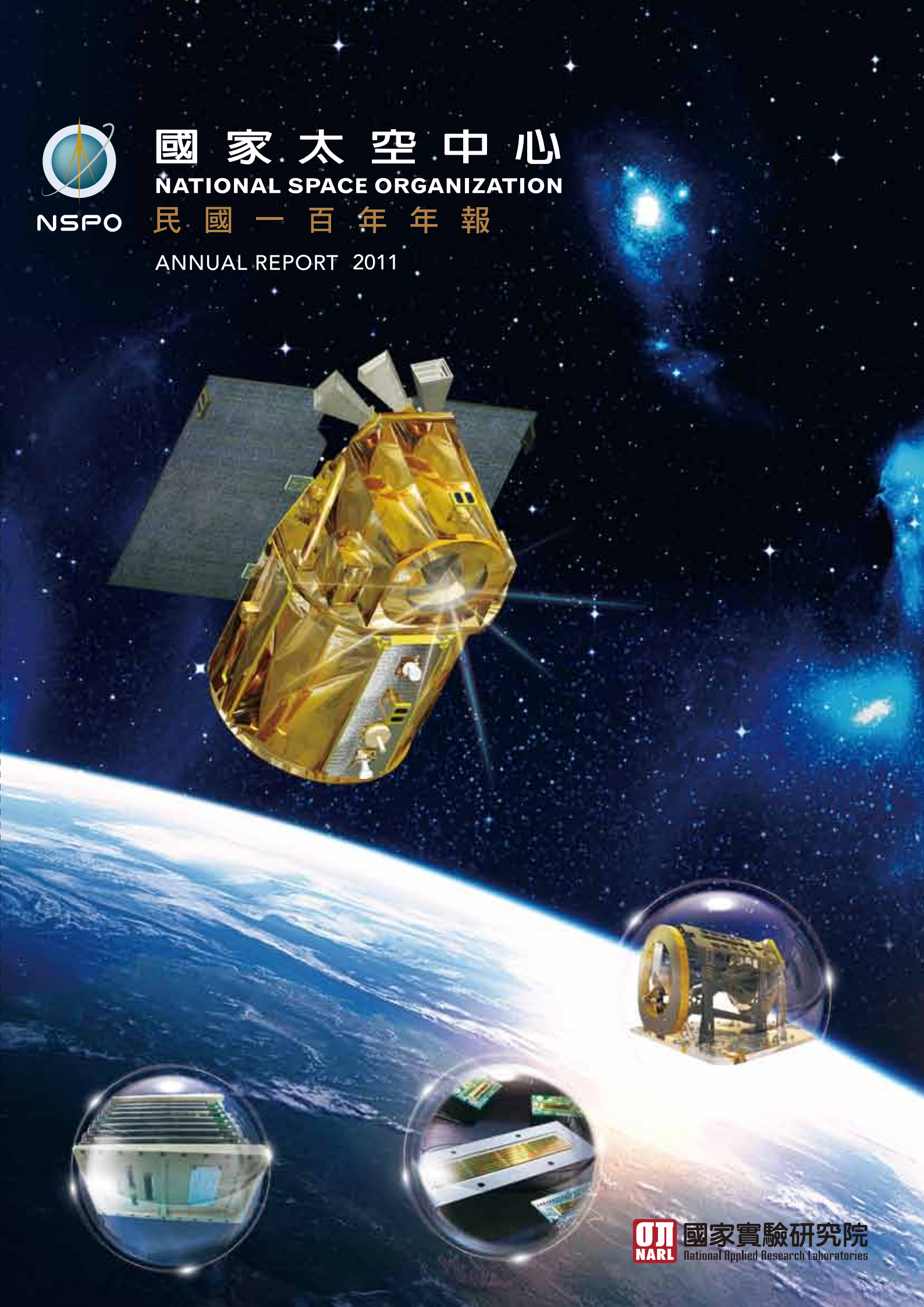
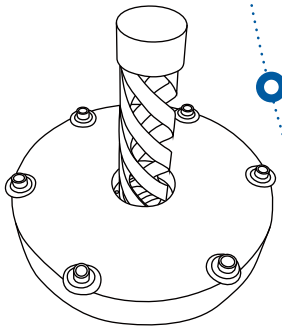
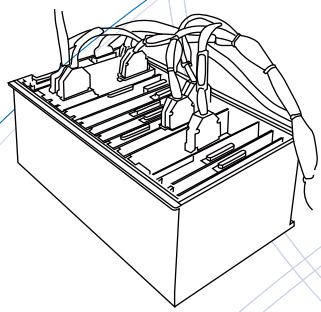
國家太空中心
NATIONAL SPACE ORGANIZATION
民國一百年年報
ANNUAL REPORT 2011



國家實驗研究院
National Applied Research Laboratories

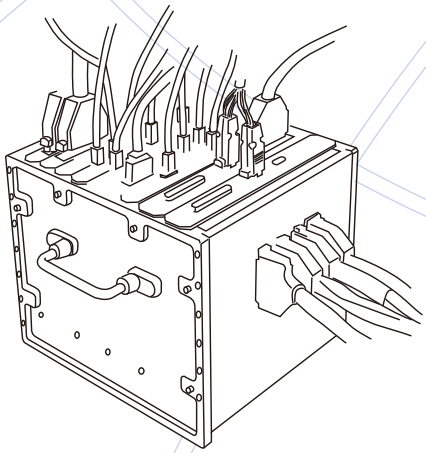


S-Band 天線
(S-Band Antenna)

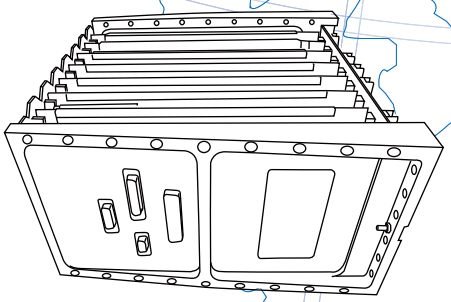


電力控制與分配單元
(Power Control and
Distribution Unit, PCDU)

指令與資料管理單元
(Command and Data
Management Unit, CDMU)



遙測酬載電子單元
(Remote Sensing
Instrument Electronic
Unit, RSI EU)



願景

- 成為創新與卓越的太空科技研發機構
- 發展具臺灣優勢與競爭力的太空計畫

任務

- 建立自主太空科技能量
- 滿足社福民生需求
- 推動尖端太空科學研究

價值

- 關鍵技術的研發
- 核心能量的傳承
- 優質團隊的養成

Vision

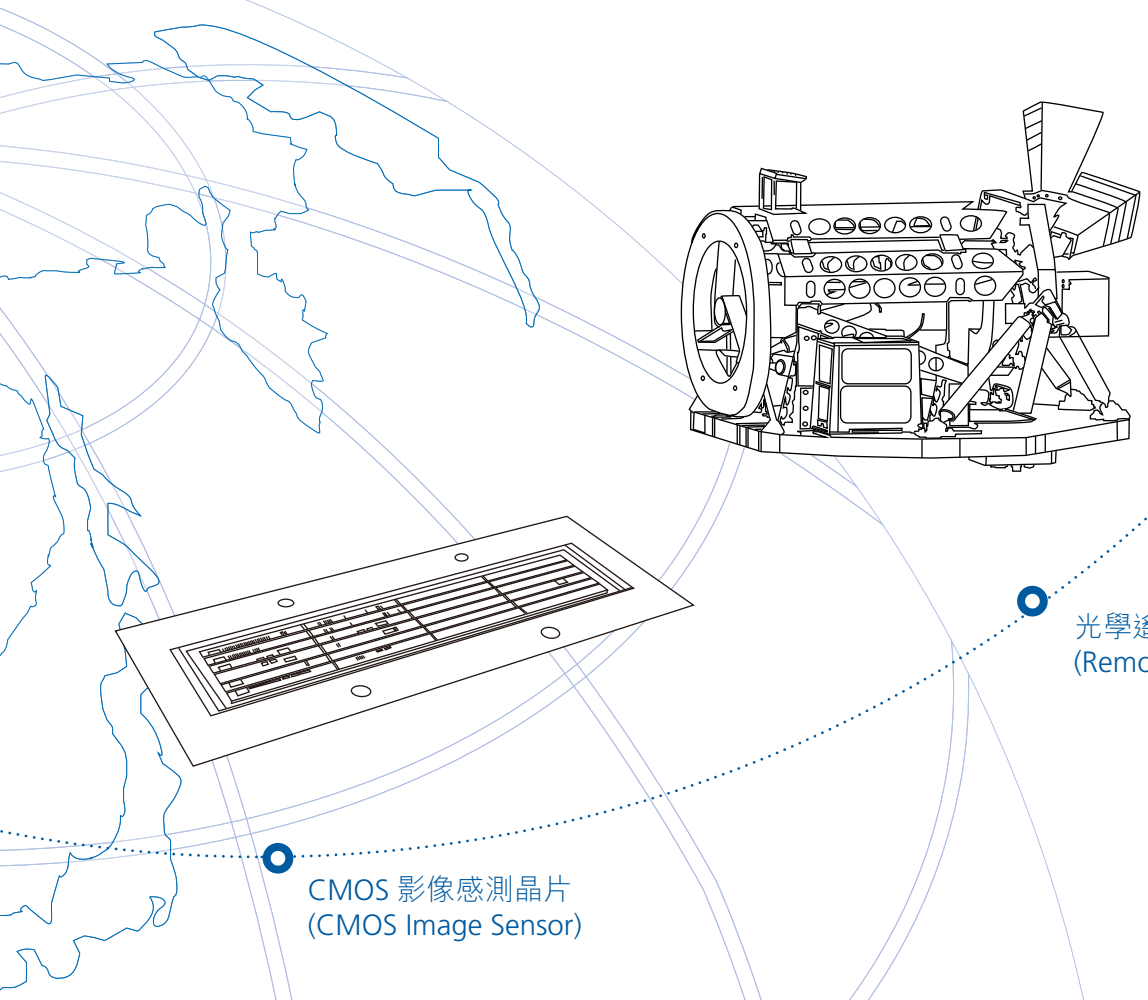
- Become a center of innovation and excellence for space technology
- Conduct space programs with Taiwan's strength and global competitiveness

Mission

- Establish indigenous space technology
- Fulfill pronounced societal impacts
- Promote frontier space science research

Value

- Innovative space technology
- Core competence heritage
- Elite integrity team



光學遙測酬載
(Remote Sensing Instrument, RSI)

CMOS 影像感測晶片
(CMOS Image Sensor)

福衛五號自主關鍵元件
Indigenous key components of FORMOSAT-5

主任的話
Message from the Director General

2011 年欣逢國家太空中心成立二十週年，回顧過往，除順利完成第一期十五年「國家太空科技發展長程計畫」，福爾摩沙衛星一號、二號及三號相繼成功發射並順利運轉外，並接續啟動 2010~2014 年太空科技中程計畫，福爾摩沙衛星五號及七號計畫的順利開展推動，象徵我國太空計畫已邁向自主發展的新紀元。

在全體同仁與合作夥伴的努力下，2011 年乃是國家太空中心成果豐碩的一年，福衛五號遙測衛星的順利研製、臺美合作福衛七號氣象星系任務的推動、兩次混合式探空火箭的成功飛試、福衛三號順利運轉五週年、國際合作計畫反物質磁譜儀二號 (AMS-02) 的成功發射等，皆顯示我國太空計畫的任務目標已逐步落實，無論在計畫推動、技術創新、國際合作、資料應用等方面的成效已逐步顯現。

福衛五號計畫乃是國家太空中心結合國內資源，首次自主研製的光學遙測衛星，除面對技術創新的挑戰外，也是我國太空科技垂直向下紮根、橫向整合能量的關鍵計畫。2011 年在產學研的攜手合作下，多項國產自主發展關鍵元件，完成了功能與環境測試，充分展現臺灣在太空科技的自主能量，並開創自主太空級關鍵元件的新紀元，更是福衛五號由設計發展邁向製造測試新的里程。

福衛七號計畫是延續福衛三號計畫成果，臺美再次合作的大型氣象星系計畫，將部署 12 枚衛星加上 1 枚國家太空中心自主研製的衛星，分二次發射，執行全球導航衛星系統 (GNSS) 大氣掩星觀測任務。2011 年與美國海洋暨大氣總署 (NOAA) 共同完成聯合計畫管控文件及星系任務及衛星系統設計，國家太空中心並啟動自主研製衛星設計工作及關鍵元件的發展，預期福衛七號計畫將於 2012 年正式全面展開。

國家太空中心在國際間持續與守望亞洲（Sentinel Asia）、UNOSAT、International Charter 及國內慈濟基金會等組織合作，提供即時福衛二號影像資料，協助全球救災、災害調查及與環境變遷等研究。尤其日本 311 大地震期間，國家太空中心提供日本政府，連續二周的福衛二號影像，充分展現對臺灣對國際社會人道救濟之承諾及貢獻。另外，2011 年適逢福衛三號運轉五週年，國家太空中心特舉辦第五屆福衛三號星系資料使用者研討會暨 2011 年國際 GPS 掩星觀測研討會 (ICGPSRO 2011)，獲得全球使用者熱烈的迴響與肯定。

展望未來，國家太空中心將以「關鍵技術的研發」、「核心能量的傳承」、「優質團隊的養成」為核心價值，持續向前邁進並追求卓越，希望各界繼續予以本中心督促、指導與支持，讓臺灣太空科技能在國際舞臺綻放光芒。

國家太空中心主任 張桂祥

In the year of 2011, when NSPO celebrates her 20th anniversary, we're proud of the achievements of her goals set forth in the 1st phase of the 15-year National Space Program. These include the successful launches and operations of FORMOSAT-1/2/3, and the advancement of the Space Technology Middle-Term Plan spanned from 2010 to 2014, and the substantial progress of FORMOSAT-5/7 programs. The success marks the important epoch in the space technology development in Taiwan.

Under the tremendous effort of all colleagues and partners, NSPO deliver fruitful results from the development of FORMOSAT-5 remote sensing satellite, the promotion of FORMOSAT-7 constellation under Taiwan-US cooperation, the two successful flight tests of hybrid sounding rocket, the completion of FORMOSAT-3 5th year milestone, and the launch of AMS-02 under multi-nation effort. These demonstrate that we gradually enjoy the outcomes exerted from the program promotion, technology innovation, international cooperation, and data applications of Taiwan's space program.

FORMOSAT-5 is NSPO's first optical remote sensing satellite attempted to integrate various domestic resources vertically and horizontally to confront the challenges during the course of the indigenous space technology development. With seamless cooperation among various organizations from local industry, academia and research institutes, the successful development of several key components has demonstrated Taiwan's competence in the arena of space technology. FORMOSAT-5 is now formally proceeding to the integration and test phase.

FORMOSAT-7 is a follow-on program of FORMOSAT-3. This program involves 12 satellites plus one to be developed in-house in NSPO. Those satellites will be deployed in two separate launches for GNSS radio occultation mission. In 2011, NSPO and NOAA worked together to complete the Joint Management Control Plan, the mission definition, and the system design. At NSPO, we have formally initiated the development of NSPO-built satellite and its key components. It is expected that FORMOSAT-7 program will be in full progress in the coming 2012.

In addition to the two satellite programs, international cooperation is another important NSPO outreach activity. By providing nearly real-time FORMOSAT-2 images, NSPO continues its effort to work with various international organizations, such as Sentinel Asia, UNOSAT, International Charter, and Tzu Chi Foundation, for disaster relief and environmental monitoring. One significant contribution of NSPO's efforts is to support the disaster of 311 Japan Earthquake and Tsunami. For two weeks in a row soon after the quake, NSPO has provided Japanese government with FORMOSAT-2 images that match our humanitarian relief commitment pledged for international community. Also, in the 5th FORMOSAT-3 Data User Conference held by NSPO, where various applications based on FORMOSAT-3 RO data were presented and discussed, is another remarkable contribution made for and recognized by global user community.

In the future, to pursue "Innovative space technology", "Core competence heritage", and "Elite integrity team" will be the core values of NSPO in our course to excellence. NSPO welcome instructions, recommendations, and supports from all aspects that may heighten the competitiveness of Taiwan's space technology in the international arena.

Director General of NSPO Shyy-Shin Chang

目錄 Contents

年度活動記要
Annual Events

2011.12.09

福衛七號計畫臺美指導委員會第二次會議 (ESC#2)

FORMOSAT-7/COSMIC-2 2nd ESC Meeting

2011.12.05

電磁相容與天線測試實驗室通過 ISO/IEC 17025:2005 認證

NSPO Awarded the Certificate of ISO/IEC 17025:2005 for EMC and Antenna Test Lab

2011.11.24

舉辦「光學遙測衛星關鍵技術研討會」

Conference on the Critical Technology for Optical Remote Sensing Satellite

2011.04.15

福爾摩沙衛星三號成功運作五週年慶

Celebration of the Fifth Anniversary of FORMOSAT-3/COSMIC Launch

2011.05.16

完成「垂直大氣耦合探測相機 (E-VAC) 科學任務及酬載計畫」

The E- VAC Project Completed

2011.05.31

混合式探空實驗火箭飛試成功

Successful Flight of Experimental Hybrid Rocket

2011.04.13

舉辦「第五屆福衛三號星系資料使用者研討會暨 2011 年國際 GPS 掩星觀測研討會」

The Fifth FORMOSAT-3 / COSMIC Data Users Workshop and International Conference on GPS Radio Occultation 2011

2011.04.12

福衛七號計畫臺美指導委員會第一次會議 (ESC#1)

FORMOSAT-7/COSMIC-2 1st ESC Meeting

2011.04.11

完成福衛七號系統需求審查會議 (SRR)

FORMOSAT-7/COSMIC-2 System Requirement Review (SRR)

2011.11.18

美國國家太空總署致贈感謝狀表揚國家太空中心對 AMS-02 貢獻

NASA Presented Certificate of Appreciation on AMS-02 to NSPO

2011.11.11

國家太空中心二十週年慶

Celebration of the 20th Anniversary of NSPO

2011.11.05

舉辦「2011 年探空火箭科技論壇」

Sounding Rocket Technology Forum 2011

2011.09.06

完成福衛五號衛星本體細部設計審查 (CDR)

FORMOSAT-5 Spacecraft Bus Critical Design Review (CDR)

2011.06.01

國科會審議通過福衛七號計畫執行計畫書

FORMOSAT-7 Execution Plan Approved

2011.06.28

完成福衛七號系統設計審查會議 (SDR)

FORMOSAT-7/COSMIC-2 System Design Review (SDR)

2011.07.07~07.11

2011 年太空環境測試技術應用研習營

Space Environmental Test Technologies and Applications Workshop

2011.07.25

通過國際標準 ISO 9001、ISO 27001 與 ISO14001 驗證

NSPO Awarded the Certifications of ISO9001, ISO27001, and ISO14001

2011.03.31

與慈濟基金會簽署國外災區衛星影像支援合作備忘錄

NSPO and the Tzu Chi Foundation had signed the overseas disaster area satellite image support cooperation memorandum

2011.02.23

舉辦被動式微波輻射計使用者需求說明會

Users Conference of Microwave Radiometer 2011

2011.01.05~1.06

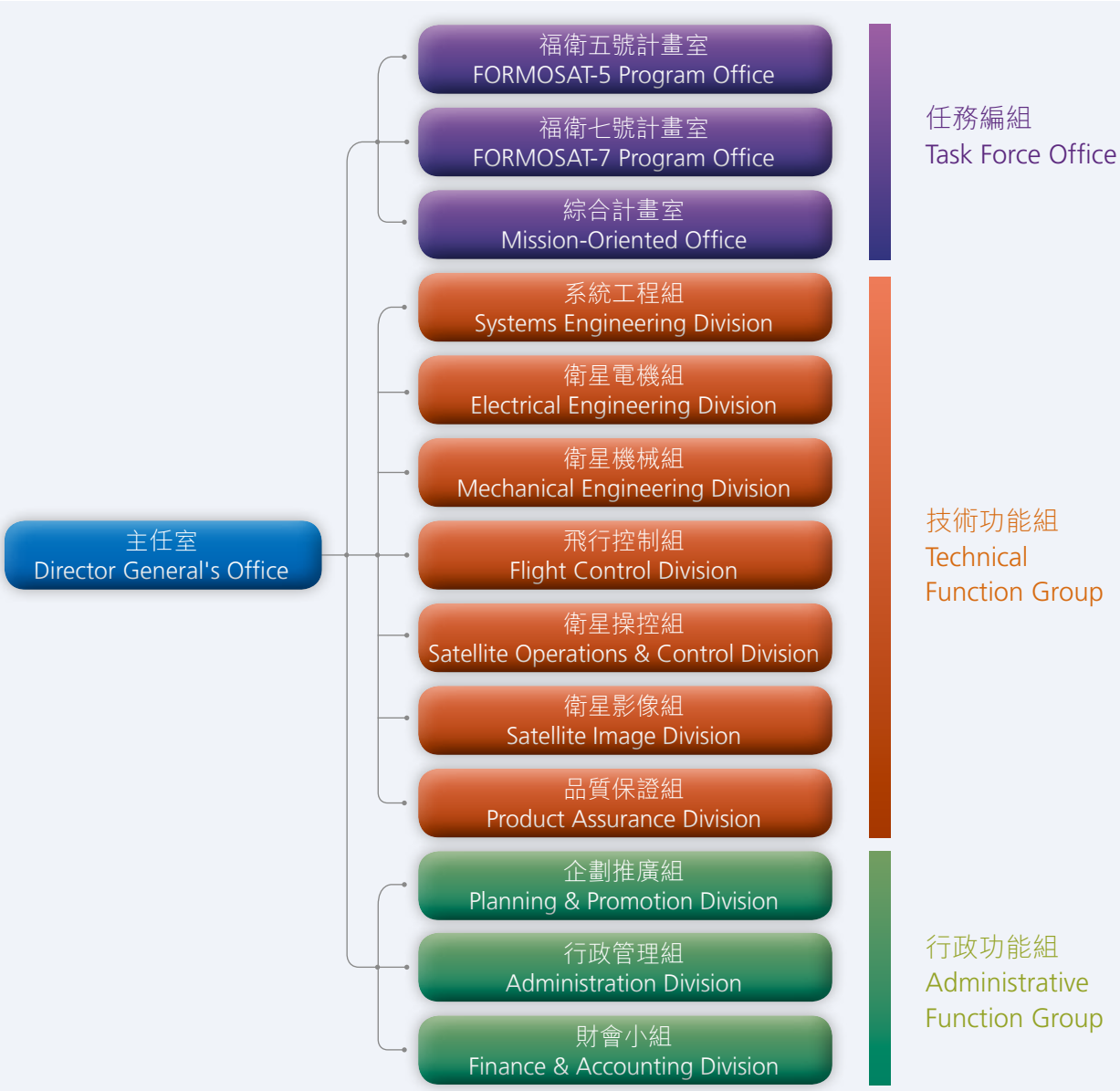
舉辦 CMOS Applications in Astronomy and Space Sciences 研討會

The Workshop on CMOS Applications in Astronomy and Space Sciences

組織架構 Organization

國家太空中心（以下簡稱太空中心）是臺灣唯一負責太空相關事務的專責單位，兼具國家太空科技政策執行機構與太空科技發展機構的特性，以執行衛星計畫為主軸，加強推動學術研究、建立臺灣自主太空科技、進行尖端太空科學研究及推動衛星應用為任務目標。

NSPO acts as the national space agency and is responsible for the space technology development in Taiwan. NSPO's mission objectives are to carry out the national space programs, to promote scientific researches, to establish full capacity of the self-reliant space technology, to conduct cutting-edge space science researches, and to implement the satellite applications to enhance the positive societal impacts.

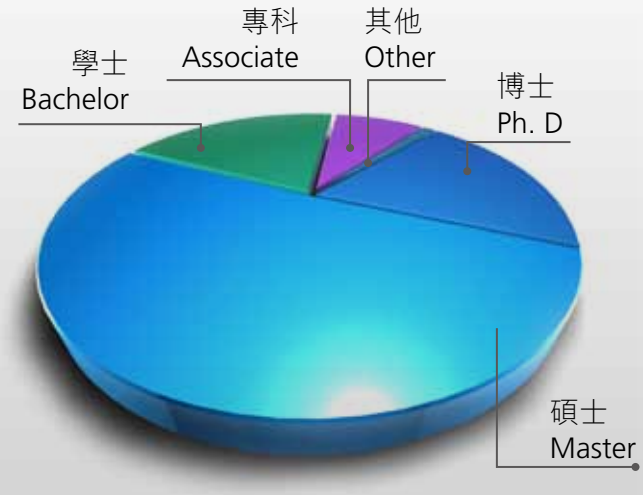


人力配置
Human Resources

職稱人數統計圖表
Human Resource Allocation

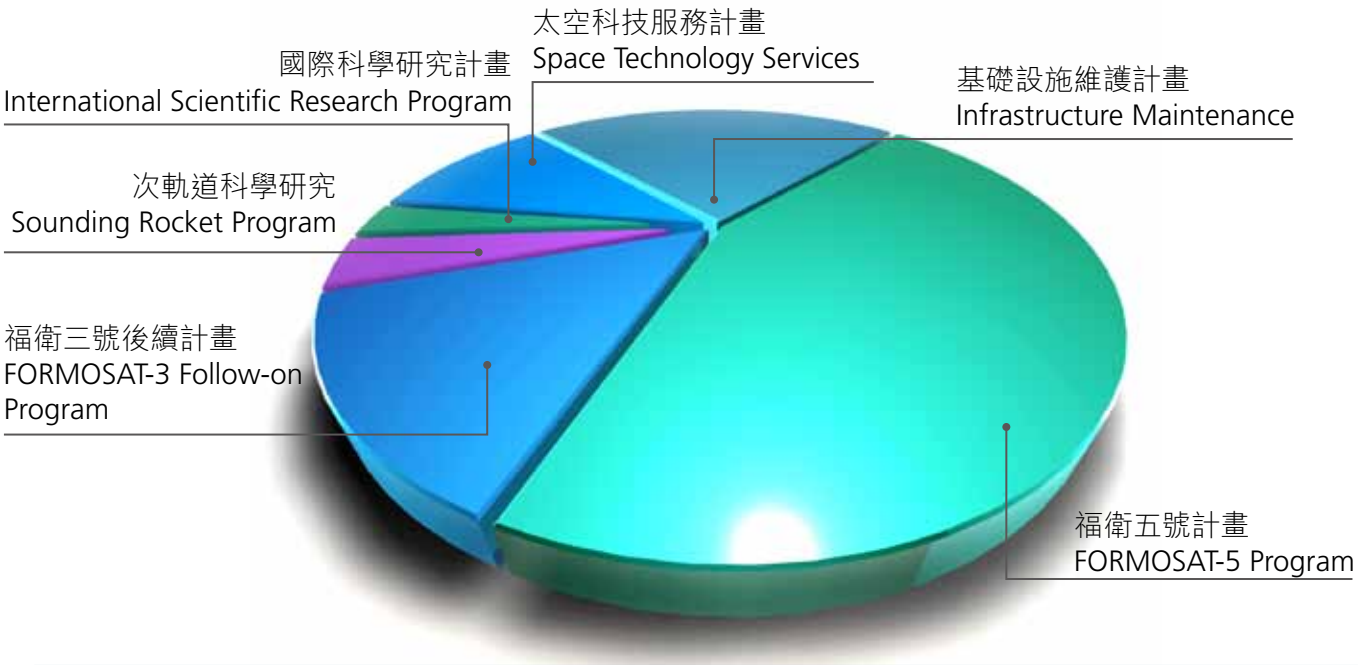
職稱 Title	人數 Number	百分比 (%) Percentage
研究人員 Researcher	106	55
工程人員 Engineer	30	15
技術人員 Technician	21	11
行政人員 Administrator	37	19
合計 Total	194	100

學歷人數統計圖表
Education Qualification

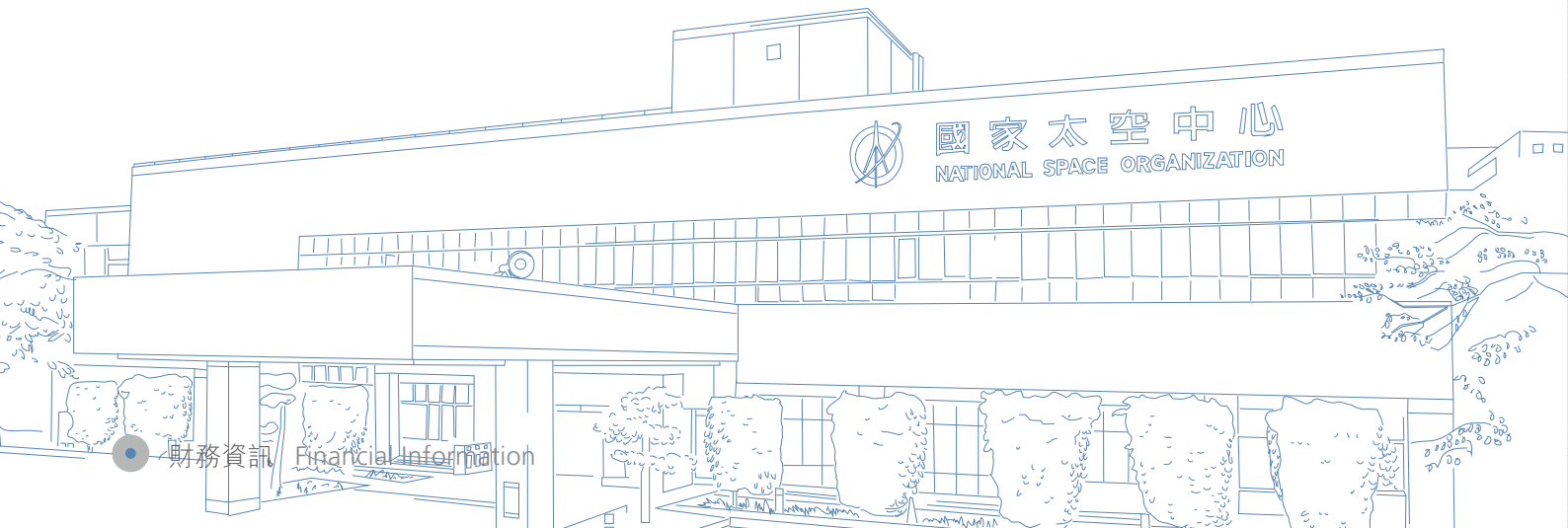


學歷 Education	人數 Number	百分比 (%) Percentage
博士 Ph. D	38	20
碩士 Master	99	51
學士 Bachelor	37	19
專科 Associate	18	9
其他 Other	2	1
合計 Total	194	100

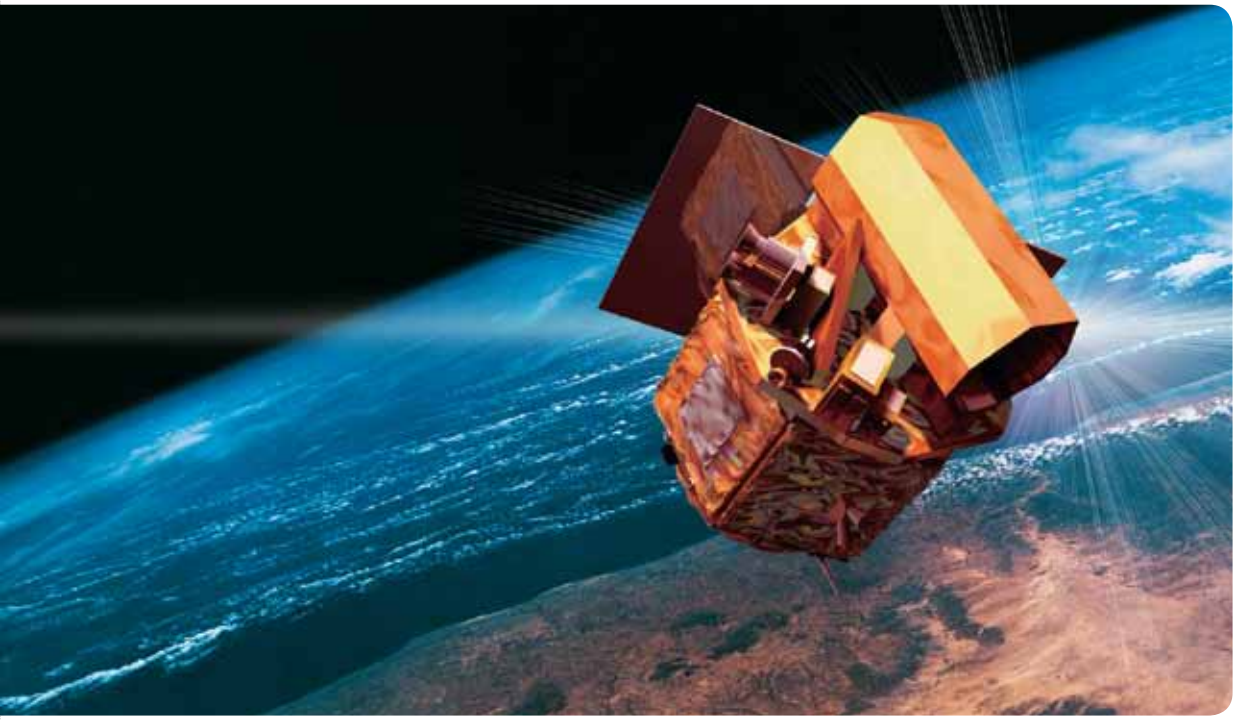
財務資訊
Financial Information



2011 年計畫別 Program	預算數 (億) Budget ($ M USD)	百分比 (%)Percentage
福衛五號計畫 FORMOSAT-5 Program	5.7 (19)	44
福衛三號後續計畫 FORMOSAT-3 Follow-on Program	1.84 (6.1)	14
次軌道科學研究 Sounding Rocket Program	0.52 (1.7)	4
國際科學研究計畫 International Scientific Research Program	0.37 (1.2)	3
太空科技服務計畫 Space Technology Services	1.39 (4.7)	11
基礎設施維護計畫 Infrastructure Maintenance	3.17 (10.6)	24
合計 Total	12.99 (43.3)	100



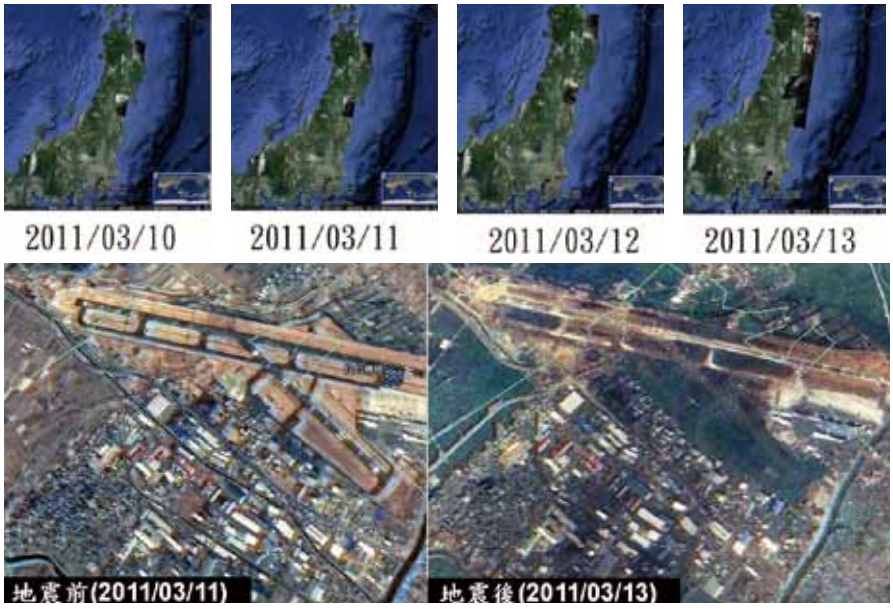
福爾摩沙衛星二號計畫
FORMOSAT-2 Mission



福爾摩沙衛星二號。
(FORMOSAT-2)

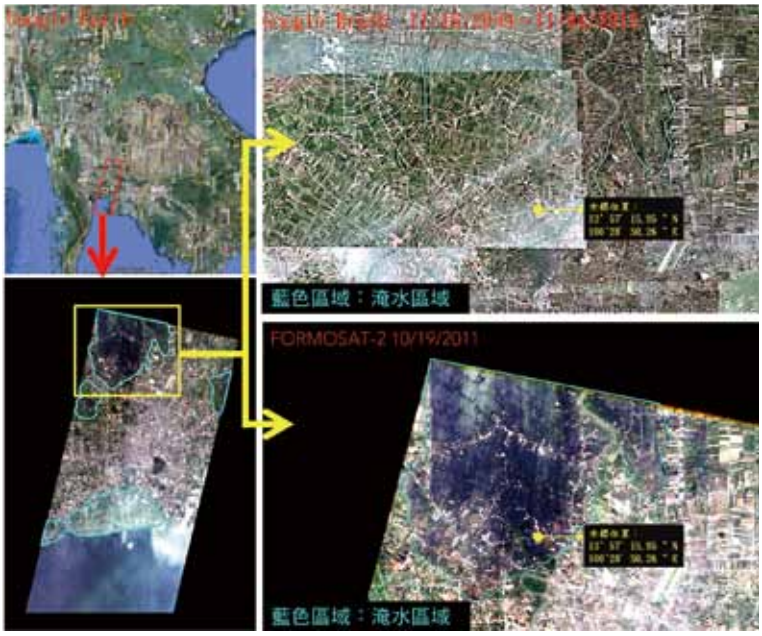
福爾摩沙衛星二號（福衛二號）是臺灣第一枚遙測衛星於 2004 年 5 月 21 日成功發射，進入距地球表面 891 公里的太陽同步軌道飛行，福衛二號任務為對臺灣及全球陸地及海域進行近實時之遙測作業，它在白晝地區拍攝的影像資料可應用於國土規劃、資源探勘、環境保護、防災救災等。當衛星運行到黑夜地區 (eclipse) 時，進行對高層大氣象上閃電之自然現象科學觀測，觀測結果提供做為科學實驗研究。因此，福爾摩沙二號之任務係兼具「遙測」與「科學」兩大任務。

在影像拍照方面，福衛二號除了例行的拍照任務外，在支援國內外環境及災害監控包括：2011 年國內南瑪督颱風、艾莉颱風、蘇花公路崩塌等事件，太空中心均在第一時間內遞交福衛二號監控影像予相關單位以全力協助救防災決策與相關作業。於國際間持續與守望亞洲（Sentinel Asia）、



1 日本 311 大地震之連續取像 (Crises of Japan 311 Earthquake)

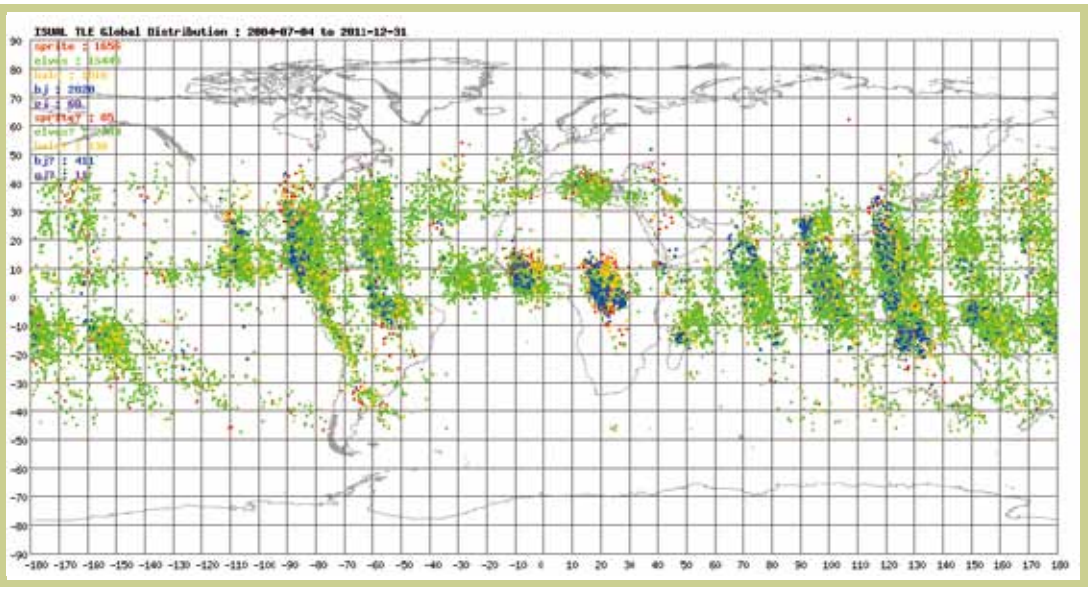
UNOSAT、International Charter、泰國 GISTDA 等及慈濟基金會等組織合作，提供福衛二號影像資料協助全球災害調查、救災工作及與環境變遷等研究。2011 年間共支援 56 次緊急取像需求，包括日本 311 大地震之連續取像❶、泰國水災之淹水判釋❷及美國新墨斯哥州野火等，充分展現福衛二號對臺灣及國際社會之重要性。



❷ 泰國曼谷水災影像判釋 (Disaster Area assessment of Thailand Floods)

在科學實驗方面，2011 年高空大氣閃電影像儀 (ISUAL) 觀測資料發表成果論文共 14 篇，在觀測的 TLE 事件中，記錄了紅色精靈 (sprite) 300 例、精靈暈盤 (halos) 258 例、淘氣精靈 (elve) 3,393 例、巨大噴流 (gigantic jets) 14 例，藍色噴流 (blue jet) 719 例，總計 4,684 例，歷年來全球分佈圖如圖 3 所示。

為有效將防救災影像資料交付相關單位，太空中心除與國內資料分送中心合作外，並參與國研院「發展地球觀測近即時高解析三維環境應用平臺」整合型計畫，結合國家災防中心、國家高速網路中心等進行合作以建立一國內防救災資料提供標準作業程序。



❸ ISUAL 拍攝的高空短暫發光現象全球分布圖（＊資料期間：2004/07/04~2011/12/31）
(ISUAL TLE Global Distribution Statistics, From 2004/07/04 to 2011/12/31.)

FORMOSAT-2 is the first remote sensing satellite developed by NSPO and was successfully launched on May 21, 2004 onto the Sun-synchronous orbit located at 891 kilometers above the ground. The main mission of

FORMOSAT-2 is to conduct remote sensing imaging over Taiwan as well as on terrestrial and oceanic regions of the entire earth. The images captured by FORMOSAT-2 during daytime can be used for land distribution analysis, natural resources research, environmental protection, disaster prevention, rescue work, etc. When the satellite travels to the eclipsed zone, it will observe natural phenomenon such as lightning in the upper atmosphere. The observation data can be used for further scientific experiments. Therefore, FORMOSAT-2 carries both "remote sensing" and "scientific observation" tasks in its mission.

In 2011, NSPO supports corresponding disaster relief organizations with FORMOSAT-2 images for rescue operations when Nanmadol and Aere typhoons slammed Taiwan. Also, NSPO provided those organizations the aftermath images of land sliding for better disaster management. In addition, NSPO teams up with various international organizations, such as the UNOSAT, the International Charter, the Sentinel Asia, and the Tzu Chi Foundation, to perform relief and environmental monitoring related research efforts. In 2011, NSPO supported 56 imaging tasks for emergency response during the crises of Japan 311 earthquake ❶, the disaster area assessment of Thailand floods ❷ and the New Mexico wildfire. These efforts have fully demonstrated the contributions of NSPO toward the societies of Taiwan and the world.

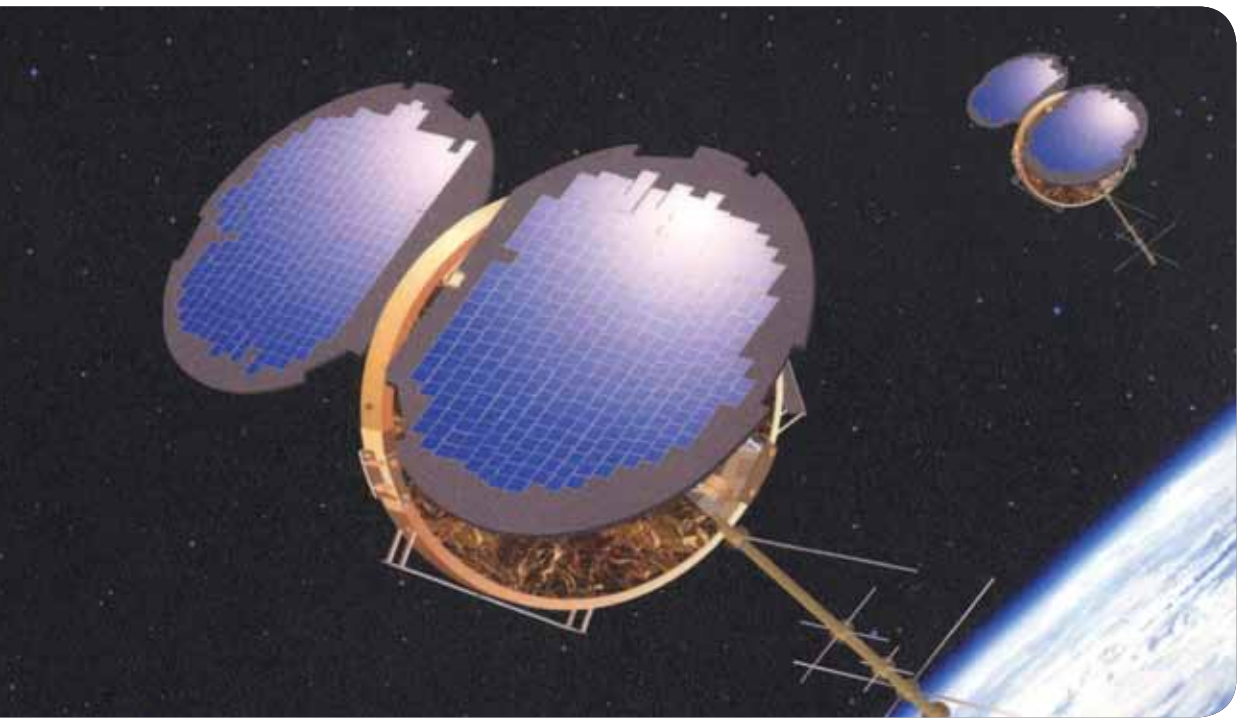
For the science mission, a total of 14 papers were published based on ISUAL data. The various events ISUAL observed and recorded include 300 sprites, 285 halos, 3393 elves, 14 gigantic jets, and 719 blue jets. These events were illustrated in ❸.

In order to provide the disaster images to the official institutions/organizations within a real time frame, NSPO not only cooperates with domestic data distribution center but also joins Taiwan NARL's 3D GIS including the National Science & Technology for Disaster Reduction (NCDR) and the National Center for High-performance Computing(NCHC) to establish an SOP for providing the disaster images.

成果統計 Statistics

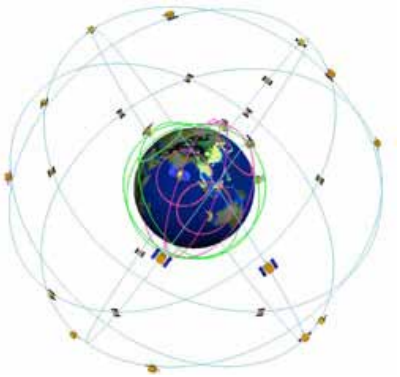
項目 Item	數量 Quantity	單位 Unit
支援國內政府計畫 No. of domestic government project support activities	47	項 Number
支援國內外重大災害次數 No. of disaster support activities (Domestic & International)	56	次 Number
影像拍攝 Imaging area	117.847	百萬平方公里 Million square kilometers
影像銷售 Image sale	30,987 (1.03)	仟元 ($ M USD)

福爾摩沙衛星三號計畫
FORMOSAT-3/COSMIC Mission



福爾摩沙衛星三號。
(FORMOSAT-3/COSMIC)

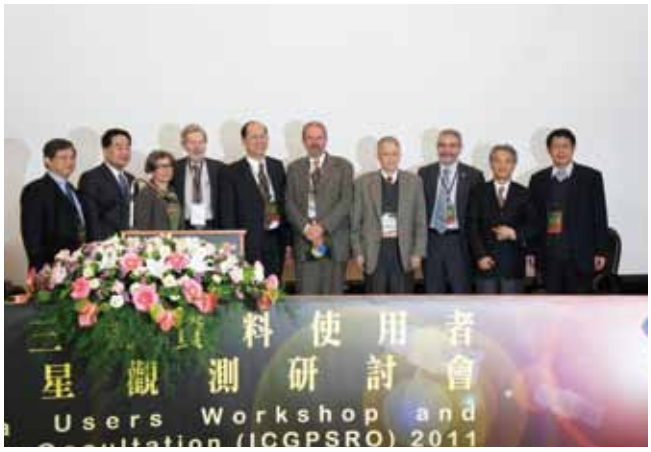
福爾摩沙衛星三號 (以下簡稱福衛三號) 是一大型臺美雙邊國際合作計畫，於 2006 年 4 月 15 日一次發射六顆微衛星，分佈於地球表面 700~800 公里高之不同軌道中，分別圍繞著地球運轉，組成涵蓋全球的低軌道微衛星星系來接收美國 24 顆全球定位衛星 (GPS) 所發出的訊號，提高氣象預報更新的頻率，使氣象報告具有實際的效益外，更可用於長時間之氣候變遷現象之研究、對電離層進行動態監測、進行全球太空天氣之預報、和提供地球重力研究等相關科學研究。



福衛三號的成功，促使我國躍升為氣象資料輸出國，目前 ECMWF 及 NCEP 數值預測作業中心實際應用的結果顯示，福三資料可提升全球模式預測 (在 500hPa 的高空) 的準確度約 6% (預測 168 小時進步 10 小時)，相當於讓世界各國的全球模式預測能力進步 (提前或少花費) 至少 6 年，獲得國際高度認同。

福衛三號掩星資料分析，由太空中心與學研界共同執行「全球定位科學應用研究」，2011 年於福衛三號發射五周年舉行國際掩星資料使用者研討會裡完成福衛三號資料分析、掩星資料進行颱風與豪雨個案分析與模擬、並利用福衛三號資料效益推估發展中的福衛七號計畫及其資料應用於全球大氣與氣候模擬與分析前置技術發展、和應用於太空天氣分析模擬等前置技術發展、科學任務規劃、國際交流及科普教育等工作，所有參與人員均推崇福三貢獻並期盼福衛七號計畫儘早部署完成。

The FORMOSAT-3 mission, a major collaboration space program between Taiwan and the U.S., also known as COSMIC (Constellation Observing System for Meteorology, Ionosphere, and Climate) consisting of six Low Earth Orbit (LEO) satellites is an experimental "Science Mission" for demonstrating the usefulness of Radio Occultation (RO) in operating numerical weather prediction, climate monitoring, and space weather forecasting. The constellation satellites were successfully launched on April 15, 2006 and orbiting at 700~800 km altitudes with evenly separated orbit planes for global coverage to retrieve radio occultation signals from the U.S. 24 GPS satellites. The retrieved near real-time RO weather data by the six satellites were integrated into the Numerical Weather Prediction (NWP) model by many major weather forecast centers and research institutes for real-time weather predictions and cyclone/typhoon/hurricane forecasts. In addition to the advanced improvement in weather forecast, the FORMOSAT-3 RO data has been demonstrated to be valuable for the climate change observation, space weather monitoring and forecast, and earth gravitational study & related researches.



1 第五屆福衛三號星系資料使用者研討會暨 2011 年國際 GPS 掩星觀測研討會 (The Opening Ceremony of the Fifth FORMOSAT-3 Global Data User Workshop and the 2011 International Conference on GPS Radio Occultation)

2 第五屆福衛三號星系資料使用者研討會暨 2011 年國際 GPS 掩星觀測研討會與會人員 (The International Participants of the Fifth FORMOSAT-3 Global Data User Workshop and the 2011 International Conference on GPS Radio Occultation)

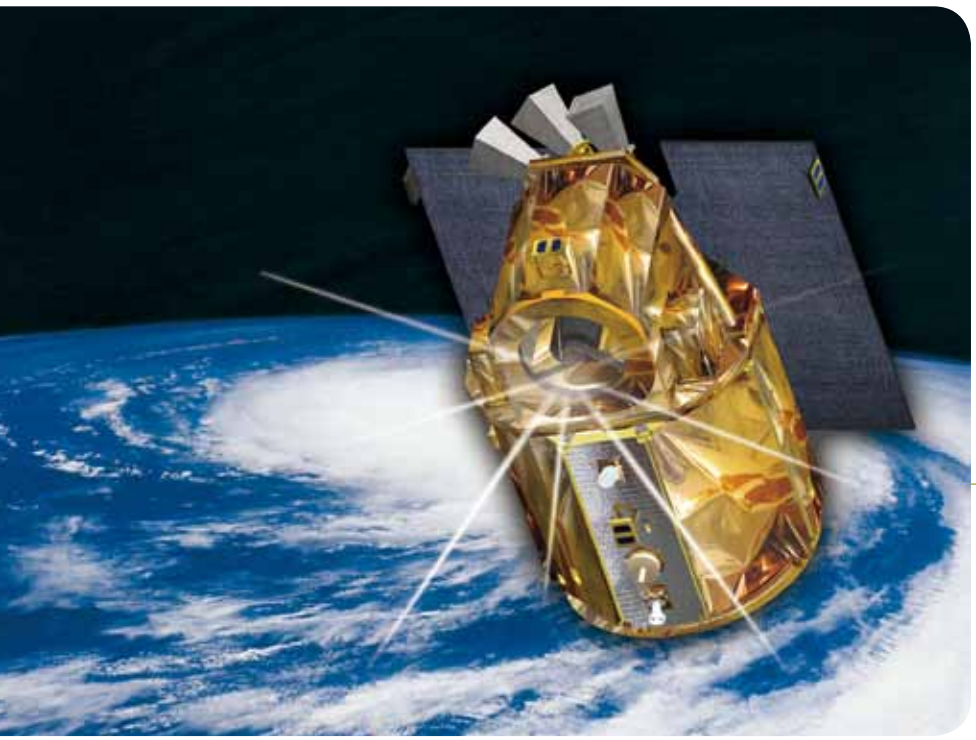
The success of the FORMOSAT-3 mission has advanced Taiwan to become one of the crucial global weather data providers. ECMWF and NCEP through their evaluation indicated the FORMOSAT-3 RO data application can improve the global weather prediction accuracy (at 500hPa altitude) by 6%. That is approximately 10-hour improvement for 168-hours forecast. As a reference, the previous global model prediction accuracy improvement is at an average of 1% per year. Therefore, the introduction of the FORMOSAT-3 RO data in the forecast assimilation model is equivalent to a 6-year effort, saving time and cost in the forecast accuracy improvement and that is well recognized by the international weather community.

NSPO and the Taiwan weather research community established the GPS Application Research Center (GPSARC) to study the societal impacts of the FORMOSAT-3 RO data. As presented in the Fifth FORMOSAT-3 Global Data User Conference and the 2011 International Conference on GPS Radio Occultation, the GPSARC has completed in 2011 the post simulation and the Operation System Simulation Experiment (OSSE) of two critical typhoon and monsoon cases using the impact effects of FORMOSAT-3 RO Data. Likewise, the GPSARC also completed in 2011 the climate model and space weather model simulations for the FORMOSAT-7 mission constellation development, conducted the relevant scientific mission planning, international collaboration and popular science education. All participants in the GPSARC unanimously praised the FORMOSAT-3 mission achievements and were looking forward to the launch of the FORMOSAT-7 constellation.

成果統計 Statistics

項目 Item	數量 Quantity	單位 Unit
資源使用國家數 No. of country of registered users	59	國 country
註冊使用者 Registered users	1781	帳號 Account
掩星點數 (大氣層) No. of sounding points (Atmosphere)	3,178,863	筆 Profile
掩星點數 (電離層) No. of sounding points (Ionosphere)	3,090,908	筆 Profile

福爾摩沙衛星五號計畫
FORMOSAT-5 Program



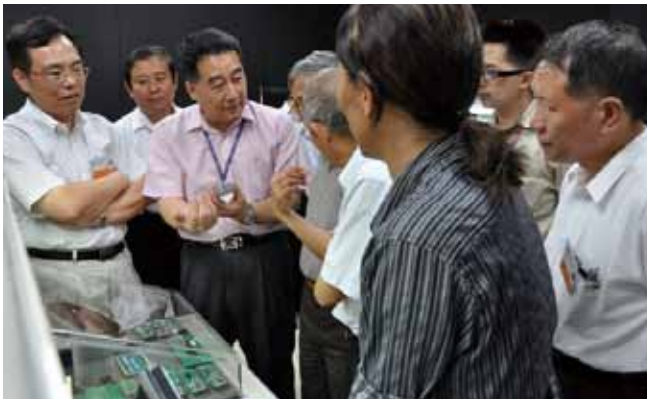
福爾摩沙衛星 5 號。
(FORMOSAT-5)

福爾摩沙衛星五號（以下稱為福衛五號）為我國第一顆自主發展的光學遙測衛星，其任務軌道為高度 720 公里再訪週期 2 天的太陽同步軌道，可提供 2 米解析度的全色 (Panchromatic) 影像和 4 米解析度的多光譜 (Multi-spectral) 影像 ❶，委由 SpaceX 公司使用 Falcon 9 火箭將衛星送入太空任務軌道，以執行對地觀測任務。延續福衛二號任務繼續提供全球影像服務，並期能藉由本計畫的執行，建置我國光學遙測酬載與衛星本體研製能量。由中央大學發展之 " 先進電離層探針 "(Advanced Ionospheric Probe，AIP) 科學酬載亦將搭載於福衛五號，可量測電離層電漿密度、速度、溫度、與環境背景磁場等物理量。

福衛五號計畫於 2011 年已由設計發展階段，正式邁入元件製造測試階段，先後完成包括衛星本體細部設計審查 ❷、影像處理系統與發射載具細部設計審查，及地面系統驗收審查等多項重要里程。所完成的重要工作分太空系統、地面系統及關鍵元件等三方面，敘述如下：

❶ 福衛五號影像模擬圖 (Simulation of FORMOSAT-5 Imagery)

2 福衛五號衛星本體細部設計審查會 (Critical Design Review of Spacecraft Bus)

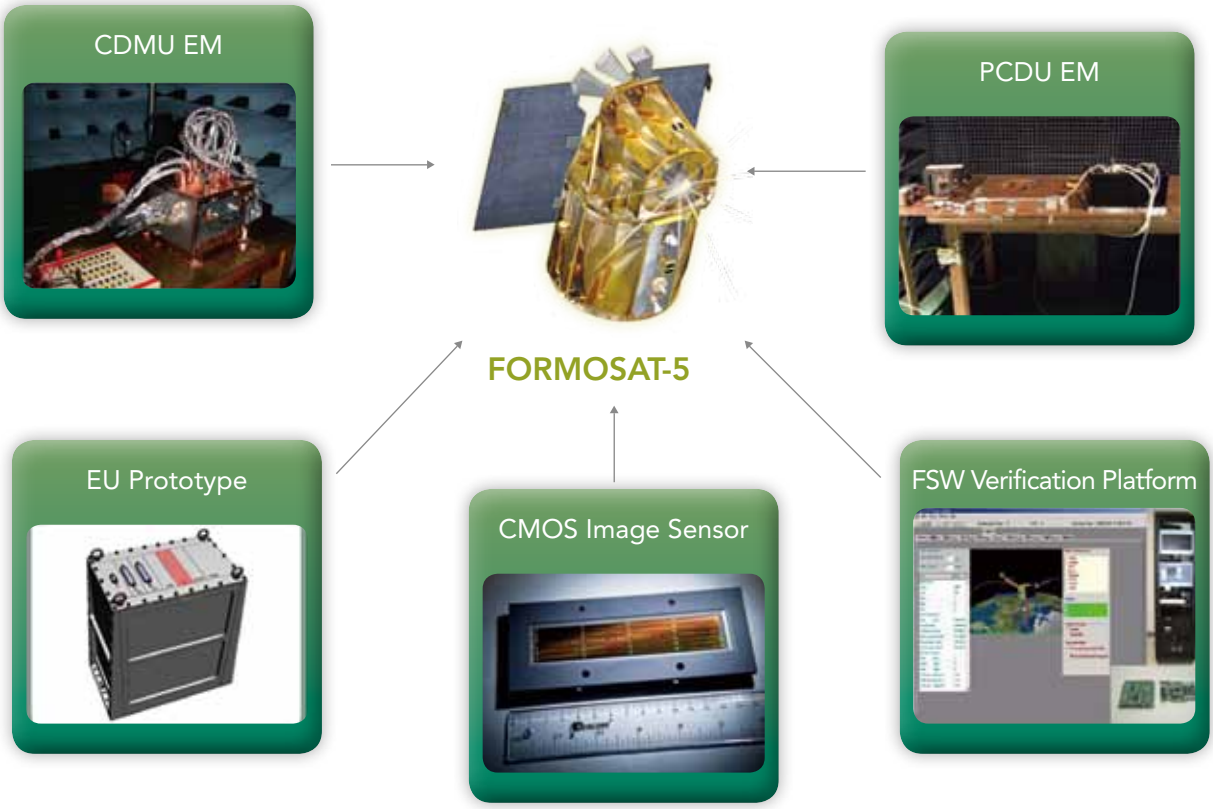


3 遙測酬載技術研發整合型計畫會議 (RSI project review meeting)

太空系統發展成果包括：衛星本體設計與關鍵元件開發、確立與發射載具介面設計、光學遙測酬載研發及科學酬載研發等。衛星本體發展由太空中心進行自主研發，已完成衛星本體細部設計審查，涵蓋內容有衛星結構之設計、整合與出圖、太陽能板展開機構之初步及細部設計、衛星反應輪抑振方案研究、姿態控制硬體迴路測試系統發展、微波通信與遙測影像傳輸次系統之設計與發展、電機地面支援輔助測試設備之設計與硬體發展等，審查結果確認相關的規格與設計皆符合需求；在衛星系統驗證部分也完成工程發展體第 3 階段的電力次系統測試工作；發射載具完成細部設計審查，確認衛星與發射載具介面規格，同時完成第一次星箭耦合分析，確認衛星與發射載具之相容性。光學遙測酬載研發3由太空中心、儀器科技研究中心（儀科中心）、晶片系統設計中心（晶片中心）及國內研究單位與廠商，共同來執行，完成取像儀實驗體 (ExM-100)，用來練習光學組裝測試以獲取操作實務經驗；完成大型光機飛行件加工及量測所需設備之建置；延續 2010 年度，研發團隊已有效掌握主要關鍵技術，飛行元件陸續遞交驗收，預計 2012 年度可開始進行整合測試；科學酬載研發完成介面需求定義，並且選定由中央大學負責發展先進電離層探針科學酬載。

依本計畫需求，地面系統包括建置操控系統與影像處理系統。操控系統部分，本年度完成系統合格測試備便審查、系統整合測試備便審查、系統驗收審查等工作，整個系統的發展將於 2012 年度可完成本計畫所需功能之全部建置；影像處理系統部分，則完成影像處理系統細部設計，並訂定各次系統軟體單元之測試計畫，俾便於下一階段完全之程式實做與系統測試。

除了發展衛星系統、建置地面系統之外，本計畫亦負責關鍵元件研發，國產元件包括指令與資料管理單元（CDMU）、電力控制與分配單元（PCDU）、飛行軟體（Flight Software）、遙測酬載電子單元（Electronic Unit）、CMOS 型聚焦面組合（CMOS Type FPA）等五項4。由太空中心與國內產業界及研究單位合作或委外發展，2011 年度關鍵元件發展順利進行，其中飛行軟體完成 4.0 版本測試及功能驗證平臺 3.2 版本建置；指令與資料管理單元完成工程驗證體遞交與 EMC 環境測試；電力控制與配置：完成工程驗證體遞交與單元環境測試；遙測酬載電子單元：完成雛型體遞交；CMOS 型聚焦面組合：完成 CMOS 影像感測器關鍵技術驗證複審及 CMOS 影像感測器晶片之試製與測試。



4 福衛五號自主關鍵元件 (Indigenous key components of FORMOSAT-5)

FORMOSAT-5, to be operated in a sun synchronous orbit at 720-km altitude with a two-day revisit cycle, is the first indigenous satellite in Taiwan. A primary payload, optical remote sensing instrument (RSI), will be provide 2-m panchromatic (PAN, black & white) and 4-m multi-spectral (MS, color) imagery 1. The objectives of the program are to serve the FORMOSAT-2 imagery users' incessantly and to build up Taiwan's space technology on the remote sensing payload and spacecraft bus. A scientific instrument, Advanced Ionospheric Probe (AIP) proposed by National Central University, has been chosen as the secondary payload.

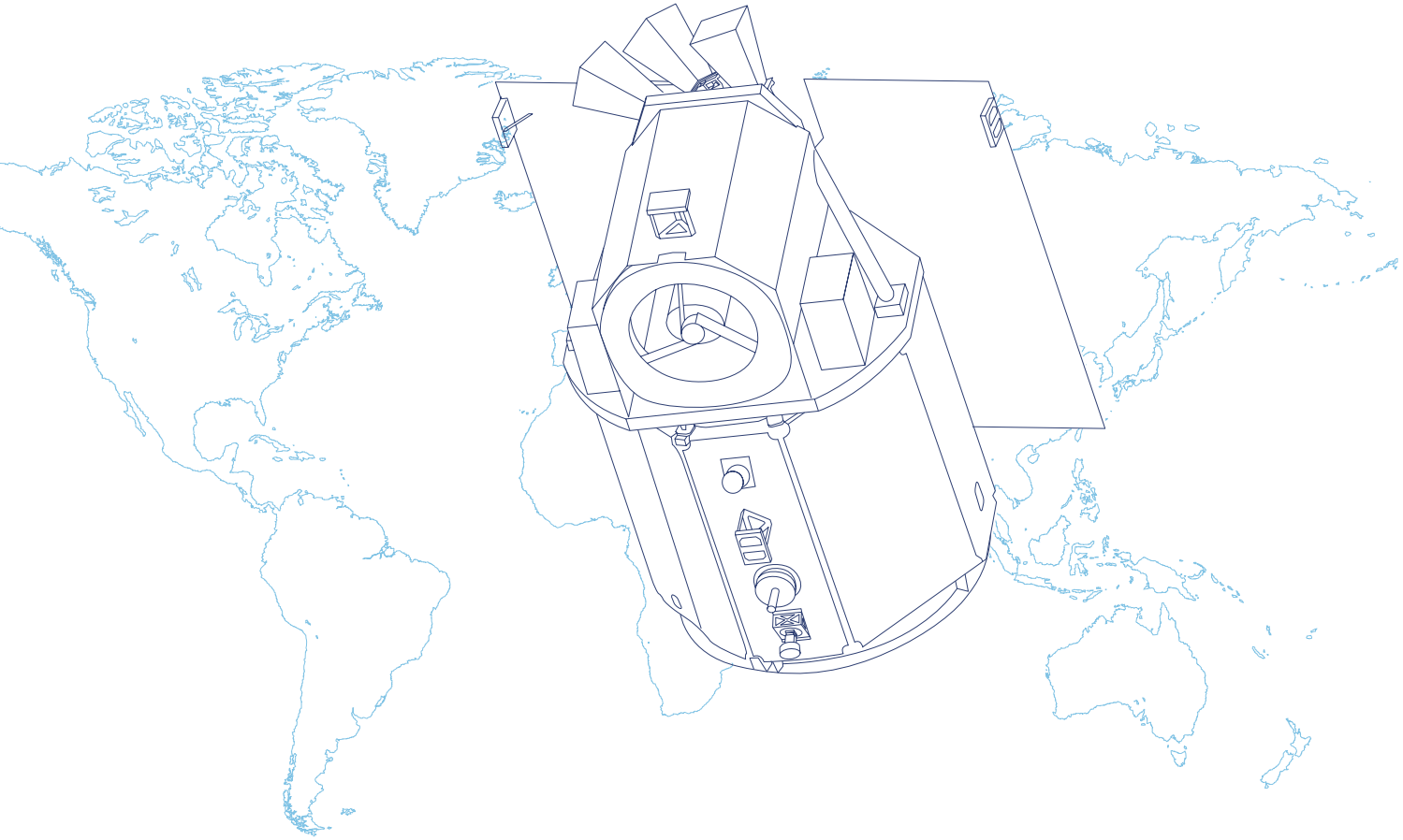
In 2011, FORMOSAT-5 program completed several milestones such as critical design reviews of spacecraft bus 2 , image processing system and launch services, as well as system acceptance review of satellite operations system. FORMOSAT-5 program moved forward steadily from design phase into fabrication and test stage. The major accomplishments in space segment, ground segment and key components are described as follows.

In space segment, the accomplishments include spacecraft bus development, launcher design, optical RSI payload and science payload development. FORMOSAT-5 program continues to build up the indigenous space technology on spacecraft bus; completed the critical design review of spacecraft bus, structure designs and drawings, detailed design of solar panel deployment mechanism, trade study on reducing reaction wheel vibration, attitude control hardware-in-the-loop test system, X-band transmitter design, radio frequency equipment assembly, and electrical ground support equipments. Functions of power subsystem have been validated on satellite engineering development model with flight software build 3.0. Launch service went through its critical design review, in which the interface designs between launch vehicle and FORMOSAT-5 were confirmed. Compatibility between satellite

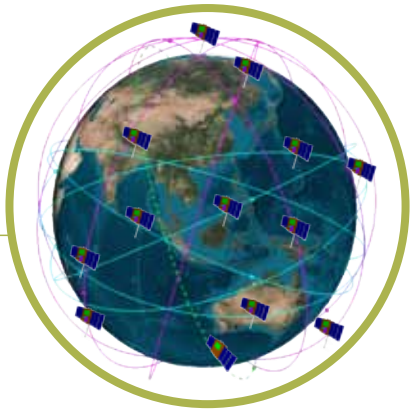
and launch vehicle was assured by passing the couple load analysis. The optical RSI payload ③ is being developed by NARL's centers of NSPO, Instrument Technology Research Center (ITRC) and National Chip Implementation Center (CIC), as well as domestic research organizations and companies. ExM-100 structure was completed as a test bed for preparing optical subsystem assembly procedures. Through validating the key technologies of RSI project, RSI flight components are being fabricated and tested domestically. Science payload, interface requirement document was also finalized in 2011.

Ground segment includes satellite operations system and image processing system. During the year of 2011, satellite operations system accomplished test readiness review for formal qualification test and system integration test, in addition to finishing system acceptance review. Complete satellite operations system facility will be set up by 2012. Meanwhile, image processing system finished its critical design and test in plans for validating computer software components and computer software units are ready for performing both unit and system tests in the next phase.

In addition to the space segment and ground segment tasks, development of key components is also one of the program goals. Five key components include Command Data Management Unit (CDMU), Power Control & Distribution Unit (PCDU), Flight Software, payload Electronic Unit (EU) and CMOS Type Focal Plane Assembly (FPA) ④ . They are developed by NSPO and domestic organizations & companies. Accomplishments include flight software build 4.0 design and testing, CDMU EMC testing and EBB (Elegant Bread Board) delivery, PCDU environmental tests and EBB delivery, EU EBB delivery, and CMOS sensor technology validation and sensor prototype fabrication.



福爾摩沙衛星七號計畫
FORMOSAT-7 Program

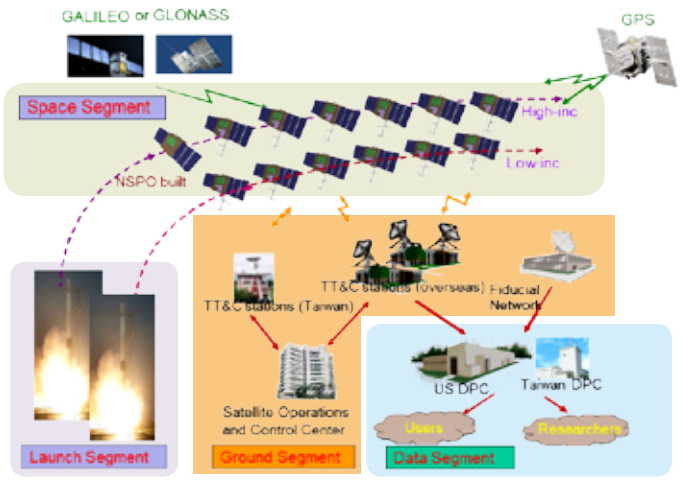


福爾摩沙衛星 7 號。
(FORMOSAT-7)

福爾摩沙衛星七號 (以下簡稱福衛七號) 是臺美共同執行的國際合作計畫，預計發展 12 枚衛星及 1 枚自主衛星，衛星星系將部署在高低兩個傾角，目前規劃於 2016 年及 2018 年分兩批發射。福衛七號由臺美雙方分工執行，太空中心負責系統整合、衛星本體、及任務操作等，美方由美國國家海洋暨大氣總署 (NOAA) 為代表，統籌提供任務酬載、發射載具、地面站、及資料處理等[1]。太空中心自行發展的自主衛星預定與第 2 組衛星一同發射，擴增福衛七號星系系統任務的可用度，並作為自主關鍵元件的太空實證平臺。

依臺美雙方協議之合作計畫管理機制成立指導委員會 (Executive Steering Committee, ESC)，以訂定任務方針與監督聯合計畫的執行，臺美雙方於 2011 年共召開 3 次聯合計畫管理會議 (JPMO#8~#10) 及 2 次計畫共同指導委員會議（ESC#1~#2）[2]。依據計畫里程碑進度，2011 年 4 月在臺灣的太空中心召開系統需求審查會議（System Requirement Review, SRR），完成福衛七號任務基線之定義 (表 -1) 與系統需求之定義。2011 年 6 月在美國召開系統設計審查會議（System Design Review, SDR），完成各任務系統之設計與介面定義。此外，為確實掌握計畫重要技術性能指標，持續追蹤福衛七號衛星酬載之質量分配及總重變化，以及衛星酬載之電力分配及總電力變化。

在自主關鍵元件部份，完成 GPS 導航接收機雛形體[4]，及三軸光纖陀螺儀之開發與遞交。同時成立一個由太空中心、颱洪中心、氣象局與學研界所組成研發團隊，持續進行掩星資料處理及運用系統分析與先期建置作業。



1 福衛七號任務系統架構
FORMOSAT-7 Mission Architecture

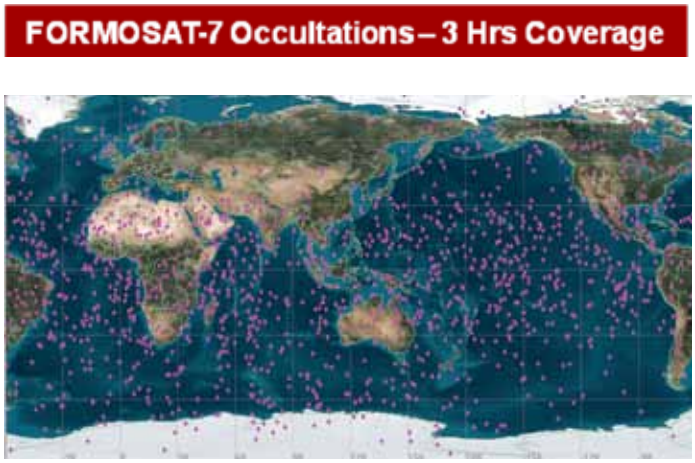
2 福衛七號計畫指導委員會第二次會議 (2011 年 12 月)
FORMOSAT-7 ESC#2 Meeting (December 2011)

FORMOSAT-7/COSMIC-2 Program (simplified as FORMOSAT-7 Program in the following descriptions) is a major collaboration space program between Taiwan and the U.S.. The FORMOSAT-7 Program calls for 12 mission satellites plus one NSPO-Built satellite. The 12-satellites are planned to be launched and deployed in two clusters of 6-satellites into the designated low and high inclination angle orbits in 2016 and 2018, respectively. NSPO, the designated representative for Taiwan in this collaboration program, is responsible for system engineering 1 , the spacecraft buses, and the mission operation, etc. NOAA, the designated representative for the U.S., is responsible for the required mission payloads, the launch system, the ground system, and the data processing system, etc.

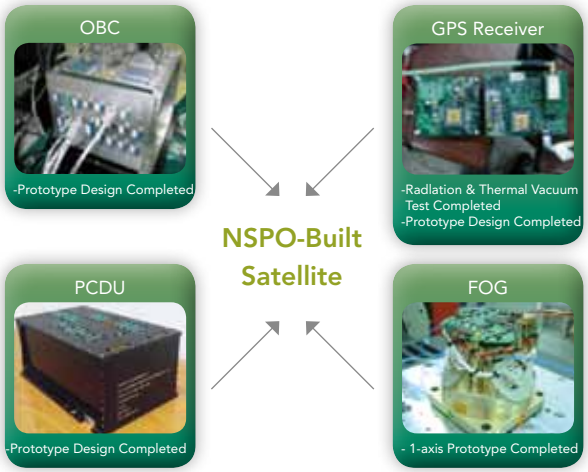
FORMOSAT-7 Program is a follow-on program to the successful FORMOSAT-3 Program. The NSPO-Built satellite that is planned to be launch in the second cluster will enhance the usefulness of the FORMOSAT-7 constellation and will be served as the space qualification platform for the self-reliant key components for the future standard bus of this class.

Based on the mutually agreed Joint Management Control Plan (JMCP), the Executive Steering Committee (ESC) has been established to provide joint executive direction to the Joint Program, and to assess the performance of the Joint Program Management Office (JPMO) which is established to manage and operate the Joint Program tasks and activities. Taiwan and the U.S. has jointly conducted three JPMO meetings (JPMO#8~#10) and the first two ESC meetings (ESC#1 and #2 – Figure 2) in 2011. In addition, both sides concluded the System Requirement Review (SRR) that established the FORMOSAT-7 Mission baseline (as illustrated in Table 1 below) and the system requirements at NSPO in April 2011. And the System Design Review (SDR) has been conducted to conclude the system design and the required segment interfaces for the mission with full representatives of all mission segments in June 2011 in the U.S.. To accurately manage the satellite technical integrity during developing mission payload to assure the mission success, NSPO also keeps tracing the mass and power variation.

NSPO also has made significant progresses in the development of self-reliant key components for NSPO-Built satellite. Among them, the prototype models for a GPS Receiver and a three-axis FOG IRU (Fiber-Optic Gyro Inertial reference Unit) had been developed. A joint task force, as a part of the mission team build-up in Taiwan, formed by NSPO, Taiwan Typhoon and Flood Research Institute (TTFRI), Central Weather Bureau (CWB), and the major academia research community, etc., has been established for the GNSS Radio Occultation data processing and utilization. The implementation of the initial phase has been completed.



3 福衛七號 3 小時掩星點數分佈模擬
(FORMOSAT-7 Radio Occultation 3-hr Distribution)



4 福衛七號自主發展元件現況
(Key Component Status of NSPO-Built Satellite)

表一 福衛七號計畫任務基線
Table 1 FORMOSAT-7 Mission Baseline

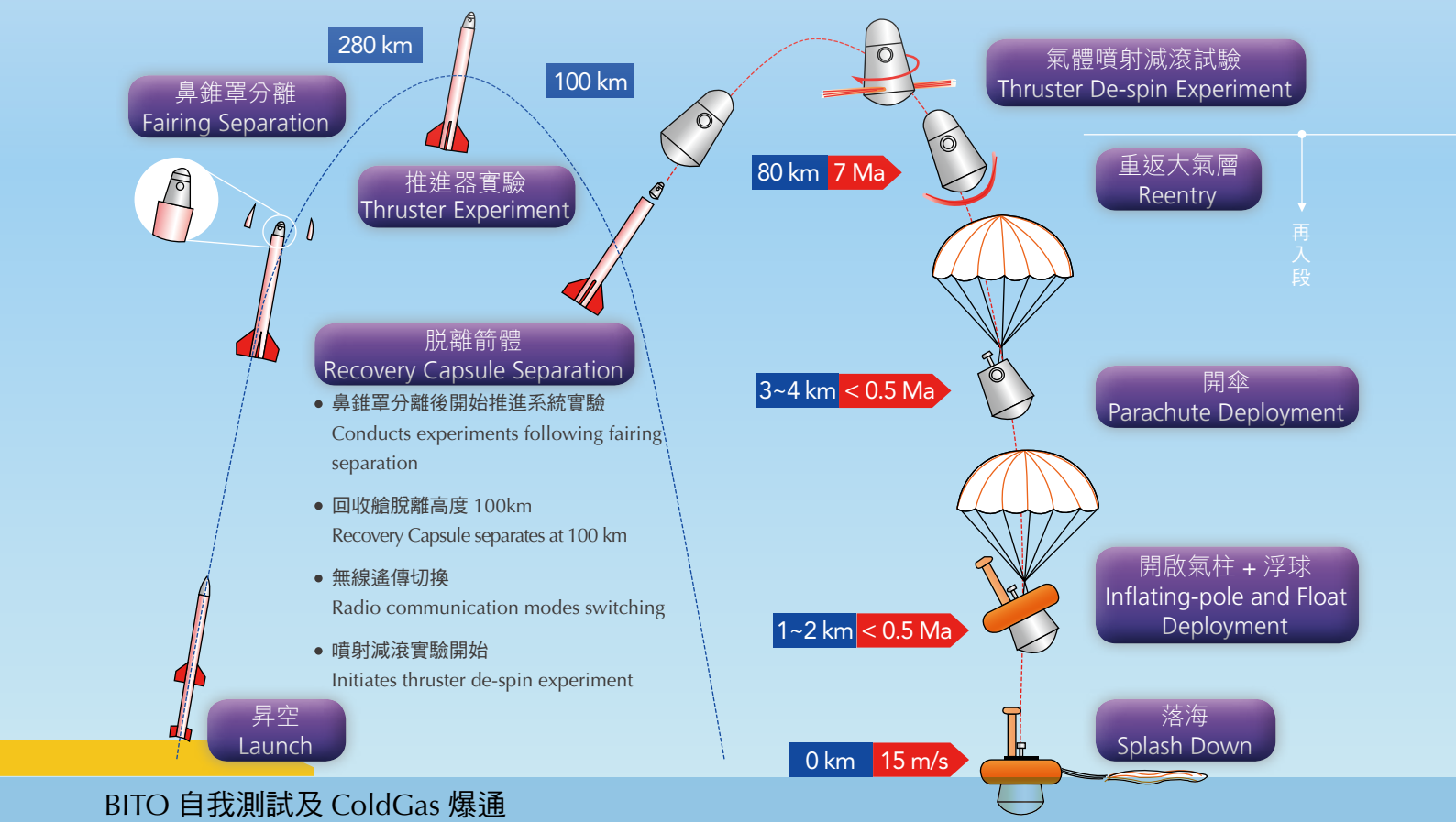
福衛七號 FORMOSAT-7	第一次發射 First Launch	第二次發射 Second Launch
任務目標 Mission Objectives	• 每天 8,000 筆大氣剖面資料 8,000 atmospheric profiles per day	
星系 Constellation	• 6 枚任務衛星 6 Mission Satellites • 軌道傾角 24~28.5 度 Inclination: 24~28.5 deg. • 任務軌道高度 520 公里 Altitude: 520 km	• 6 枚任務衛星 +1 枚自主衛星 6 Mission Satellites +1NSPO-Built Satellite • 軌道傾角 72 度 Inclination: ~ 72 deg. • 任務軌道高度 720 公里 Altitude: 720 km
任務酬載 Mission Payload	掩星訊號接收儀 TriG	掩星訊號接收儀 TriG
科學酬載 Science Payload	美方提供 U.S. Science Payloads: • 信標儀 Radio Beacon Scintillation Instrument • 離子特性量測儀 Velocity, Ion Density and Irregularities (VIDI) Instrument	臺灣提供科學酬載，選擇策略為： Taiwan Science Payload: Selection Criteria: • 能配合主要掩星任務 Supporting Radio Occultation Mission • 能以星系方式執行之科學儀器 Operating in Constellation • 過去科學酬載經驗之傳承 Having heritage
任務壽命 Mission Life	5 年 5 Years	5 年 5 Years
發射載具 Launch Vehicle	EELV 相容載具	Minotaur IV series ， Falcon 9，EELV 相容載具
發射時程預估 Target Launch Period	2016	2018

次軌道科學實驗計畫
Suborbital Science Experiment Program

次軌道科學實驗計畫，計畫的任務是發射探空火箭執行科學實驗，協助科學儀器的自主發展、太空元件的關鍵技術發展與驗證、及學界探空火箭技術的發展，並建立發射載具技術。

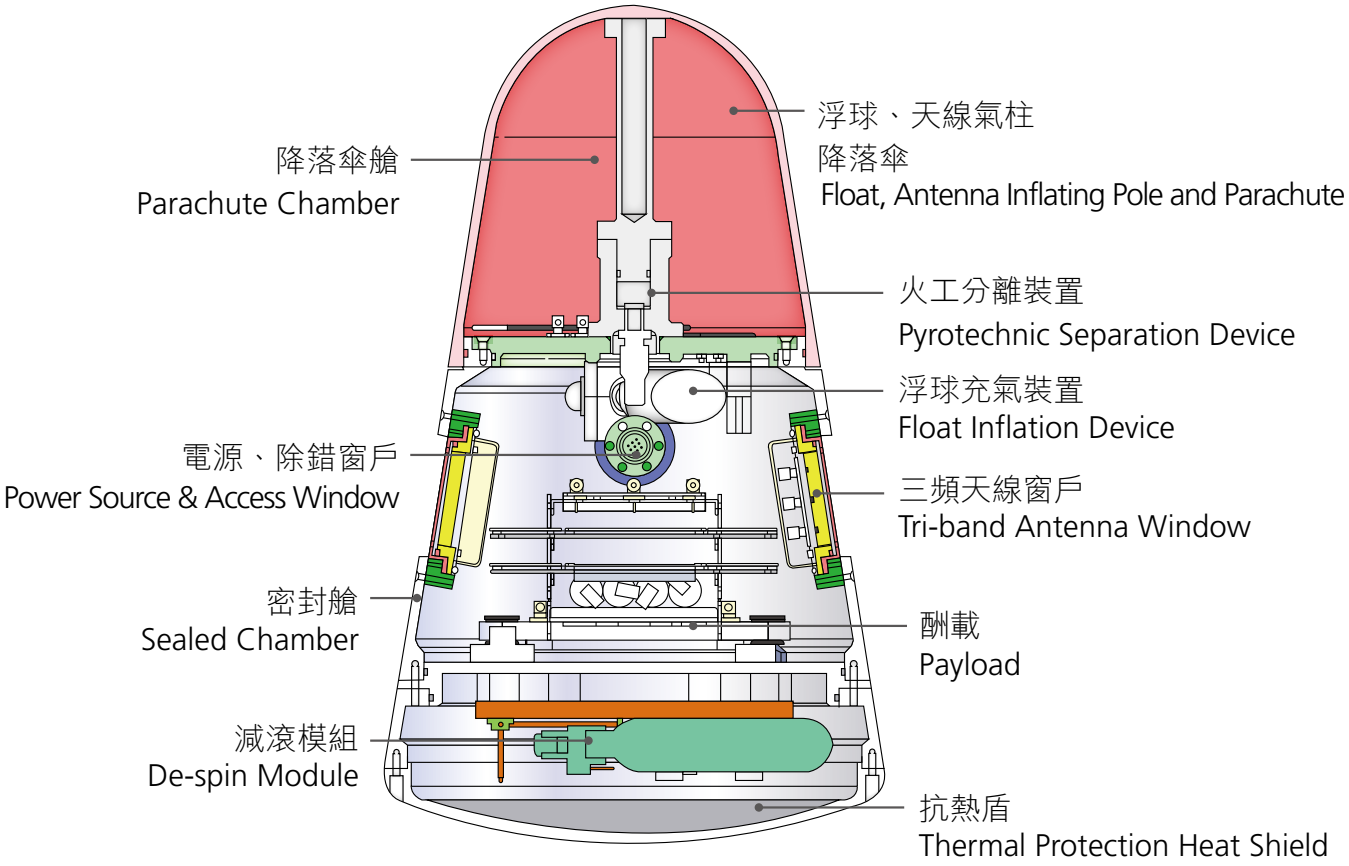
2011 年完成了探八計畫初步設計審查，其中包括探八火箭設計、研製時程、整合測試程序及安全操作規劃，及科學實驗程序確認 1 2；探九計畫完成與火箭的介面定義及酬載系統驗證 3，通過整體計畫的初步設計審查；探十實驗完成與火箭的介面初步規劃及酬載系統測試驗證，其中包括國內首次設計的中性粒子分析儀 (Neutral Particle Analyzer)。

1 探八科學實驗程序圖 (Sounding Rocket 8 experiment flight sequence.)

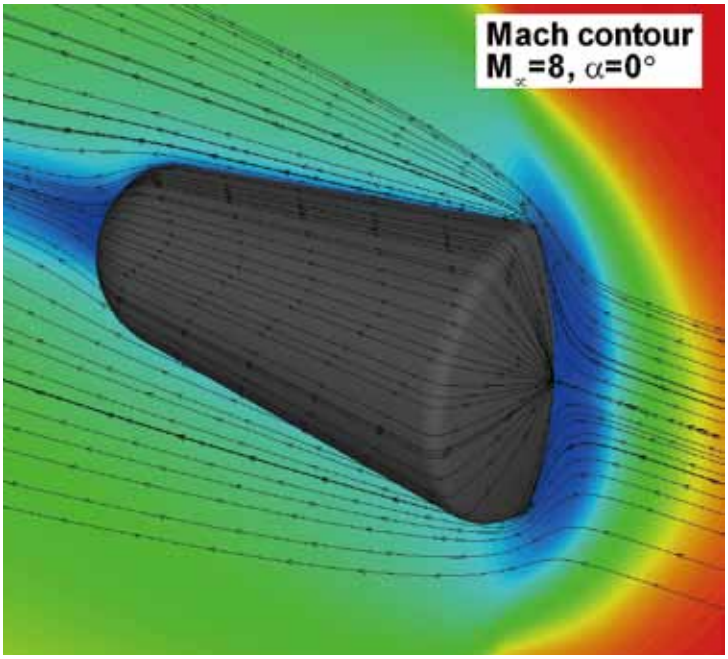


BITO 自我測試及 ColdGas 爆通
Pre-launch System Check

2 探八回收艙科學酬載及再入大氣分析圖
(Sounding Rocket 8 recovery capsule payload and the reentry flow analysis)



探八回收艙科學酬載



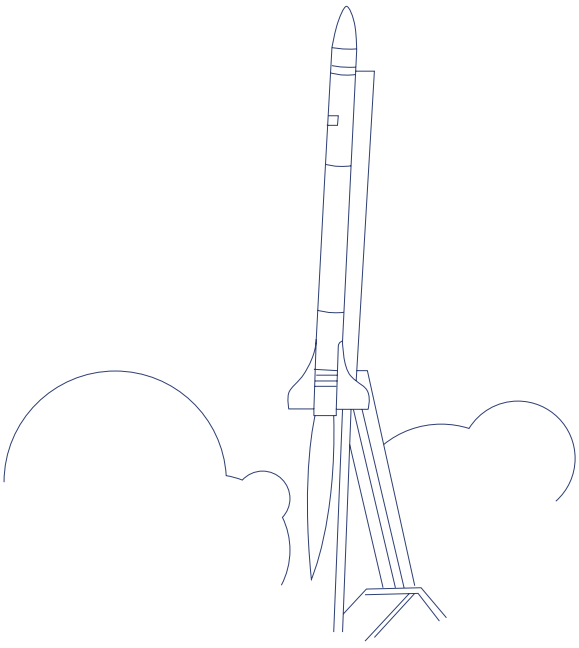
再入大氣分析圖

在探十一先期研究方面，太空中心與國內大學團隊合作發展的「混合式實驗火箭先期研究計畫」，本次採用先進的混合式火箭推進系統設計，提昇整體的推進效率，於 2011 年 5 月 31 日及 9 月 3 日執行發射，挑戰了 13 公里新高及驗證通訊遙傳能力之提昇 3。本計畫由交通大學及成功大學兩個研究團隊執行，本次為成功大學團隊的飛試任務。混合火箭的飛試搭載了太空中心及國內學界研製之測試儀器，火箭飛行的資料順利地經由無線電通訊下傳至地面接收系統，這些資料經過詳細分析，進一步驗證了火箭系統的整體性能，此次飛試所展示混合式實驗火箭性能的提昇，對大學研究團隊的太空科技發展與應用，是再一次的肯定與鼓舞。

The mission of the Suborbital Science Experiment Program of Taiwan is to launch sounding rockets to conduct science experiments, assist the indigenous developments, validate the scientific instruments; the key technologies of space components and university-based sounding rocket technologies, and to establish the technical capabilities of launch vehicle.

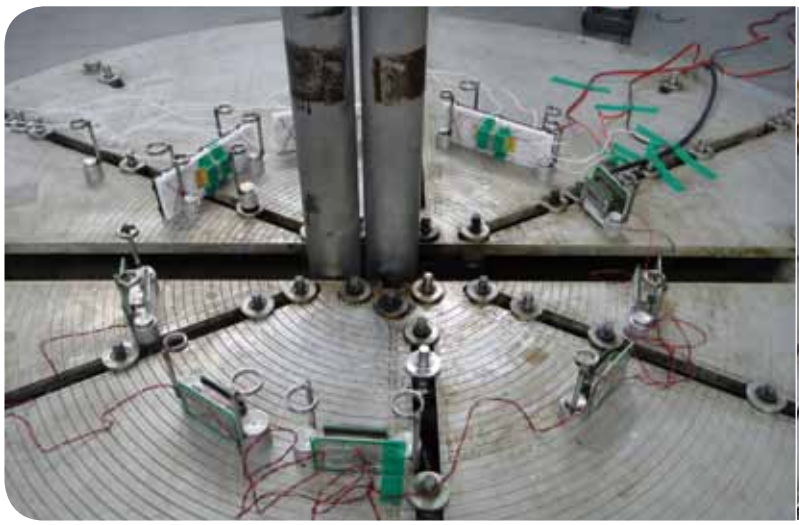
In 2011, the preliminary design review of the Sounding Rocket 8 program was completed, which includes the rocket design, fabrication schedule, integrated testing schedules and operation safety planning, and the confirmation of the flight sequence 1 2 . The preliminary design review and interface definitions with payload system validations for the Sounding Rocket 9 program was also completed in 2011. For the Sounding Rocket 10 program, the preliminary planning for the payload interface and system validations was completed, which include the first Neutral Particle Analyzer instrument completely designed domestically.

In the Sounding Rocket 11 pre-study program, NSPO has been in collaboration with universities in Taiwan for the developments of experimental hybrid sounding rockets. Advanced hybrid rocket propulsion designs have been incorporated in the present programs which lead to two launch campaigns on May 31 and September 3, 2011, challenged an altitude of 13 km with testing of the improved telemetry systems 3. Research teams of the National Chiao Tung University (NCTU) and the National Cheng Kung University (NCKU) are involved in this program. The flight tests of hybrid rockets carrying the instruments designed and fabricated by the university teams, demonstrated the overall performance of the hybrid rocket system and the data linkage between the onboard telemetry and ground reception systems, which have reaffirmed and encouraged the space technology development and application capabilities of the university research teams.



3 混合式火箭第二階段發射活動 (Hybrid rockets second stage launch operations)

系統工程
Systems Engineering



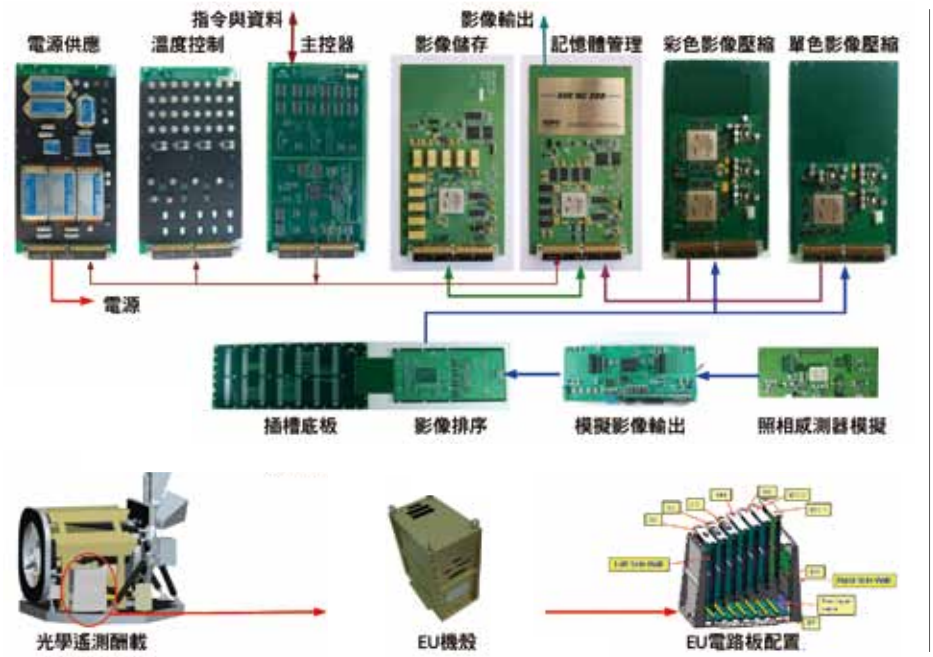

1 CMOS 影像感測器輻射測試 (CMOS Image Sensor Radiation Test)

系統工程主要任務是以系統工程的技術與經驗，提供全盤太空計畫的規劃、分析、擇優及管理，這包括太空段、發射段、地面段及資料段的各別與互動考量。因此，系工組負責由所交付的任務需求，來執行任務分析與定義，進而配合其他功能組執行系統分析與定義，並訂定系統工程管理及工程設計測試驗證的程序與步驟，最後執行反覆確認與驗證的步驟，使最後衛星或載具的設計與性能，能最符合各系統的任務需求。

2011 年主要成果為：

1. CMOS 影像感測器設計與發展：CMOS 聚焦面組合 (FPA) 及 CMOS 影像感測器為國內首次研製，於 2011 年完成 FPA 初步設計審查會議及 CMOS 影像感測器關鍵技術驗證審查會議，及兩次晶片試作的功能與輻射測試 1；遙測酬載電子單元 (EU) 則完成雛型體遞交審查 2，與固態記錄器雛型體及電機地面輔助設備遞交審查；在 CMOS 影像感測器測試環境建置方面，完成 CIS 晶片訊號擷取環境 3，CMOS 影像感測晶片從開始發展至今已歷經 4 次下線，不斷進行設計精進。

2. 依據「福衛七號衛星本體系統需求文件」完成任務衛星本體構型及模擬分析，包括任務酬載 Tri-G 其 POD 天線及 OCC 天線、科學酬載 (RF Beacon) 天線、科學酬載 (VIDI) 感應器 I 及 II 視角 (Field of View，簡稱 FOV)，與衛星太陽能板轉動所可能產生干擾，及不符合 FOV 不可遮蔽之需求研究與評估 4 5。

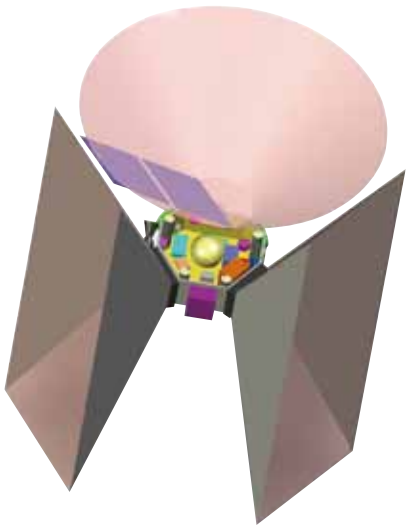


2 遙測酬載電子單元系統介面圖 (RSI EU Interface Diagram)

3 CIS 晶片訊號擷取環境 (CIS Chip Injection Test-set)

The main tasks for systems engineering is to provide completed planning, analysis, optimization and management for overall space program that includes the interaction between space segment, launch segment, ground segment, and data segment, through systems engineering techniques and experiences.

The primary jobs for Division of Systems Engineering are as follows: first, to do mission definitions and analysis from mission requirements; second, to define system and analysis cooperated with other functional divisions; third, to establish the processes for system engineering management and engineering design tests and verifications; and finally, to validate the final design and performance for satellite or launch vehicle that can meet mission requirements.



4 任務酬載儀器（TriG）OCC 天線 FOV 需求及太陽能板單軸旋轉立體圖例 (FOV by TriG OCC Antenna and the Single Assess Rotation Solar Panel)

The main achievements for Division of Systems Engineering in 2011 are:

1. Designs and developments for CMOS imaging sensor:

   Both CMOS Focal Plane Assembly (FPA) and imaging sensor are first designed and manufactured in Taiwan. In 2011, we completed Preliminary Design Review meeting for FPA, Critical technology validation review meeting for CMOS sensor, and conducted functional and radiation tests for prototype chips twice ❶. We also completed shipping reviews for prototypes of RSI Electronic Unit (EU) ❷ and solid state recorder, and EGSE. For the establishment of CMOS test environment, we built a CIS chip signal ingestion test-set ❸. Since we started to develop the CMOS sensor, the performances of CMOS sensor are improving continuously.

2. FORMOSAT-7 Mission Analysis: Based on FORMOSAT-7 satellite bus system requirements document. The satellite bus configuration and simulation analysis have been completed, which include assessments of Field of View (FOV) inference among antennas of POD and OCC for mission payload Tri-G, antenna for RF Beacon, sensor I, II for VIDI and rotated satellite solar panels ❹ ❺.

	FOV	Sun Beta = 0 deg	Sun Beta = 45 deg	Sun Beta = 90 deg
OCC 1 & 2	Azi:+/- 60 deg Elv:+/- 25 deg	No 	No 	No 
POD 1 & 2	75 degHalf-Angle Cone	No 	Yes 	Yes 
RF Beacon	65 degHalf-Angle Cone	No 	Yes 	No 
IVM	45 degHalf-Angle Cone	No 	No 	No 
SPLP	30 degHalf-Angle Cone	No 	No 	No 

❺ 福衛七號 FOV 遮蔽研究初步分析 (Preliminary FOV Sheltering Analysis of FORMOSAT-7)

電機工程
Electrical Engineering

1 衛星電腦工程體整合測試
(CDMU EM Integration and Test)

電機組致力於衛星電機次系統與關鍵電子元件發展，含設計、分析和驗證測試工作，自主研發關鍵電子元件主要為指令與資料處理單元 (亦稱衛星電腦)、電力控制與分配單元，遙測酬載電子單元。本組並負責衛星電機系統在工程驗證平臺之驗證與確認 (Verification & Validation, V&V)。

2011 年度之工作成果說明如下：

1. 指令與資料處理次系統：完成福五指令與資料管理單元 (CDMU) 工程體硬體、與軔體設計，印刷電路板之佈局與製造，電路板之組裝與測試，及單元整合、電機功能測試、與電磁相容測試 1。

2. 電力次系統：完成福五衛星北半球照相與南半球照相不同飛行姿態下最大可用太陽電力之模擬、電力控制與配置單元（PCDU）工程驗證體（EQM）已成功通過太空環境驗證、衛星線束為福衛五號衛星所有電氣介面實現的總成，目前已完成超過 1000 條線段定義的線束組 W01 工程驗證體製作測試，並已完成衛星模型製作以進行衛星線束飛行體繞線與製作 2。

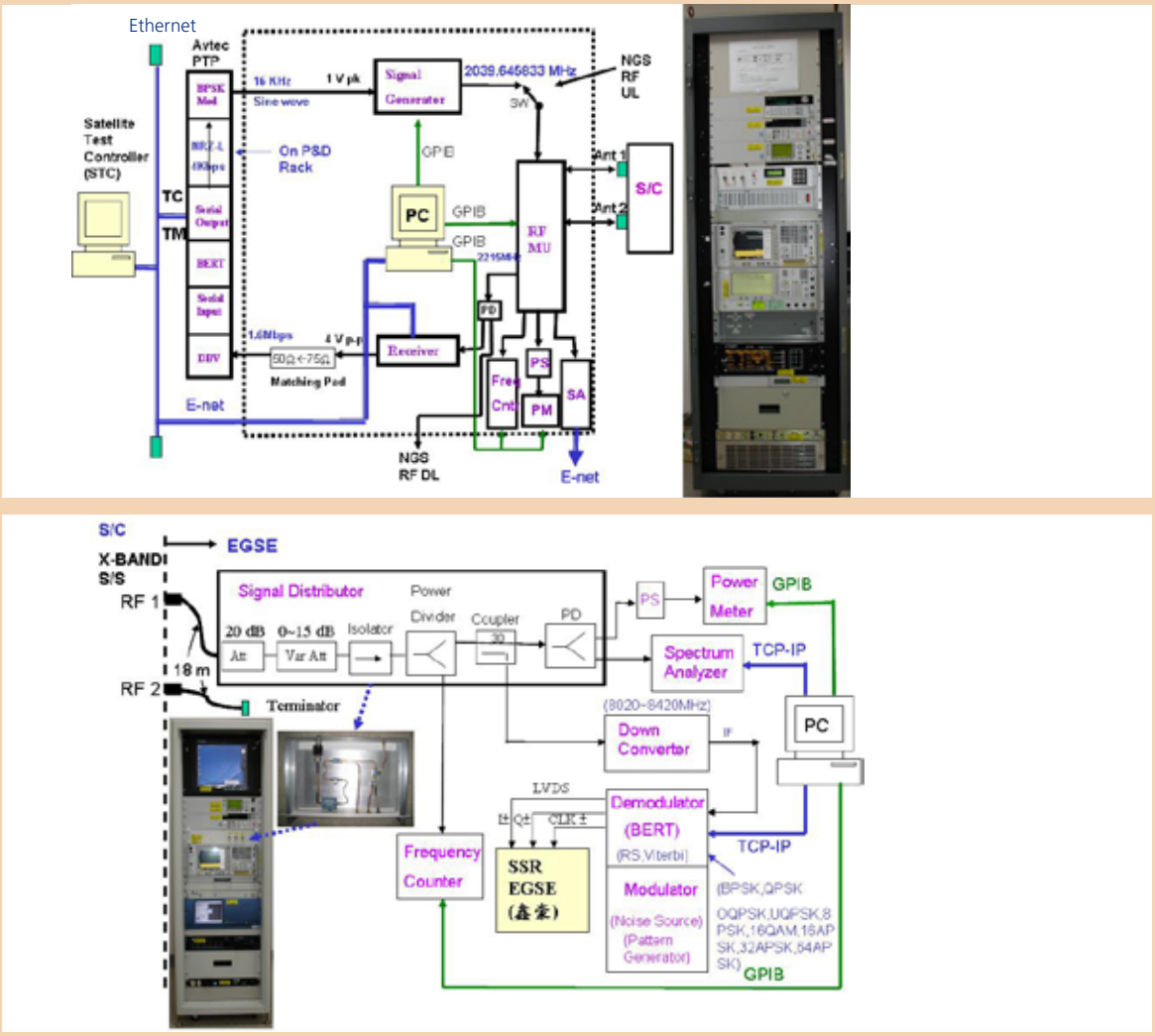
3. 電機地面支援輔助測試設備：支援衛星系統測試之電機地面支援輔助測試設備，完成了福五 S 與 X 頻段測試櫃之多項設計與製作 3，亦完成支援 CDMU 自動化測試之衛星電腦測試設備設計、製造組裝、與測試，及其測試主控軟體。

4. 微波通信次系統：完成福五 S 頻段射頻組件性能測試。此外亦與國內廠商完成研製 QPSK 調解 X 頻段發射器雛型體，含每秒達 100M 位元之數位基頻信號產生器、X 頻段升頻器、及達 22 瓦特輸出之微波固態功率放大器，奠定未來國內發展高瓦數 X 頻段發射器飛行體的基礎 4。

5. 遙測酬載電子單元：完成福五遙測酬載電子單元雛型體設計，印刷電路板之佈局與製造，電路板之組裝與測試，及單元整合及功能測試。單元包含電源模組、照像機控制模組、影像資料壓縮處理模組、記憶體控制模組、及達 128G 位元之記憶體模組 5。

6. 衛星系統之驗證與確認：使用飛行軟體 3.1 版，完成福五電力控制與配置單元與衛星電腦介面測試、及電力次系統功能與性能驗證與確認測試。

2 製作衛星線束之模型體 (Mock-up for Satellite Flight Harness Fabrication)



3 S-Band 與 X-Band Rack 的系統圖及實體圖 (S- & X-band Rack System Block Diagrams and Photos)

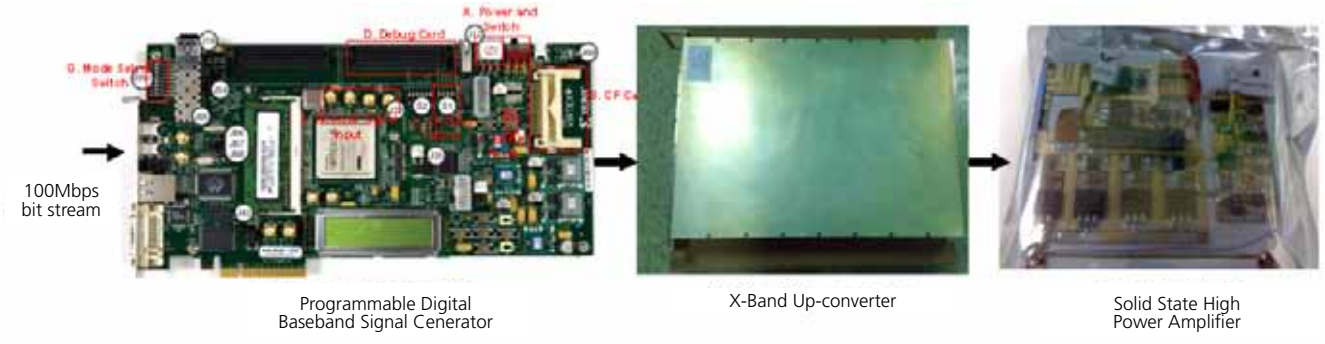
The EE Division focuses on the electrical subsystem and key components development, mainly on Command and Data Handling (C&DH) Subsystem, Electrical Power Subsystem (EPS), RF Communication Subsystem, and Electrical Ground Support Equipment (EGSE). Key components cover Command and Data Management Unit (CDMU), Power Control and Distribution Unit (PCDU, and Remote Sensing Payload Instrument (RSI) Electronic Unit (EU). EE Division also works on the Satellite Electrical System Verification and Validation on so-called Engineering Development Model (EDM). In 2011, the division has made the following achievements.

1. Command and Data Handling (C&DH) Subsystem

The CDMU Engineering Model (EM) development has been finished, including hardware and firmware, PCB layout and fabrication, board assembly, test, and unit integration, Electrical Functional Test (EFT), and Electro-magnetic Compatibility (EMC) test 1.

2. Electrical Power Subsystem (EPS)

Analyses on the maximum available solar power at different attitudes for FORMOSAT-5 imaging in the southern and northern Hemisphere has been finished 2. The PCDU Engineering Qualification Model (EQM)



4 達 22 瓦特輸出之 X 頻段發射器雛型體 (X-band Transmitter EBB with an Output Power up to 22 Watts)

5 遙測酬載電子單元雛型體 (Prototype of RSI EU EBB)

has approved the space environmental verification test . More than one thousand wire segments have been complete for EDM harness. A satellite model for flight harness routing and fabrication was finished.

3. Electrical Ground Support Equipment (EGSE)

The EGSE is used to support the satellite system test. The design and fabrication of FORMOSAT-5 S- and X-band RF Rack have been accomplished 3 . The CDMU tests set design, fabrication, assembly, and validation test has been finished, including its System Test Controller software. The test set provides the features to support the auto test by Auto Test Sequence (ATS).

4. Telecommunications Subsystem

The function and performance test of the S-band Radio Frequency Equipment Assembly (RFEA) has been accomplished. Additionally, the Telecommunication department co-works with domestic company, has developed a QPSK-modulated X-band transmitter Elegant Bread Board (EBB) 4 , which includes a 100 Mbps digital baseband signal generator, X-band up-converter, and 22 watts Solid State Power Amplifier (SSPA), which strongly establish the technical foundation for future Flight Model (FM) development.

5. Remote Sensing Instrument Electronic Unit (RSI EU)

The EE Division is co-working with the CSIST and Camels Technology, Inc. on the RSI EU development. Currently, the RSI EU EBB has been finished, including hardware and firmware, PCB layout and fabrication, board assembly and test, and unit integration & functional test 5 . The EU contains power, camera control, image data compression, memory control, and up to 128 Gbits memory modules.

6. System Verification & Validation (V&V):

The major achievements for satellite V&V activities are PCDU to CDMU interfaces tests and electrical power subsystem function, performance verification and validation test.

飛行控制
Flight Control Engineering

飛行控制組的任務包含建立衛星姿態控制與飛行軟體兩個次系統的完整能量、主導關鍵導航與控制元件的研製及建立航太製作工藝與測試能量，以支援本中心與國內的衛星計畫發展，並支援福衛二號與福衛三號的運轉維護與問題排除。2011 年飛行控制組完成或精進的主要研發成果計有，完成福衛五號姿控測試器驗證與初步姿控閉迴路測試、完成福衛五號飛行軟體重大改版並完成此版飛行軟體的姿控功能驗證、完成數項太空級導航接收機關鍵技術驗證、更新「電磁相容與天線測試實驗室」設備並取得全國實驗室認證基金會的認證、與取得美國太空總署「衛星電子組件聚合物運用」之工藝技術能量。

姿控測試器是衛星測試最關鍵的設備之一，在與衛星連接進行測試前，事先對它進行完整的驗證能確保衛星的發展時程。飛行控制組延續 2010 年發展的『姿控測試器驗證平臺雛型』，於今年完成研製操作型的『姿控測試器驗證平臺』1。在福衛五號姿控測試器 2011 年中運抵太空中心後，更以此自製的姿控測試器驗證平臺完成姿控測試器之驗證，隨後在沒有衛星工程發展體的情形下，也初步完成福衛五號衛星姿控次系統閉迴路性能測試。根據國外衛星大廠的經驗，提前完成姿控測試器驗證與初步閉迴路測試，在進入衛星工程發展體測試階段時 2，可以有效地縮短工程發展體測試階段 3~6 個月。

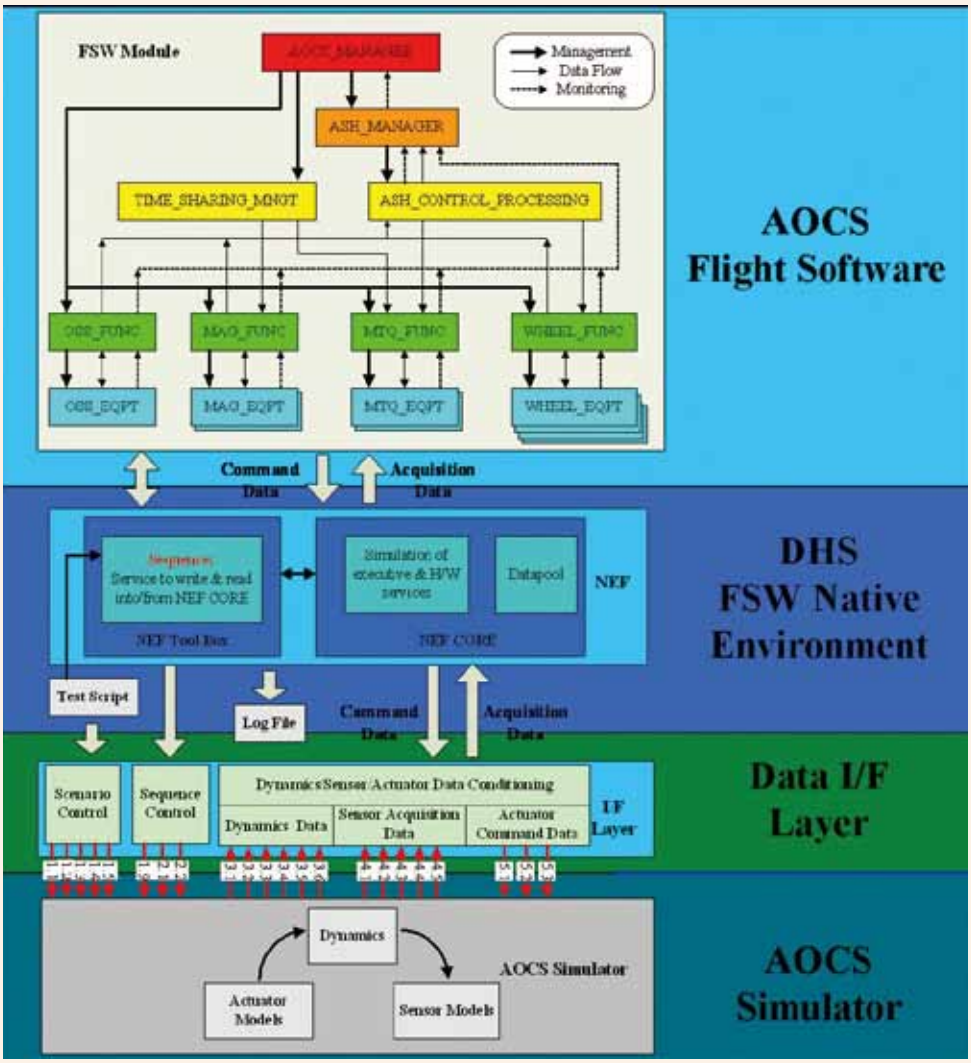
福衛五號飛行軟體 3.2 版為配合衛星電腦由雛型體（EBB）升級至工程體（EM）之重大改版，所有飛行軟體模組由 3.1 版升級為 3.2 版時，皆歷經大幅度之設計變更、軟體原始程式碼修訂、與完整之模組測試。飛行控制組亦以本組發展之姿控功能驗證軟體 3，初步完成驗證 3.2 版飛行軟體之正確性。此外，藉由本次飛行軟體版本升級，飛行控制組也主導衛星各次系統的指令與遙傳訂定等工作。

飛行控制組所屬之「電磁相容與天線測試實驗室」建置已經超過十年，許多儀器設備已經趨於老舊。為了維持實驗室設備的妥善率以支援中心衛星計畫與對外服務，本組於 2011 年完成實驗室大部分的設備更新與備品採購，並通過全國實驗室認證基金會的實驗室認證。2011 年底，本實驗室與電機組亦共同完成太空中心首例之衛星元件傳導性電磁相容測試 4。

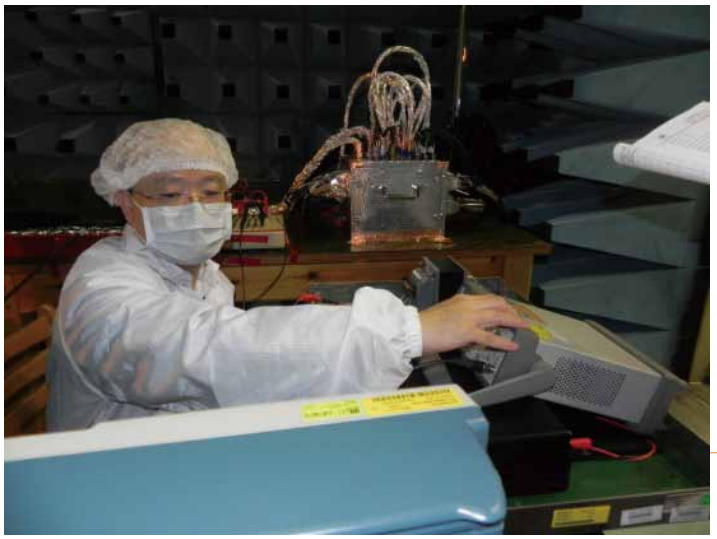
1 福衛五號衛星姿控測試器（右）與姿控測試器驗證平臺（左）。
AOCS EGSE (right) and AOCS Board Simulator (left)

2 衛星工程發展體測試 (Testing Activities on Satellite Engineering Development Model)

2010 年飛行控制組完成研製探空火箭用的導航接收機，並受命繼續研製太空級導航接收機。2011 年已經完成太空級接收機電路設計、電子電機零件選用、中央處理器輻射特性量化測試、FPGA 升級與程式升級等關鍵工作。此外，亦完成接收機之 Single Event Latchup 保護電路 5 設計與初步測試，測試結果顯示此電路能在極短時間內（數個微秒）切斷電源以移除 Latchup ，可以有效地保護接收機。



3 衛星飛行軟體的姿控功能驗證架構。(Configuration of Satellite Flight Software Attitude Control Function Validation Bench)



4 「電磁相容與天線測試實驗室」順利完成太空中心首例的衛星元件傳導電磁相容測試。(EMC and Antenna Test Lab complete its first satellite component conducted EMC test in NSPO.)

To support the NSPO and domestic satellite projects, including operation and emergency response for existing FORMOSAT-2 and 3, the Flight Control Division (FCD) needs to establish necessary capability for satellite attitude control and flight software subsystems, develop key navigation and control components, upgrade manufacturing workmanship to aerospace-grade and acquire necessary testing facility for validation. In 2011, those credible accomplishments or advancement that FCD deliver includes the validation of FORMOSAT-5 Attitude and Orbit Control Subsystem (AOCS) test bed, preliminary AOCS loop closure test, major revision for FORMOSAT-5 Flight Software (FSW) and associated AOCS functional test, validation of several key technologies for space-grade GPSR, refurbishment of EMC(Electromagnetic Compatibility) and Antenna Test Lab instruments and its accreditation from Taiwan Accreditation Foundation (TAF), Technology transfer of Polymeric Application on Electronic Assemblies from NASA.

AOCS Electrical Ground Support Equipment (EGSE) is one of the most critical satellite integration and test (I&T) equipments which requires comprehensive test before real satellite fitted into test loop and reduce the risk of the I&T schedule from unforeseen delay. Soon after the arrival of AOCS EGSE in the mid of 2011, FCD completed the validation test of the AOCS EGSE with homemade AOCS Board Simulator 1 . Later on, with the help of the AOCS Board Simulator, the first cut FORMOSAT-5 AOCS loop closure test was completed without satellite engineering model.

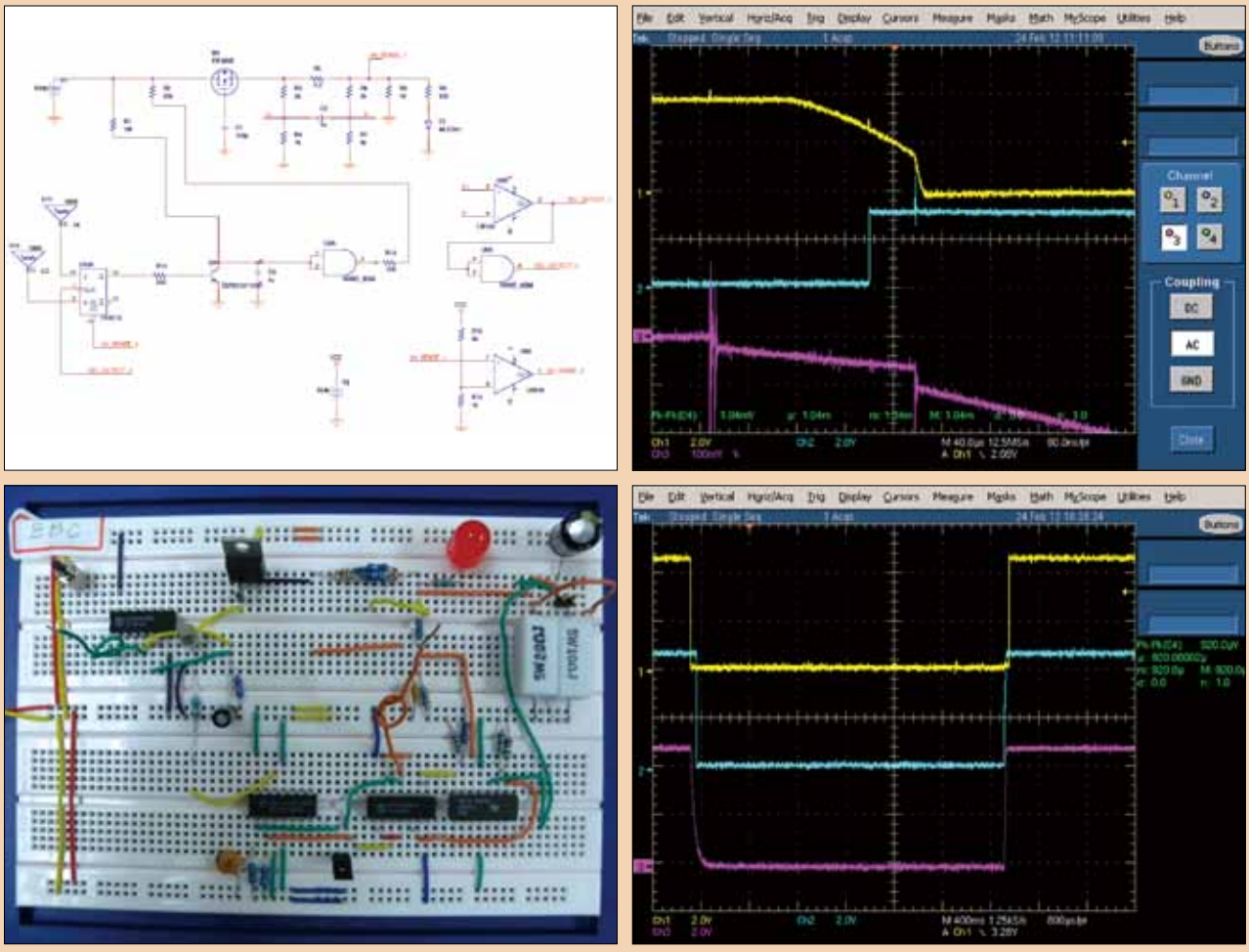
From the lessons by several global major aerospace companies, the completion of AOCS EGSE validation and associated loop closure test prior to I&T test campaign may save 3~6 months on the satellite engineering development model during I&T phase.

The next credible milestone FCD deliver in 2011 is the major upgrade of FORMOSAT-5 Flight Software version 3.2 for EM (Engineering Model) from old version 3.1 for EBB (Engineering Bread Board) through significant design change, source code revision and comprehensive module test to complete the whole process. During the

course of upgrade, ACS Function Validation Bench ❷ developed by FCD plays the key role for the validation of FSW version 3.2. Also, FCD take the lead in formulating satellite Telecomm (TC) and Telemetry (TM) for all subsystems during the upgrade process.

It has been more than a decade since the establishment of EMC and Antenna Test Lab, there are many instruments might face the aging problem. In 2011, FCD update most of those instruments, acquire necessary backup components and certify the lab test capability to maintain the readiness of the lab for NSPO satellite program developments and outreach services. Around the end of 2011, the lab complete the first satellite component conducted EMC test ❸ together in NSPO with Electrical Engineering Division.

Finally, after the development of sounding rocket GPS receiver in 2010, FCD continue its space grade GPS receiver development project under NSPO's indigenous component development plan. In 2011, FCD complete several key tasks including circuit design, electronic part selection, CPU radiation characterization test, upgrade of on-board FPGA and its firmware. In the mean time, FCD mature the protection circuit design against Single Event Latch up (Figure 4) and associated preliminary test. The test result reveals its capability of being able to protect GPS receiver from part latch up by cutting down electrical current within a few microseconds.



❺ Latchup 保護電路能有效保護衛星元件免於太空高能輻射粒子而損壞。(Latchup protection circuit may prevent satellite components from the damage caused by high energy charged particles impinging)

機械工程
Mechanical Engineering

衛星機械工程主要任務為衛星結構與機構次系統、熱控次系統、推進次系統及光學微系統之規範制定、設計分析與驗證等工作，以滿足衛星於地面、發射及太空等各階段之操作需求。

2011 年度核心技術研發工作成果如下：

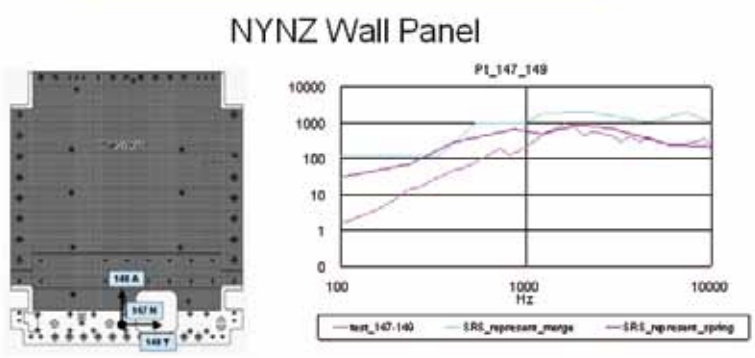
1. 衝擊響應頻譜與隨機振動響應對衛星結構之分析 ❶：配合學理基礎研究及福衛二號之結構設計相關資料，從簡單結構之評估開始進行相關的分析與實驗，進一步以福衛二號衛星結構為實例，進行音振與爆振的測試資料交叉驗證，最後建立隨機振動響應與衝擊響應頻譜之分析方式，可作為後續衛星於設計階段建立衛星元件衝擊環境規範的研發方式及衛星本體音震測試的預測基礎。

2. 自主推進技術研發：工作成果包含完成低壓推力測試艙建置、推進系統模組試製及相關焊接成品檢測、推進控制介面和模擬器的研製，以及推進燃料與充壓氣體裝填和卸載設備原型硬體組測。

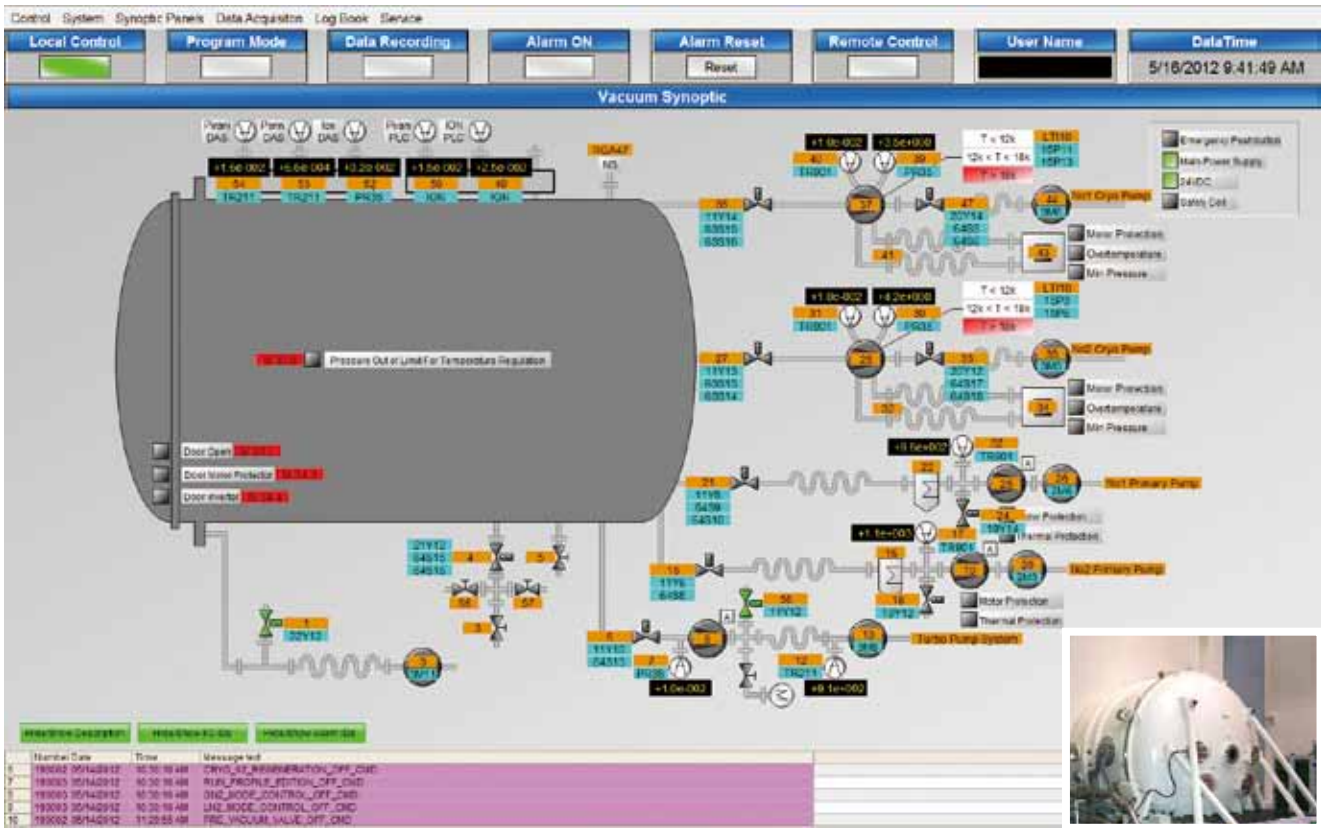
3. 大型熱真空艙控制系統自主升級 ❷：本系統於 1997 建置完成，因系統老舊，經由本案達到國內自主研發完成系統控制升級，節省經費超過 3000 萬元，同時掌握未來系統零組件更新彈性，大幅降低衛星整測風險。

4. 光機驗證平臺建立 ❸：建置光學系統量測設備，提升光學量測精度與能力，支援福衛五號遙測酬載 ExM100 之組裝量測。

代表性ＳＲＳ曲線的建立



❶ 衝擊響應頻譜與隨機振動響應對衛星結構之分析 (Shock response spectrum and random vibration response on satellite structure analysis)



2 大型熱真空艙控制系統更新 (Thermal Vacuum Chamber Control System Upgrade)

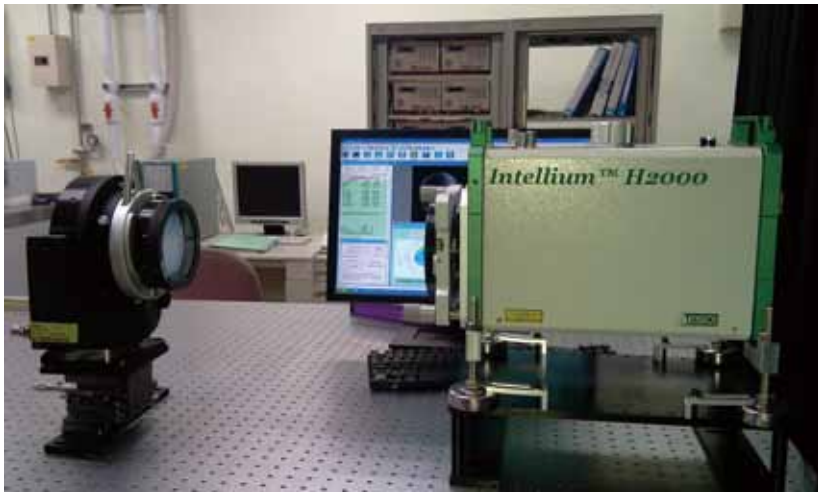
2011 年度衛星計畫主要工作成果如下：

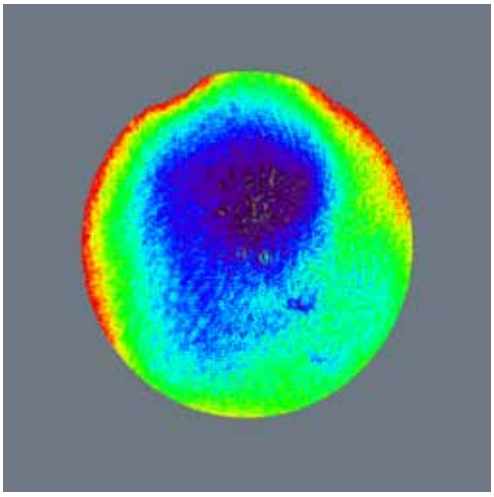
1. 結構次系統設計分析：執行福衛五號本體結構構型設計 4、機械設計整合工作及本體結構細部分析，並完成福五衛星飛行線束模型體，來驗證線束設計的妥適性以及完成太陽能板展開機構的工程體，以確保衛星入軌時可依需求展開太陽能板。

2. 熱控次系統設計分析：建立福衛五號細部熱分析模型 5，計算各種可能情況並篩選出極熱態、極冷態與安全模式之分析案例，設計輻射散熱面積及所需之加熱器功率等，以維持衛星溫度在安全溫度範圍。

3. 推進次系統設計分析：完成福衛五號衛星推進次系統的元件及管路配置設計 6；推進次系統與衛星結構、電氣和熱控等介面設計；推進次系統規格分析；以及推進元件功能驗證測試等工作。

4. 遙測酬載光機系統發展：福衛五號光學遙測酬載結構體設計與分析、光學遙測酬載結構體製造、遙測主鏡靜定支撐架設計及驗證、細部熱控分析模型及熱控硬體配置設計等。





3 建立高精度光機性能檢測技術 (High Precision Opto-mechanical Measurement Technology)

The Mechanical Engineering Division (MED) manages the Structure and Mechanism Subsystem, Thermal Control Subsystem, Reaction Control Subsystem and Optical and Microsystem Engineering and contributes the satellite development project in design, analysis, verification and assessments. MED is also in charge of developing core technologies and fundamental researches for application in future satellite programs.

In 2011, MED attained accomplishments in various areas and portrayed as follows.

1. Shock response spectrum and random vibration response on satellite structure analysis 1 : The analysis starts from theoretical research on simple structure analysis correlation with experimental data which extracted from FORMOSAT-2 satellite design information. Based on these fundamental studies, more analysis on complex structures exposed on shock and acoustic induced random vibration environments can be progressed. Finally, the complete methodologies for satellite structure shock vibration response analysis as well as satellite structure acoustic induced random vibration prediction are effetely created.

2. Self-reliant Propulsion Technologies: achievement the development of the Low Pressure Thrust Measurement Chamber, (2) two prototypes of the RCS AIT Modules, the RCS Control Unit and Simulator, and the prototype of the Propellant/Pressured gas loading and unloading System.

3. Self-reliant upgrade of thermal vacuum chamber facility control system 2 . Since Thermal vacuum chamber was built in 1997, it needs to be upgraded for further operation and mission satisfaction. By the successful upgrade in 2011, it is not only save over 30 million NTD, but also have the benefits of helping to reduce the satellite testing risk and more flexibility of further system maintenance & component utilization.

4. Opto-mechanical test platform 3 : Optical measurement system was built to provide high accuracy measurement of optical components and telescope system. The system had been used to measure FORMOSAT-5 RSI ExM100 optical performance during assembly phase.

In 2011, MED attained accomplishments in satellite program as follows:

1. Satellite structure design and analysis: It includes FORMOSAT-5 satellite mechanical integral design 4 ,

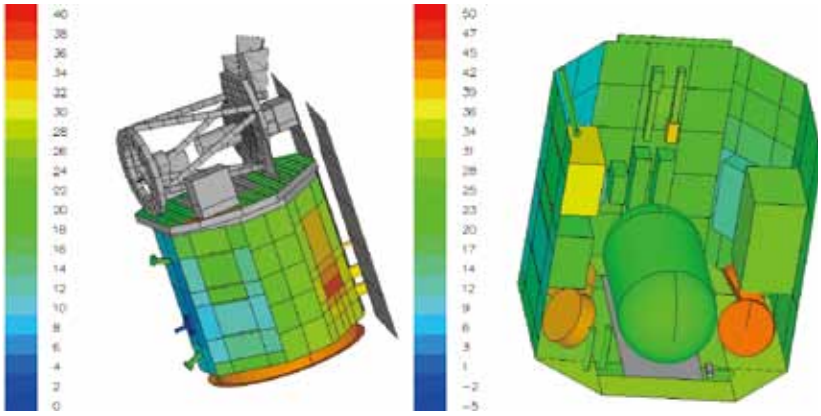
satellite structure detail design and analysis. Furthermore, FORMOSAT-5 satellite harness routing design is also completed and solar array deployment mechanism functions have been verified by engineering model.

2. Thermal Control Subsystem (TCS) design and analysis: Build the detailed thermal analytical models 5 and perform the satellite thermal analysis under the different operation conditions to identify the critical thermal hot and cold conditions. Design and measure the required radiator size and heater power to maintain the satellite temperatures within the allowable temperature limits.

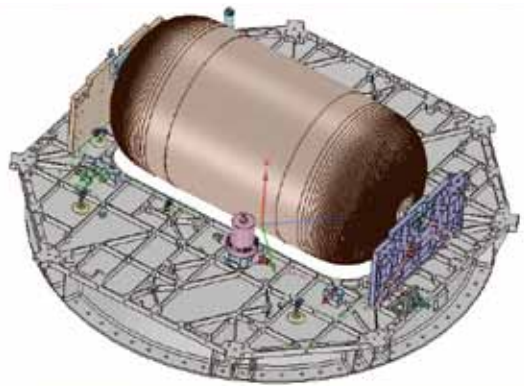
3. RCS Design and Analysis: Complete the design and analysis for the FORMOSAT-5 Propulsion Subsystem, including the components layout and pipeline routing design 6, performance analyses, and component level verifications, tests and reviews the RCS associated mechanical, electrical and thermal interfaces.

4. Telescope system development: Performed FORMOSAT-5 RSI structure design and analysis, thermal design and analysis, primary mirror ISM design and verification.

4 福衛五號本體構型(上圖: Stowed) (下圖: Deployed) (FORMOSAT-5 satellite main body construction (upper: stowed, lower: deployed))



5 衛星飛行軟體的姿控功能驗證架構。(FORMOSAT-5 satellite facet thermal control design and analysis)



6 福衛五號推進次系統配置設計 (FORMOSAT-5 propulsion subsystem components layout and design)

衛星操控
Satellite Operations & Control

1 福爾摩沙衛星衛星操控架構圖 (FORMOSAT Satellite Operations Control Architecture)

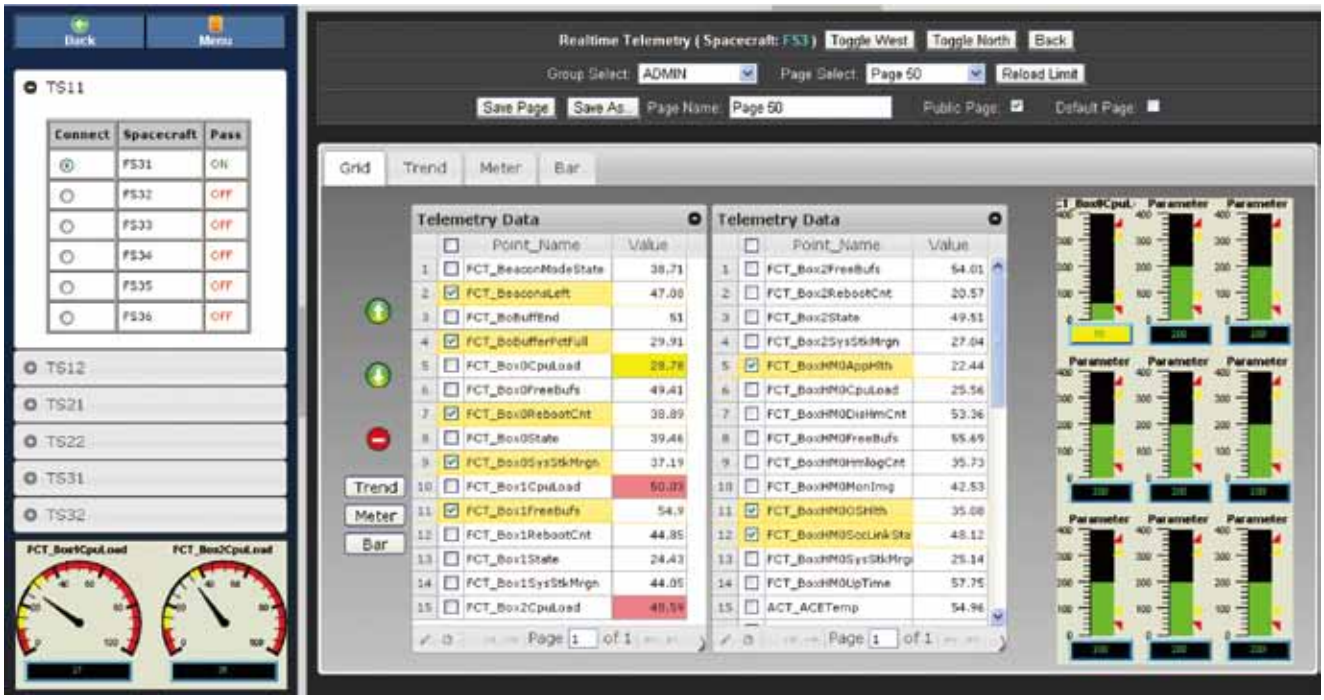
自福衛一號發射以來，衛星任務操作維護團隊歷經了福衛一號、二號及三號的衛星操作任務，對衛星操控經驗的累積及地面設施的維護奠定了豐富的基礎，也確保了現有衛星的指令上鏈、資料擷取、衛星追蹤、軌道判定與控制及資料處理與分送等全程任務的正常運作。並於現有的基礎下，亦積極推動技術移轉及產學研合作，共同建立了國內衛星地面操控系統發展及設施維護的自主能力與技術層次，大大降低了國外技術支援的依賴度。

衛星操作控制中心是衛星任務操控的主要核心，具備有指令傳送、健康監控、軌道判定與控制、排程規劃及資料分送等功能，藉由國外技術，於 1994 年發展完成。但基於我國太空計畫發展的長期目標，自 2010 年起，太空中心成立一產研合作的研發案，與國內新鼎系統公司共同開發衛星地面操控系統，歷經兩年來的努力鑽研，完成了衛星操控的雛形建立，已具有衛星資料接收與指令傳送的能力。同時，亦基於網頁化是資訊傳輸趨勢，雙方並就網頁化互動式的衛星遙傳資料顯示平臺進行研發，此平臺可支援多種瀏覽器與行動裝置（iPad 及 iPhone 等），將提供衛星健康資料的監控及快速簡易衛星資料的查詢，可大幅提升了衛星監控的便利性與時效性。

衛星地面站負責指令訊號的傳送及衛星資料的接收，本中心分別於中壢中央大學及臺南成功大學設有一及二座的 S 頻段遙傳追蹤指令地面站，也於新竹設置一 X 頻段遙測影像資料接收站負責遙測影像資料的接收。其中，中壢

站與臺南一站於 1997 年建置完成，但經長期持續地支援福衛系列衛星的任務操作，已逐漸老化與性能降低，因此於 2010 年開始，進行中壢站的更新翻修工程。為建立大型衛星天線系統更新維護的國內自主能力，本案仍採產研合作的模式，委由國內廠商臺亞衛星通訊公司來執行，於 2011 年初完成後，已投入福衛系列的操控任務，據一年來的實際運轉結果，中壢站翻修後的主要性能，皆已恢復到原始的設計規格，實際驗證了產研合作下的國內自主能力。因此，臺南一站也在相同模式下，於 2011 年起，開始進行翻修更新工程，此工程預計於 2013 年中完成，將可為國內於此領域中，累積更多的自主能力與經驗。

確保現有衛星任務的正常操作及酬載資料量的水平是衛星操控的兩大目標。為達此目標，加強衛星任務操作維護團隊的訓練、落實標準作業程序的執行、提昇衛星操作自動化、加速異常處理的反應速度及維持地面設施運轉的高妥善率等，是衛星操控所有人員不變的努力方向。同時，如何運用多年來累積的經驗，於產學研合作下，建立衛星操控及地面設施維修的國內自主能力，是我們的理念，也是衛星操控對未來新衛星計畫挑戰的因應。



2 網頁化互動式衛星遙傳資料顯示平臺 (Web-based Interactive Satellite Telemetry Display Platform)

After the launch of FORMOSAT-1, the satellite mission operation team has experienced the mission operations of FORMOSAT-1, -2 and -3, accumulated a lot of satellite operation experience and maintenance capability on ground facility. The operation team assures all the mission operations such as command uplink, data reception, satellite tracking, orbit determination and control, data processing and distribution. Under the existing basis, the goal is now focusing on technology transfer, industry academy cooperation, and the build-up of self-reliance and technology level in domestic development and maintenance of satellite ground system to reduce the dependency on foreign technical supports.

3 遙傳追蹤指令中壢站更新翻修 (Overhaul Engineering of Chung-li TT&C Station)

Satellite Operations & Control Center (SOCC) is the core of satellite mission control. It has the functions of sending commands, monitoring state-of-health (SOH) data, orbit determination & control, operation planning & scheduling, and data distribution. It was built up in 1994 under foreign technology. However, based on the long term goal of national space program, NSPO initiated a research project for industry cooperation, NSPO and ACS Inc. to jointly develop a satellite operations control system. After two year efforts, the proto type of the software system has been developed for receiving telemetry and sending commands. Subsequently familiar with the trend of web-based data transfer, both parties also proceed to develop the platform for web-based interactive display of satellite telemetry. The platform can support various browsers and mobile devices (iPad and iPhone) for satellite SOH monitoring and data enquiry to enhance the convenience and effectiveness in satellite operations.

Satellite ground stations are in charge of the satellite command uplink and telemetry reception. NSPO has three S-band TT&C stations, one in the National Central University in Chung-li (TS1 station), two in the National Cheng Kung University in Tainan (TS2, TS3 stations), one X-band receiving station in Hsin-chu for remote sensing data reception. TS1 and TS2 station were built up in 1997. Once long term supports on FORMOSAT series satellites, the two stations have been aged and degraded. The overhaul engineering of TS1 station started in 2010. To establish the domestic capability in the upgrading and maintenance of a large antenna system, the overhaul engineering was contracted to and executed by a domestic company called Teleport Access Services Inc. It was completed in early 2011. The overhauled TS1 station has been operated against FORMOSAT series satellites for over one year, and their main performance have been recovered back to the original design specifications. Since the domestic self-reliance capability has been verified and proved, Tainan TS2 station followed the same approach of overhaul engineering from 2011. This work will be completed in the middle of 2013. Much more self-reliance capability and experience will be accumulated in this technical extent.

The main goals of both satellite operations and control are to assure the successful operations on the existing satellite missions and the data volume of the payload. To achieve these goals, the satellite operators put a lot of efforts to strengthen the training, survey the procedures, enhance the automation, accelerate the anomaly reaction, and increase the facility supportability. The main perception and future challenge are how to utilize the accumulated experience, under the cooperation between academy and research parties, to establish domestic self-reliance capability in satellite operations control and ground facility maintenance.

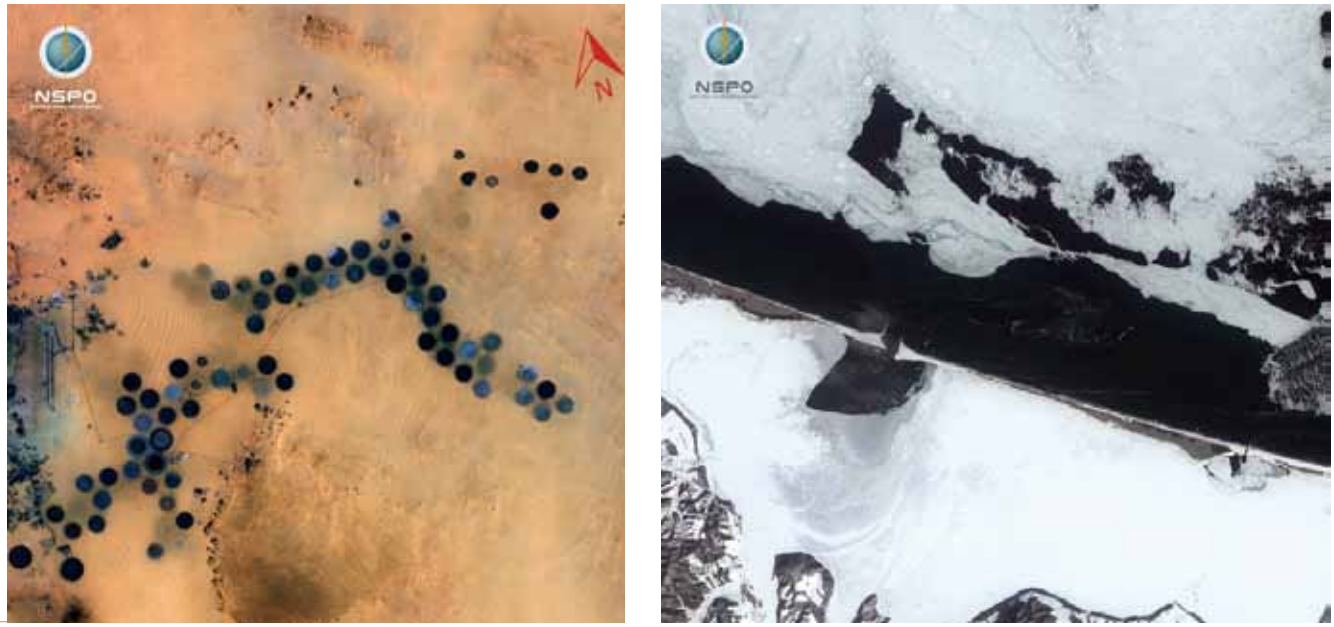
影像處理
Image Processing

衛星影像處理主要任務包括衛星影像任務分析與系統參數制定、衛星遙測影像儀系統幾何與輻射特性率定、衛星影像取像規劃與排程、衛星影像操作處理、衛星影像處理系統研發、衛星遙測影像應用研發推廣。本年度取像面積達全球陸地面積之 80%，包括：利比亞庫夫拉綠洲及日本北海道網走流冰 1 等。

2011 年持續進行各次系統軟硬體維護作業，於今年起將資料擷取次系統相關部份資料改由 LTO 磁帶儲存，並完成 AIT3 轉換 LTO 之機制，逐步進行資料儲存媒體轉換以確保福衛二號原始資料之永久保存。

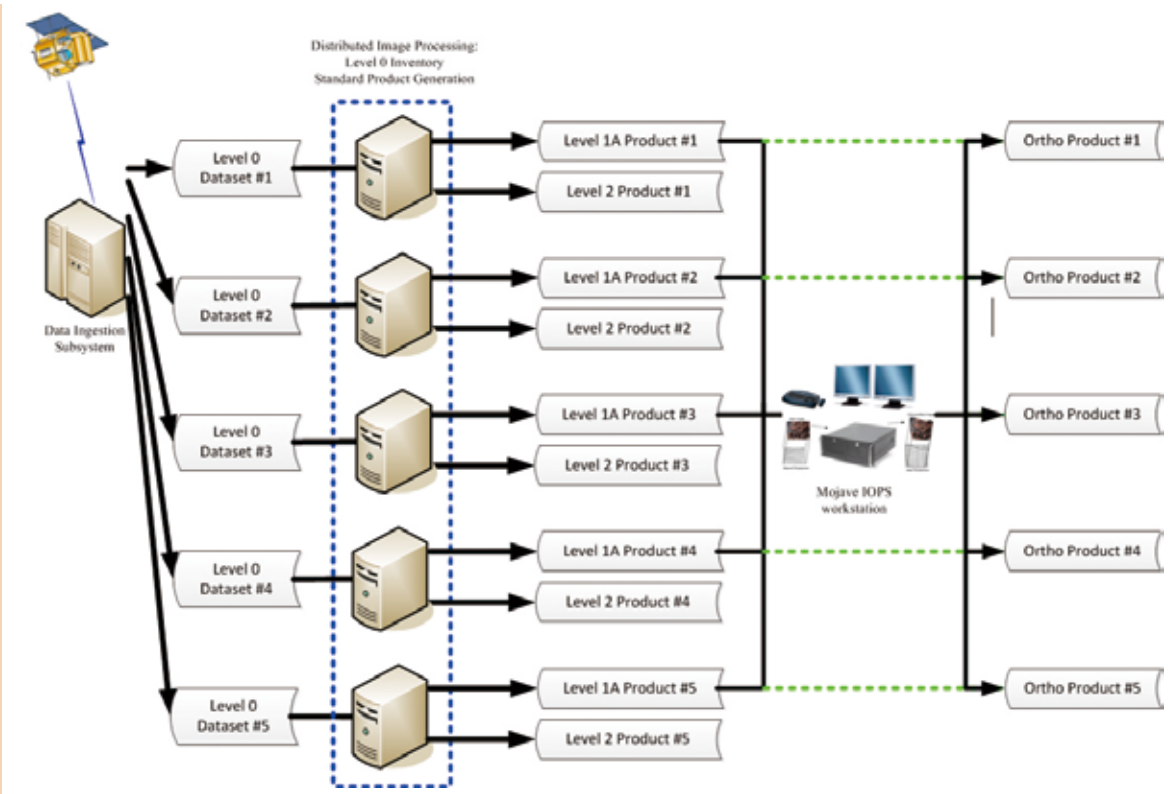
為充分發揮福衛二號效能，太空中心除持續精進取像操作外，於本年度更建置完成分散式影像處理系統以縮短影像產品提供時間進而爭取救災效率，目前太空中心已具備於影像下傳後四小時內提供五條帶標準產品能量，另輔以快速影像正射處理系統 2，可於最短時間內提供全臺近正射影像，幾何精度達 20 公尺。並參與國研院「發展地球觀測近即時高解析三維環境應用平臺」整合型計畫，結合國家災防中心、國家高速網路中心等進行合作以建立一國內防救災資料提供標準作業程序 3

為建置福衛五號影像處理系統，太空中心過去進行多項具創新性質之系統發展與影像品質分析研究。現階段，福衛五號影像處理系統之系統需求基本上已完全確立，相應之系統設計工作基本上亦已完成。福衛五號影像處理



1 左圖為利比亞庫夫拉綠洲，右圖為日本北海道網走流冰 (Left: Libya Kufrah oasis, Right: Japan Hokkaido drifts ice)

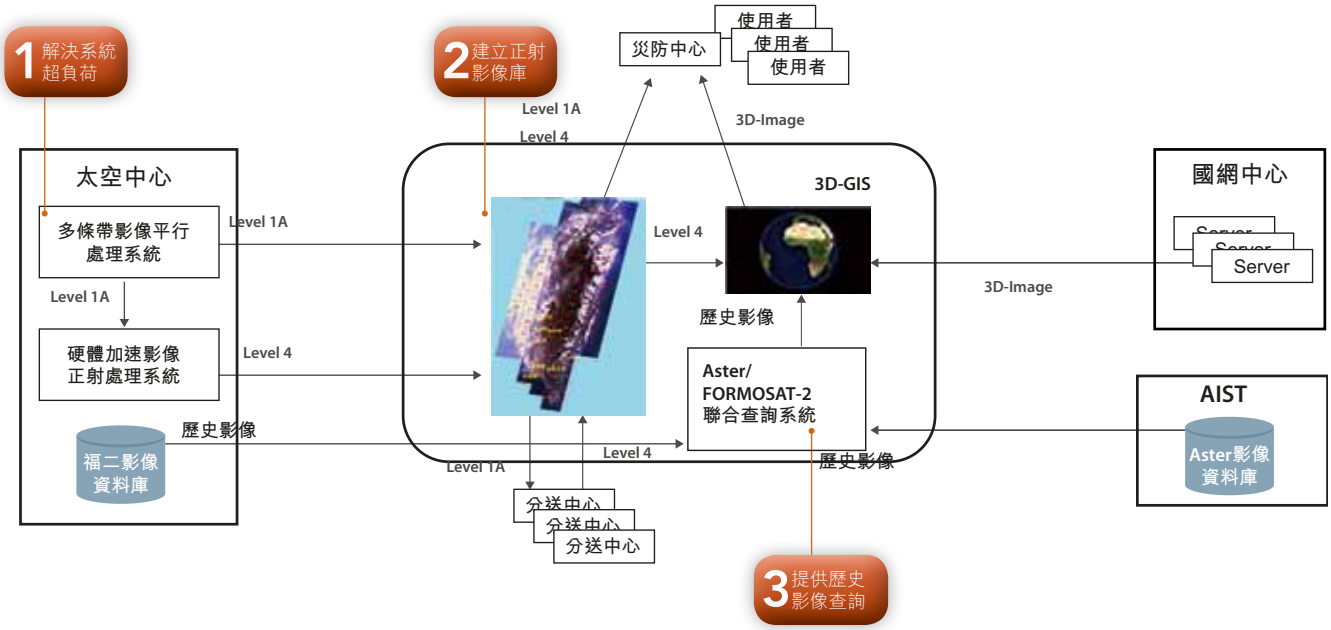
系統之資料擷取次系統為國人首度自主開發具此類功能之系統，除需具備星上影像壓縮及訊號處理技術相關知識外，發展高效能訊號處理及影像解壓縮演算法為一重要挑戰，而靈活整合 MEOS 骨架 4 則為此次系統操作效能與便利性之重要關鍵。依規劃，福衛五號影像處理系統於建置完成時亦將同時整合福衛二號影像處理能力，故此系統實為國人首度自主開發之多遙測衛星影像處理系統。



2 近即時分散式影像處理系統處理 (Proximate real time distributed image processing system)

The purpose of Image Processing is divided into following category. Those are satellite mission analysis, design of system parameter, geometrical/radiometric correction, tasking planning and scheduling, image data operation, development of image processing system and satellite image promotion. In this year, the total area covered by the FORMOSAT-2 images covers around 80% of worldwide area including Libya Kufrah oasis and Japan Hokkaido drift ice 1 . In the mean time, besides regular system maintenance, NSPO also perform the data migration from AIT3 tape to LTO archived media. This process of transferring data could ensure that FORMOSAT-2 data preserve in security and authenticity forever.

In order to boot the FORMOSAT-2 performance on monitoring the disaster, NSPO not only keep improve daily operation but also build distributed image processing system to facilitate the large volume data processing 2 . By utilize image processing facility, NSPO can provide the image products of whole Taiwan area in 4 hours after the satellite raw data are received from X-band antenna. Furthermore, the fast ortho-rectification processing system could generate the image with geometric accuracy within 20 meters.



3 衛星影像資料供應系統架構圖 (The structure of the satellite image data supply system)

During 2011, NSPO participate in the multidisciplinary project, "Development of near real-time, high-resolution, global earth observation 3D platform for applications to environmental monitoring and disaster mitigation", which conducted by NARL. This platform integrates the infrastructure of NCDR and NCHC to establish a standard operation procedure for managing the domestic disaster 3 .

During the past few years, NSPO develop several innovation researches in order to establish FORMOSAT-5 Image Processing System. Currently, the primarily system requirement and critical design have been completed. It is worth to remark that the data ingestion subsystem (DIS) is the first one developed by Taiwanese. Progress this system design requires not only knows well on board image data compression but also utilizes the backbone of MEOS system efficiently 4 . According to proposal, this system is designed to integrate FORMOSAT-2 system as a multi- satellite image processing system, and is developed by Taiwanese themselves.

4 DIS MEOS 系統 (the DIS MEOS System)

品質保證
Quality Assurance

太空中心於 2011 年持續品質系統維持與精進改善，通過國際標準組織的 ISO 9001:2008 品質管理系統、ISO 27001:2005 資訊安全管理系統、ISO 14001:2004 環境管理系統、OHSAS 18001:2007 職業安全衛生管理之續評驗證 1。

在福衛五號計畫的品保工程，完成「衛星本體細部設計審查」，針對系統安全、可靠度、硬體品保、軟體品保、零件材料與製程、型態管理等工作現況進行報告，並完成星象追蹤儀運送前審查與磁力計的關鍵審查等會議。在零件品保工程方面，針對福衛五號衛星電腦（CDMU）及遙測酬載電子單元（RSI/EU）兩項自主發展關鍵設備研發，持續進行飛行規格電機電子零件採購品保工作，包括：採購文件品質需求訂定、同等品技術審查、履約管理稽催、技術問題審查與處理、零件接收檢驗 2及驗收等，共有六個採購批次，為協助解決各項合約與技術問題，赴供應商進行必要稽核以，督促廠商重視並加強履約管理以加速完成零件遞交。

在可靠度工程方面，本年度持續的配合衛星系統設計進度，加強福衛五號失效模式效應與關鍵性分析 (FMECA)，並依分析結果提出改善建議與方法，提供設計弱點的改善建議以提高衛星系統的可靠度。在軟體品保工程方面，協助飛控組完成福衛五號飛行軟體的工程發展體（EDM）第 3.2 版，並針對測試驗證結果提供潛在性的程式問題給予程式設計單位進行改正 3，完成衛星品保軟體系統整合；另外持續進行影像處理系統的處理技術品質保證工作。

1 授證儀式 (Certificate Ceremony)

品保教育訓練方面，為強化參與福衛五號計畫人員瞭解品質紀律與需求，辦理「年度衛星品保教育訓練」，總計有 76 人次完成訓練，參加人員包括太空中心、微像科技公司及儀科中心等。另外為建立本中心飛行電機電子零件工程能量，經由『飛行電機電子零件工程支援服務』合約，本年度辦理了 3 次專業訓練課程，參訓人員踴躍，包括電機組、品保組、飛控組等電子設備研發人員，共有 18 人次全程參與課程並取得結業證書 4。

福衛七號品保工作部份，因應衛星本體採購招標作業，完成產品保證需求文件、驗收標準與程序、技術文件需求等採購文件之準備，以及自主發展衛星所使用的零件、材料與製程品質需求及執行計畫。

在資訊安全方面，辦理教育訓練課程，分別為「網路趨勢與社群服務安全風險」、「網路資料加密 (VPN) 虛擬私有網路技術」、「個人資料保護法」、「個人電腦基本防護設定」等教育訓練課程，共計有 299 人次參與訓練。

在廠務設施維持方面，完成 12 份品保技術支援計畫委辦案工作報告，完成 496 件儀器校正服務，處理 312 件環境監測服務；完成 1731 件品保作業支援服務 (技術文件)；完成 193 件品質資訊管理系統開發與維護服務；完成 99 件硬體維護及軟體維護；完成環安衛各項教育訓練如緊急應變演練、新進人員訓練、環境教育訓練等，以確保衛星計畫品質朝向高品質、高可靠度及高安全性以提供太空產品與優質服務。

2 電路板接收檢驗 (Inspection of receiving PC Board)

The NSPO has made progress and continuous quality improvements in 2011. For examples, she has been awarded international standard certifications such as ISO 9001:2008 Quality Management System, ISO 27001:2005 Information Security Management System, ISO 14001:2004 Environmental Management System and OHSAS 18001:2007 Occupational verification of continued assessment of safety and health management 1 .

Quality assurance division completed the FORMOSAT -5 satellite bus system safety and reliability analysis; hardware and software quality assurance; parts materials and processes, configuration management and work

3 工程發展體軟體測試驗證報告 (Certificate report about the validation of engineering development software)

status at the critical design review meeting. The satellite computer (CDMU) and the Electronic Unit for Remote Sensing Instrument (RSI / EU) are two developing projects of self-development of key equipment for NSPO research and development projects. The ongoing flight specifications of the electrical and electronic components procurement quality assurance activities, including setting the quality requirements of the procurement documentation and equivalent technical reviewing performance management and processing of technical problems, the parts receiving inspection 2 and acceptance. In order to assist in resolving the contractual and technical problems, QA engineer and the contract staff went to the supplier. compliance onsite audit in order to accelerate the completion of parts delivery from Spain in December.

For the reliability engineering, we continued with the satellite system design process by failure mode effects and criticality analysis (FMECA) on the FORMOSAT-5. According to the EMECA results, we recommended the design improvements and reinforcement design weaknesses to improve the satellite systems reliability degrees. We also assisted the flight control group to complete the FORMOSAT flight software for the Engineering Development Model (EDM) version 3.2. For test validation results, we provided a potential program to give the programming unit correction 3 , to complete the integration of satellite software quality. Also, other quality assurance activities of the image processing system are ongoing.

4 飛行電機電子零件工程訓練
(Engineering training of the avionic electronic components)

In order to strengthen participation in FORMOSAT-5 by collaborators, the annual satellite QA training was held. A total of 76 people completed the training. Participants included the NSPO, CMOS Sensor Inc. and ITRC engineers. To fulfill the Flight Electronic Parts Engineering Support Services Contract, the QA held professional training courses on the establishment of the flight of the NSPO electrical and electronic parts engineering technology capability. The trainees included the turbine quality assurance group; the flight control group and electronic equipment R & D personnel. A total of 18 people obtained certificates of completion. 4

FORMOSAT-7 quality assurance of the satellite system procurement processes has been completed in this year. The satellite Product Assurance Requirement Document, the Acceptance Criteria and procedures, the independent development of satellite used parts, the materials and process quality demand and the implementation plan and other procurement documents also have been finished.

The conference of QA reviewed network trends and community services in information security has been held at the ISO 17025 training sessions. A total of 299 people participated. Topics included security risks, virtual private network technical overview, personal data protection law and PC protection settings.

To maintain the satellite I&T facility, QA completed 12 QA technical support reports, 496 of instrument calibration services, 312 environmental monitoring services, 1731 quality assurance operations support services (technical documentation), 193quality information management system development and maintenance services, 99 hardware maintenance and software maintenance. In additions, the education and training in environmental safety and health such as emergency response exercises are completed to ensure the orientation of the satellite program high quality, high reliability and high security, to provide space products and quality service.

4 飛行電機電子零件工程訓練
(Engineering training of the avionic electronic components)

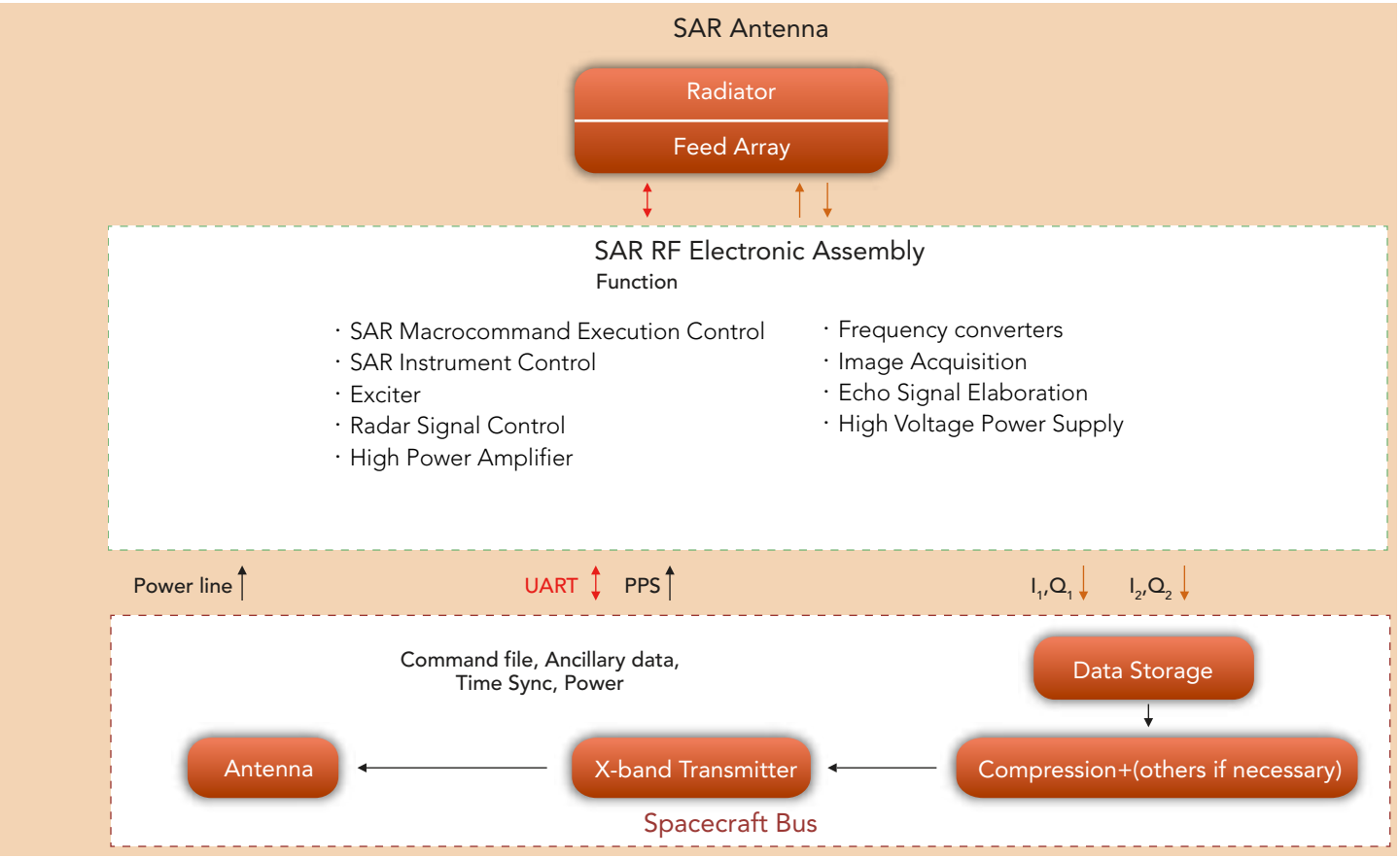
先期任務發展
Missions Feasibility Studies

任務發展計畫是為發展臺灣未來衛星任務而成立的計畫。其任務以「環境觀測、災害防救」為主軸，整合國內氣象、災防等民生需求，規劃合成孔徑雷達、微波輻射計、以及高光譜影像儀等三項與太空遙測科技相關之任務酬載進行研發，並為下一階段衛星任務作準備。

2011 年主要成果說明如下：

1. 合成孔徑雷達 (SAR) 衛星酬載發展研究計畫：完成任務系統 / 酬載定義 (與審查會議)、使用者服務與觀測需求 (與專家會議)、初步任務需求 (與審查會議)、星載 SAR 酬載系統功能暨介面等 1 重要工作。

2. 微波酬載天線研究規畫計畫：在完成 MWR/SAR 反射式天線模擬分析設計、MWR 轉動平臺設計、SAR 展開機構分析設計、衛星 SAR 和 MWR 天線配置、重量與材料評估等相關工作後，本計畫亦已順利通過第二階段 (被動式微波偵測儀天線需求分析) 審查。

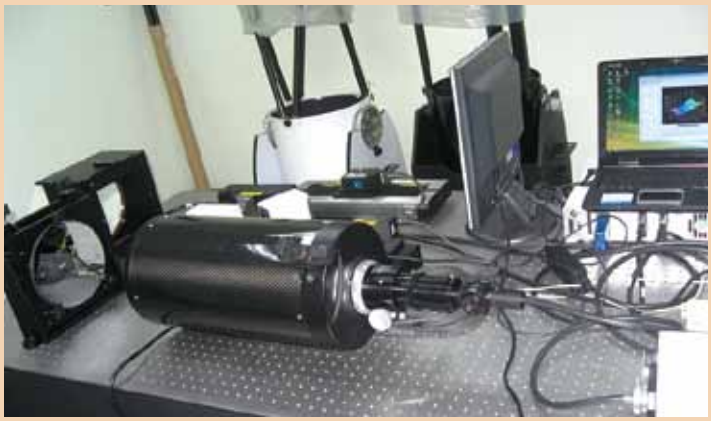


1 星載 SAR 酬載系統功能暨介面方塊圖 (Space borne SAR payload system function and interface block diagram)

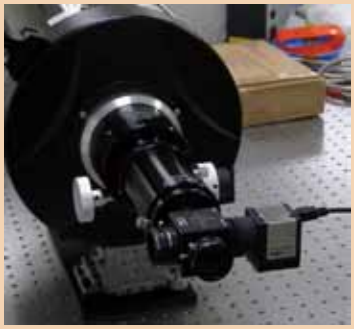
3. 高光譜影像儀原型工程研發計畫：本年度已召開系統需求審查 (SRR)、系統設計審查 (SDR)、關鍵設計審查 (CDR) 等各項會議，完成各階段之設計審查工作。同時在太空中心建立光機調校平臺與發展高光譜系統設計驗證技術 ❷；並順利完成第一階段原型體整合測試備便審查 (ITR)。

4. 微波輻射遙測任務發展研究計畫：藉由調查並彙整國內各氣象預報與災害防治等相關單位 (使用者) 對星載微波輻射計之需求，完成使用者需求說明會 ❸ 與審查；並完成期中審查與遞交微波輻射遙測應用需求文件及使用者需求文件。

5. 微波輻射計系統開發研究計畫：完成一單頻段的微波輻射計原型體設計，以做為微波輻射計系統功能與規格之驗證，並供衛星酬載任務規畫的參考。本年度已完成可行性分析審查與系統設計審查 (SDR) 兩個重要哩程碑；並遞交可行性分析報告與涵蓋六個頻段的酬載系統設計報告。



波前感測實驗驗證與光機性能調校平臺



❷ HSI 光機調校平臺與 WFE 波前像差實驗驗證
(HSI opto-mechanical system calibration platform and wave-front error experimental verification)

The Missions Development Program will develop future satellite missions for Taiwan. The mission is primarily for "Earth Observation; Disaster Prevention and Rescue" by integrating domestic requests for weather forecast and disaster prevention. To achieve this mission vision requires the research and development of three different space remote sensing instruments including Synthetic Aperture Radar (SAR), Hyper-spectral Instrument (HSI) and Microwave Radiometer (MWR). Not only can the technology been development but also will the people in Taiwan fully benefit from this successful mission.

The major accomplishments in 2011 are described as follows:

1. SAR Payload Development Project: Space-borne SAR missions and associated payload systems have been surveyed and studied to set up the SAR mission system and payload definitions in Taiwan. The user service and observation requirements as well as the elementary mission requirements are also deduced. A system function and interface block diagram is proposed as shown in Figure 1 .

2. Microwave Payload Antenna Research Project: The research team has done the work including MWR/SAR reflector-type simulation and design, MWR rotating platform design, SAR deployment mechanism design, space-borne SAR/MWR antenna configuration and weight/material estimates, etc. The second-phase review meeting for MWR antenna requirement analysis was also completed.

3. HSI Prototype Development Project: Design review review meetings such as SRR, SDR, and CDR have been successfully held for different phase of HSI payload system development. The opto-mechanical calibration platform had been established at NSPO in order to develop the technology for HSI system design verification 2 . The first phase of the ITR review for the prototype model was also completed.

4. MWR Mission Development Project: The weather forecast and disaster mitigation related user needs for space-borne MWR payload applications in Taiwan have been surveyed and assessed. The MWR mission team has conducted the User Requirements Review 3 and delivered the Applications Requirements Document and the User Requirements Document.

5. MWR System Development Project: The MWR system development team has conducted the feasibility study and SDR, delivered the Feasibility Analysis Report and the Payload System (covering six frequency bands) Design Report. In order to validate the system function and specifications, a single band radiometer prototype model has been designed.

3 微波輻射遙測任務使用者說明會 (MWR Mission Requirements User Conference)

先進自主衛星推進技術發展計畫
Satellite Propulsion System Development Project

1 合作協議書簽署會議 (Agreement Sign-up Conference for RCS Academic Research and Development Cooperation Project)

為促進我國長期太空科技及衛星相關基礎能量發展，並落實技術生根及人才傳承，太空中心與成功大學共同推動「委託研究發展先進自主衛星推進技術」長期合作案，結合太空中心衛星實務經驗與學界研發能量，共同建立研發實驗室，並規劃飛行展示所發展的綠色推進系統，達成第一階段國內衛星推進系統技術自主發展的目標。

2011 年完成合作協議書簽署 1 及第一次期中審查等重要計劃時程，在自主元件及系統研發方面，完成之工作項目說明如下：

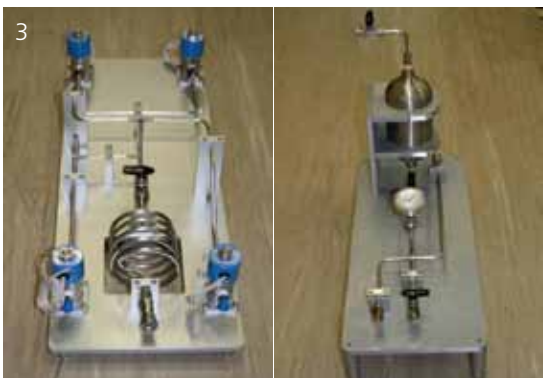
1. 推進器和燃料儲槽測試模組 2 設計、製造及初期性能測試。
2. 推進實驗室已完成建築設計及建照審查，並於年底完成營建發包。
3. 真空艙整修工程。
4. 第一階段組裝技術研發，完成兩組推進系統試製模組 3 ，並進行組裝工藝技術檢測。
5. 完成推進控制介面模組研製 4 。
6. 完成推進燃料與充壓氣體裝填和卸載設備原型硬體組測。
7. 建置完成低壓推力測試艙。

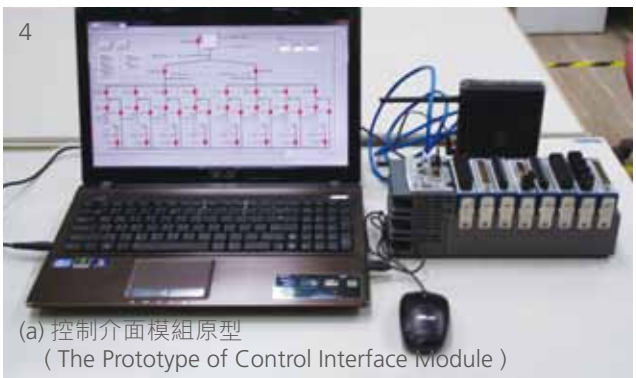
In a bid to enhance the development on the self-reliant technology, aerospace-related science and engineering development, NSPO and NCKU have aimed at establishing a long-term cooperation between both parties. Through the approach of matching fund, the laboratories for satellite propulsion engineering development will be built up. The objective of this cooperation project is intended to develop the hydrogen peroxide mono-propellant satellite propulsion system, which is considered in the category of green propulsion. The established technologies will be verified by the demonstrative, engineering, and quasi-flight modules. It is highly anticipated that the success of this particular project may consolidate indigenous satellite propulsion capability within Taiwan.

In 2011, the Agreement Sign-up Conference ❶ and the first Mid-term review were achieved according to the development plan. Major tasks been achieved in 2011 about the self-reliant key components and system are listed below.

1. The design, assembling and preliminary performance test for the Thruster and Propellant Tank Demonstration Models ❷.
2. The architectural design and the construction license review for the Propulsion Laboratory. The contract of the construction has been issued by the end of 2011.
3. The restoration engineering for the Vacuum Chamber.
4. Two sets of Assembly and Integration Test Modules ❸, and workmanship check for domestic vendors/ manufacturers.
5. The Control Interface Module and the Simulation Interface Module ❹ for the propulsion system.
6. The propellant and pressured gas loading and unloading system.
7. The construction and performance verification of the Low Pressure Thrust Measurement Chamber.

(b) 模擬器 (Simulation Interface Module for RCS)





(a) 控制介面模組原型
(The Prototype of Control Interface Module)

❷ 推進器與燃料槽測試用模組 (Thruster and Fuel Tank Performance Test Module)

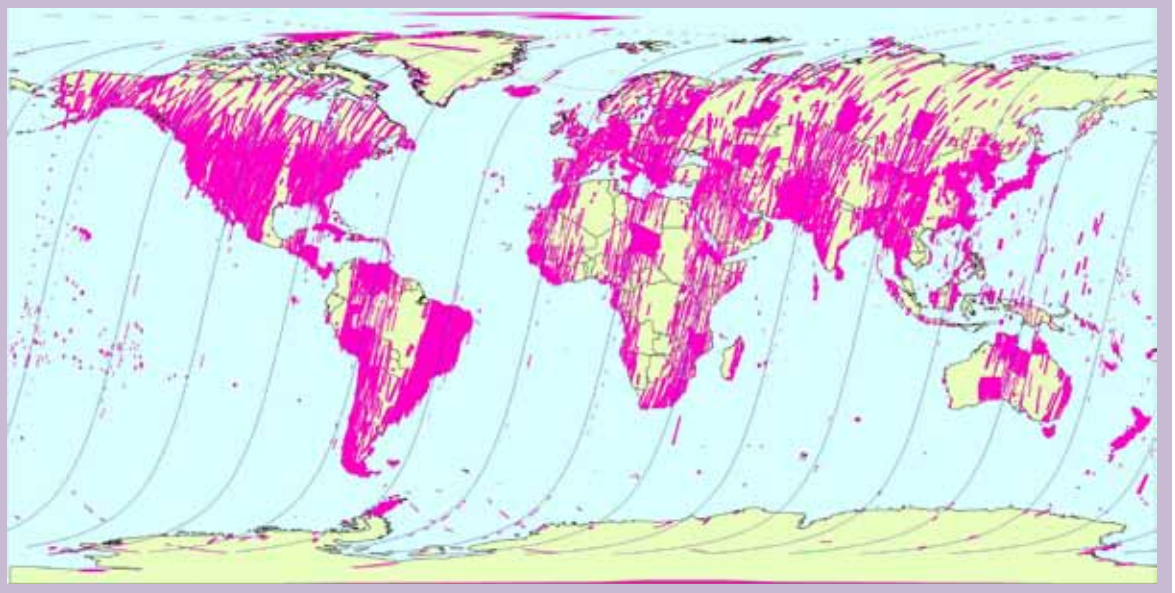
❸ 推進系統試製模組 (RCS Assembly and Integration Test Modules)

❹ 推進測試控制介面 (Propulsion Assessment Interface)

遙測影像推廣
Remote Sensing Image Promotion

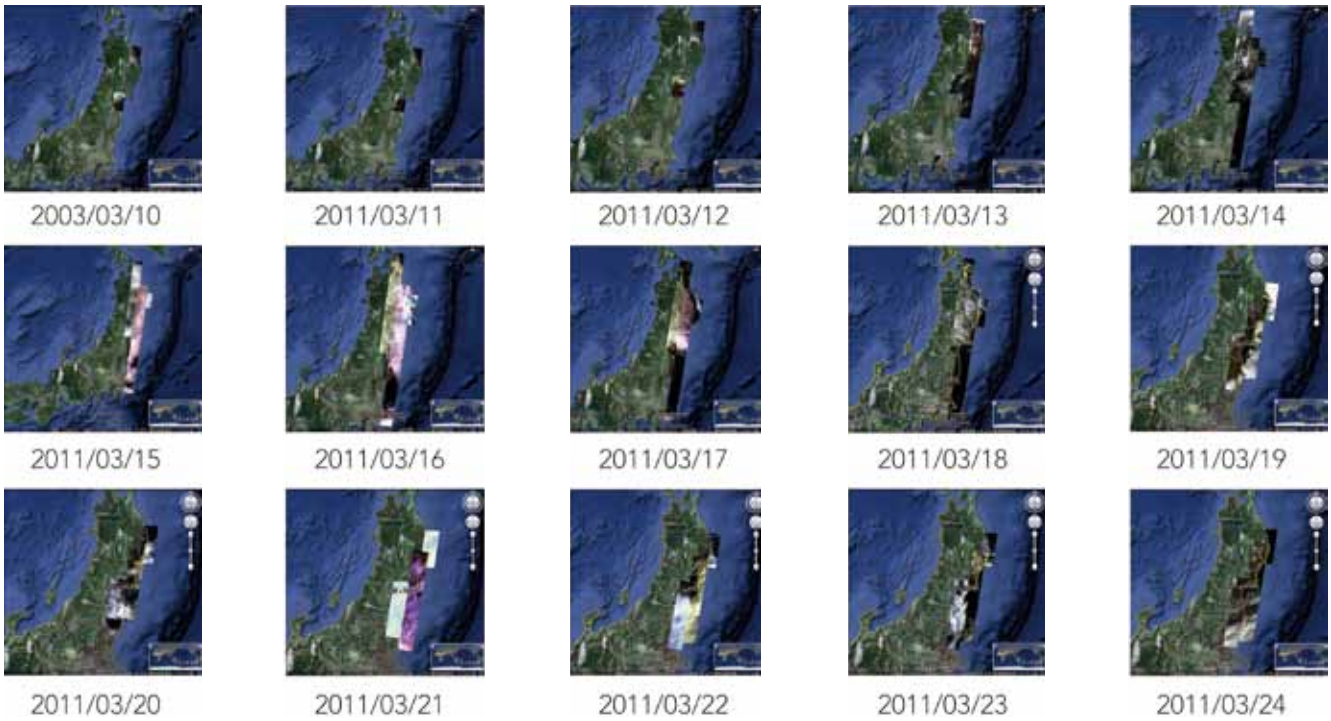
福爾摩沙衛星二號（福衛二號）發射至今已運轉超過 7 年，其取像總面積已超過 20,000 個臺灣大小 1 ，對防救災應用而言，快速取得即時災情資料及進行災區持續監測為其任務重要關鍵。福衛二號因具備每日再訪特性，故除可以於第一時間獲取資料外，亦可提供高密度連續時序觀測資料 2 。所獲取衛星遙測影像資料除被廣泛應用於環保、教育、外交、國土規劃、及農林漁牧等不同用途外，在防救災應用的貢獻上更已為國內外所肯定。

目前福衛二號影像銷售部分，在國內主要透過臺灣大學地理系遙測及空間知識實驗室、臺灣師範大學地理系、中央大學太空及遙測中心及成功大學防災研究中心等北中南四家分送中心，各分送中心皆由具備遙測專業知識專家學者團隊所組成，負責國內福衛二號影像產品銷售、影像加值技術研發、產學合作及客戶服務等任務。此外，在國際學術合作方面，各分送中心亦積極應用福衛二號衛星影像於國際學術合作上，例如日本北海道流冰觀測、尼加拉瓜國際合作案、宏都拉斯、薩爾瓦多自然生態保護區之環境變遷與自然資源之分類 3 、美國密蘇里州立大學學術合作案等，為我國外交與學術上皆建立實質互惠管道。



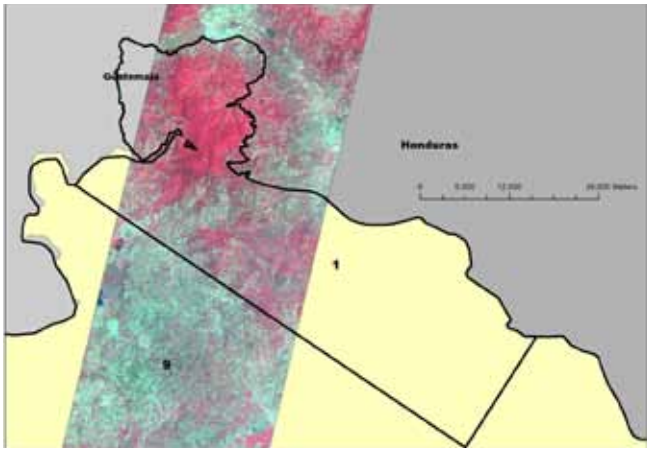
1 福衛二號全球取像區域圖 (The global area covered by the FORMOSAT-2 images)

FORMOSAT-2 satellite was launched in 2004 and remains in good operating condition more than 7 years. The total area covered by the images is more than 20,000 times of the territory of Taiwan 1 . Regarding to the disaster management application, it is crucial to obtain the accurate and timely information from devastated area. Due to the daily revisit capacity, FORMOSAT-2 could take initial image and continuously monitoring after large disasters occurred over the world 2 . Meanwhile, those data also has been applied on various aspects such as environment, education, diplomacy and agriculture.



2 日本 311 大地震連續取像快覽圖 (FORMOSAT-2 time-serial images of 311 Earthquake)

National Space Organization has established four distribution centers for satellite images throughout Taiwan. Those are National Taiwan University Spatial Information Research Center, National Taiwan Normal University FORMOSAT-2 Image Application and Distribution Center, National Central University Center for Space and Remote Sensing Research and Nation Cheng Kung University Disaster Prevention Research Center. Each distribution center has the technical expertise and experience in handling satellite images. To provide professional and quick services to satisfy the clients' general needs, these centers are well staffed and equipped with modern hardware. The industry's capacity is also well integrated so that the application areas for FORMOSAT-2 can be greatly expanded. Meanwhile, each center also cooperate with international institute to promote the utilization of FORMOSAT-2 image on various aspects such as the monitoring drift ice on Hokkaido of Japan, environmental change of natural ecological protection areas on Honduras 3 , academic cooperation project with Missouri State University and diplomat project with Nicaragua government. Through those successful projects, the academic and diplomatic channel have been established, which benefit on both Taiwan and international community.



3 福衛二號監測薩爾瓦多自然生態保護區之環境變遷與自然資源之分類 (FORMOSAT-2 monitoring the environmental change of natural ecological protection areas on Salvador)

整合測試服務
Integration and Test Services

國家太空中心衛星整測大樓於 1994 年 9 月開工動土，迄今已成功完成福衛一、二、三號不同功能衛星的組裝測試，是國內唯一擁有完整且符合國際太空標準的組裝和測試場地。
2011 年完成之主要測試服務案及成果分別說明如下：

1. 成功執行 UFFO 實驗儀器環境模擬測試 :
   極迅瞬變光源太空觀測計畫 (Ultra-Fast Flash Observation，UFFO) 為國際合作科學衛星計畫，任務目標在監測恆星死亡或是中子星與黑洞互相撞擊時所爆發的伽瑪射線爆。太空中心負責實驗儀器太空環境模擬測試，包含熱真空測試與振動測試 ❶。本次測試以最嚴謹的衛星測試方式進行，過程中雖面臨相當多挑戰，但在團隊共同努力下一一克服，獲得 UFFO 國際團隊高度讚賞，特別來函表達感謝。

2. 完成福衛五號電力控制與分配單元 (PCDU) 熱真空測試 ❷ :
   福衛五號電力控制與分配單元 (PCDU) 為由太空中心與中科院共同研製的自主發展關鍵元件之一，提供衛星電力之控制與分配。經歷 8 個熱真空溫度循環，反覆驗證 PCDU 元件在太空冷熱環境的功能運作正常，象徵福衛五號計畫已由設計發展階段，正式邁入元件製造測試階段。

3. 完成成大 CKUTEX 微衛星熱真空驗證測試、振動測試 ❸ 與質量特性量測 :
   協助建立國內大學微衛星驗證技術及建立微衛星的發展技術能量。

4. 完成交大探空十一號火箭先期研究計畫航電系統振動測試 :
   驗證探空十一號火箭先期研究計畫中所發展的航電系統在極端環境下的可靠性，並經由驗證過程中檢測出任何造成航電系統故障或損毀的原因。

5. 完成太空中心自主研發 GPSR V4 熱真空測試與振動測試 :
   驗證太空中心自主研發 GPSR 元件之熱控設計與結構設計，以評估未來在軌道環境與發射動態環境下是否能正常操作。

❶ UFFO 系統組裝及測試準備 (UFFO system assembly & test preparation)

2 福衛五號 PCDU 熱真空測試絕熱材料安裝 (FORMOSAT-5 PCDU thermal blankets components installation and preparation for the thermal vacuum test)

3 CKUTEX 微衛星振動測試 (NCKU CKUTEX micro satellite vibration test set-up)

The Satellite Integration & Testing (I&T) Building is located adjacent to the office of National Space Organization (NSPO) in Hsinchu Science-based Park. The construction of the Satellite Integration & Test Building was commenced in September 1994. It's the only Satellite I&T Building in Taiwan. The Satellite Integration & Test Building has so far completed satellite tests for "FORMOSAT-1", "FORMOSAT-2", and "FORMOSAT-3".

In 2011, the following test services were conducted and associated test objectives were also completed:

1. NSPO Successfully Conducted UFFO Instrument Environmental Tests: Ultra-Fast Flash Observatory (UFFO), an international collaboration satellite project, is designed to observe the instantaneous signals of gamma-ray bursts. NSPO and UFFO teams successfully completed thermal vacuum test and vibration test in July 2011 with excellent collaboration. The success of UFFO testing activity demonstrates the commitment of NSPO in support of the domestic science community and also boosts the visibility of NSPO in the international cooperation of the space science mission.

2. Completed FORMOSAT-5 satellite Power Control & Distribution Unit(PCDU) component thermal vacuum test: The Power Control and Distribution Unit (PCDU) is developed by the joint team of NSPO and Chung Shan Institute of Science and Technology (CSIST). PCDU EM is the first delivered made-in-Taiwan spacecraft key components for FORMOSAT-5. Thermal vacuum test was completed in August after went through 8 temperature cycles. This activity marks a new milestone of FORMOSAT-5 moving toward the verification phase of the key indigenous components.

3. Completed CKUTEX experimental satellite thermal vacuum test, vibration test & mass properties measurements for National Cheng-Kung University: To support domestic university build up the capability of micro experimental satellite development and validation techniques.

4. Completed the avionic component vibration test of #11 sounding rocket feasibility study project. The avionic component vibration test is conducted to evaluate the avionic component reliability in extreme environmental conditions. It also can detect the root cause of failure or damage during evaluation processes.

5. Completed the component level thermal vacuum & vibration tests of the NSPO self-reliant spacecraft GPSR development model Ver.4 : To validate the thermal and structural design of the NSPO self-reliant spacecraft GPSR component and the operation reliability in orbit and launch environment conditions have been evaluated.

電磁相容與天線測試實驗室 ISO/IEC 17025:2005 認證通過

Certificate of TAF for EMC and Antenna Test Lab

太空中心所屬電磁相容與天線測試實驗室，主要為執行衛星計畫的電磁相容測試與天線量測等工作，同時提供國內外產、官、學、研界所需的相關測試與量測服務。電磁相容方面，實驗室可提供軍規與民用規範之測試服務；天線量測方面，則涵蓋一般型至大型天線、頻率由數百 MHz 至數十 GHz 之七軸全自動天線量測服務。至今為止，本實驗室已經為工研院、電檢中心、交通大學、中衛科技、華城電子等國內單位提供相關服務。

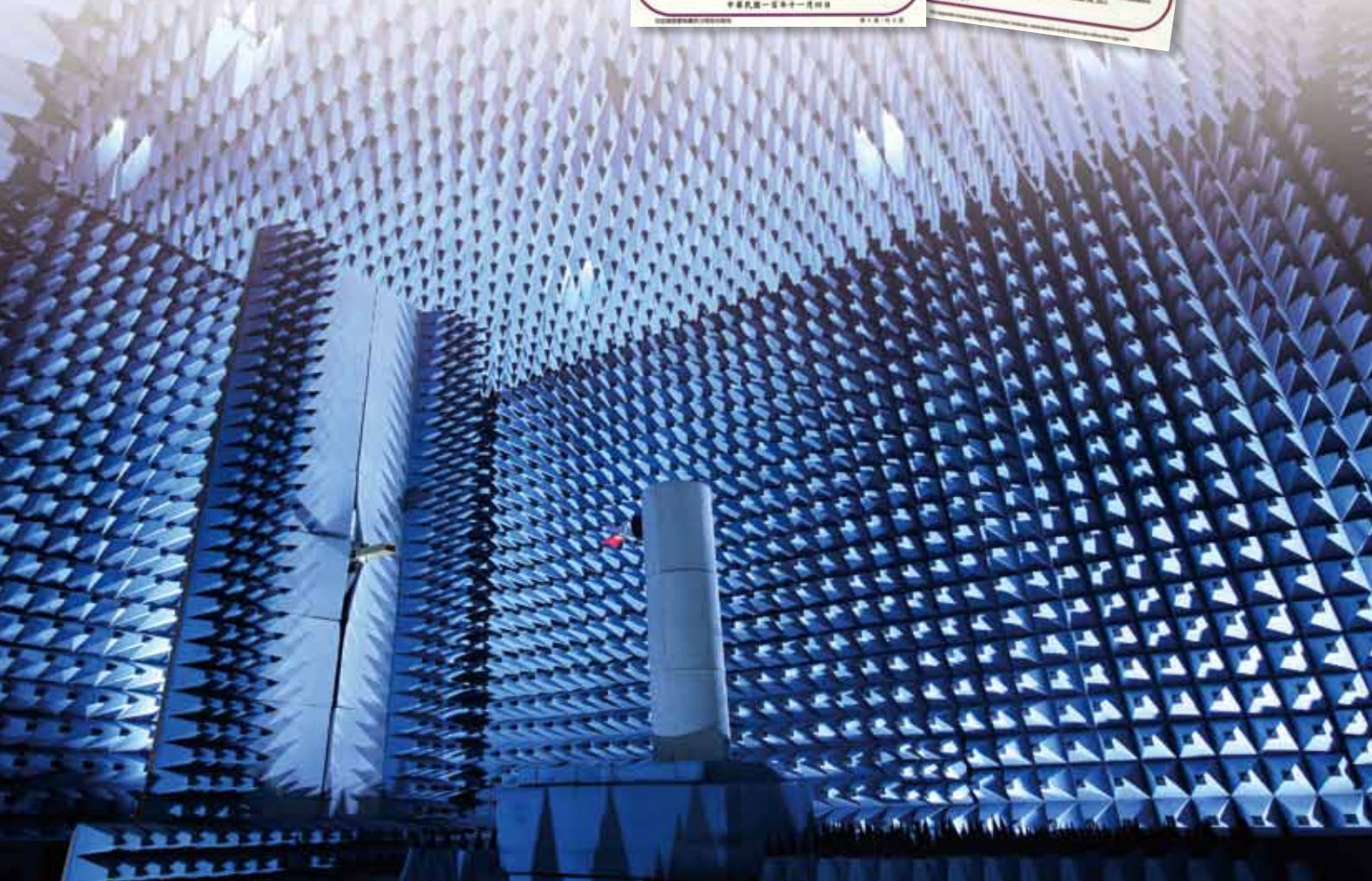
太空中心為確保實驗室品質及技術能力，提升實驗室公正性及公信力，於 2011 年 12 月 5 日通過全國認證基金會 (TAF) 之實驗室之認證1，符合 ISO 17025: 2005 標準規範2，認證項目為「頻率範圍在 1GHz ~ 6GHz 之天線場型測試」。認證所涵蓋之測試服務包含常用的 GPS 、GSM1800、無線網路、藍芽、衛星 S-band 與基地臺等天線系統之場型量測，從申請認證到評鑑僅五個月時間即獲通過，對測試人員是莫大的肯定。

1 經濟部標準檢驗局局長陳介山親自頒發證書 (Dr. Jay-San Chen, Director General of the Bureau of Standards, Metrology and Inspection (BSMI) presented the Certificate to NSPO in the ceremony.)

The EMC and Antenna Test Lab of NSPO has been operated to characterize the component electromagnetic compatibility and antenna pattern in support of various NSPO satellite projects. In the mean time, the lab also provides EMC related test and measurement services to customers from industries, government agencies, academia, and research institutes. For electromagnetic compatibility, the lab is capable of providing the testing services in accordance with military and civil standards. As for the antenna measurement, the lab is capable of providing 7-axis automatic antenna characterization services from regular to large sized antennas with frequency ranged from hundreds MHz to tens of GHz. Up to date, the lab has provided services for a variety of domestic customers including ITRI, ETC, NCTU, Jonsa Technologies Co., Ltd, RF Castle Electronics Co., Ltd, etc.

The EMC and Antenna Test Lab of NSPO filed the application for certification to Taiwan Accreditation Foundation (TAF) in June of 2011 and was granted the official recognition in November of 2011. The Certificate recognizes the lab is fully complaint to the ISO 17025: 2005 standard. The item certified by TAF is: "Antenna pattern measurement with frequency ranged from 1GHz to 6GHz" which covers assorted antennas of GPS, GSM1800, WiFi, Bluetooth, S-band (satellite), and base stations. The whole process took only amazingly short period of five months which is well thought-out by all participants of the reorganization to their capability and effort.

2 ISO/IEC17025: 2005 證書 (ISO/IEC17025: 2005 Certificate)



太空科普教育
Space Science Education Outreach

1「變動的地球與防災科技」特展，定時播放太空中心福二及福三相關影片（“A Changing Earth and Disaster Prevention Technology Special Exhibition,” scheduled broadcast of video related to NSPO FORMOSAT-2 and 3)

2「2011 科學季：未來科技狂想曲」特展（“2011 Science Season: Technologies of Future” Special Exhibition)

太空科普教育活動於 2011 年可分為特展、太空環境測試技術應用研習營、科普教育、學術教育與出版品及參訪等五個部分，詳細說明如下：

1. 特展

2011 年共舉辦三項特展，包括變動的「地球與防災科技特展」、「2011 科學季：未來科技狂想曲」及「飛向太空 20 年 - 福爾摩沙的太空夢」，展出內容有福衛系列大型海報、衛星影像圖說、發射火箭模型及模擬動畫等，此外本中心同仁以「福衛二號觀照全世界」、「2012 太空天氣」及「福衛三號 - 最精準的太空溫度計」為題與民眾互動，讓民眾更深入的了解我國的太空科技。1 2

2. 太空環境測試技術應用研習營

太空環境測試技術應用研習營已持續舉辦四年，辦理成效卓著，獲得各方好評，透過實作演練，將上課所學之理論基礎與實務結合，提升國內學者及青年學子在各項太空環境測試實務操作上之應用能力，並啟發學員對科學的興趣，並配合現場參觀與實際操作之課程安排，以深刻瞭解衛星整測之實務。藉由本活動特別設計之課程安排，期能對於國內大專院校之在學學生、研究生甚至大學教授與業界能一窺太空科技之機會，藉此培育未來太空科技人才。3

3. 科普教育

- 福衛二號及福衛三號之科學應用與普及教育

由太空中心與國立臺灣師範大學及國立中央大學聯合主辦，分別進行福衛二號及福衛三號科學體驗營、研習營與競賽等活動，引導高中生對科學研究的邏輯思考和創意，讓太空知識與科技融入日常生活；此外為照顧弱勢環境及離島學童，舉辦科學探索教育推廣營，以圓孩童們一窺太空的夢。4

-「皮米衛星 (PicoSat) 系統課程」遠距教學課程

與虎尾科技大學、成功大學、逢甲大學、淡江大學等 4 所大學合作參與跨校際「皮米衛星 (PicoSat) 系統課程」遠距教學課程，推展太空教育，帶動國內學生自行設計製作教學微衛星風氣，提升全臺地區學子對太空科技的熱忱。

4. 學術教育與出版品

針對國內地球科學及地理資訊教育的推廣，除了提供資料給各大學進行遙測影像科學研究之外，另配合教育部所頒訂的各級學校教學課綱，將遙測科技整合至正式或是課外教材之中，推廣遙測在教育層面的應用並教導及推廣遙測影像於教學上的應用約 20 餘項，包含國小、國中、高中、大學教材與教學計畫更與國際學術合作多項計畫。

5. 參訪

2011 年度共計 97 梯 3,830 人次造訪問太空中心。「2011 年候鳥計畫」學員深度參訪臺灣的團體行程亦將本中心列為其中，太空中心提供給海外華裔學子太空科技能力最佳之學習環境，相對也提高本中心之能見度。未來太空中心將持續推廣太空教育，開放衛星操控中心及衛星整測廠房供社會大眾進行參訪，讓大眾更了解太空中心於太空科技的成果與貢獻。

Space Science Education Outreach in 2011 could be divided into the five sections of Special exhibitions, Space Environmental Test Technologies and Applications Workshop, Science education, Academic education/Publications and Visit, as detailed below:

1. Special Exhibitions

Three special exhibitions were held in 2011 including “A Changing Earth and Disaster Prevention Technology Special Exhibition,” “2011 Science Season: Technologies of Future,” and “20 Years of Flying towards Space: Formosa’s Space Dream.” These exhibits displayed content such as large-scale posters of the FORMOSAT series, satellite image diagrams, rocket launch models, simulation animations, etc. In addition, our colleagues took “FORMOSAT-2 reflects on the world,” “2012 Space Weather,” and “FORMOSAT-3, the most accurate space thermometer” as topics for interacting with the public, which allowed participants to better understand our nation’s space technologies. 1 2

2. Space Environmental Test Technologies and Applications Workshop

The Space Environmental Test Technologies and Applications Workshop has been held for four consecutive years with impressive results and has received praise from all parties. Basic theories learned in the classroom are combined with practice through implementation exercises to enhance the proficiency of domestic academics and young students in the practical operation of various space environment

3 太空環境測試技術應用研習營 (Space Environmental Test Technologies and Applications Workshop)

tests and to inspire trainee interest towards science. A curriculum that coordinates site visits and practical operation conveys a deep understanding of the practice of satellite measurements. Through this event's specially designed curriculum, a chance at a glimpse into space technology is offered to domestic college and university students, postgraduate students, and even university professors and members of the industry, in an effort to cultivate future space technology talents. 3

4 福爾摩沙衛星三號資料應用科學競賽發表會 (FORMOSAT-3 Data Application Science Competition Press Conference)

3. Space Science Education Outreach

- Scientific Applications and Education Outreach of FORMOSAT-2 and 3

Organized by NSPO, National Taiwan Normal University, and National Central University, the FORMOSAT-2 and FORMOSAT-3 Science Camps were implemented separately. Activities such as training camps and competitions can guide the logical thinking and innovation of high school students in the field of scientific research and allowe space knowledge and technology to be integrated into daily life; in addition, in order to care for disadvantaged and outlying island students, a scientific exploration education promotion camp was held to fulfill the children's dream of glimpsing space. 4

- "Picosat Systems Course" Distance Learning Courses

In collaboration with National Formosa University, National Cheng Kung University, Feng Chia University, and Tamkang University, an inter-university "Picosat Systems Course" distance learning course was established to promote space education, spur domestic students a trend of Pico satellite's design and creation, and enhance the enthusiasm of all students in the Taiwan region towards space technology.

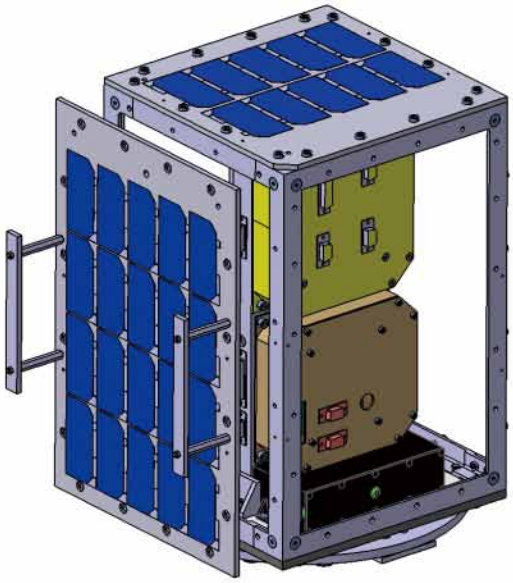
4. Academic Education and Publications

Focusing on the promotion of domestic education in earth science and geographic information, and providing data to various universities for remote sensing imagery research, we also collaborate in the production of syllabuses with schools at all levels as promulgated by the Ministry of Education to integrate telemetry technology into official or extra-curricular teaching materials as a way of promoting telemetry applications in education. Educational applications of teaching and promoting telemetry imagery total approximately 20 items, including teaching materials for elementary schools, junior high schools, high schools and universities, and lesson plans that collaborate even more closely with numerous international academic plans.

5. Visit

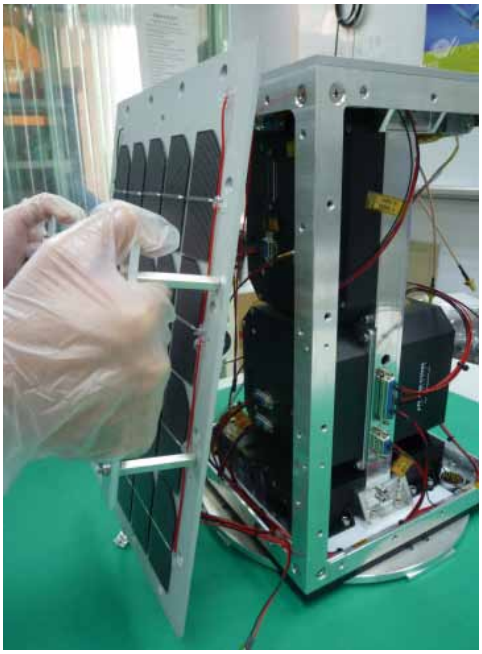
In 2011, a total of 97 tiers representing 3,830 people toured NSPO. The group itinerary of the "2011 Taiwan Tech Trek" to thoroughly visit Taiwan listed our center as an attraction. NSPO provides the best learning environment for space science and technological capabilities to overseas Chinese, while comparatively enhancing this center's visibility. In the future, NSPO will continue space education outreach, open our Satellite Operations Control Center and Satellite Integration & Test Facility to the public for tours to allow the public to understand the achievements and contributions of NSPO to space technology.

微衛星 CKUTEX 與科學酬載 E-VAC
Experiment Microsatellite-CKUTEX and E-VAC

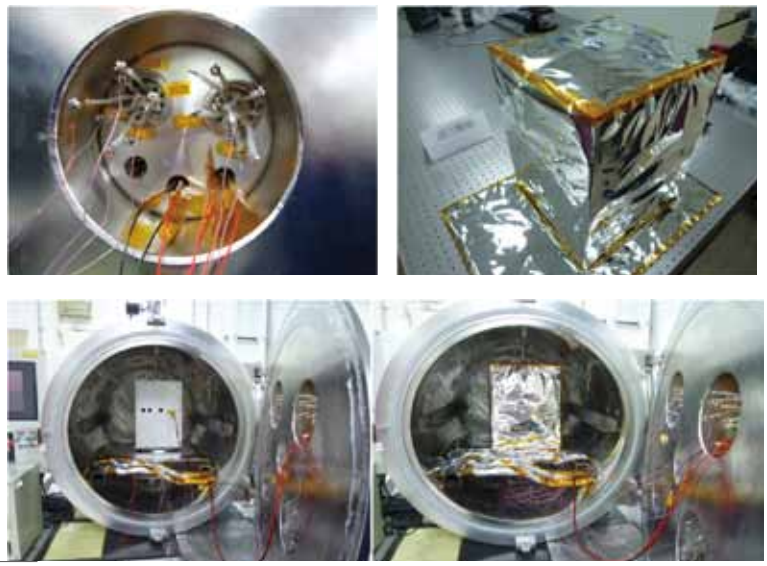


1 微衛星實體組裝與構型 (Microsatellite assembly and configuration)

實驗型微衛星研製計畫是由成功大學 CKUTEX 微衛星團隊負責執行微衛星之設計製作發展 1；太空中心提供必要的經驗傳承、技術協助及計畫審查。CKUTEX 微衛星已於 2011 年度完成相關微衛星環境測試 2 及系統驗證確認，在運送前審查會議時遞交飛行體給太空中心 3；並順利通過計畫之期末審查會議。本計畫自 2008 年底啟始至 2011 年底完工為止，歷時三年終於圓滿劃下句點，完成培植大學自主發展微衛星系統設計、分析、整合、測試與品保等完整能量的目標。



垂直大氣耦合成像儀 (E-VAC) 科學酬載計畫主要由成功大學研發團隊在太空中心的協助下，自主發展完成一組科學探測儀器雛型。此科學酬載任務目標為進行垂直大氣耦合探測及海洋水色照相。全案於 2011 年 4 月完成期終審查並驗收通過。



2 微衛星熱控環境驗證測試構型 (Test configuration of microsatellite for thermal soak test in vacuum environment)

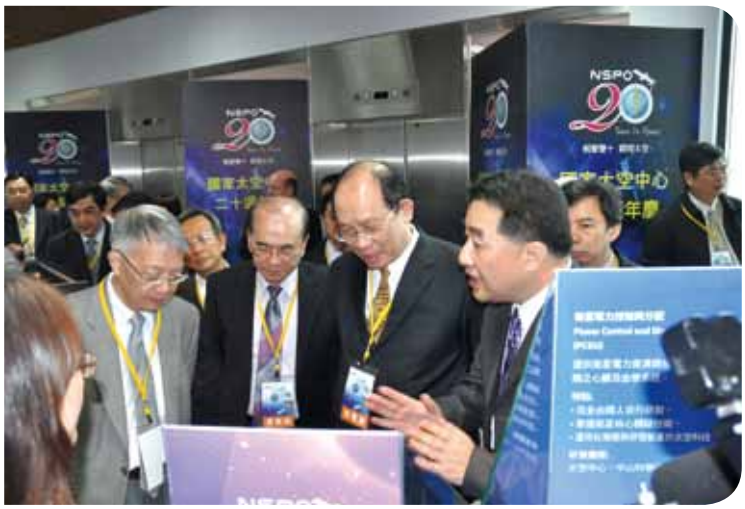
The Experimental Microsatellite Project was designed and developed 1 by CKUTEX team in National Cheng-Kung University (NCKU); NSPO helped this project through instructing and educating the team by the technology transfer of microsatellite development, the project review and monitoring. The CKUTEX satellite environmental tests had been conducted 2 in 2011 before the flight model was delivered to NSPO in the Pre-Shipment Review (PSR) meeting 3 and the project was successfully completed in Final Review (FR) meeting. The Experimental Microsatellite Project has been executed for 3 years from 2008 to 2011. The goal of this project has been fully achieved by successfully establishing university capability in the microsatellite development of system (with all subsystems) design, analysis, integration and test, quality assurance, etc.

The E-VAC project has developed a sophisticated scientific instrument prototype, which is an excellent domestic team effort by NCKU and NSPO. The mission objective of the E-VAC space instrument is to investigate vertical atmospheric coupling and to image ocean colors. The E-VAC project completed its Final Review in April 2011.

3 微衛星飛行體運送遞交 (Microsatellite flight model delivery in PSR meeting)

國家太空中心二十週年慶
NSPO 20th Anniversary

1 太空中心二十週年慶祝大會 (NSPO 20th Anniversary)



2 太空中心研發成果展示 (NSPO R & D Achievement Exhibition)

太空中心成立二十週年慶祝大會於 2011 年 11 月 11 日盛大舉行 1 。國科會李羅權主委等各界長官親臨指導，肯定太空中心二十年的戮力經營，成功執行福衛一號、福衛二號與福衛三號等三個衛星計畫，為我國奠定太空自主發展的厚實基礎、培養優質的太空科技人才，並建立國際知名度。李主委亦表達對落實自主太空科技政策的支持，期勉太空中心每位同仁，秉持著不屈不撓的研發精神來面對未來更嚴苛的挑戰，為深耕臺灣的太空科技發展繼續打拼奮鬥。

2011 年 11 月 12 日緊接著舉辦 Open House 活動，包括：

1. 操控中心、衛星整測廠房及各項設施與研發成果展 2 ：展出內容包括探空實驗火箭、遙測影像儀、光纖陀螺儀…等，其中光纖陀螺儀更是首次近距離呈現給國人。透過參觀行程，讓來賓瞭解我國太空科技發展的歷程以及各種核心設備。

2. 動手做衛星紙模型與水火箭活動：動手組裝衛星立體紙模型活動 3 ，讓來賓了解衛星的結構及元件功能等基本知識；水火箭以回收的寶特瓶製作，並進行發射實驗，藉由動手製作的過程認識火箭發射的原理 4 。

此次活動吸引不少民眾，來自新竹地區大專院校、中小學生以及員工眷屬朋友逾 600 人，與會來賓除了對我國國家太空計畫發展留下深刻的印象外，更透過參觀與動手做活動增加對太空科技的認識與瞭解。

The ceremony of the 20th anniversary of NSPO was held on November 11, 2011 at Hsinchu Science Park 1. Minister Lou-Chung Lee of National Science Council and leaders from all sectors provide personal guidance and recognized 20 years of painstaking NSPO operation. The successful execution of the FORMOSAT-1, 2 and 3 satellite programs laid a concrete foundation for the autonomous development of our country's space program, cultivated outstanding talents in space technologies, and established international renown. Every colleague in NSPO should be encouraged to uphold an unyielding and confident R & D spirit to face more rigorous challenges in the future and continue the struggle to cultivate Taiwan's development of space technologies.

An Open House event was held on November 12, including:

1. Satellite Operations Control Center, Satellite Integration & Test Facility, various facilities, and an R & D achievement exhibition 2: Exhibitions included experimental sounding rockets, Remote Sensing Instrument (RSI), Fiber Optic Gyros, etc. This was the first time Fiber Optic Gyros were displayed at close range to the public. By touring the exhibition, guests were able to understand the process of our nation's space technology development and various types of core equipment.

2. DIY Paper Satellite and Water Rocket Event: Assembling 3D Paper Satellite Models by Hand (Figure 3) allowed guests to understand basic satellite knowledge such as structure and components; water rockets were made with recycled bottles and launch experiments were performed. Participants became familiar with the principles of rocket launch through the process of hands-on construction 4.

This event attracted many young people, totaling more than 600 from Hsinchu-area colleges and universities, middle/elementary school students, and the family and friends of employees. In addition to receiving a lasting impression of the development of our national space program, participating guests also increased their understanding of and familiarity with space technologies through observation and hands-on events.

3 動手做衛星紙模型 (DIY Paper Satellite Models)

4 動手做—水火箭發射 (DIY - Water Rocket Launch Experiments)

福爾摩沙衛星三號成功運作五週年
FORMOSAT-3 Fifth Anniversary of Operations

1 福衛三號 (FORMOSAT-3 / COSMIC)

福爾摩沙三號衛星 (以下簡稱福衛三號) 1 於 2006 年 4 月 15 日在美國加州范登堡以一箭六星方式成功發射世界首創的微衛星氣象星系，2011 年 4 月 15 日屆滿五周年，順利達成「氣象、電離層及氣候之衛星星系觀測系統」任務目標。

福衛三號星系自在太空軌道上運轉 5 年來，迄今共計接收到大氣資料 256 萬筆，電離層 264 萬筆，目前全球總共有 55 個國家，1508 個註冊使用者從事相關氣象預報及學術研究，成績斐然，被國際間譽為「最精準的太空溫度計」，也被評為對未來氣象測候最具影響力的系統之一。

由於福衛三號星系系統的部署，在科學研究上亦有許多重大的突破，例如在電離層研究方面，科學團隊針對發掘赤道異常、大氣停駐波、夜間中緯度異常、電漿洞、電漿匱乏灣等研究，科學成果豐碩。另外，對於南極上空平流層溫度垂直結構的連續觀測、全球氣候監測、聖嬰現象颱風路徑預報、電離層對於地震現象測量等亦有許多科研成果。福衛三號除獲國際知名期刊：NATURE、SCIENCE、TAO、BAMS、SPECTRUM、GEOSCIENCE AND REMOTE SENSING、ECMWF 及 JCSDA Newsletter 顯著報導外，並有數百篇 SCI 論文，以及數以千計學術論文的產出。

太空中心在臺北市福華文教會館於「第五屆福衛三號星系資料使用者研討會暨 2011 年國際 GPS 掩星觀測研討會（Fifth FORMOSAT-3 / COSMIC Data Users Workshop and International Conference on GPS Radio Occultation 2011）」，舉行福衛三號發射五周年慶祝活動，計有來自全球 18 國福衛三號資料使用者約 150 人，共同見證此歷史時刻；太空中心張桂祥主任邀請福衛三號合作團隊美國科學基金會 (NSF) Dr. Jay Fein 及美國大學大氣聯盟 (UCAR) 總裁 Dr. Rick Anthes 共同切蛋糕祝賀福衛三號五周年任務完成 2 。

2 福衛三號發射五周年慶祝活動 (5th Anniversary Celebration of FORMOSAT-3 Launch)

The FORMOSAT-3 constellation for Radio Occultation (RO) mission consisting of six satellites 1 in Low Earth Orbit (LEO) was launched on April 15, 2006. It's the first constellation weather satellites launch in cluster formation. On April 15, 2011, the FORMOSAT-3 has reached the 5th anniversary since launch and has accomplished the intended mission goals of the "Constellation Observing System for Meteorology, Ionosphere, and Climate"

The FORMOSAT-3 constellation orbiting the Earth for 5 years has retrieved 2.56 million and 2.64 million RO profiles for Atmosphere and Ionosphere, respectively. The FORMOSAT-3 has attracted 1508 registered global data users in 55 countries for weather forecasting, climate monitoring and related research studies. FORMOSAT-3 has proven to upsurge the accuracy of the predictions of hurricane/typhoon/cyclone behavior, significantly improve long-range weather forecasts, and monitor climate change with unprecedented accuracy and was appraised as the "The Most Accurate and Stable Thermometer in Space" by the international weather community. The FORMOSAT-3 RO data is as well evaluated as one of the most influential systems for the future Earth observation and monitoring. The FORMOSAT-3 constellation RO data also significantly contributed to the major scientific breakthroughs in ionosphere, such as standing waves study, mid-latitude ionosphere anomaly, plasma caves, El Nino / La Niña observation, and pre-earthquake observation, etc. In addition, the FORMOSAT-3 global RO data also enable the continuous observation of the vertical temperature profiles in the stratosphere above Antarctic for ozone studies and global climate change observations. The FORMOSAT-3 scientific results have been presented in hundreds of SCI papers and thousands of the conference reports worldwide. The FORMOSAT-3 mission achievements have also been published in many major international articles and journals: Nature, Science, TAO, BAMS, Spectrum, Geoscience, Remote Sensing, and ECMWF & JCSDA Newsletters.

NSPO took the opportunity of the 5th anniversary of the FORMOSAT-3 launch conducted the FORMOSAT-3/COSMIC Data Users Workshop along with the 2011 International Conference on GPS Radio Occultation at Howard International House between April 13 and 15, 2011 in Taipei. More than 150 international global users and researchers from 18 countries participated in this event and jointly witnessed the five-year mission achievements. Dr. Guey-Shin Chang of NSPO Director General invited Dr. Jay Fein of National Science Foundation (NSF) and Dr. Richard Anthes of University Corporation for Atmospheric Research (UCAR), the key representative contributors of the U.S. joint mission partners, in the cake cutting celebration event for the completion of the fruitful five-year mission achievements 2 .

美國國家太空總署頒贈 AMS-02 感謝狀

NASA Presented Certification of Appreciation on AMS-02 to NSPO

1 美國國家太空總署 AMS-02 計畫感謝狀 (NASA AMS-02 Project Certificate of Appreciation)

反物質磁譜儀二號 (AMS-02) 於 2011 年 5 月 16 日搭載於美國國家太空總署 (NASA) 太空梭奮進號 (Space Shuttle Endeavour / STS-134）發射升空，部署於國際太空站上，進行長期科學實驗，其實驗結果深受各界期待。美國國家太空總署 (NASA) 特別致贈感謝狀 1 ，表揚太空中心對 AMS-02 計畫具體貢獻。太空中心於 2002 年正式受邀參與 AMS-02 計畫，為亞洲地區唯一受邀參與計畫的太空機構，主要負責電子元件熱真空測試及全程參與熱控系統發展，順利完成任務，獲得 NASA 的感謝狀，也象徵臺灣太空科技貢獻再次獲得國際肯定。

AMS-02 on board the Space Shuttle Endeavour (STS-134) was launched on May 16 at Kennedy Space Center, Florida, USA. AMS-02 is the major physical science experiment on the International Space Station (ISS) that will collect data for a decade. NSPO is the only space agency in Asia invited to join AMS-02 project. Due to the success of the AMS-02 mission, NSPO received the NASA's Certificate of Appreciation for the dedicated service in support to the AMS-02. NSPO is one of major partners of the AMS-02 project and has made the significant contribution to the success of the AMS-02 development, particularly in the thermal vacuum tests of electronics crates of AMS-02 detector. This certificate represents the NSPO's space technology is recognized by the international space community.

國家太空中心與慈濟基金會簽署合作備忘錄

The Cooperation Memorandum between NSPO and Tzu Chi Foundation

太空中心福衛二號具備每日再訪取像的能力，對於發生災害地區第一時間及持續監測非常有助益。慈濟基金會秉持人道救援精神，常發動第一時間趕赴災區現場救難。雙方鑑於衛星影像支援全球救援行動的重要性，共同發揮臺灣對國際社會的影響力，特於 2011 年 3 月 31 日假花蓮慈濟基金會靜思堂簽訂合作備忘錄。

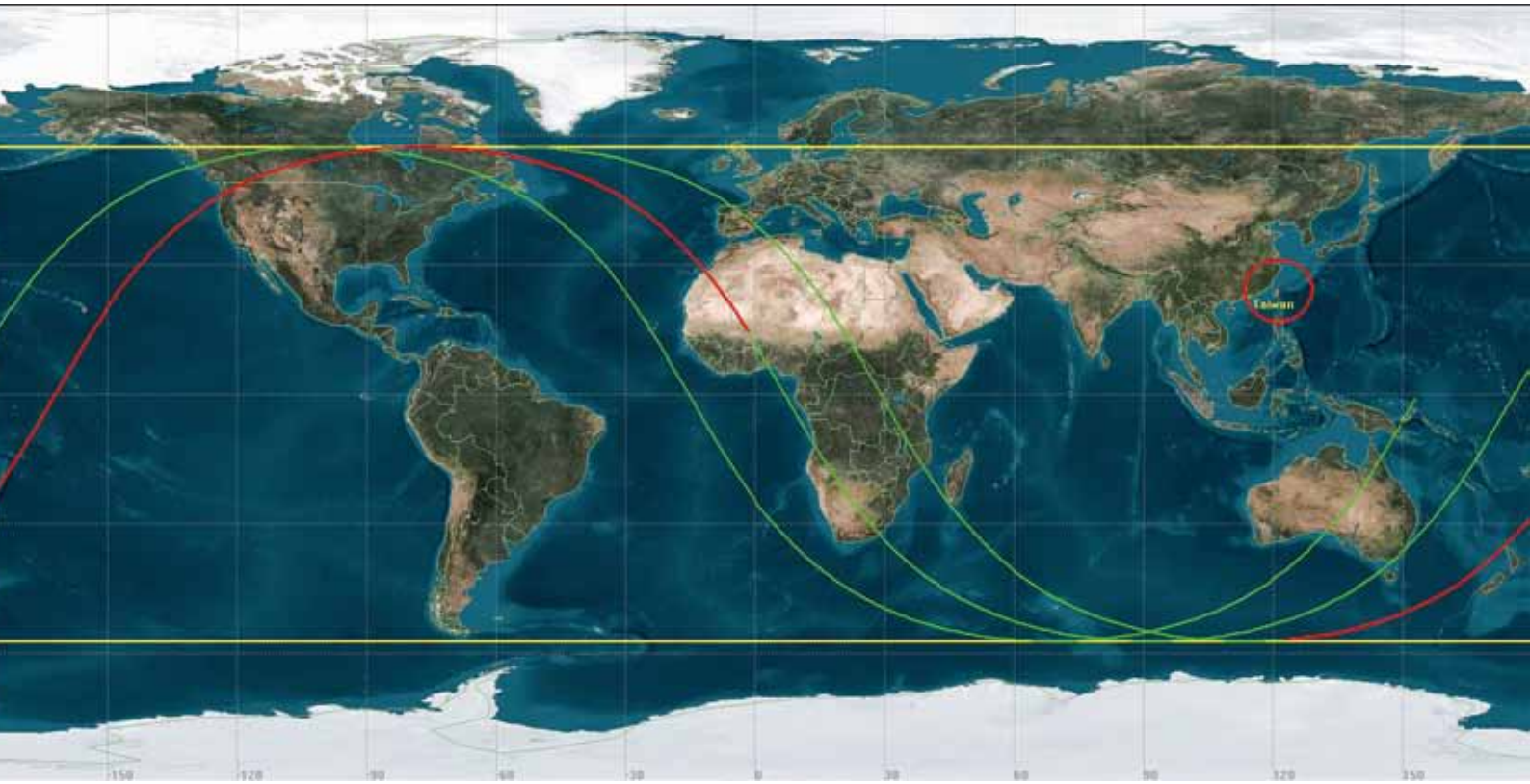
NSPO's FORMOSAT-2 satellite with its daily-revisit capability can provide very helpful information for first-time and continuously monitoring the disaster areas. Based on the humanitarian relief spirit, Tzu Chi Foundation frequently went to the disaster areas at the first time to help victims. As recognizing the importance of the satellite images to support the global relief operations and to show Taiwan's responsibility to international society, both organizations had signed the cooperation memorandum on March 31, 2011 in Hualien Tzu Chi Foundation.

1 太空中心與慈濟基金會簽署國外災區衛星影像支援合作備忘錄
(The cooperation memorandum of the satellite images support signed by NSPO and Tzu Chi Foundation)

UARS 與 ROSAT 衛星墜落

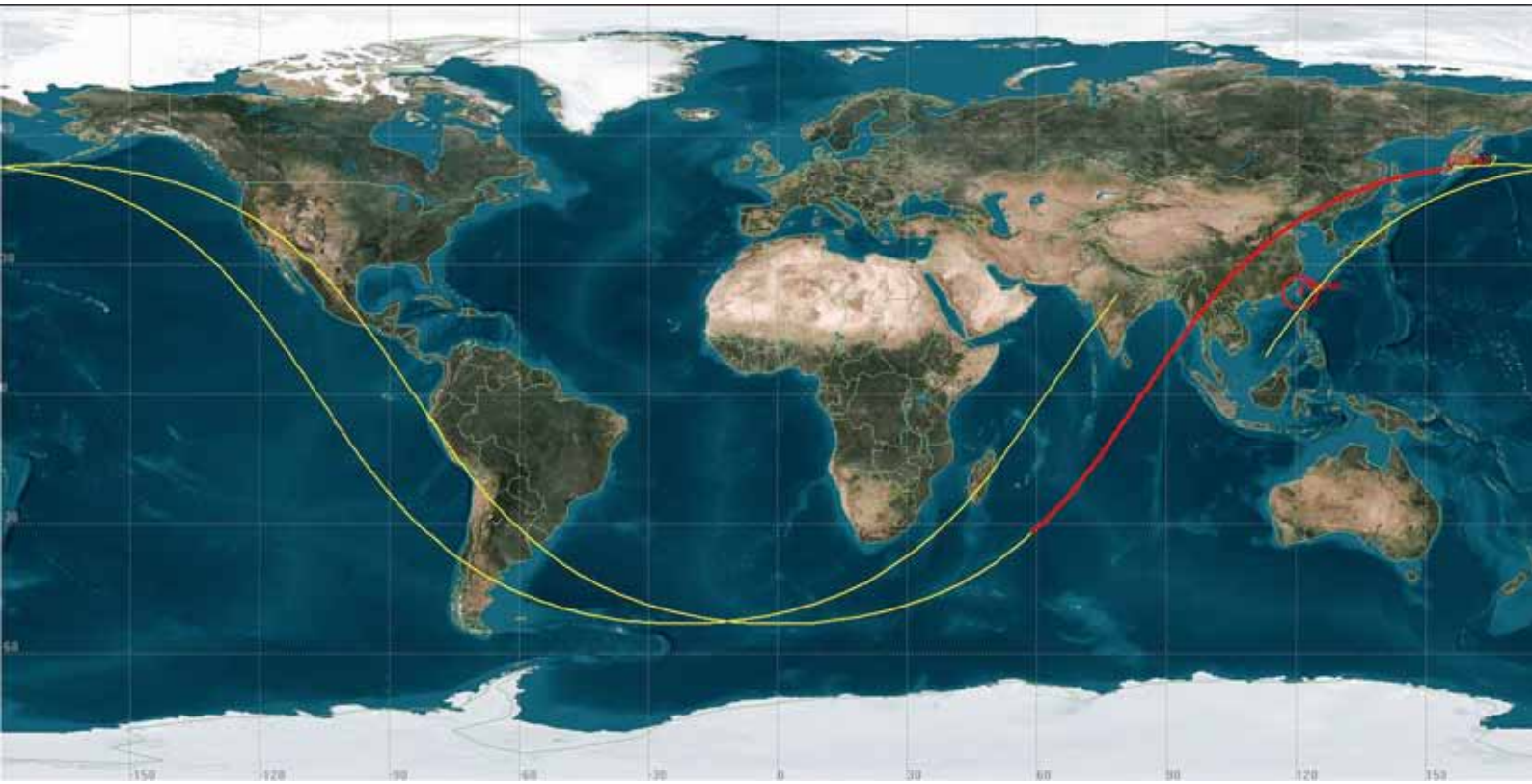
Re-Entries of UARS and ROSAT Satellites

美國大氣研究衛星 UARS 於 2011 年 9 月 24 日墜落 1 ，隨後德國天文研究衛星 ROSAT 於 2011 年 10 月 23 日墜落 2 。由於可能落點涵蓋地球 80% 以上的面積，衛星墜落造成民眾擔憂。衛星墜落前幾天開始，本中心即利用 NRLMLISE-00 Density Model 計算軌道，並利用 Ground Contact Analysis 準確預估臺灣警戒時間，提報行政院中央災防辦公室，並在 NSPO 網站發布提供國人參考。



1 美國航太總署 (NASA) UARS 軌道模擬圖，臺灣時間 2011.9.24 11:00~15:00。最後確定衛星於 11:45~12:45 (如紅線所示) 落在太平洋，沒造成任何損害。(Orbit simulation chart of the NASA’s satellite UARS at 2011.9.24 11:00~15:00 Taiwan time. The satellite was confirmed to re-enter over the Pacific Ocean during 11:45~12:45 (shown as red line) without any damages reported.)

NASA's satellite UARS (Upper Atmosphere Research Satellite) re-entered on September 24, 2011, and then DLR's satellite ROSAT (ROentgen SATellite) also re-entered on October 23, 2011. Since the probable falling locations covered over 80% of the global area, the satellite re-entries triggered people anxiety. Beginning several days before the reentry, NSPO calculated the orbits using NRLMLISE-00 Density Model, and accurately predicted the surveillance time through the ground contact analysis. The simulation results were reported to the Office of Disaster Management of the Executive Yuan, and posted on the NSPO public website for the references.



2 德國航太中心 (DLR) ROSAT 軌道模擬圖，臺灣時間 2011.10.23 8:30~11:30。最後確定衛星於 9:45~10:15 (如紅線所示) 落在印度洋，沒造成任何損害。(Orbit simulation chart of the DLR's satellite ROSAT at 2011.10.23 8:30~11:30 Taiwan time. The satellite was confirmed to re-enter over the Indian Ocean during 9:45~10:15 (shown as red line) without any damages reported)

愛心義賣會
The Love Charity

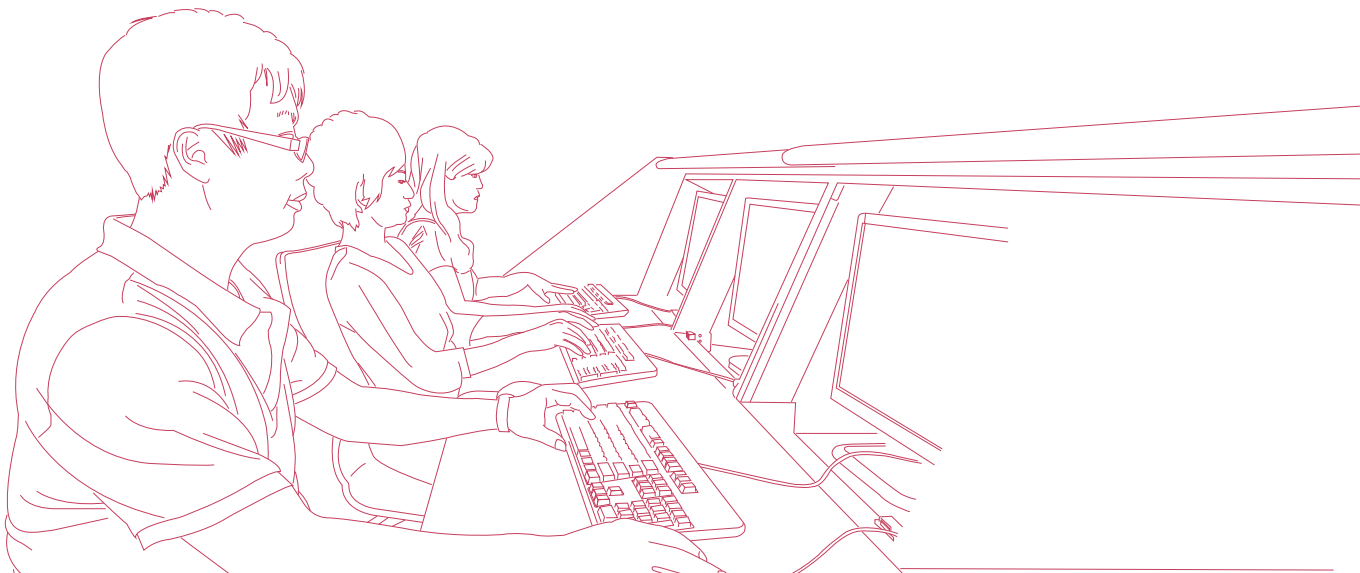
1 愛心義賣會活動 (Love charity activities)

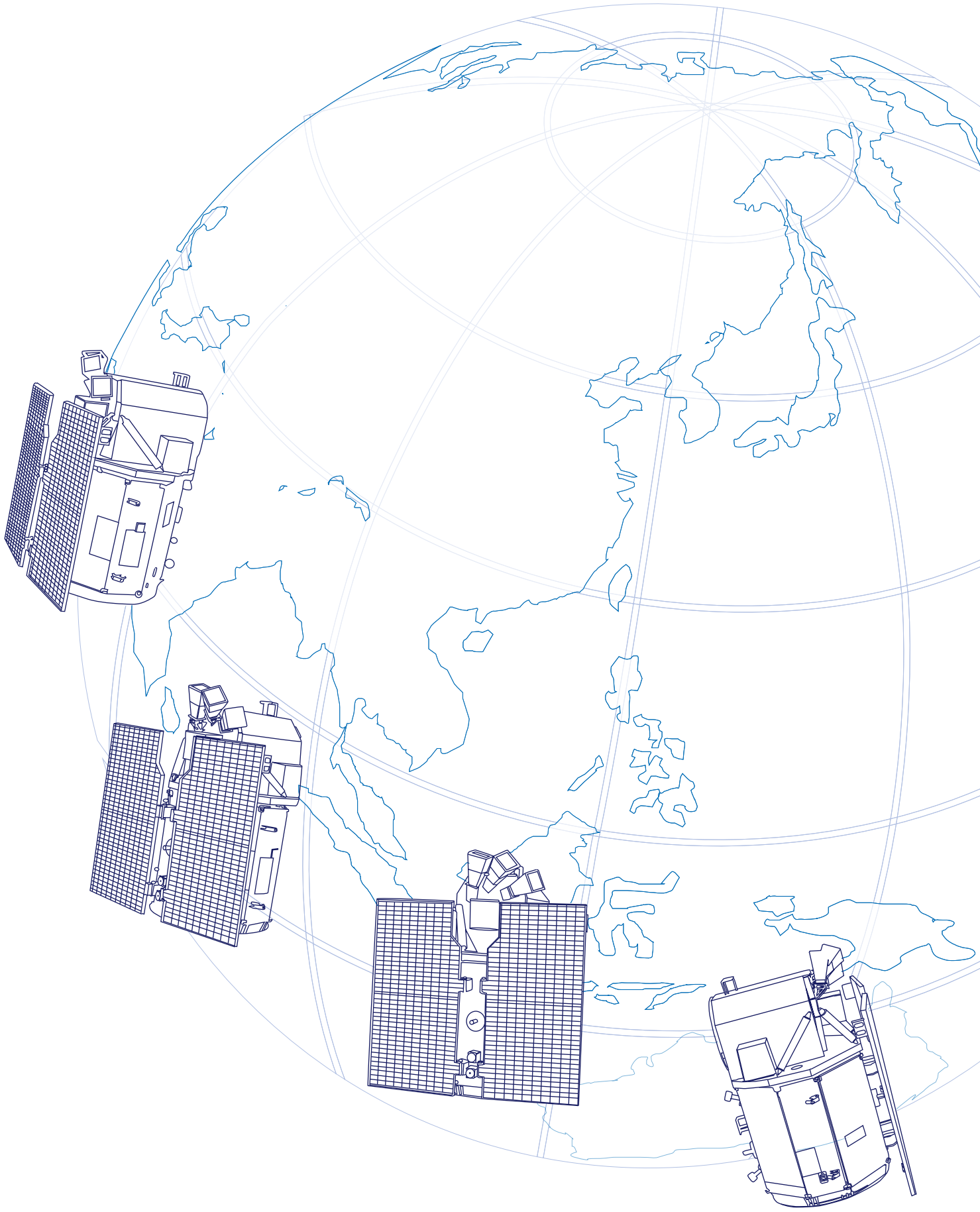
太空中心於 2011 年度發起愛心義賣會，希望集結同仁力量關懷弱勢族群，義賣會在同仁們大力支持下圓滿完成。義賣所得與捐贈物資全數贈予「苗栗縣私立幼安教養院」，幼安教養院長期協助身心障礙朋友之教育、訓練、養護與復健，希望藉由本次的義賣會給予最大的支持與協助，發揮同仁無私奉獻與人道關懷的精神。

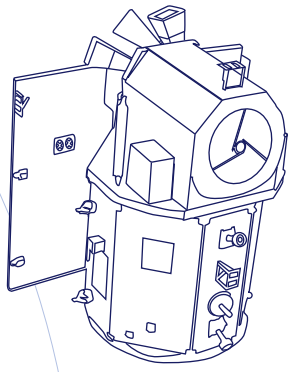
National Space Organization (NSPO) launched the charity sale to raise funds for the support projects to assist underprivileged. Without the help of volunteers, who devote and support the NSPO with the time and effort, it wouldn't be able to turn the project into a success. All contributions from individual supporters, sponsorship and fundraising will be directed to Yu An Retarded Children's Home Miaoli R. O. C. This will enable the continuous support, assistance and education to help them through their lives. NSPO would like to thank everyone who helps us to achieve our goal in helping the underprivileged to have a better future.

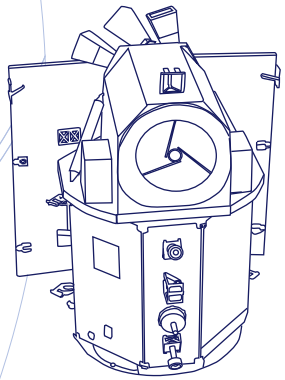
重要成果統計
Major Achievements

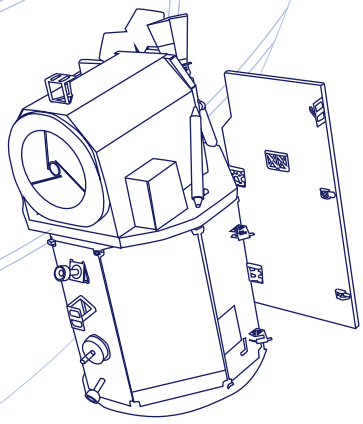
項目 Item		數量 Quaintly	單位 Unit
服務成果 Service Results	設施及技術服務用戶數 Facility and technical services	161	戶 household
	影像提供使用數量 Satellite image services	1768	幅 scene
氣象資料提供 Meteorological DataProvide	註冊使用者 Registered users	1781	帳號 Account
	掩星點數 (大氣層) Accumulated Occultation (Atmosphere)	3,178,863	筆 Profile
	掩星點數 (電離層) Accumulated Occultation (Ionosphere)	3,090,908	筆 Profile
研發成果 R&D Results	中心發表論文數 Papers published by NSPO	64	篇 paper
	研究 / 技術報告 Technical reports published by NSPO	173	篇 paper
人才培育 Education Outreach	參與計畫之碩博士生人數 Graduate students in joint research programs	99	人 person
	教育訓練人次 Training workshop participants	611	人 person
	參訪人次 NSPO visitors	3830	人 person
專利 Patents	專利取得件數 No. of patent obtained	2	件 Case
	專利申請件數 No. of patent application	8	件 Case











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