Space Science and Engineering at National Central University

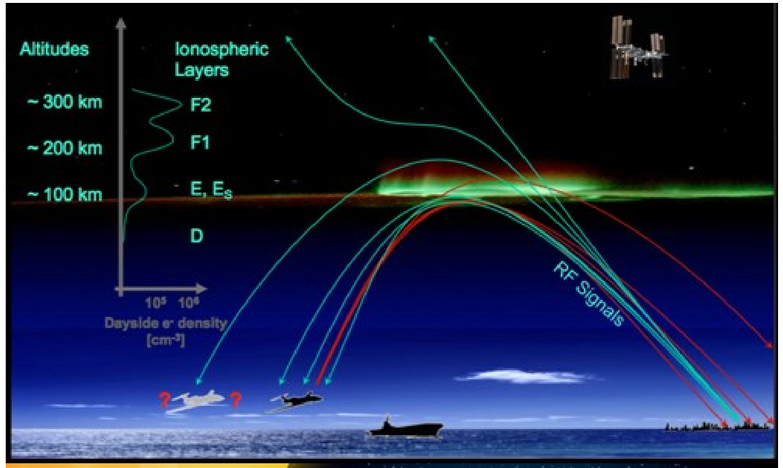
Department of Space Science and Engineering
Center for Astronautical Physics and Engineering
National Central University, Taiwan

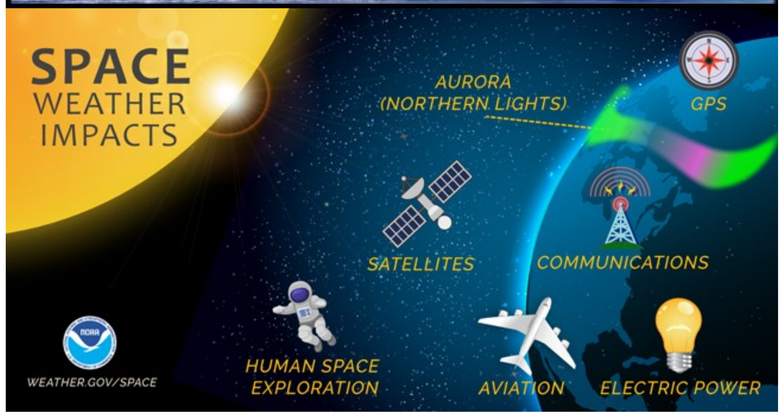
National Central University



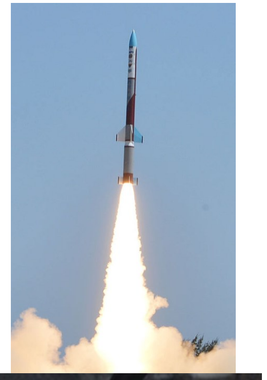
- Located 40 minutes outside Taipei in Taoyuan City (桃園市, near airport).
- Students: ~11000
- Established in Taiwan in 1962 as follow-on to 1957/1958 International Geophysical Year that saw the first satellites launched to explore the ionosphere, magnetosphere.
- Programs in Space Science & Engineering, Remote Sensing, Astronomy.
  - Sole Taiwan university with Space Science and Engineering Department (undergraduate and graduate).
  - Taiwan's first university space center: Center for Astronautical Physics and Engineering (CAPE).

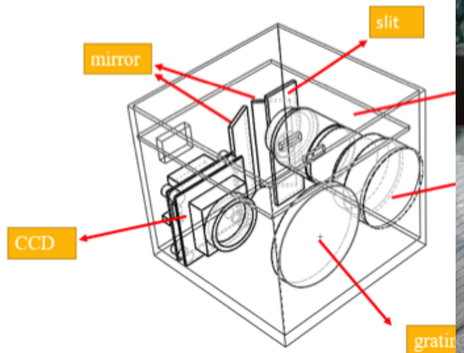
Evolution of NCU Space Capacity

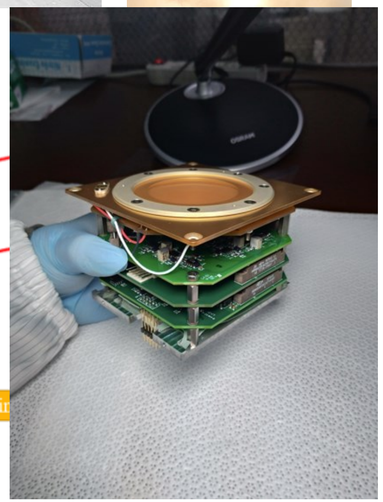




1960 – 1989
Space Physics,
Space Weather & Environment







1990 – 2010s
Payloads & Instruments

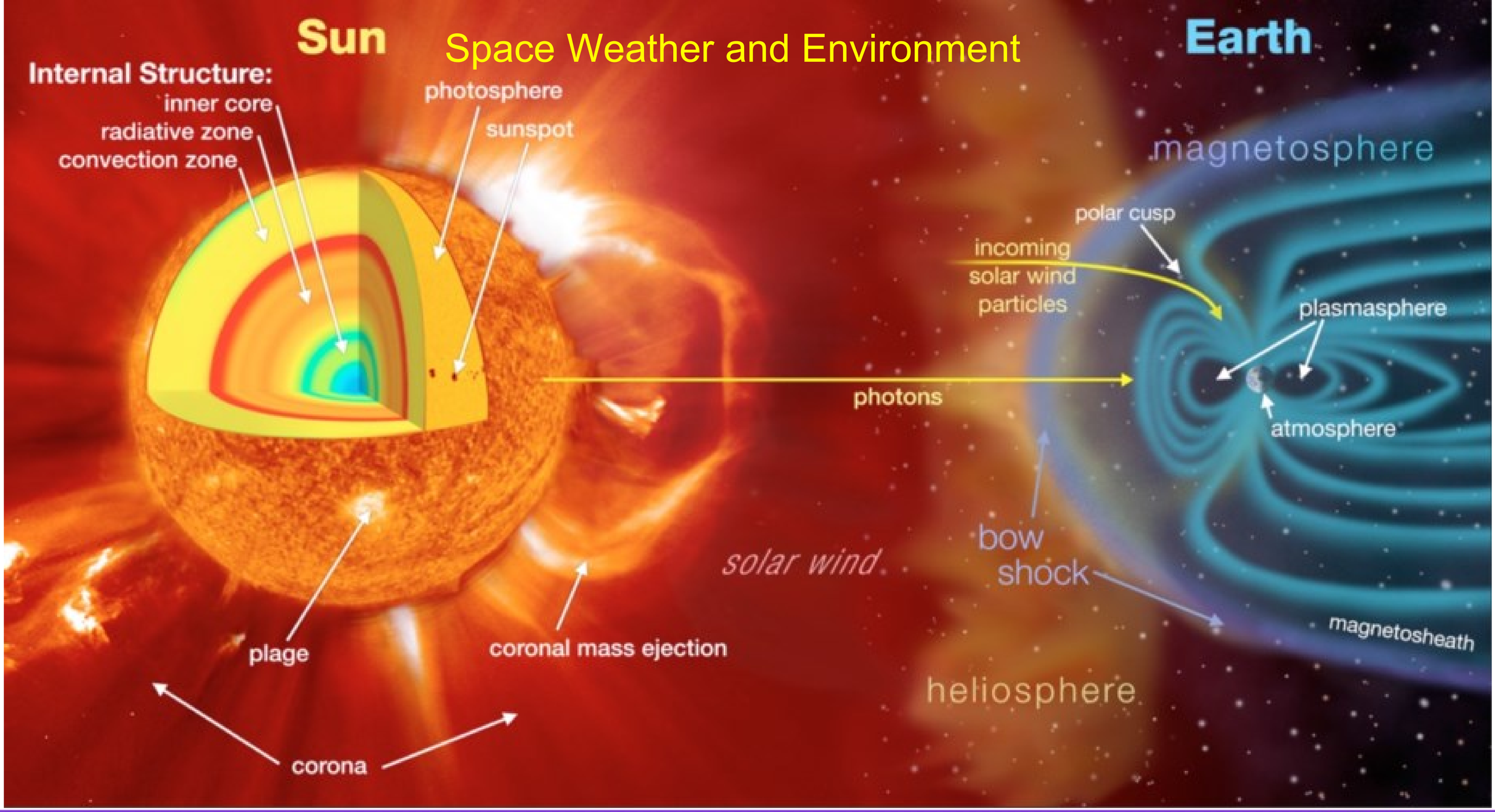
2015 - present
Space Systems Engineering

Department of Space Science and Engineering

First undergraduate class graduated in 2024.

- Formed from 2020 merger of Graduate Institute of Space Science and Engineering and Department of Atmospheric Science Space Science Group. Teaching and research in space utilization.
- 11 current faculty (1/3 female), 2 researchers, 6 joint appointments.
- Student count:
  121 undergrad, 45 masters, 10 PhD.
- Student allocations:
  - Undergrad: 32 per class.
  - Masters: 23 per class.
  - PhD: 6 per class. Joint academic-industry slots with National Chung-Shan Institute of Science and Technology (defense R&D body) and Taiwan Space Agency (TASA).
- Students required to take classes in both **science** and **engineering**. Inter-departmental study encouraged. Emphasis on **space physics** and **system integration**.

Space Weather and Environment

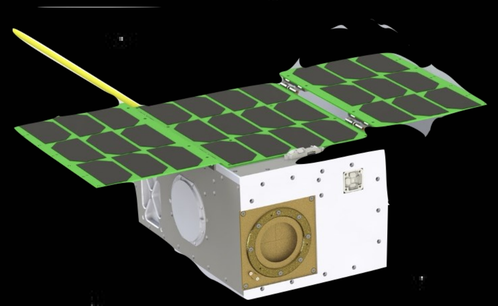


INSPIRE

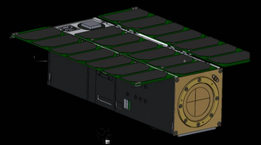
- **In**ternational **S**atellite **P**rogram in **R**esearch and **E**ducation. Established 2015.
  - Starting point for our smallsat program at NCU.
- Objectives:
  - Develop constellation of small satellites for science missions and supporting ground network.
  - Hands on curriculum for mission formulation, spacecraft engineering, operations, science data analysis.
- https://lasp.colorado.edu/home/inspire/
- Evolved into COSPAR Task Group to Establish a Constellation of Small Satellites.

Institution	Country	Joined
University of Colorado at Boulder	USA	2015
Indian Institute of Space Science and Technology	India	
National Central University	Taiwan	
Laboratoire Atmosphères, Milieux, Observations Spatiales	France	2016
Nanyang Technological University	Singapore	2017
Sultan Quaboos University	Oman	
Kyushu Institute of Technology	Japan	
University of Alberta	Canada	2018
University of Iowa	USA	
Forschungszentrum Jülich	Germany	
Tel Aviv University	Israel	2019

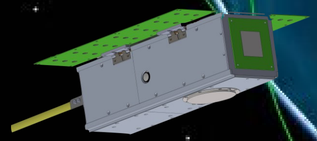
Our Spacecraft Fleet



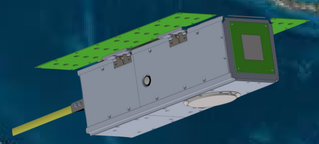
INSPIRESat-1
Launched 2022/2/14
Ionosphere, Heliophysics
International Collaboration
US, IN, TW



IDEASSat
Launched 2021/1/24
Ionosphere, Tech Demo

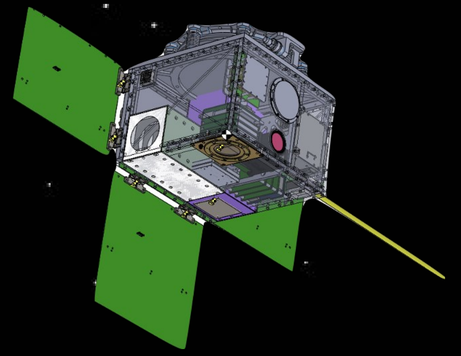


Koyo
2024 Q3
Flight Dynamics, Tech Demo
Industry Partnership: Aegiverse

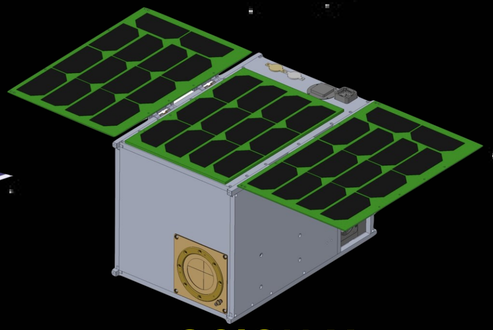


SAISI
2024
Internet Of Things, AIS

PEARL
1C, 1H Launched 2023/11/12,
1A, 1B 2025
B5G Communications
Industry Partnership: Foxconn



ARCADE
Launched 2023/7
Ionosphere, Mesosphere, VLEO
International Collaboration
SG, DE, TW, US, IN

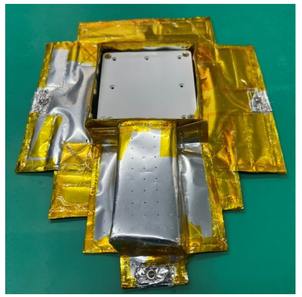


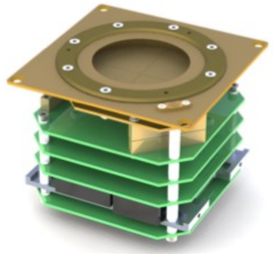
SCION-X
2026/6
Ionosphere, Hyperspectral Imaging
Industry Partnership: Wistron

Upcoming Launch Manifest

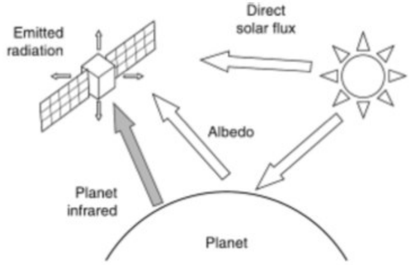
Mission / Type	Developers	Mission Objectives	Launch Date / Provider
Deep Space Radiation Probe, Lunar Payload	NCU	Ionizing radiation, deep space capacity building	2024/12, ispace
Koyo, 3U CubeSat	NCU, Aegiverse, Hex20	Tech Demo, Drag Characterization	2025 Q3/Q4, Skyroot
COSPAR-1, 3U CubeSat	CU Boulder, NCU, LATMOS, Hex20	Solar spectrum, ionizing radiation, climatology	2025 Q3/Q4, Skyroot
PEARL-1A, -1B	NCU, Foxconn	Inter-satellite link, ionosphere	2025/2026
SAISI 3U CubeSat	NCU, Hex20	AIS payload qualification	2026, TBR
SCION-X 12U CubeSat	NCU, Wistron	Hyperspectral imaging, ionosphere / upper atmosphere	2026/6, SpaceX via ExoLaunch
COSPAR-2 Lunar Sentinel 6U Lunar Orbiter CubeSat	CU Boulder, NCU, LATMOS, Hex20	Space weather, AI positioning and navigation	2026 Q3/Q4, ispace

Spacecraft System Architecture

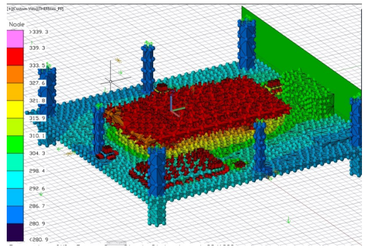


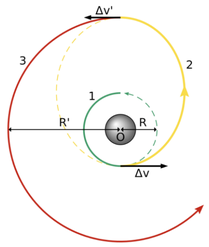


Payload
酬載



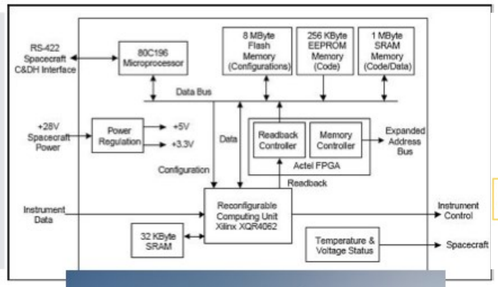
Thermal Control (TCS)
熱控

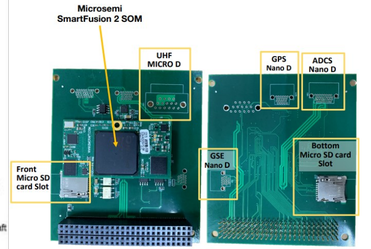


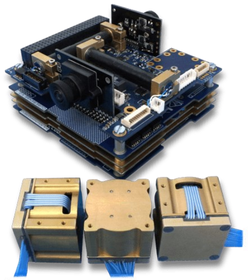


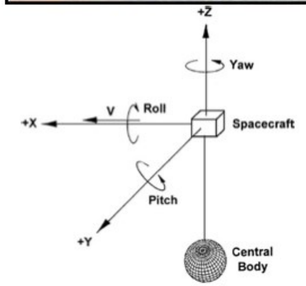
Propulsion (PROP)
推進

Command & Data Handling (CDH)
指令與資料處理



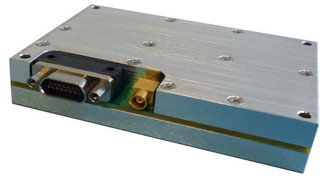


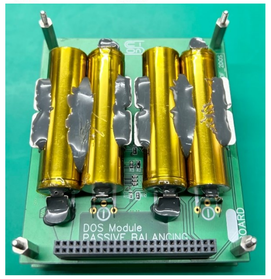




Attitude Determination & Control (ADCS)
姿態感測與控制

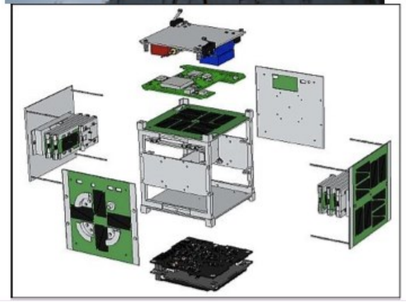
Telecommunications (COMM)
通訊

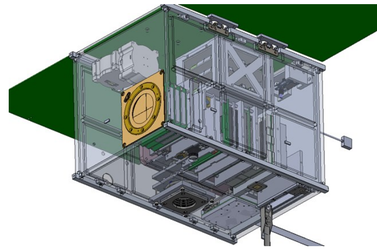




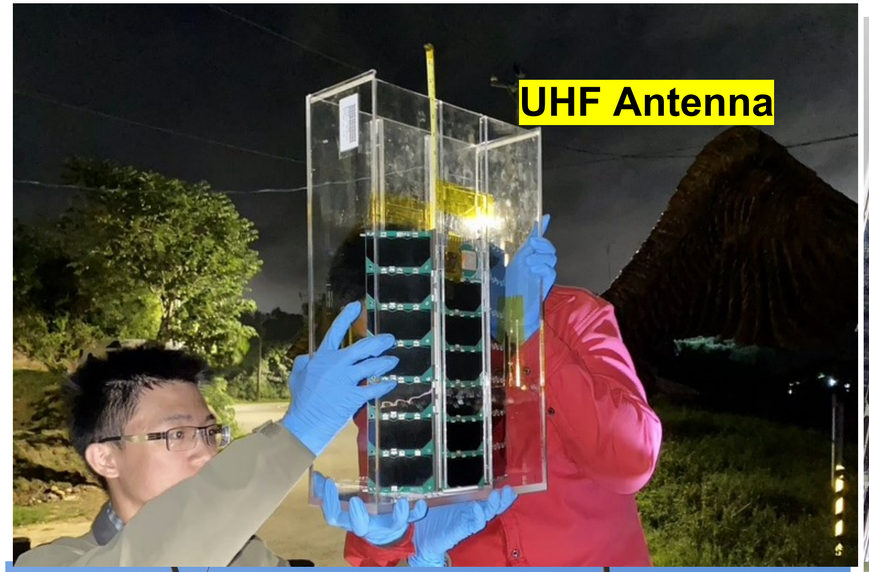
Power (EPS)
電力

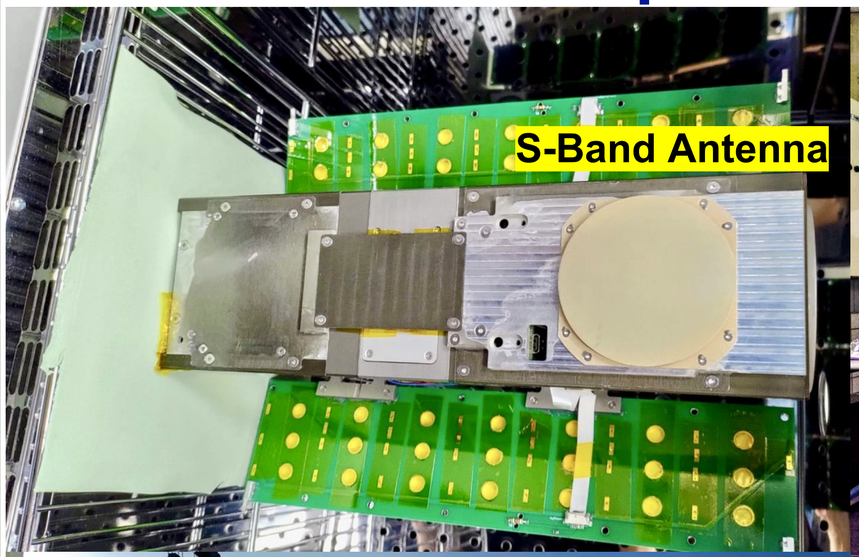
Structure & Mechanisms (ST)
結構



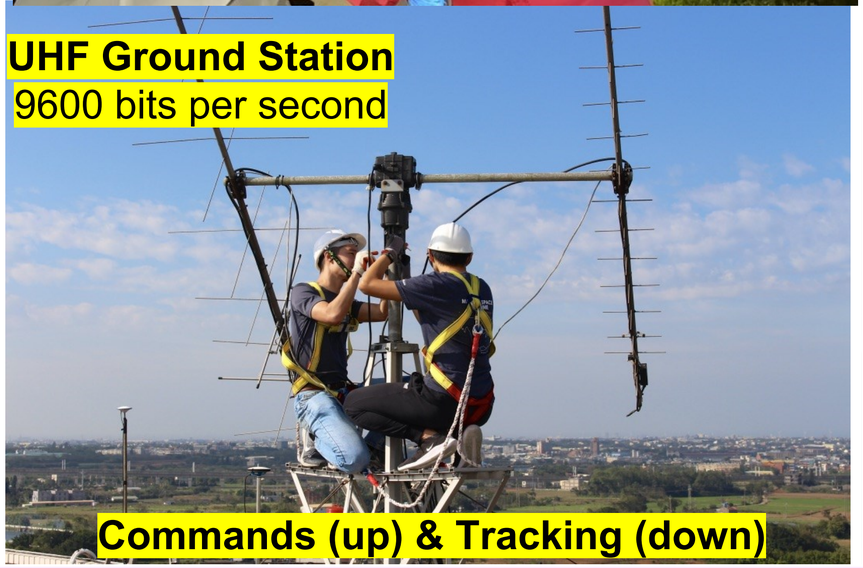


Ground Station / Mission Operations Center

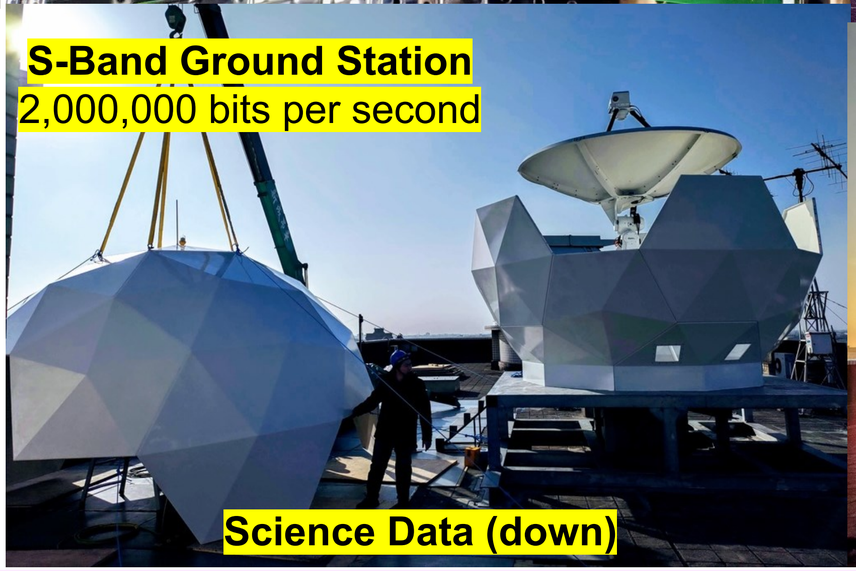




UHF Ground Station
9600 bits per second



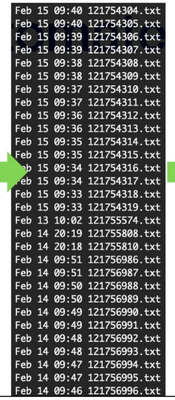
S-Band Ground Station
2,000,000 bits per second



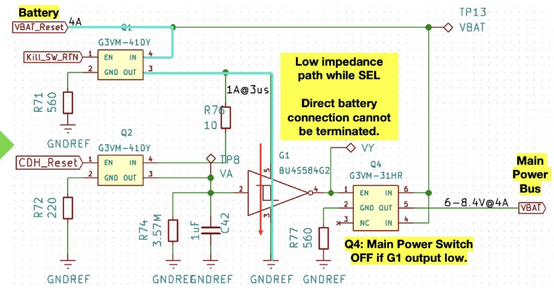
IDEASSat Flight Results

Mission Operations

Flight Data



Fault Identification



aerospace

MDPI

Article

Lessons Learned from IDEASSat: Design, Testing, on Orbit Operations, and Anomaly Analysis of a First University CubeSat Intended for Ionospheric Science

Yi-Chung Chiu [1], Loren C. Chang [1,*], Chi-Kuang Chao [1], Tzu-Ya Tai [1], Kai-Lun Cheng [1], Hsin-Tzu Liu [1], Rong Tsai-Lin [1], Chi-Ting Liao [1], Wei-Hao Luo [1], Guan-Po Chiu [1], Kai-Jie Hou [1], Ruo-Yu Wang [1], Glenn Franco Gacal [1], Pin-An Lin [1], Sittinat Denduonghatai [1], Tsai-Ru Yu [1], Jann-Yenq Liu [1], Amal Chandran [2,3], Kashyapa Bramha Naren Athreyas [3], Priyadarshan Hari [4], Joji John Varghese [4] and Mustapha Meftah [5]

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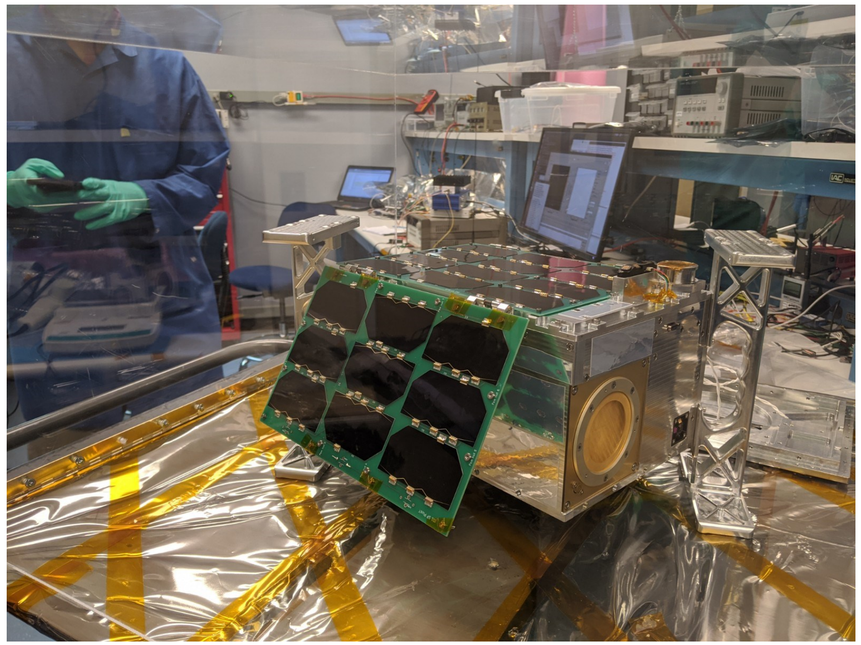
[2] Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder, Boulder, CO 80303, USA;

- Automated tracking, flight data downlink, command uplink at NCU (after lots of frantic debugging).
- Over 700 counts of flight data to verify design.
  - Good power, link, and thermal margins.
  - Early loss after approximately 2 months due to possible EPS Single Event Latchup. Designs revised.
  - https://doi.org/10.3390/aerospace9020110
- Mission lifetime: > 2 months of 6-month objective.

Lessons Learned:
Flight data is an important product.
There is no test more comprehensive than reality.
Fail fast. Revise quickly.



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Advances in Space Research 68 (2021) 2616–2630

ADVANCES IN SPACE RESEARCH
(a COSPAR publication)

www.elsevier.com/locate/asr

The INSPIRESat-1: Mission, science, and engineering

Amal Chandran [a,e,*], Tzu-Wei Fang [b], Loren Chang [c], Priyadarshan Hari [d], Thomas N. Woods [a], Chi-Kuang Chao [c], Richard Kohnert [a], Ankit Verma [d], Spencer Boyajian [a], Yi Duann [c], William Evonosky [a], Mallikarjun Kompella [d], Rong Tsai-Lin [c], Anant Kumar [d], Sarthak Srivastava [e], Bennet Schwab [a], Robert Sewell [a], Mayuresh Sarpotdar [e]

[a] *Laboratory for Atmospheric and Space Physics, University of Colorado Boulder, CO 80303, USA*
[b] *Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, CO 80303, USA*
[c] *Department of Space Science and Engineering, Center for Astronautical Physics and Engineering, National Central University, Taoyuan City 32001, Taiwan*
[d] *Indian Institute of Space Science and Technology, Thiruvananthapuram 695547, India*
[e] *Satellite Research Centre, School of Electrical and Electronic Engineering, Nanyang Technological University, 639798, Singapore*

Received 3 September 2019; received in revised form 9 June 2021; accepted 14 June 2021
Available online 24 June 2021

Joint development by students at NCU, University of Colorado at Boulder, and Indian Institute of Space Science and Technology as part of INSPIRE summer internship starting in 2017.

Initial flight experience with IDEASSat allowed for identification and implementation of ground segment bug fixes to support INSPIRESat-1.

Data saved to On Board Computer (OBC) SD Cards.

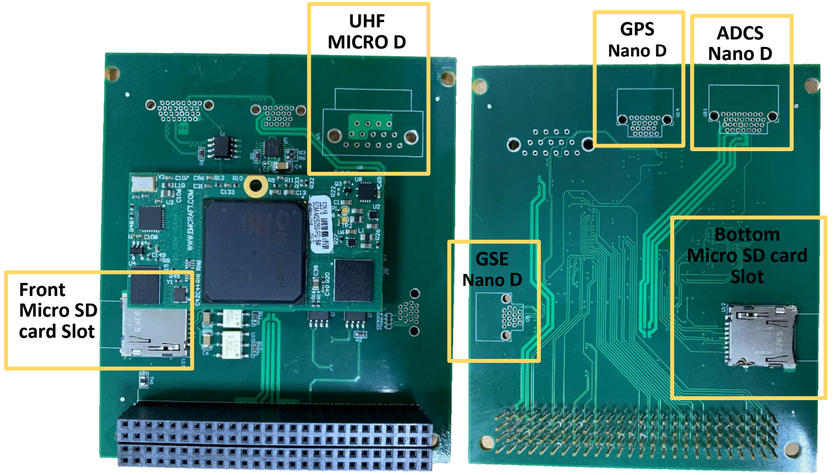
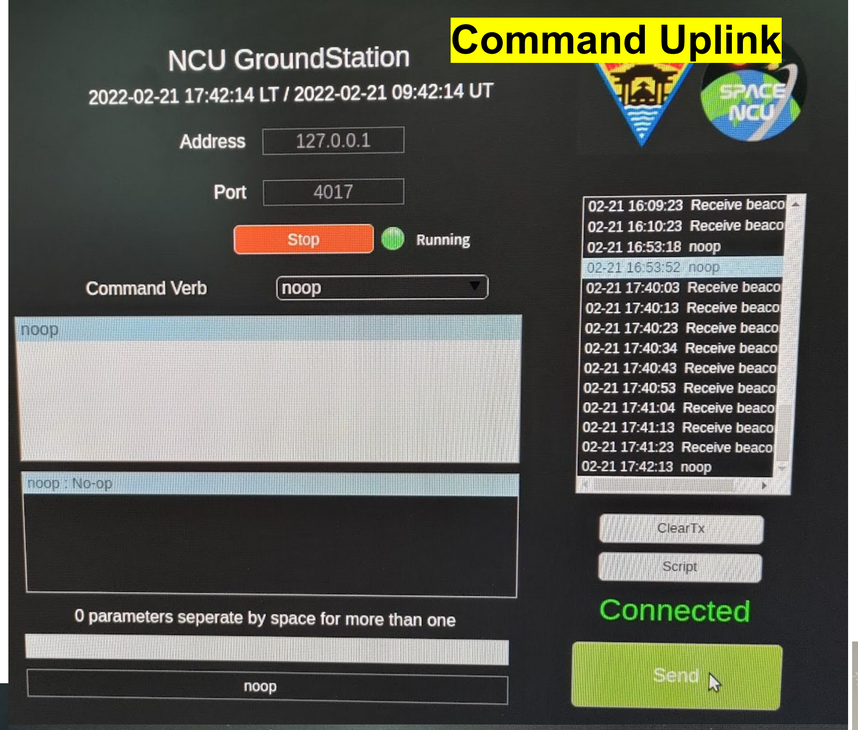
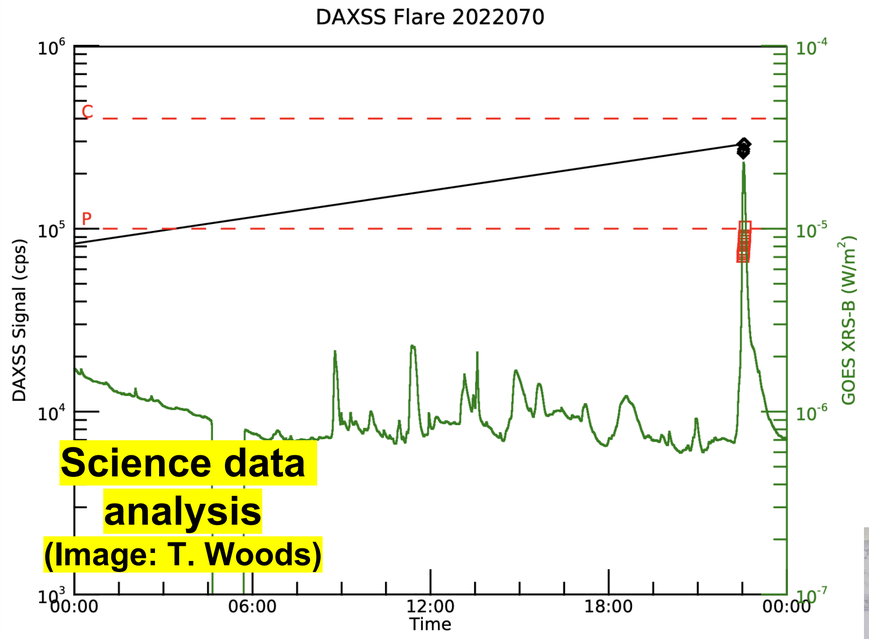


Figure 3: Connectors of C&DH interface board.

Command Uplink

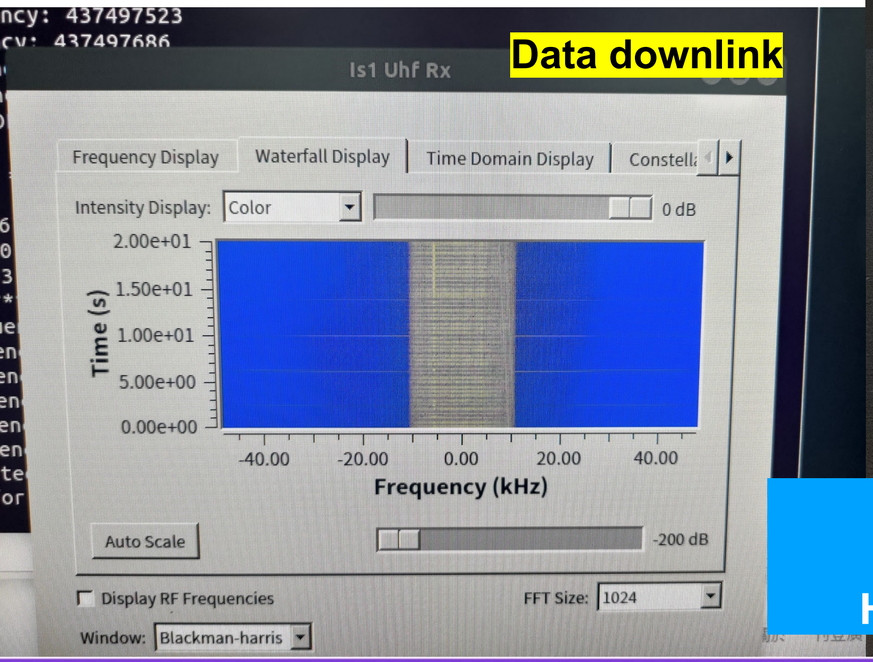


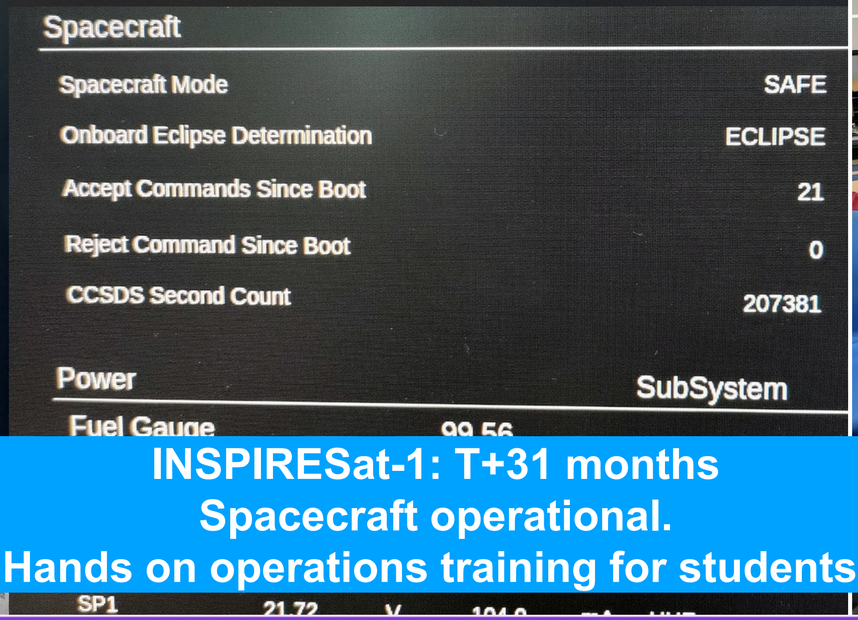


Science data analysis

(Image: T. Woods)

Data downlink





INSPIRESat-1: T+31 months
Spacecraft operational.
Hands on operations training for students.

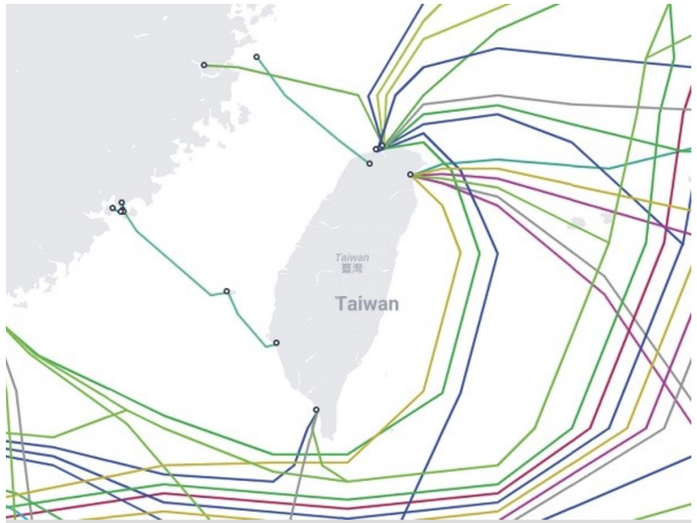
Satellite Communications Developments

TAIPEI 台北時報 TIMES

Sun, Mar 12, 2023 page1

Digital ministry to set up satellite Internet network

ADDED SECURITY: The satellite network would allow the government to stay in contact with key agencies and allies should an attack cut Internet cables



Map of submarine cables leading to and surrounding Taiwan. (Submarine Cable Map screenshot)

The Taiwan Space booth at the 2022 SATELLITE Conference and Exhibition in Washington is pictured in an undated photograph.

Photo courtesy of the Industrial Technology Research Institute

Space and LEO B5G satellite communications identified as key national priority for robust communications.

Taiwan OEM electronics and 5G communications firms actively involved / trying to be involved in LEO satcom supply chain.

Experience and Flight Heritage in NCU Smallsat Design and Communications with Foxconn

PEARL-1C, 1H (Launched: 2023/11/12):
Ku/Ka band communications payload

PEARL-1A, 1B (Launch 2025):
Inter Satellite Link

FOCUS TAIWAN
CNA ENGLISH NEWS

Science & Tech

Hon Hai satellites could soon be on their way into space

11/06/2023 09:24 PM

Like 29 Listen

Photo courtesy of Hon Hai Precision Industry Co. Nov. 6, 2023

https://focustaiwan.tw/sci-tech/202311060022

- Taiwan currently in transition from sole government space program to growing private space industry.

- As oldest academic institution with space experience in Taiwan, NCU serving to build capacity in terms of industry collaborations, personnel training, and as Track 1.5 international matchmaker.

  - Increasing number of industry partnerships with electronics and 5G communications sector have been beneficial in terms of joint development and student mentoring, tech transfer / retention, student post-graduation employment.

NCU Deep Space Radiation Probe

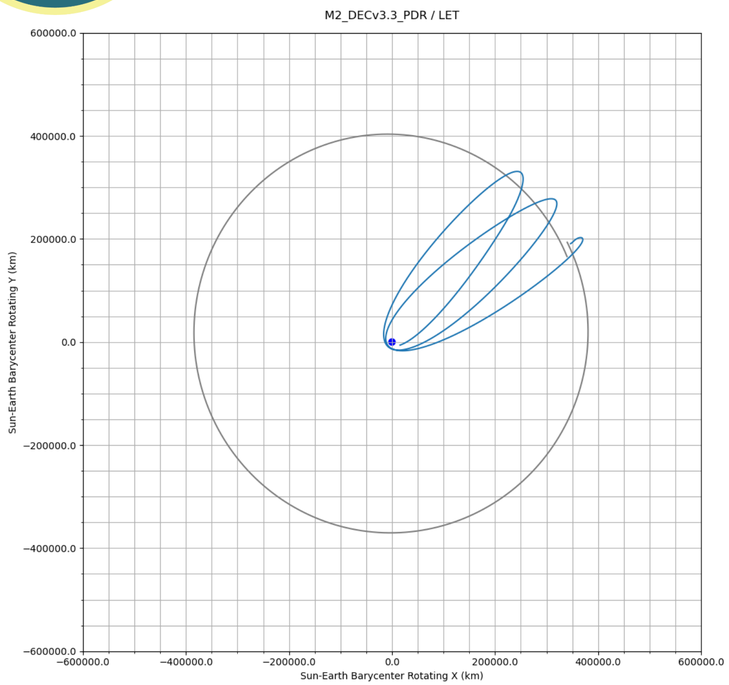
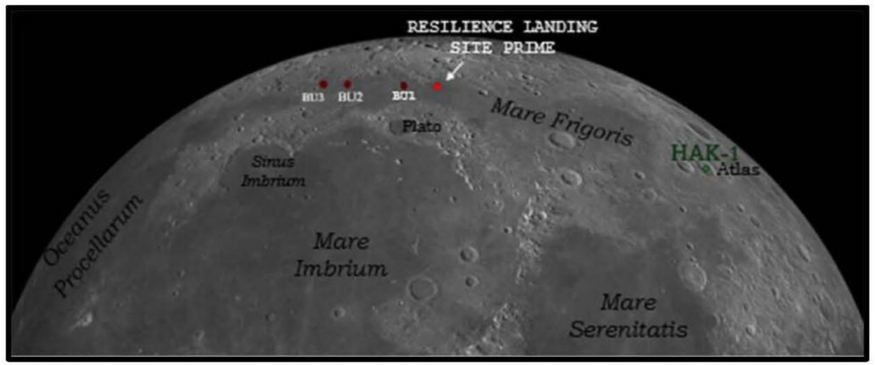
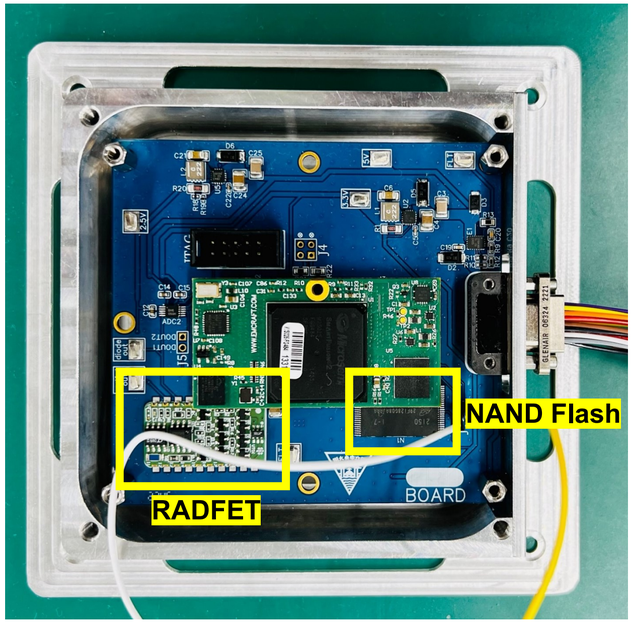


Figure: post-launch ~ lunar swing-by





- Deep Space Radiation Probe radiation dosimeter payload developed by NCU for ispace Hakuto-R Mission 2 Resilience lander to measure deep space radiation environment and effect on electronics.
  - CubeSat compatible version: Compact Radiation Probe (CRP). Launch on COSPAR-1 3U mission 2024 Q3.
  - First Taiwan mission beyond Low Earth Orbit.
- RADFET dosimeter: Radiation dose inferred from increase in threshold voltage of radiation sensitive field effect transistor. Dose rate can be calculated by regular sampling.
- SEU counter: NAND flash memory periodically scanned for bit errors, which are corrected and counted.

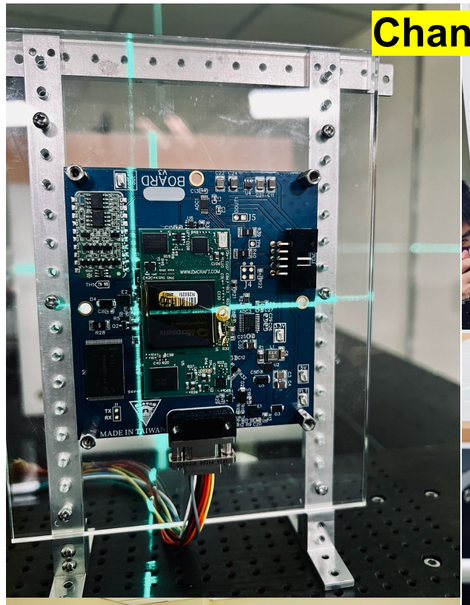
National Tsing Hua University

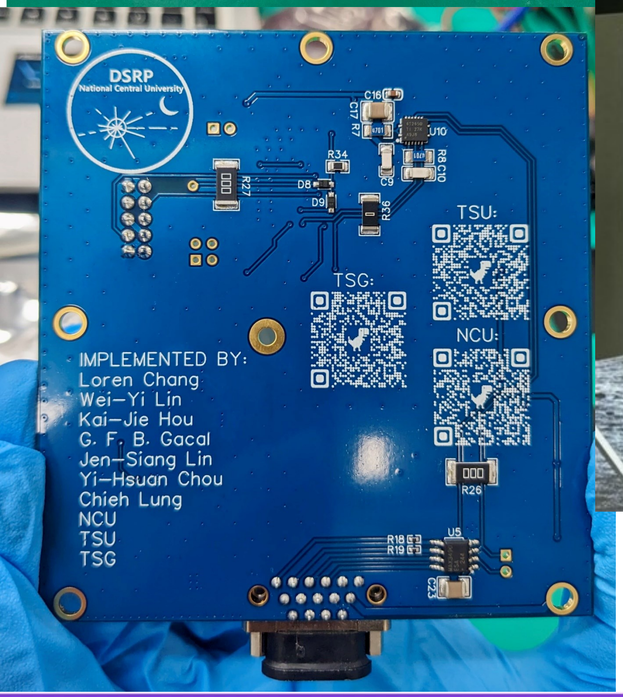
Total Ionizing Dose for Lunar Payload over 3 months:

10 krad (100 Gy) with 2 mm aluminum shielding.

Twice the dose required to cause cardiovascular and central nervous system damage and death within 3 days.

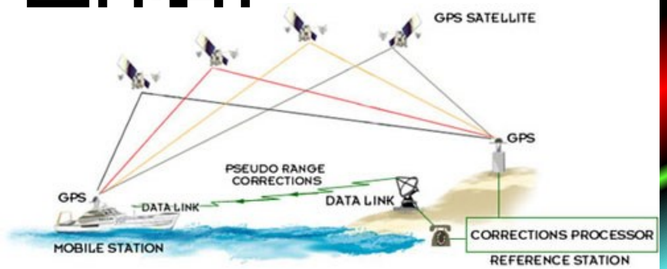
Chang Gung Hospital Proton Therapy Center

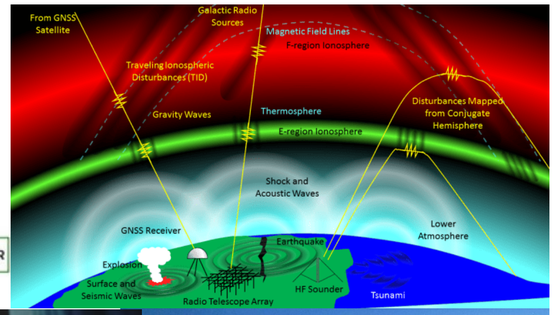




2023/12/12: FM complete, shipped to Japan.
2024/01/15: Unpackaging, final update, and formal transfer to ispace.
2024/09/12: Integration complete. Launch in December.

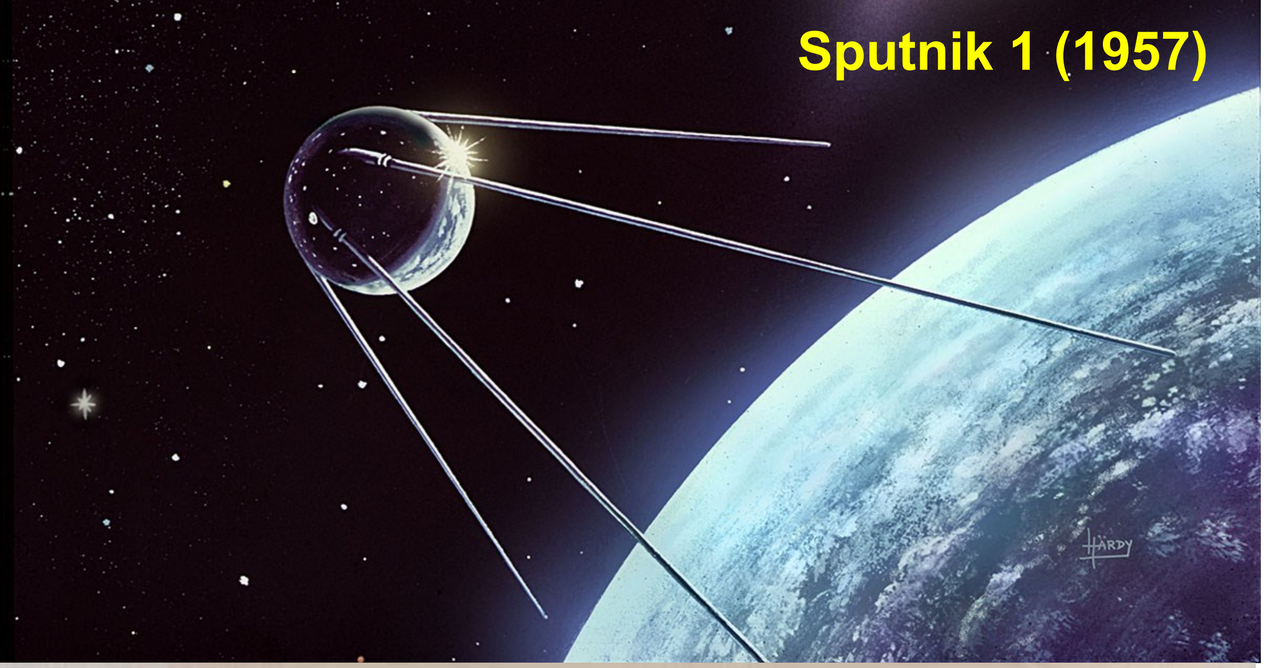
Future Work and Objectives

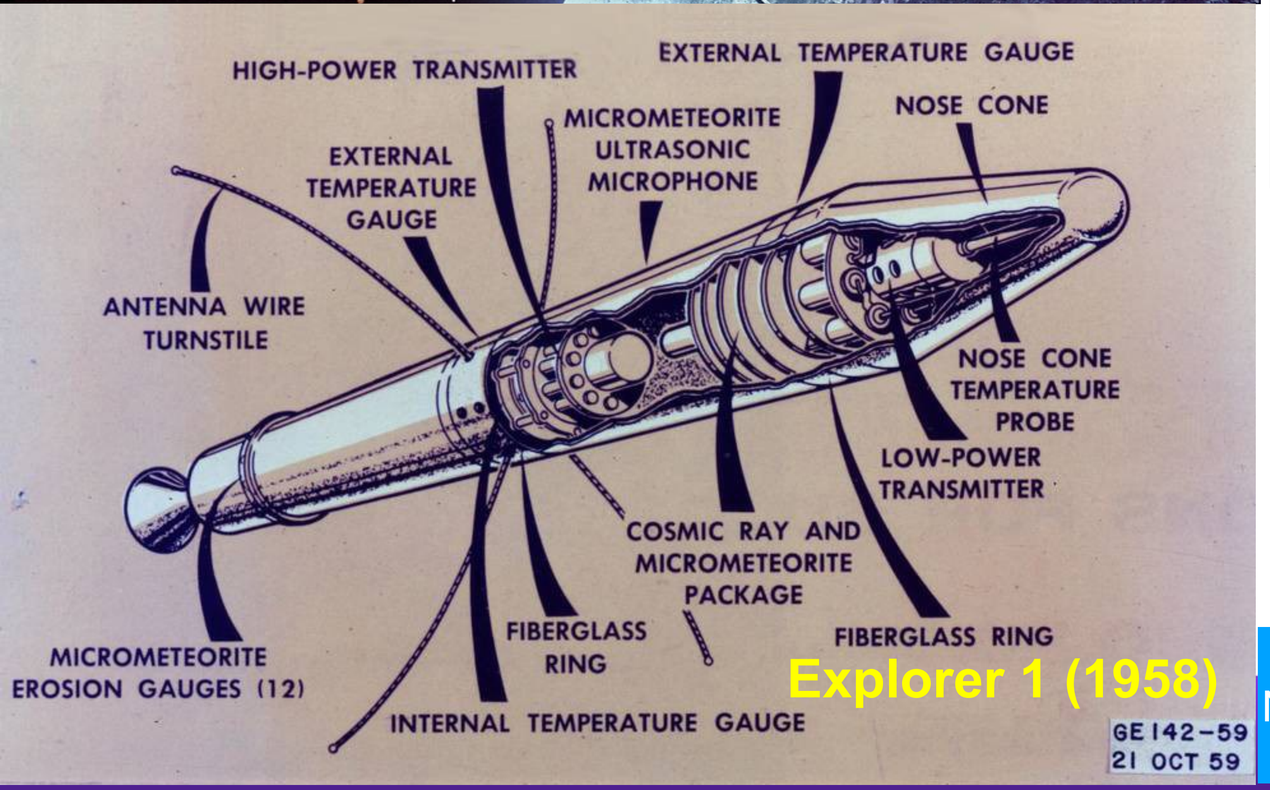


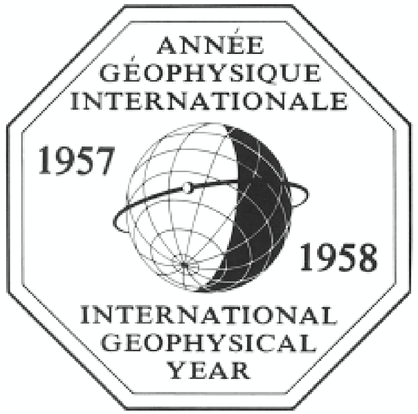


- LEO Small Satellite Applications:
  - B5G Ka band communications.
  - Satellite Internet of Things (IoT) platforms.
  - Navigation & Timing.
- Small satellite self sufficiency.
- Space situational awareness capacity development.
- Applied Space Weather / Environment Research:
  - Ionospheric effects on GNSS & applications.
  - Ionizing radiation environment monitoring.
- Microgravity / biomed experiments.
- Moving beyond LEO with new rideshare opportunities.
- Partnerships to support industry missions / capacity building.
- Continuing to provide students the opportunity for hands on learning and international exchange through participation in small satellite missions and consortiums such as INSPIRE and COSPAR TGCSS.

Appendix







1915 南京 南京高等師範學校

1921 南京 國立東南大學

1927 南京 第四中山大學

1928 南京 國立中央大學

1949

臺灣

1962 苗栗 國立中央大學 地球物理研究所

1968 中壢 國立中央大學 理學院

1979 中壢 國立中央大學

中國大陸

1952 院系整合，衍生為東南大學、南京大學等12所學校

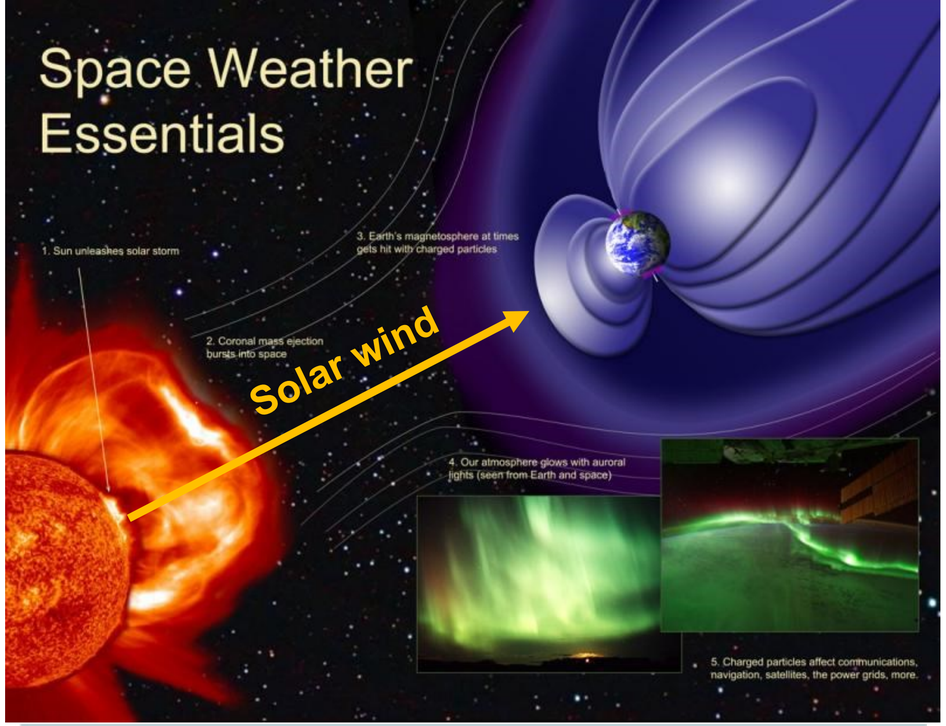
1962:
National Central University established in Taiwan with focus on Earth and space science, as an outgrowth of IGY.

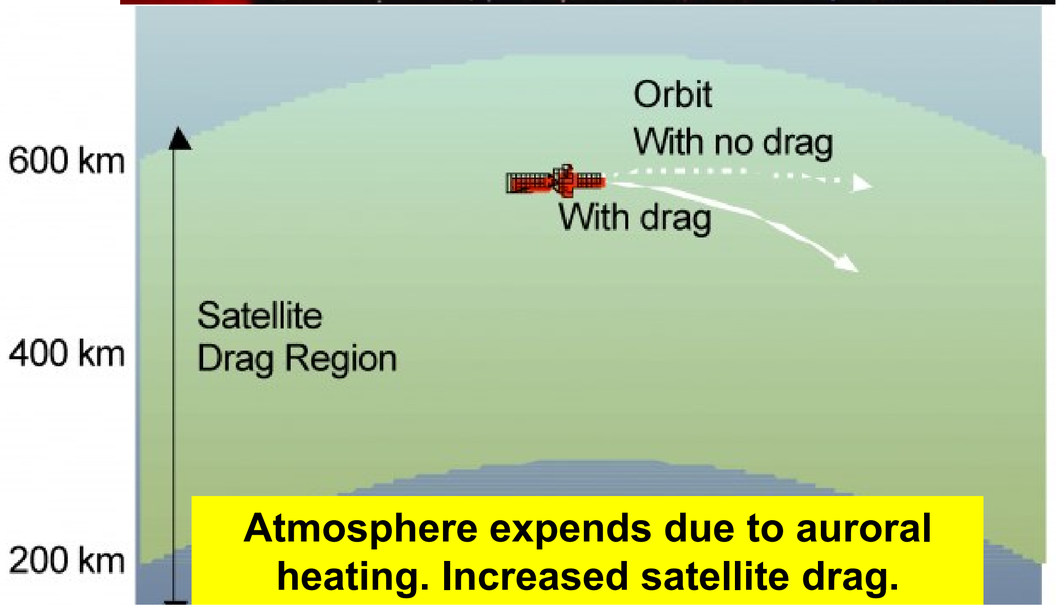
Better space weather forecast could have saved SpaceX Starlink satellites from solar storm

By Tereza Pultarova published 26 days ago

But experts know how to fix it for the future.

https://www.space.com/spacex-starlink-satellite-loss-space-weather-forecast



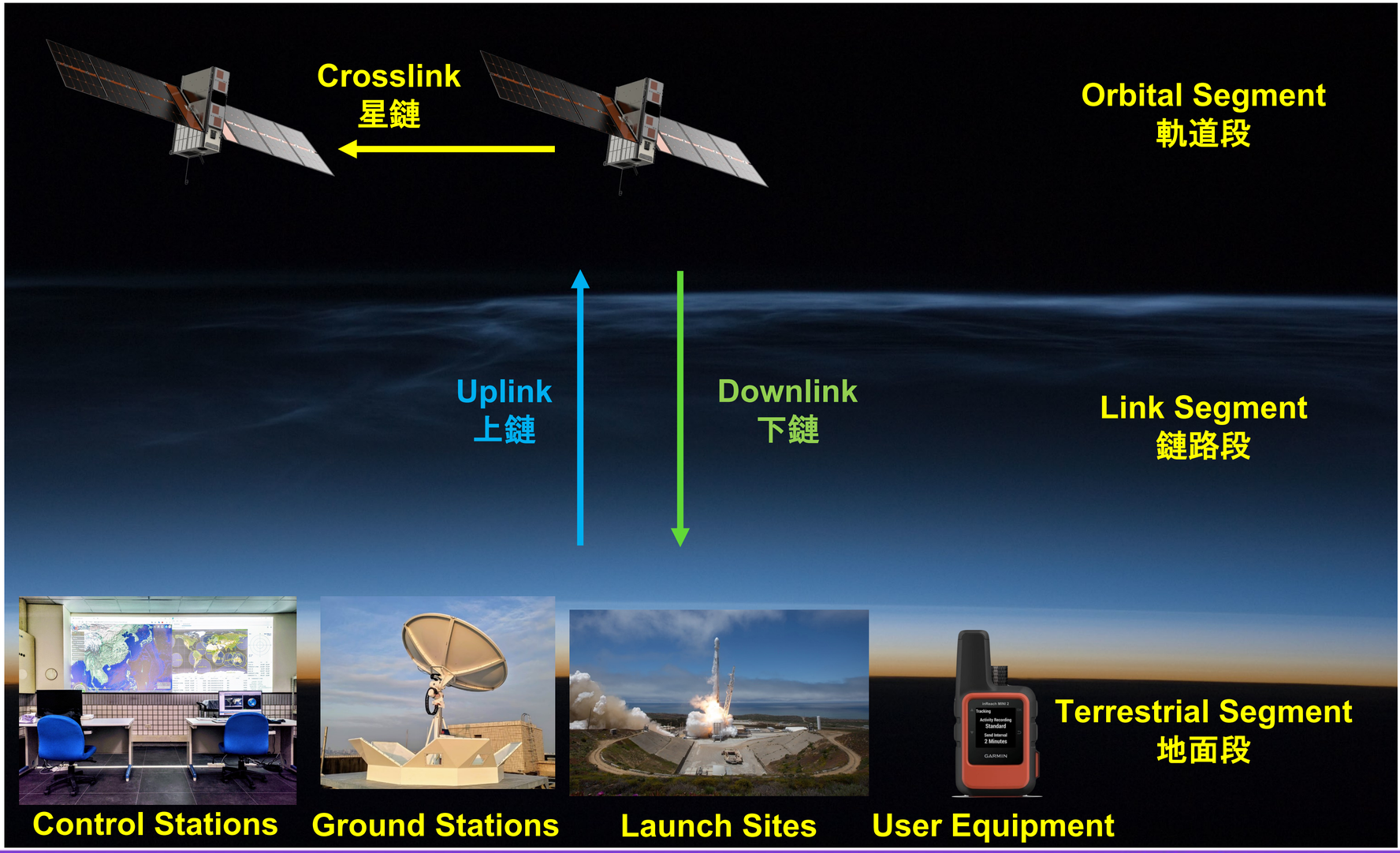


Space System Architecture

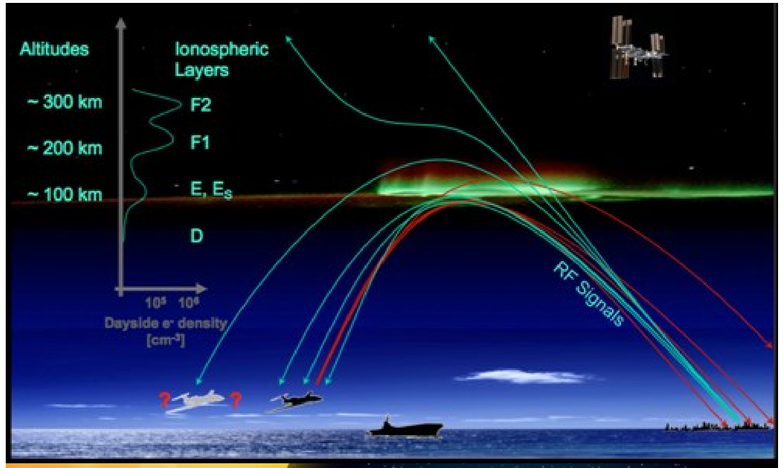
Orbital Segment
Spacecraft in orbit beyond Earth's atmosphere. Depending on the application, spacecraft can be remotely piloted, crewed, or autonomous.

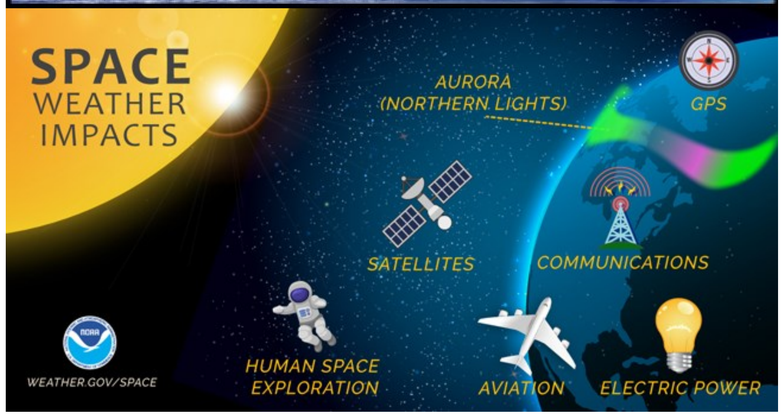
Link Segment
Signals in the electromagnetic spectrum that connect the terrestrial segment and the orbital segment. Includes uplink, downlink, crosslink.

Terrestrial Segment
Equipment within the terrestrial domains required to operate or exploit a spacecraft.

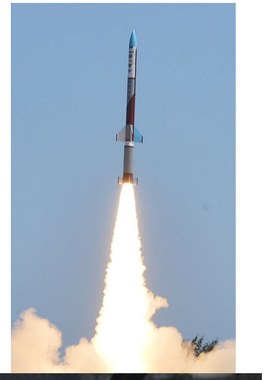


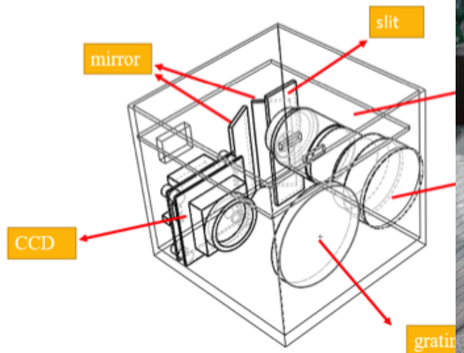
Evolution of NCU Space Capacity

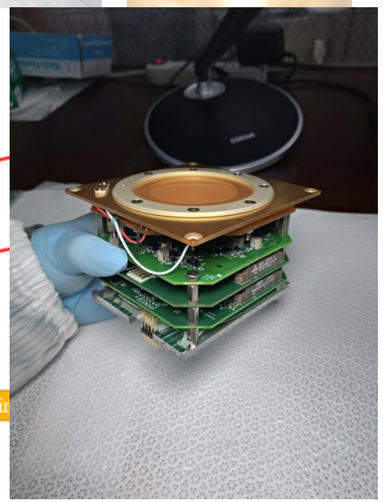




1960 – 1989
Space Physics,
Space Weather & Environment







1990 – 2010s
Payloads & Instruments

2015 - present
Space Systems Engineering