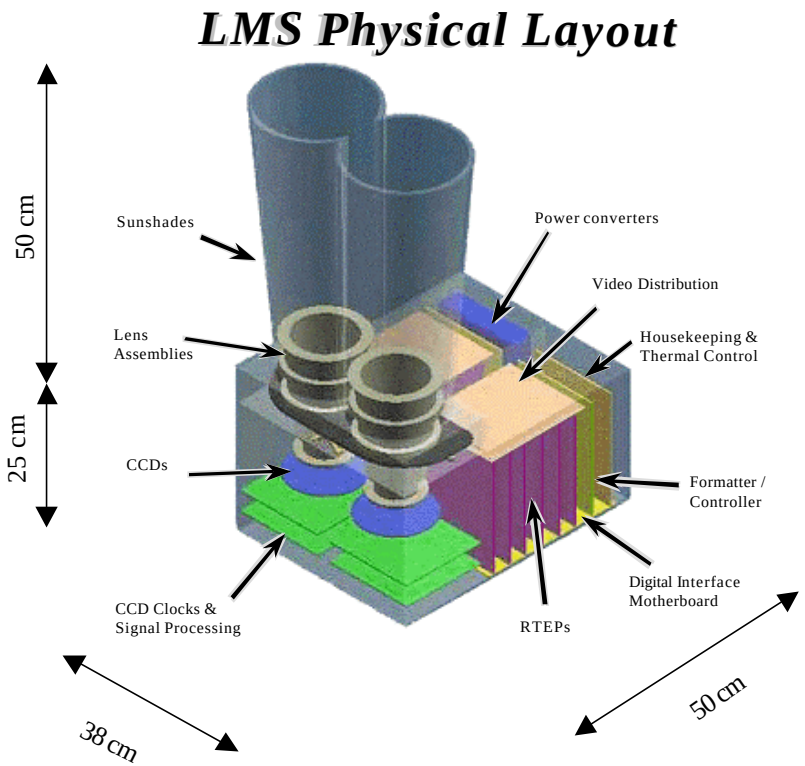
1. **HELIX proposal (MIDEX Proposal)**
   - *Exploring the evolution of solar wind and coronal mass ejection in the heliosphere*
   - *X-ray Imager*
   - *Solar wind plasma instrument*
   - *Some spacecraft subsystems*
2. **OHMIC proposal (MIDEX Proposal)**
   - *Observatory of heteroscale magnetosphere-ionosphere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


Foldout 2 - Science schematic
H1
H2
H3
H4
X-Ray
Electron flux
0 15 30 min
electrons
t=0
e-
Type III
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
EIT wave
t=15 min
As the EIT wave moves in time, different spacecraft are connected to the different locations of electron acceleration.
EIT wave
t=30 min
p+
primary measurements
contributing measurements
HELIX
Type II
1 day
2 days
Jul 2007
Aug 2007
Sep 2007
Oct 2007
Jan 2008
Apr 2008
Jun 2008
Aug 2008
Oct 2008
Dec 2008
Feb 2009
Apr 2009


93170
Kp
500
250
0
log(rate)
5.
4.
3.
2.
1.
0.
-1.
> 0.4 Mev elec.

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 millisec of UTC



Lens Assembly mounts to S/C optical bench via kinematic flexures