

# **Space Programs in Taiwan**

## **FORMOSAT 5 and FORMOSAT 7**

Lou-Chuang Lee  
NSPO / Academia Sinica  
November 2012

**National Science Council  
(NSC)**

## Supervising & Funding

**Governmental Agency**  
**A Non-Profile Organization**

## Management & Coordination

## National Space Organization (NSPO)

## National Chip Implementation Center (CIC)

## National Center for High-performance Computing (NCHC)

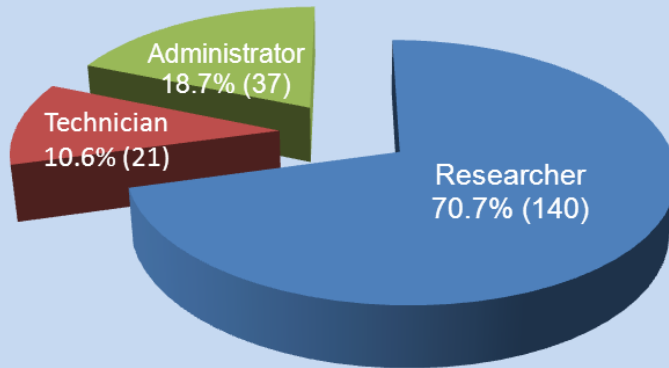
**S&T Policy Research and Information Center  
(STPI)**

## Taiwan Ocean Research Institute (TORI)

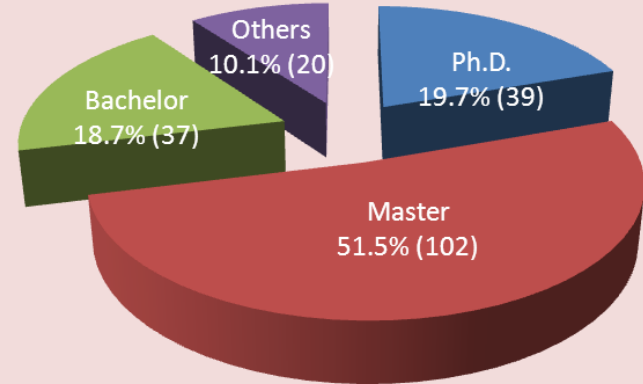
## Taiwan Typhoon & Flood Research Institute (TTFRI)

# Human Resource

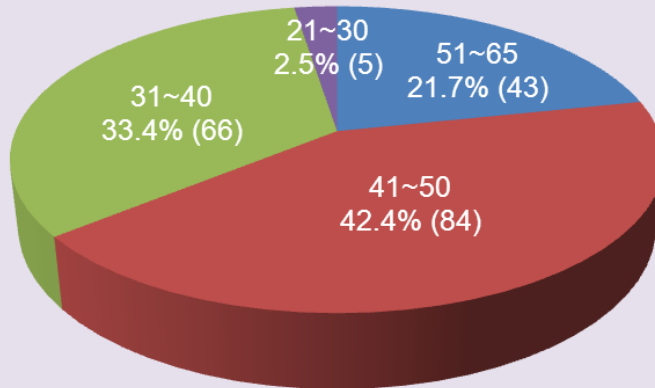
## Manpower Allocation



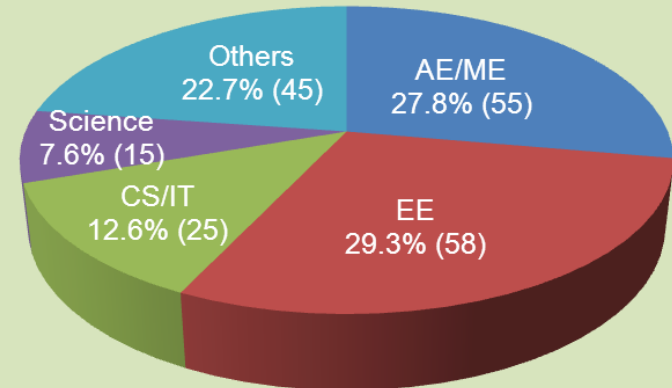
## Educational Qualification



## Age Profile

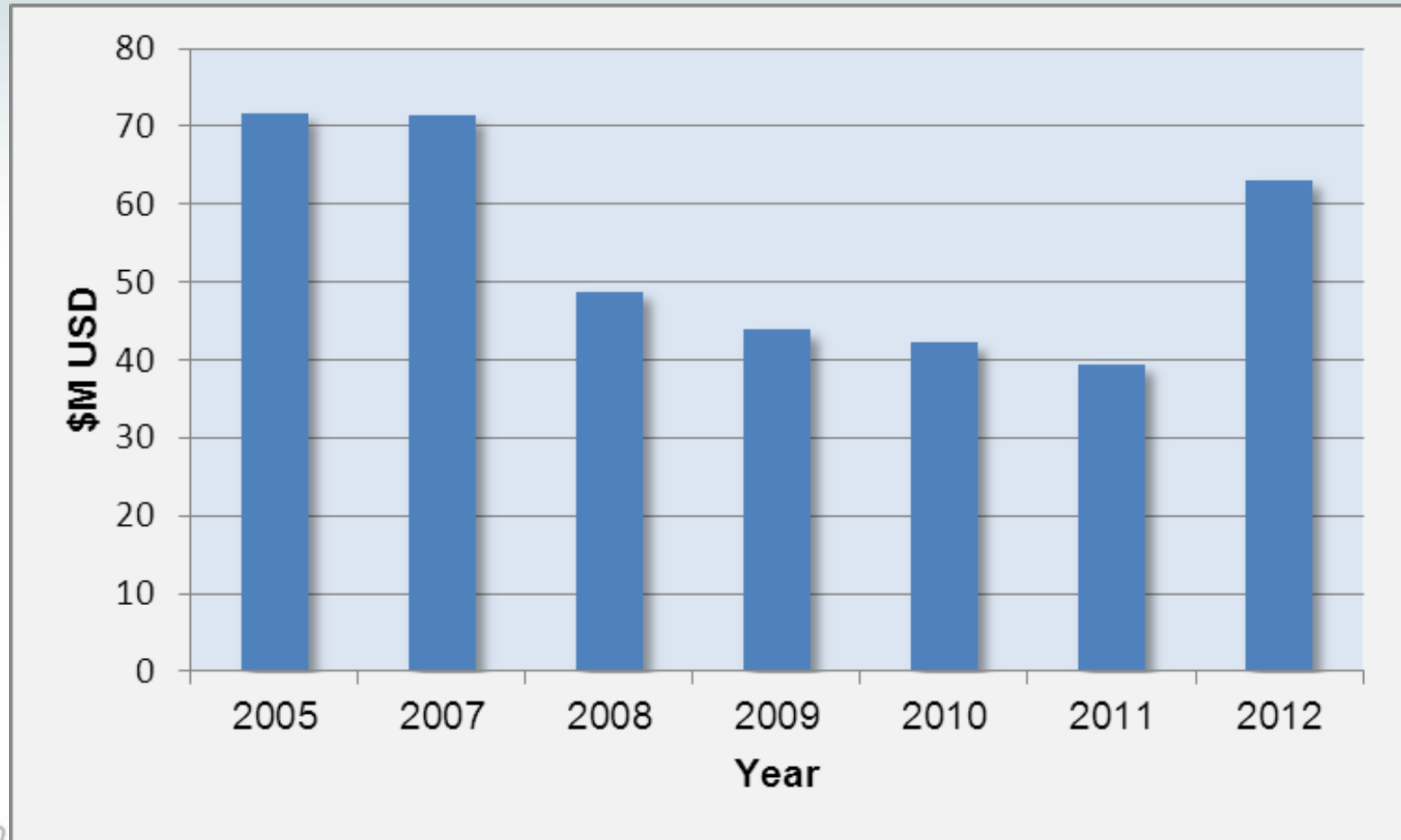


## Educational Background



**Number of Employment : 198 / Number of Subcontractor : 44**

# Budget Profile

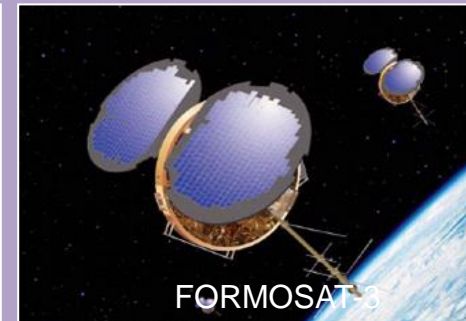


# Accomplishments

## Infrastructure



## Satellite Programs



## Foster Manpower



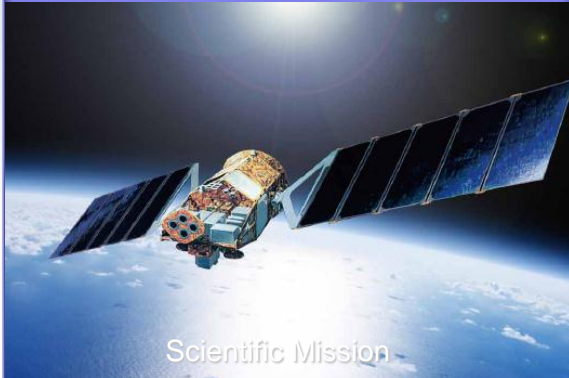


# Deployment of 3 Satellite Programs



# Mission Achievements

## FORMOSAT-1

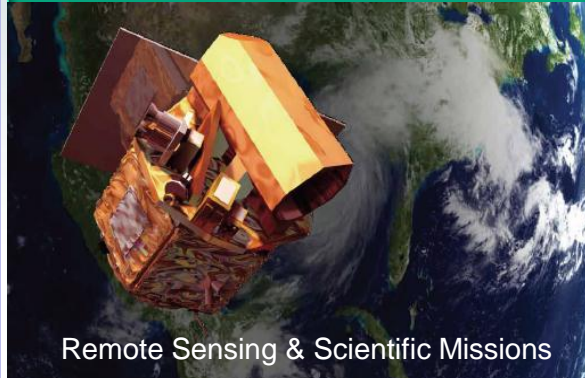


Scientific Mission

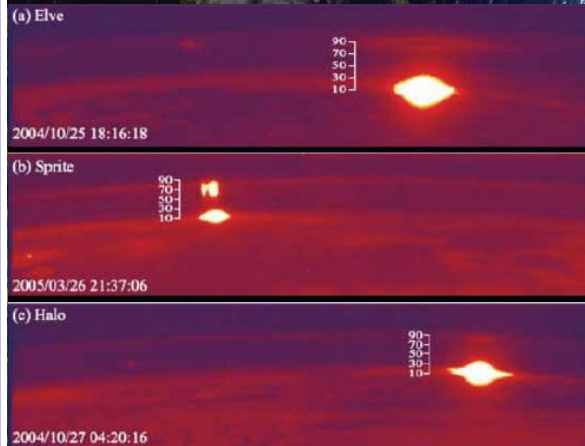


Jan 1999~ June 2004

## FORMOSAT-2

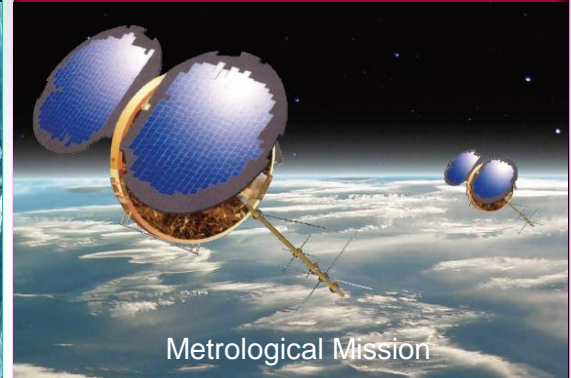


Remote Sensing & Scientific Missions

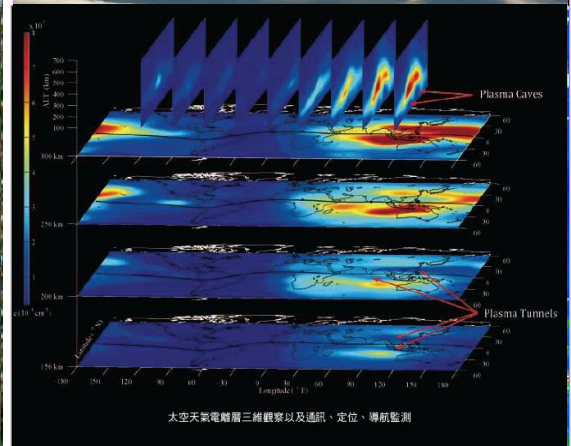


May 2004 ~ Present

## FORMOSAT-3



Metrological Mission



April 2006 ~ Present

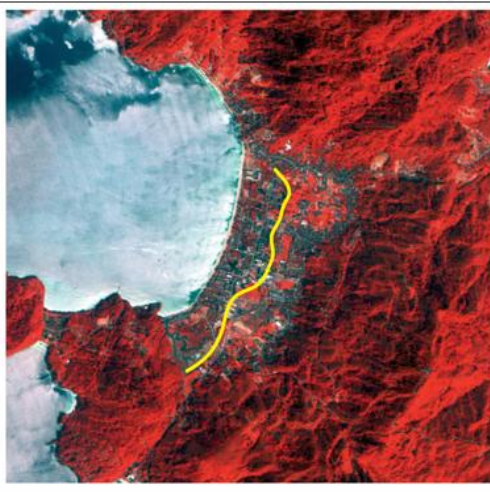


# Major Natural Disaster Supports

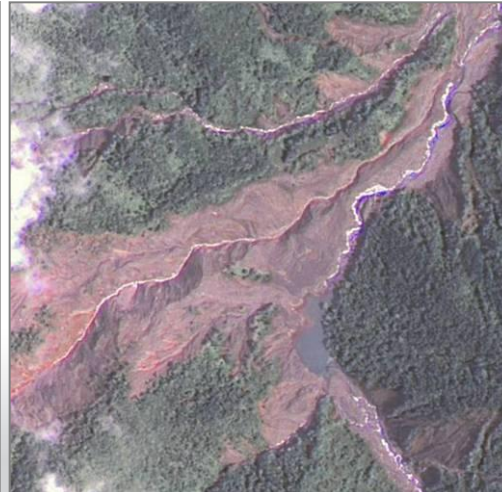
- FORMOSAT-2 has actively provided imagery to support the assessment of the major natural disasters occurred, including Southern Asia Tsunami (2004), Hurricane Katrina (2005), South California Wildfire (2007), Sichuan Earthquake (2008), Haiti Earthquake (2010), Chile Earthquake (2010), etc., since its operations.
- NSPO is one of members of Sentinel Asia and providing support to International Charter – Space and Major Disasters and UNOSAT.



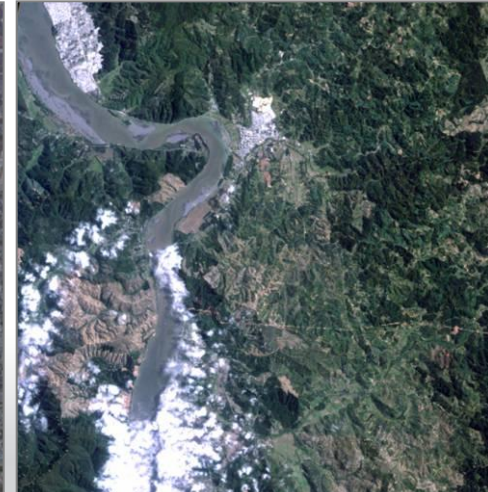
Southern Asia Tsunami (2004.12.26)



Typhoon Morakot (98.8.8)



Chile Earthquake (99.2.27)





*“Powerful electric currents have been detected in discharges between thunderclouds and the upper atmosphere. Carried by gigantic jets, they are a new factor in the model of the Earth's electrical and chemical environment.”*

PLANTING DATE AND DATE OF FIRST FLOWERS

# ISUAL's Science

## *Los Angeles Times*

June 25, 2003

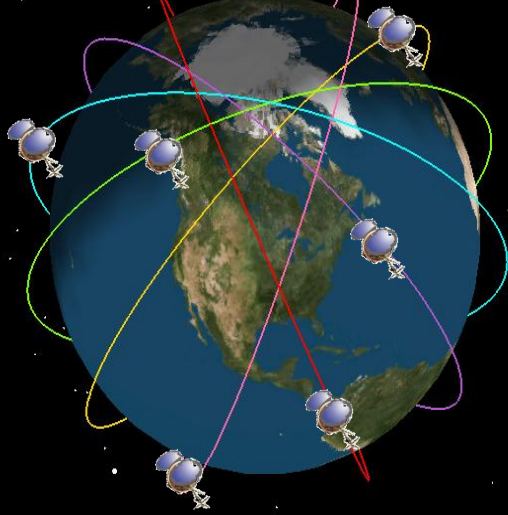
These things are so spectacular, and so startling, and we're just finding it this late in the game.

It's sort of like biologists announcing we've discovered a new human body part.



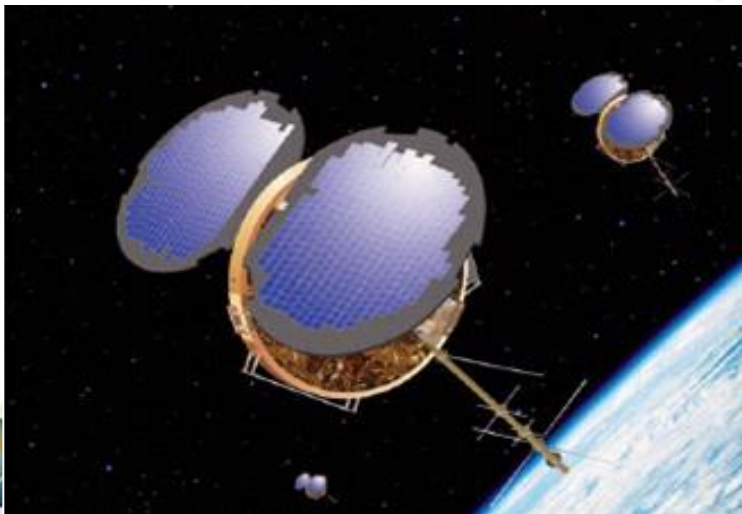
# FORMOSAT-3 Program

**FORMOSAT-3 Constellation**



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

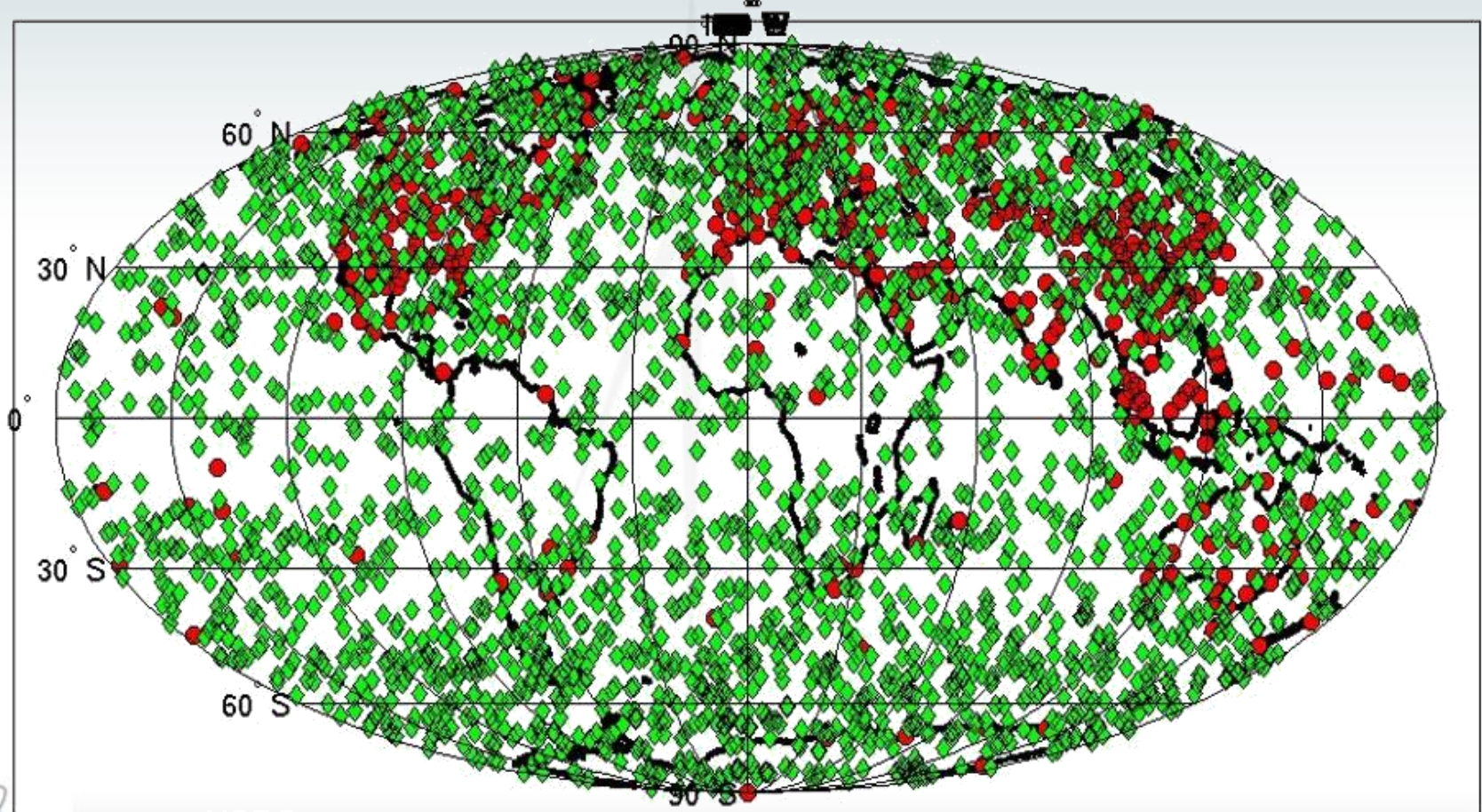
- The FORMOSAT-3/COSMIC system is a constellation of 6 low-earth-orbit (LEO) micro-satellites
- Each micro-satellite is cylindrical with weight 70 Kg, diameter 116 cm, height 18 cm
- Satellite parking orbit is approximate 500Km with 72-degree inclination.
- The individual micro-satellite will perform orbital raising maneuvers to get into 6 separate orbital planes nominally phased  $24^\circ$  apart in ascending node. The mission orbit is 700-800 km circular.
- Mission life: 2 years (design life: 5 years)
- Launch Date: April 15, 2006



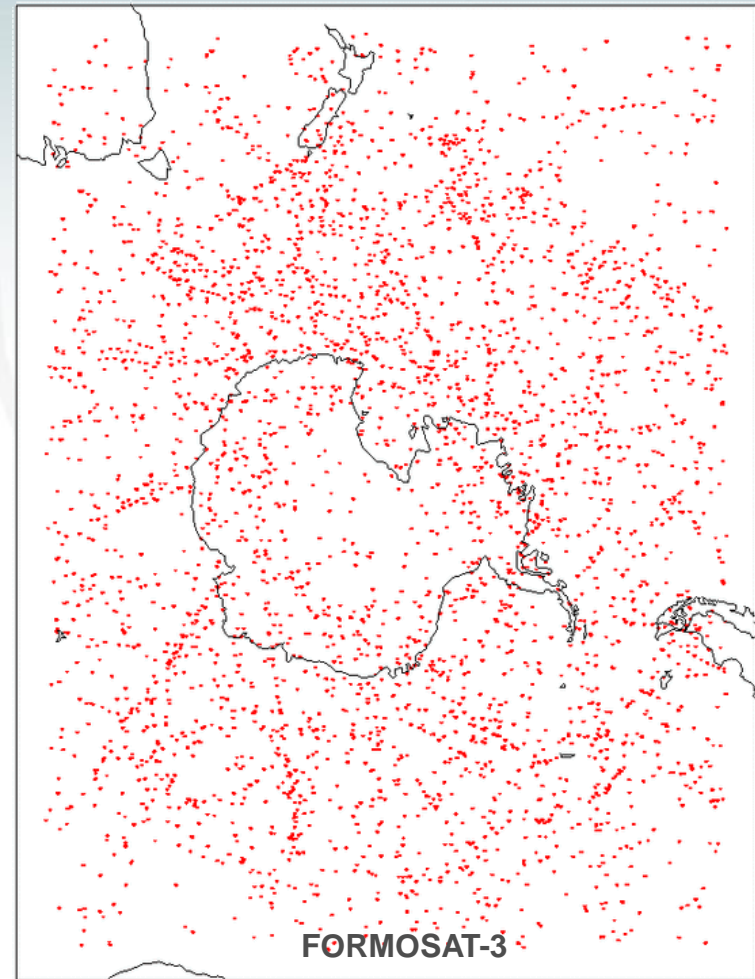
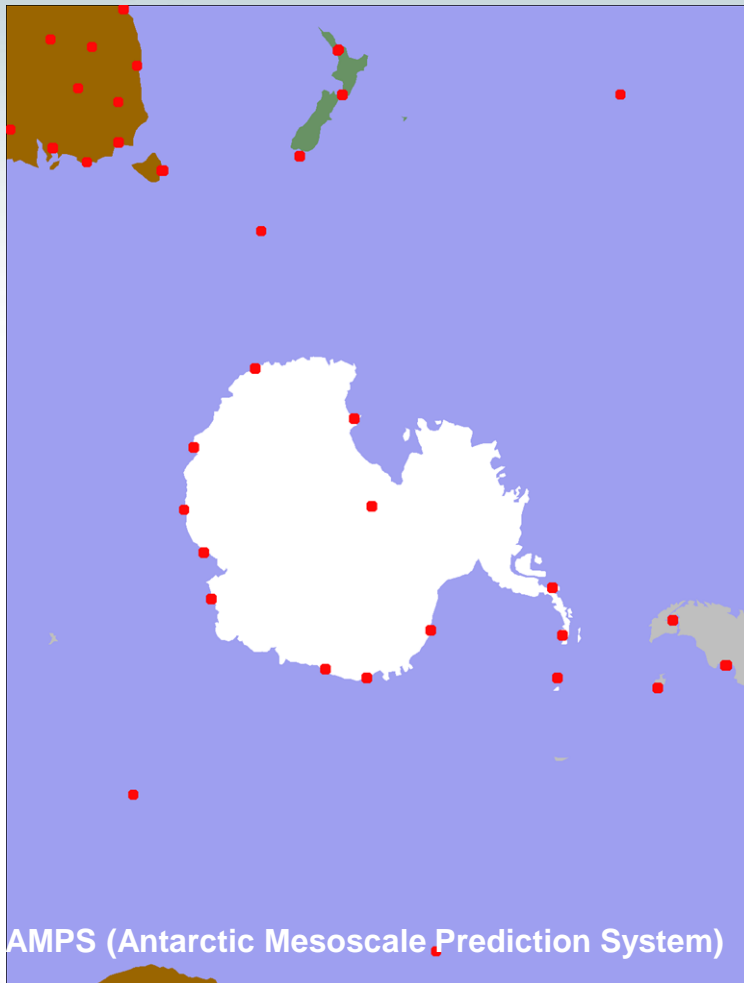


# GPS Radio Occultation Technology

Occultation Locations for COSMIC, 6 S/C, 6 Planes, 24 Hrs



# Weather Data Comparison at Antarctica

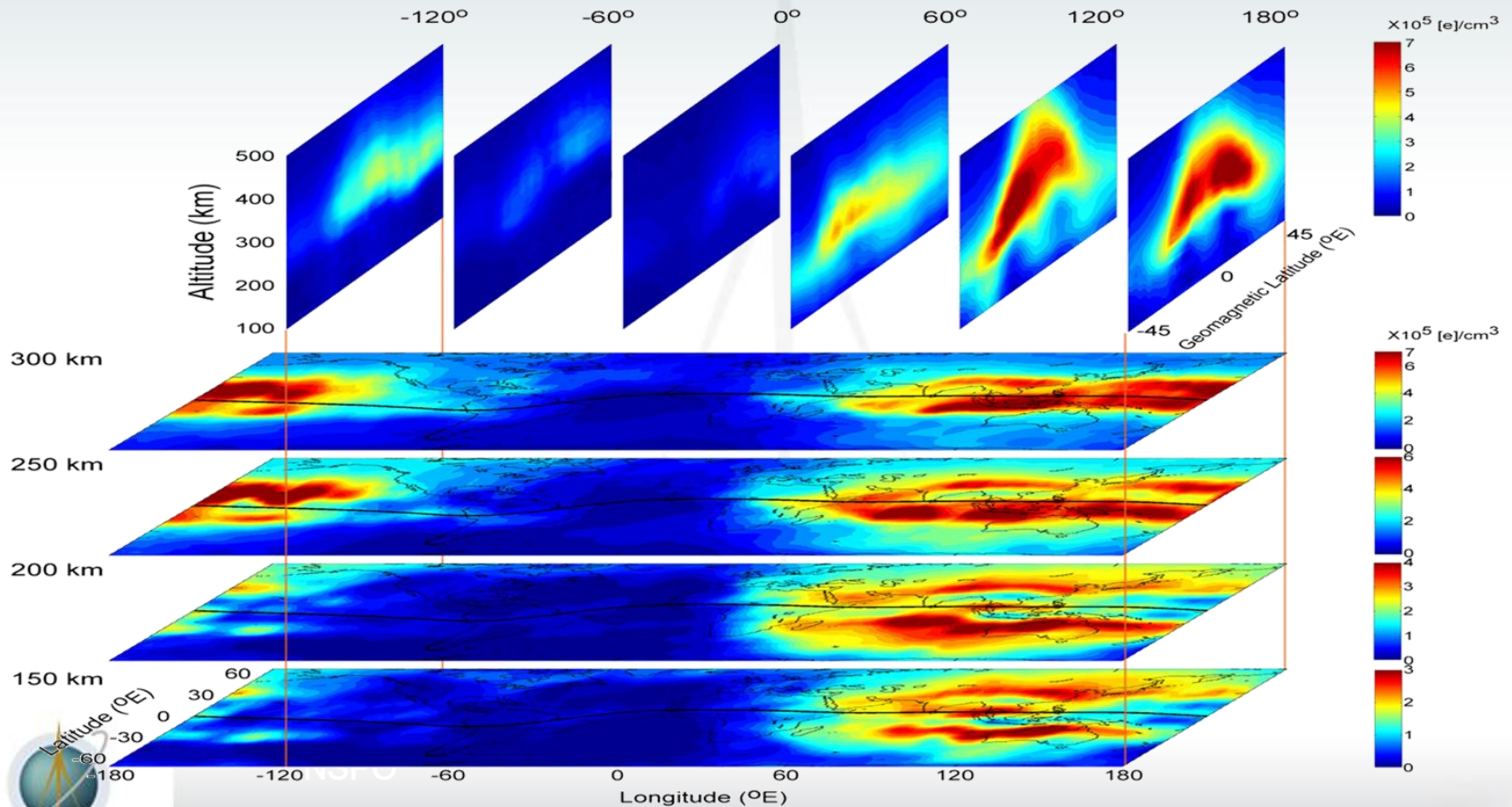


***FORMOSAT-3 / COSMIC RO data distribution over 11 days (Right) in comparison with the available data collected from the limited Weather Stations (Left) near Antarctic region daily.***



# 3D Ionospheric Structure

## Plasma Cave





# FORMOSAT-3 Mission Highlighted by Nature

news **nature** nature 17 May 2001

## Array system promises global atmospheric monitoring

David Cyranoski, Tokyo

A Taiwan-US collaboration is testing 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 Yumek 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 Chiao-Han Liu, president of Taiwan's National Central University.

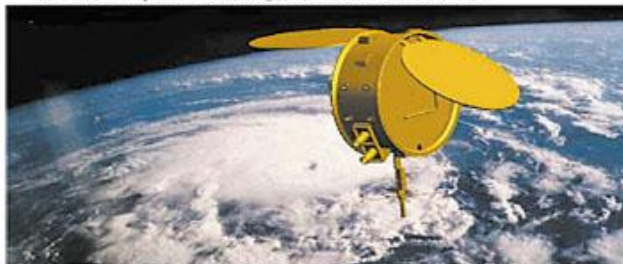
Researchers on space weather are also excited about the project, says Liu. In the ionosphere, at altitudes of about 80 km, electron density can be measured in a similar fashion to the atmospheric density. This will provide valuable information for predicting magnetic storms, which can affect the operations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



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

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The COSMIC micro-satellites equipped with GPS receivers will provide a valuable new approach to meteorology, climatology and research into space weather. The new system has the potential to significantly improve climatological measurements.

## 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

◀ A special monograph published by NSPO and UCAR on the GPS radio sounding of earth atmosphere and ionosphere.

# NSPO's Mid-term Plan (2010~2014)

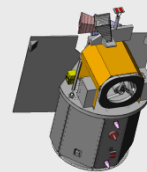


## Self-reliant Spacecraft and Optic-Electric Remote Sensing Instrument Development



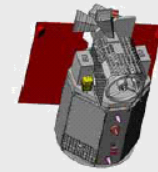
FORMOSAT-2

Remote Sensing  
Satellite Program



FORMOSAT-5

(Target Launch Date: 2013-2014)

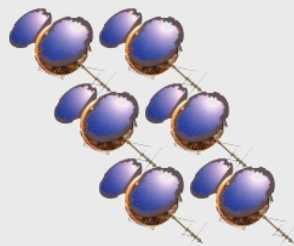


FORMOSAT-5  
Follow-on

### Earth Observation

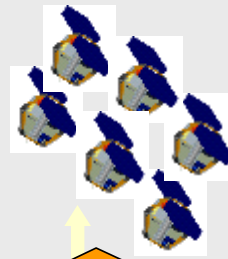
- EV Monitoring
- Disaster Support
- Data Applications

## Micro-sat Spacecraft and Constellation Operations Development

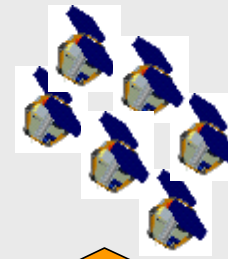


FORMOSAT-3

FORMOSAT-7



2014  
1<sup>st</sup> Set Launch



2016  
2<sup>nd</sup> Set Launch

### Atmospheric Sounding

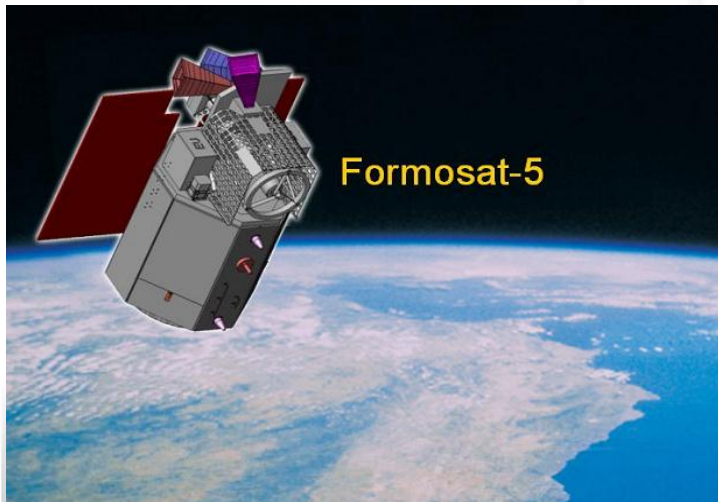
- Weather Predication
- Climate Research
- Space Weather

# FORMOSAT-5 Program

## ■ Missions:

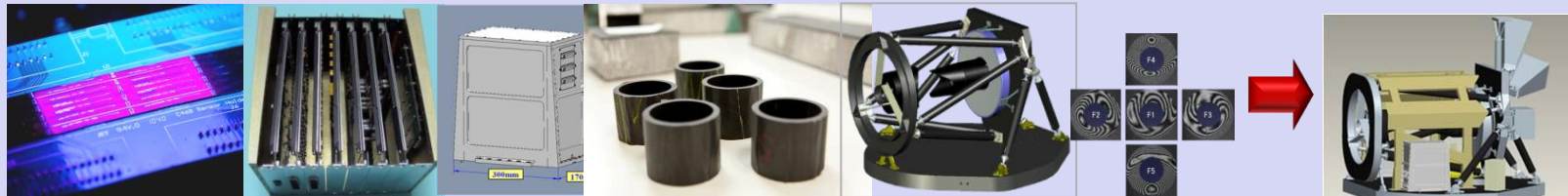
- ❑ To build up Taiwan's self-reliant space technology on the remote sensing payload and spacecraft bus
- ❑ To develop the key components of the EO-type remote sensing instrument and spacecraft bus by integrating the domestic resources
- ❑ To continue to serve the global imagery users' community of FORMOSAT-2
- ❑ To promote the space science experiment & research

## ■ Launch: 2013~2014





# Program Schedule



**RSI is 100% MIT developed by NSPO and domestic team**

RSI



**NSPO is responsible for spacecraft design and key components development**

Spacecraft

# The RSI Domestic Team

## Remote Sensing Instrument (RSI)

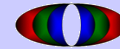


NARL (PM)  
NSPO/ITRC

(System Design, Integration & Test)



## Focal Plane Assembly/ CMOS Sensor



CMOS Sensor Inc. (FPA/CMOS)



ITRC (Filter)



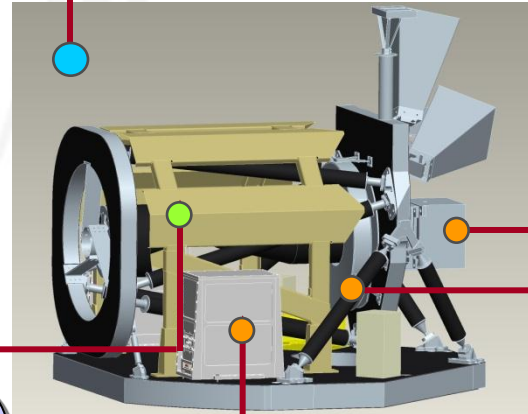
CIC (CMOS Verification)



## Telescope



ITRC (Optical Design/Mirror/Lens)  
NSPO (Structure/Thermal Design)  
ITRC/NSPO (Assembly/Calibration)



## Electronic Unit



NSPO (System Design)



CSIST (Unit Design/Manuf.)



Camels VT (SSR Design)



## Structure

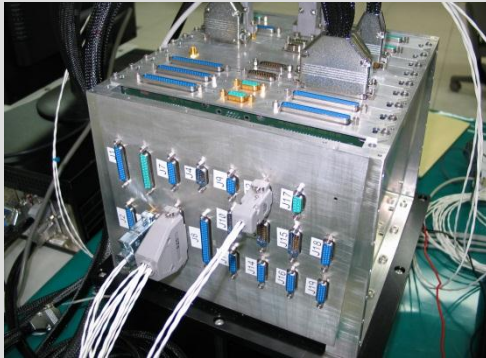
NSPO (Design)



AIDC (Manufacturing)

# Taiwan Made Components

## CMDU



LEON 3 Heritage (CGS)

- Ground Command Processing and Distribution
- Satellite House-Keeping Data Acquisition
- Satellite House-keeping and Science Data Storage
- Support On-board Failure Detection, Isolation, and Recovery Mechanism
- Support Electrical Power Control
- Support Attitude and Orbit Control
- Support Thermal Control
- Support Payload Operation

## PCDU

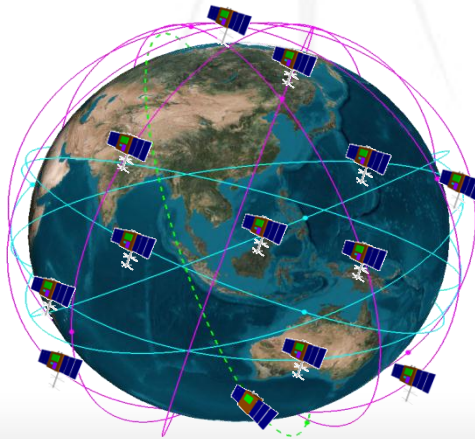


- Provide Primary Power Outlet and Control for Spacecraft and Payload Instruments
- Provide Secondary Power Outlet and Control
- Provide Spacecraft Heater Power and Control
- Provide Ordnance Power and Control
- Provide Power Fault Protection
- Provide Battery Power Regulation
- Receive CMDU Command for Power Control
- Power-related House-Keeping Data Acquisition



# FORMOSAT-7/COSMIC-2 Program

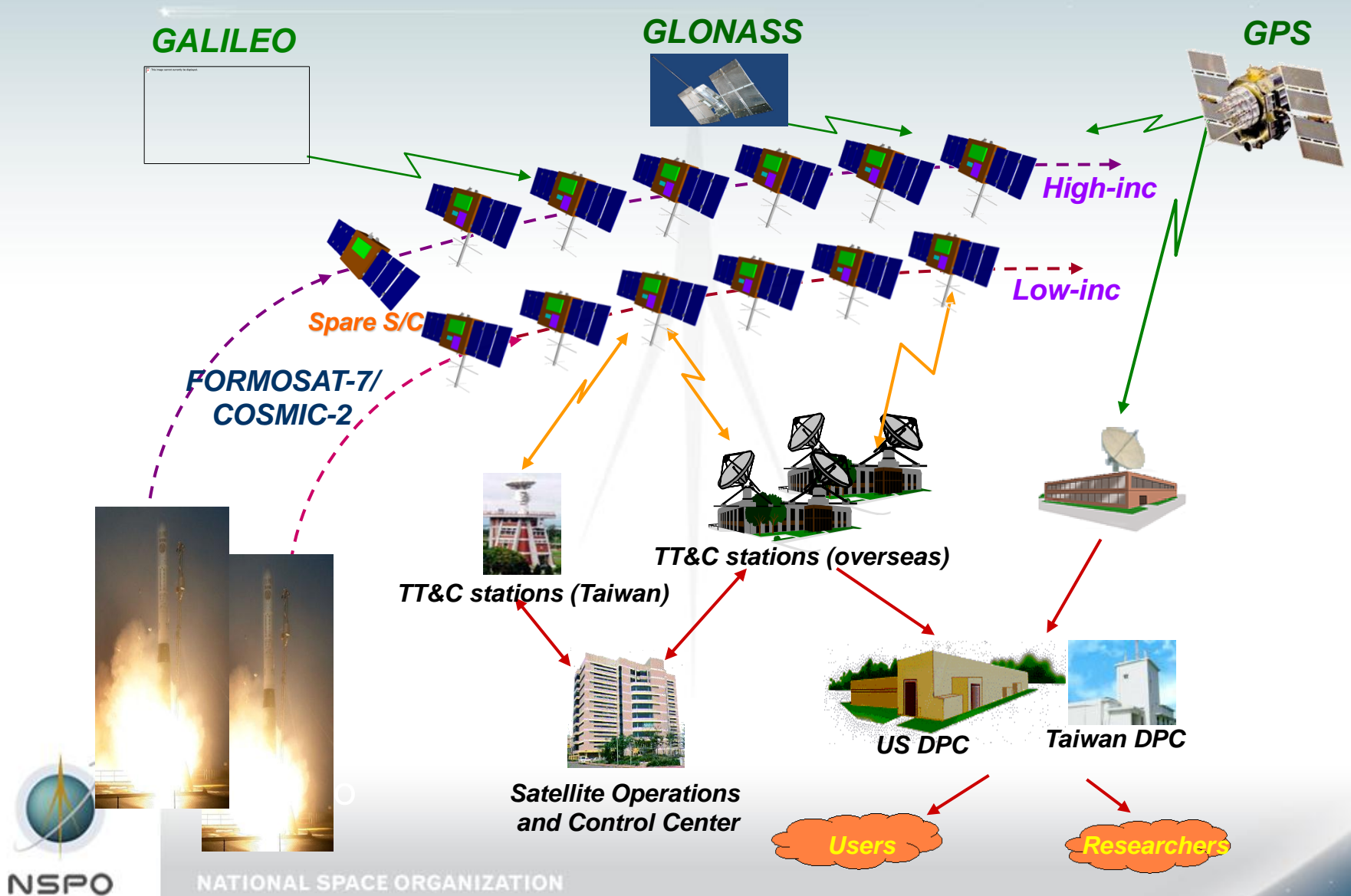
- FORMOSAT-7/COSMIC-2 is a joint NOAA/NSPO program to deploy an operational constellation system of 12 micro-satellites to perform GPSRO atmospheric and ionospheric soundings for weather forecasting and space weather monitoring.
- This will be a follow-on mission of FORMOSAT-3/COSMIC, co-developed by UCAR (US) and NSPO (Taiwan), which will begin to degrade in 2011 (end of life) and data gap is expected due to loss of satellites in next 3~4 years.



NSPO

NATIONAL SPACE ORGANIZATION

# System Architecture

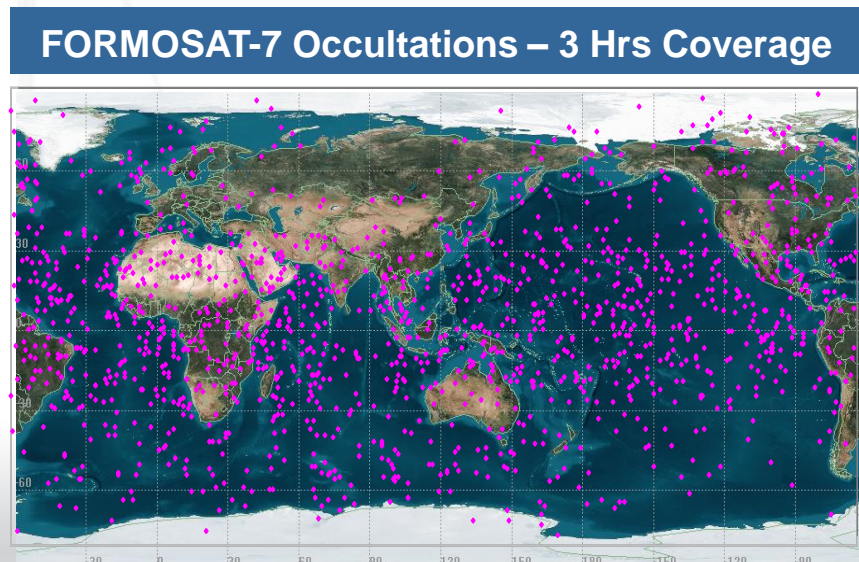
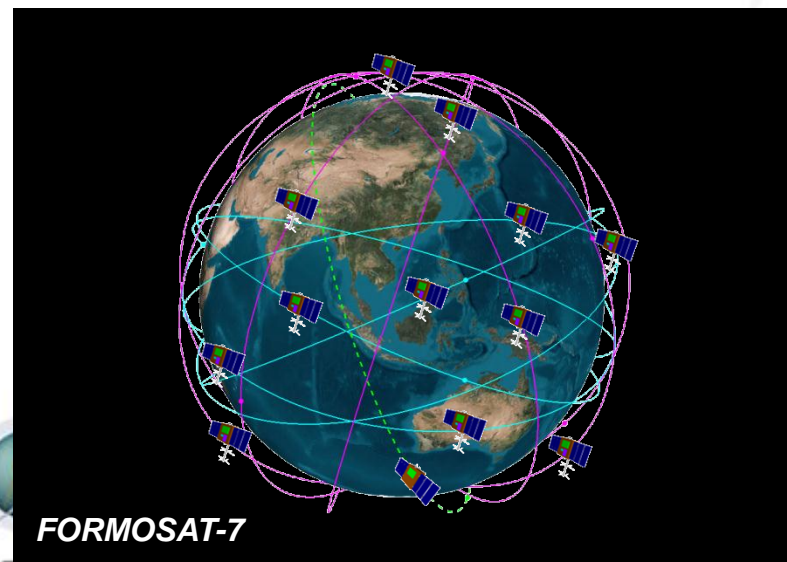
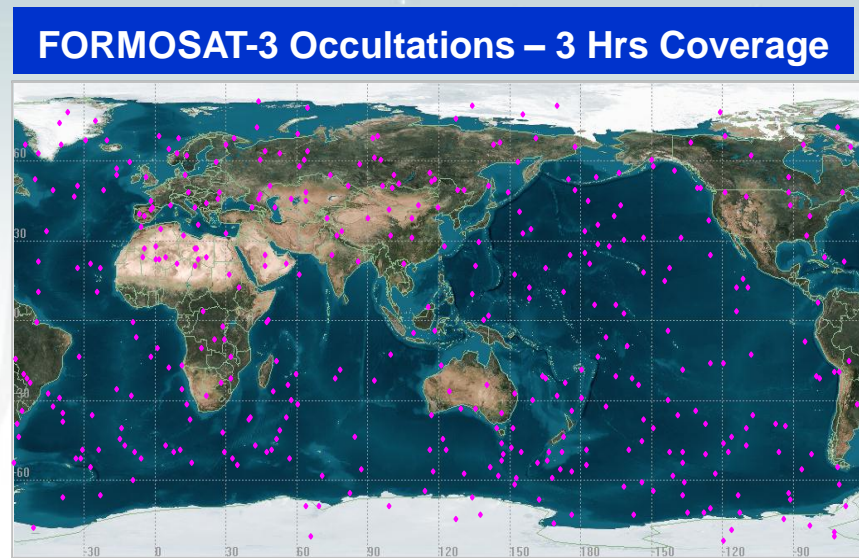
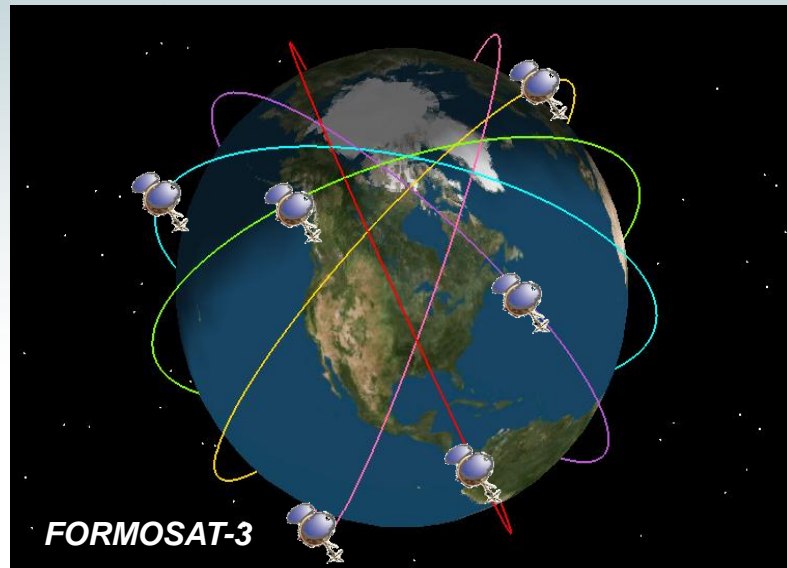


# Mission Baseline

<b>FORMOSAT-7</b>	<b>First Launch</b>	<b>Second Launch</b>
<b>Mission Constellation</b>	6 satellites (inclination ~24 deg, mission altitude ~ 520 km)	6 (or 7) satellites (inclination ~72 deg, mission altitude ~ 800 km)
<b>Mission Payload</b>	Tri-G	Tri-G
<b>Science Payload</b>	<ul style="list-style-type: none"> <li>■ 2 Band Beacon</li> <li>■ Plasma Drift/Fluctuation Sensor</li> </ul> (Together around 10kg, 22W)	Taiwan furnished payload
<b>Launcher</b>	Minotaur IV carrying 6 satellites	Minotaur IV carrying 7 satellites (including 1 spare satellite)
<b>Launch Schedule</b>	2014 Q3	2016 Q3
<b>Communication Architecture</b>	Via ground station	
<b>Mission Duration/ Spacecraft Life</b>	7 years / 5 years	



# Geographic Coverage Comparison



# Participating in AMS-02 Mission

- NSPO has joined the Alpha Magnetic Spectrometer (AMS) project, coordinated by Nobel Laureate Dr. Samuel C. C. Ting, with a responsibility for conducting thermal analyses and tests of electronics crates.
- AMS-2 has been installed on the International Space Station (ISS).



**AMS-02**



**AMS-02**





# National Space Organization

A center of innovation and excellence for space technology in Taiwan



**NSPO**  
NATIONAL SPACE ORGANIZATION

## Thank You

