Space Programs in Taiwan

FORMOSAT 5 and FORMOSAT 7

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NSPO / Academia Sinica
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Organization & Management

National Science Council (NSC)

Supervising & Funding

National Applied Research Laboratories (NARL)

Governmental Agency
A Non-Profile Organization

Management & Coordination

National Nano Device Laboratories (NDL)

National Laboratory Animal Center (NLAC)

National Center for Research on Earthquake Engineering (NCREE)

Instrument Technology Research Center (ITRC)

National S&T Center for Disaster Reduction (NCDR)

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**
- Administrator: 18.7% (37)
- Technician: 10.6% (21)
- Researcher: 70.7% (140)

**Educational Qualification**
- Master: 51.5% (102)
- Bachelor: 18.7% (37)
- Ph.D.: 19.7% (39)
- Others: 10.1% (20)

**Age Profile**
- 31~40: 33.4% (66)
- 41~50: 42.4% (84)
- 51~65: 21.7% (43)
- 21~30: 2.5% (5)

**Educational Background**
- EE: 29.3% (58)
- CS/IT: 12.6% (25)
- Science: 7.6% (15)
- AE/ME: 27.8% (55)
- Others: 22.7% (45)

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

![Bar Chart](chart.png)

<table>
<thead>
<tr>
<th>Year</th>
<th>$M USD</th>
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<tbody>
<tr>
<td>2005</td>
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<td>2007</td>
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<td>2008</td>
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<td>2011</td>
<td>30</td>
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<tr>
<td>2012</td>
<td>60</td>
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</table>
Accomplishments

Infrastructure
- Satellite T&I Facility
- Mission Operation & Control Center
- Ground Station

Satellite Programs
- FORMOSAT-1
- FORMOSAT-2
- FORMOSAT-3

Foster Manpower
- Classroom Training
- On-the-Job Training
- Team Build-up
Deployment of 3 Satellite Programs

- FORMOSAT-1
- FORMOSAT-2
- FORMOSAT-3
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.
Nature (vol. 423, 26 June 2003) published an article on “Gigantic Jets”, a new class of transient luminous events (TLEs), observed by the ROCSAT 2 Science Team from ground.

Nature also published a “News and Views” article, which provides an historical perspective on our Nature paper.

“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.”
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.
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° 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

(Global Coverage, High Spatial & Temporal Resolution)

Courtesy of NCU
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.
NSPO’s Mid-term Plan (2010~2014)

The 2nd Phase Taiwan’s Space Program Plan

Mid-term Plan

2004 2010 2014 2018

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

FORMOSAT-2
Remote Sensing Satellite Program

FORMOSAT-5
(Target Launch Date: 2013-2014)

FORMSAT-5 Follow-on

Earth Observation
- EV Monitoring
- Disaster Support
- Data Applications

Micro-sat Spacecraft and Constellation Operations Development

FORMOSAT-3

FORMOSAT-7

2014 1st Set Launch

2016 2nd 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

<table>
<thead>
<tr>
<th>Year</th>
<th>Planning</th>
<th>System/Subsystem Design</th>
<th>Key Component Manufacturing</th>
<th>System Integration &amp; Test</th>
<th>Launch</th>
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<tbody>
<tr>
<td>2008</td>
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RSI is 100% MIT developed by NSPO and domestic team

NSPO is responsible for spacecraft design and key components development
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

- 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 CDMU 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.
System Architecture

- FORMOSAT-7/COSMIC-2
- GALILEO
- GLONASS
- GPS
- Spare S/C
- TT&C stations (Taiwan)
- TT&C stations (overseas)
- Satellite Operations and Control Center
- Users
- Researchers
- US DPC
- Taiwan DPC
# Mission Baseline

<table>
<thead>
<tr>
<th>FORMOSAT-7</th>
<th>First Launch</th>
<th>Second Launch</th>
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<tr>
<td><strong>Mission Constellation</strong></td>
<td>6 satellites (inclination ~24 deg, mission altitude ~ 520 km)</td>
<td>6 (or 7) satellites (inclination ~72 deg, mission altitude ~ 800 km)</td>
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<td><strong>Mission Payload</strong></td>
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<td>Tri-G</td>
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| **Science Payload** | ▪ 2 Band Beacon  
▪ Plasma Drift/Fluctuation Sensor  
(Together around 10kg, 22W) | Taiwan furnished payload |
| **Launcher** | Minotaur IV carrying 6 satellites | Minotaur IV carrying 7 satellites (including 1 spare satellite) |
| **Launch Schedule** | 2014 Q3 | 2016 Q3 |
| **Communication Architecture** | Via ground station | |
| **Mission Duration/Spacecraft Life** | 7 years / 5 years | |
Geographic Coverage Comparison

FORMOSAT-3 Occultations – 3 Hrs Coverage

FORMOSAT-7 Occultations – 3 Hrs Coverage
Participating in AMS-02 Mission

- NSPO has jointed 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).
National Space Organization

A center of innovation and excellence for space technology in Taiwan

Thank You