NARLabs 國家實驗研究院

國家太空中心

National Space Organization

NSPO

A center of innovation and excellence for space technology in Taiwan

Data Assessment of Airborne GNSS Reflectometry Experiments for Triton Satellite Mission

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GPS/GNSS Reflectometry

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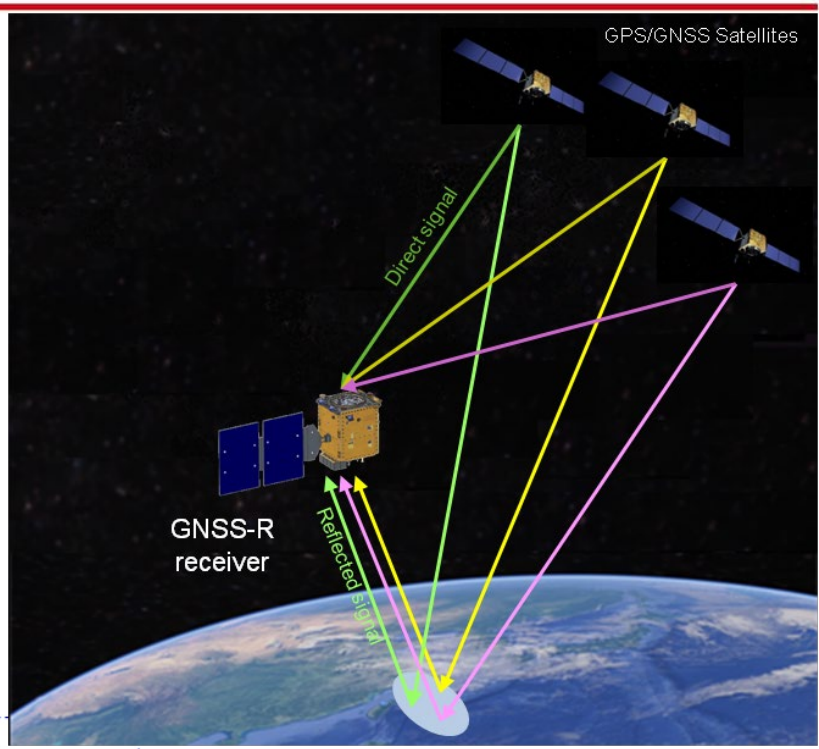
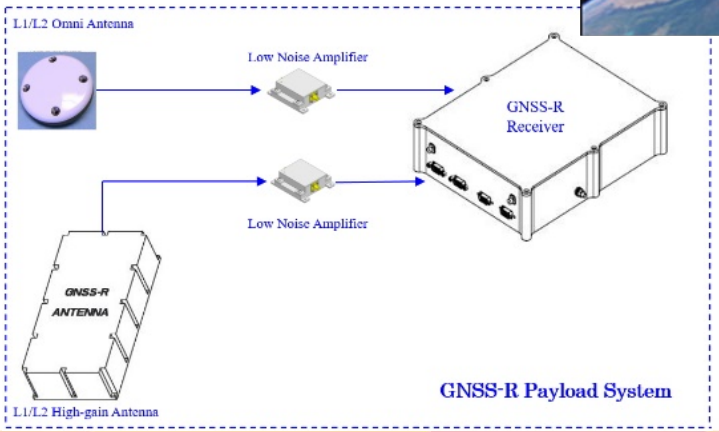
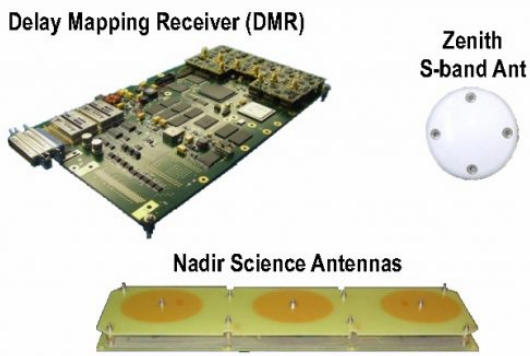
承諾・熱情・創新

- GNSS-R principle:
  - The reflected signals from GPS/GNSS satellites can provide information of Earth's surface for remote sensing applications
- GNSS-R remote sensing applications
  - Ocean: wind speed, sea ice, tsunami, hurricane
  - Land: soil moisture, glacier, lake
- Space based observations
  - UK-DMC (2003) / UK TDS-1 (2014)
  - NASA CYGNSS (2016)
  - TRITON (2021)







Triton vs. FS-7 Mission Satellite

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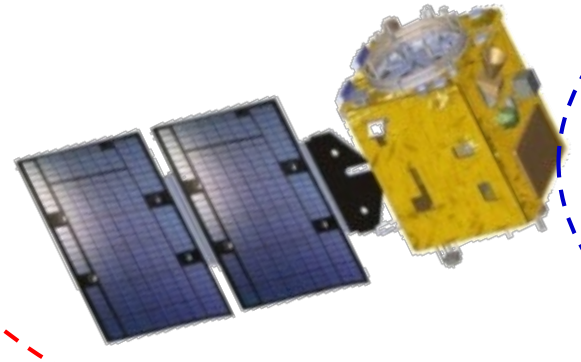
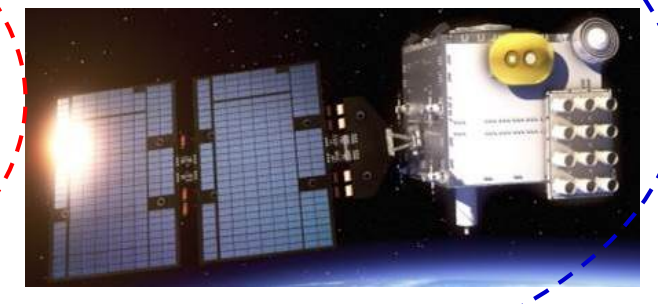
Triton (FS-7R) Mission

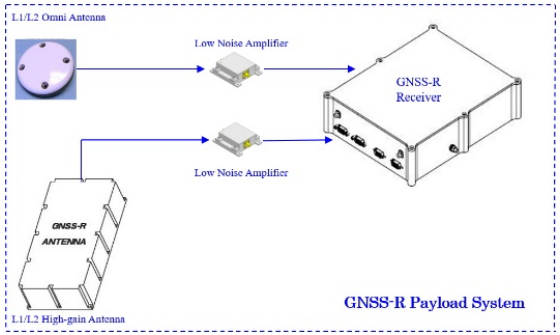


Common components:

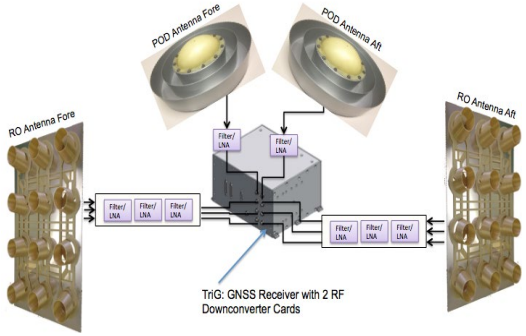
- Propulsion system
- S-band transceiver
- Reaction wheel
- Magnetometer
- Coarse sun sensor
- Magnetic Torquer
- Battery

FS-7 Mission





GNSS-R Mission Payload



TGRS Mission Payload

Triton Satellite Configurations

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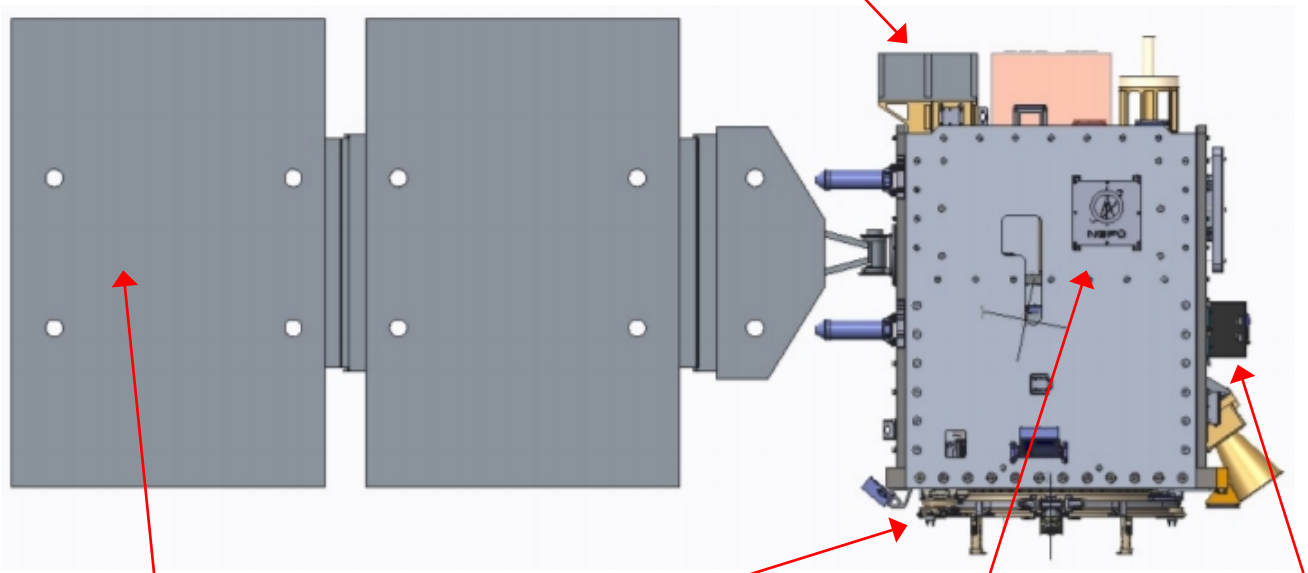
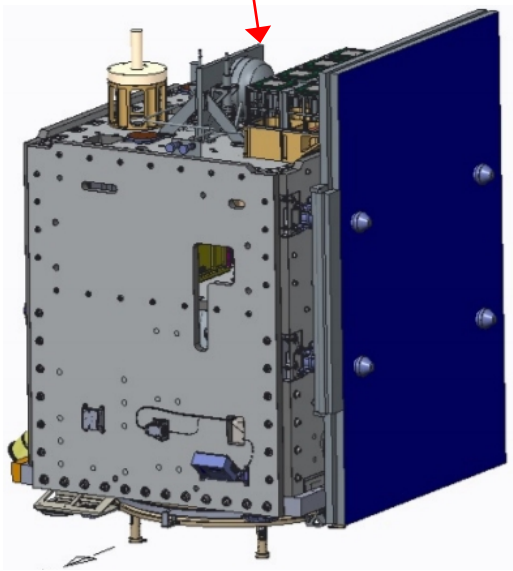


Deployed Configuration



Stowed Configuration

Triton Key Parameters and Milestone

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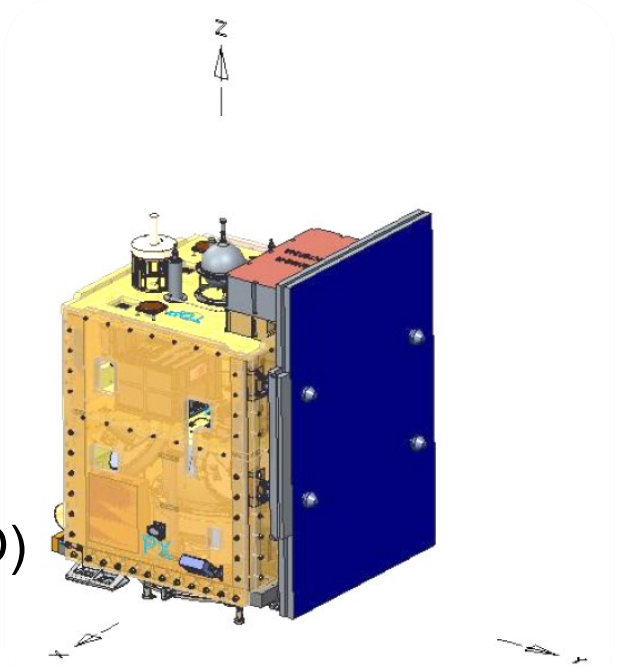
- **Spacecraft key parameters and performance：**
  - Volume (Stowed)：100x120x125 (cm)
  - Mass：< 285 kg
  - Design life time：5 years
  - Mission orbit altitude: circular 550~650 km
  - Mission orbit inclination: > 24° (including SSO)
  - Attitude control accuracy: better than 0.1 degree (3 sigma)
  - Attitude knowledge: better than 0.1 degree (3 sigma)
  - Science data storage: > 2 G-bit



Triton GNSS-R Mission Payload

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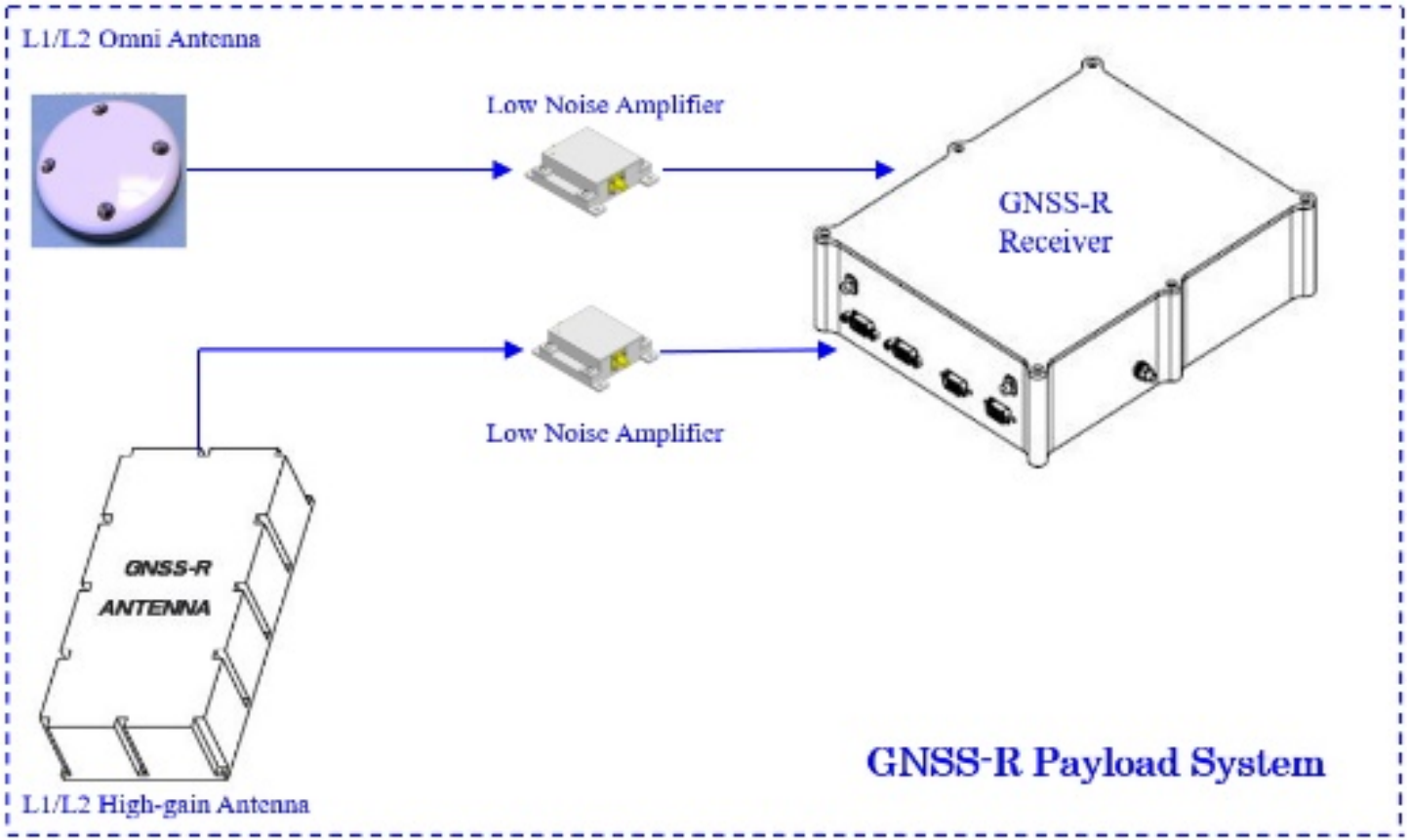
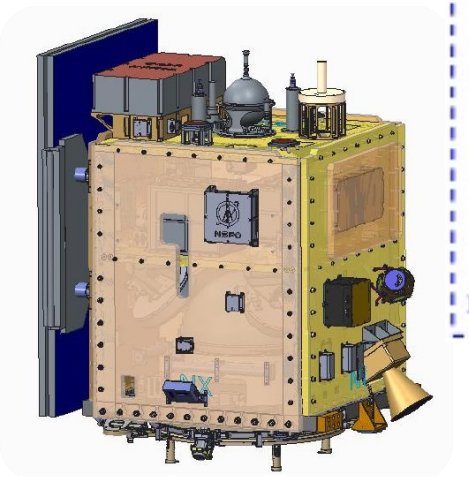




GNSS-R Mission Payload Status

■ L1/L2 LNA flight model is ready.

- Very high gain: ~33 dB
- Very low noise figure: <1.5 dB
- Gain/noise figure vs. temperature profiles will be measured.

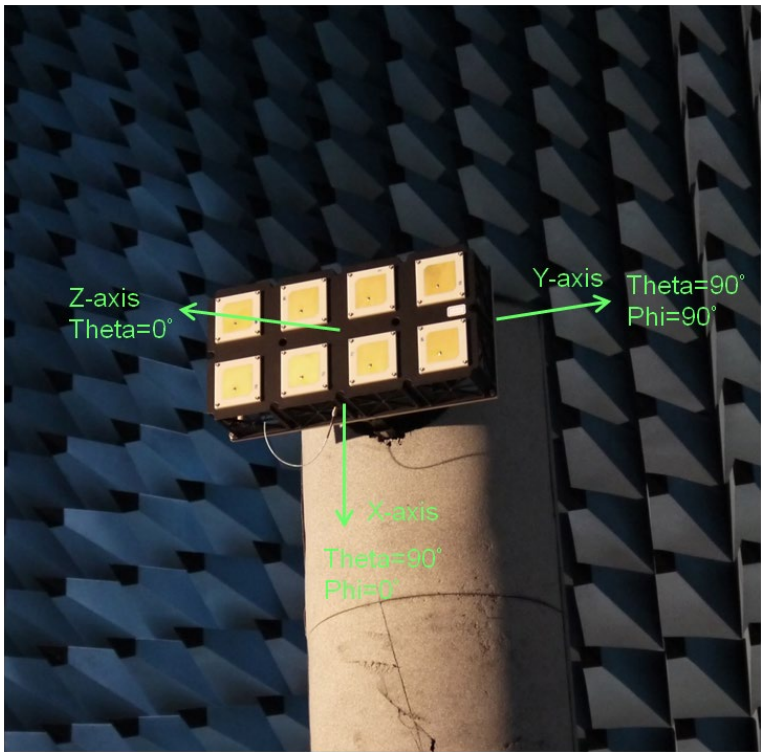
Characteristic		Value								
Sym.	Parameter	Typ.	Typ.	Typ.	Typ.	Typ.	Typ.	Typ.	Typ.	Unit
V_{cc}	**Supply Voltage**	**+2.8**	**+2.9**	**+3.0**	**+3.1**	**+3.2**	**+3.3**	**+3.4**	**3.5**	**V**
I_{cc}	Supply DC Current	25	26	28	29	30	31	33	34	mA
1.575GHz Performance										
G	Gain	32.7	32.9	33.2	33.4	33.6	33.7	33.9	34.0	dB
NF	Noise Figure	1.13	1.13	1.16	1.18	1.19	1.21	1.22	1.22	dB
S_{11}	Input Return Loss	-24.0	-21.5	-24.7	-25.0	-25.4	-24.8	-24.5	-24.5	dB
S_{22}	Output Return Loss	-12.8	-13.0	-13.4	-13.9	-13.9	-14.6	-14.7	-14.9	dB
1.227GHz Performance										
G	Gain	34.4	34.7	34.9	35.2	35.4	35.6	35.8	35.9	dB
NF	Noise Figure	1.19	1.20	1.20	1.21	1.22	1.22	1.23	1.24	dB
S_{11}	Input Return Loss	-12.3	-12.9	-13.0	-13.3	-13.3	-13.6	-13.7	-13.8	dB
S_{22}	Output Return Loss	-9.6	-9.7	-9.7	-9.8	-10.0	-10.0	-10.1	-10.1	dB

GNSS-R Mission Payload Status (Cont'd)

■ L1/L2 Nadir High-Gain Antenna flight model is ready.

- ➢ Co-work with domestic organization
- ➢ 3D antenna gain profile was measured.
- ➢ High bore-sight gain: ~14.5 dBic

Specifications	
Frequency	L1: 1.575GHz ± 10MHz L2: 1.227GHz ± 10MHz
Impedance	50Ω
Gain: (Measured within full operating temperature)	L1≧14.5dB L2≧12.7dB(TBD)
Half Power Beam Width	L1≧19° x 37° (TBD) L2≧24° x 50° (TBD)
VSWR	≦2 (Both L1&L2)
Axial Ratio	≦3 (Both L1&L2)
Size	See MIRD
Mass	≦2Kg(TBD)
Connector Type	SMA Female
Polarization	LHCP



GNSS-R Mission Payload Status (Cont'd)

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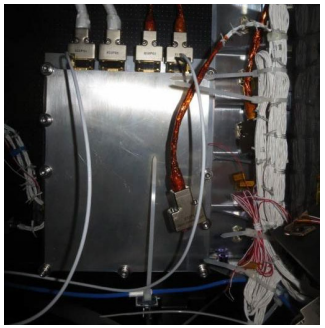
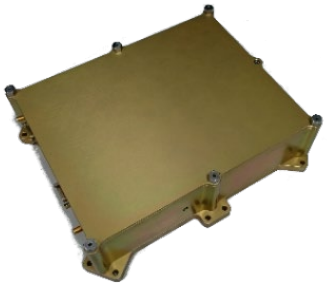
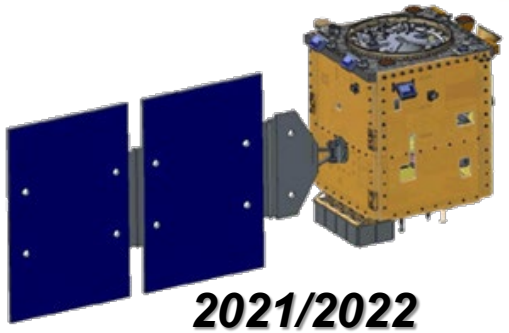
FM



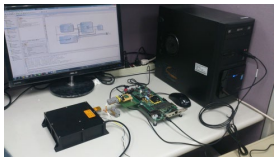
EM/EQM





2021/2022
on-orbit operation

Prototype



2016

- Definition and design of GNSS-R prototype
- Antenna gain analysis
- AIDC Flight tests and data analysis

2017

- Definition and design of EM/EQM
- Qualification environmental tests were completed.
  (EMC, TVAC, Vibration test)
- UAV flight tests
  (Data analysis / Link budget analysis)
- Galileo reflectometry DDM post-processing

2018

2019

2020

- Flight Model is ready
- Integrated and test with Triton satellite and satellite test bench
- Flight tests and data analysis
- Level-1 data retrieval

Triton Data Process System

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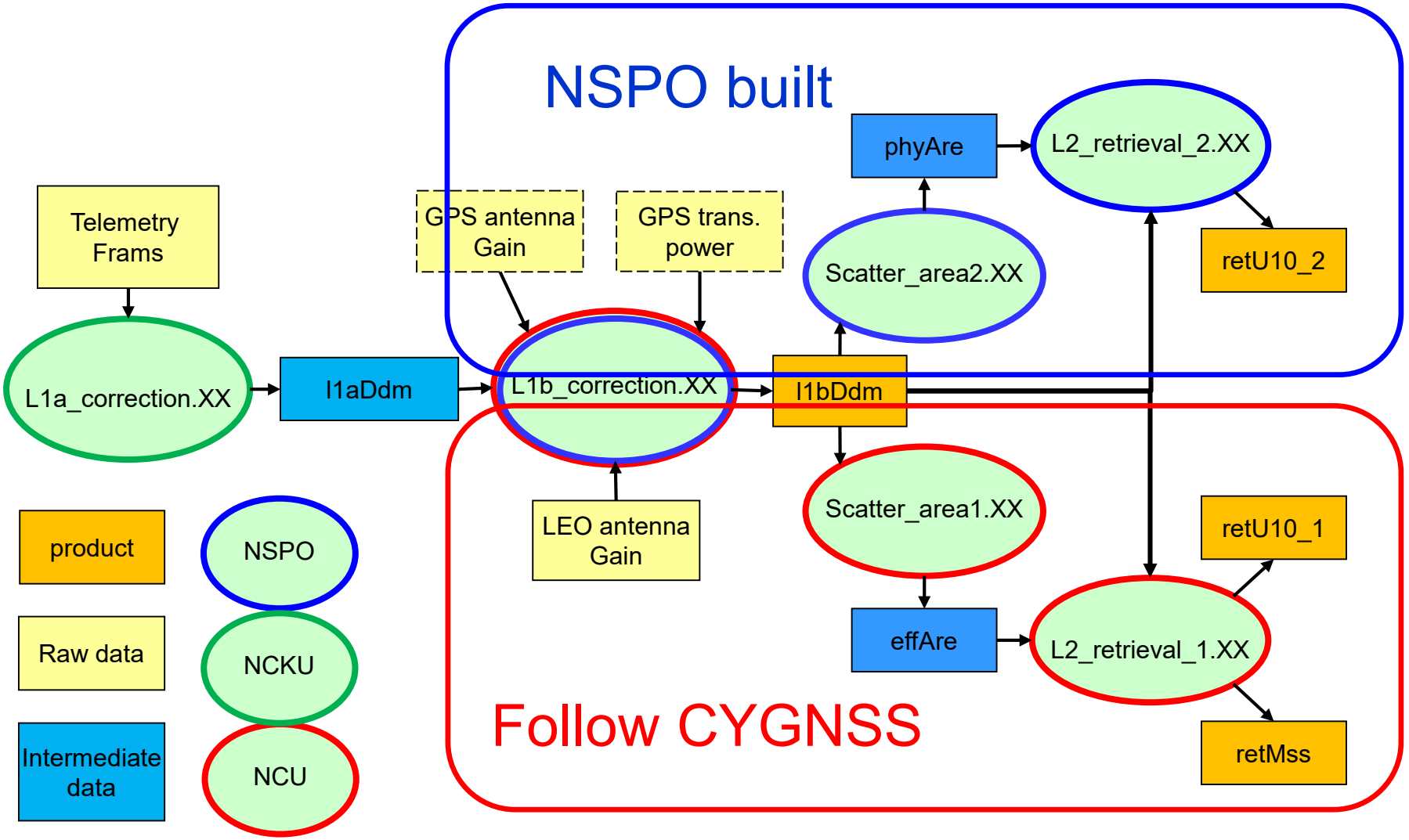

GNSS-R Payload Validation Status

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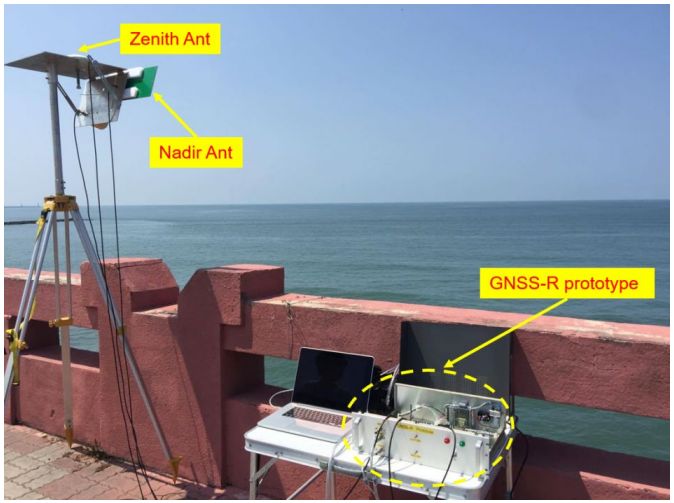
2016 Prototype

Despite ground tests have been conducted to validate the GNSS-R prototype, two airborne tests have been performed to verify the functionality of GNSS-R.



2017/2018/2019 EM/EQM/FM

During GNSS-R EM/EQM/FM development, several UAV flight tests with GNSS-R have been performed to verify the following tasks.

- Operation scheduling
- Link Budget Analysis
- Calibration mode operation
- Data validation

2020/2021 FM

GNSS-R Payload Validation Status

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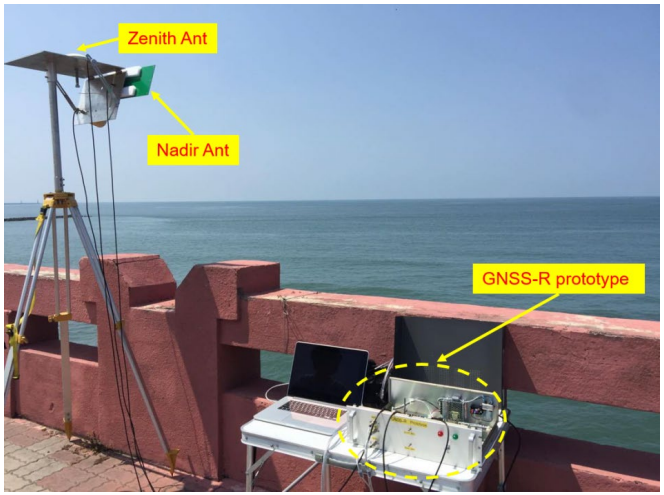
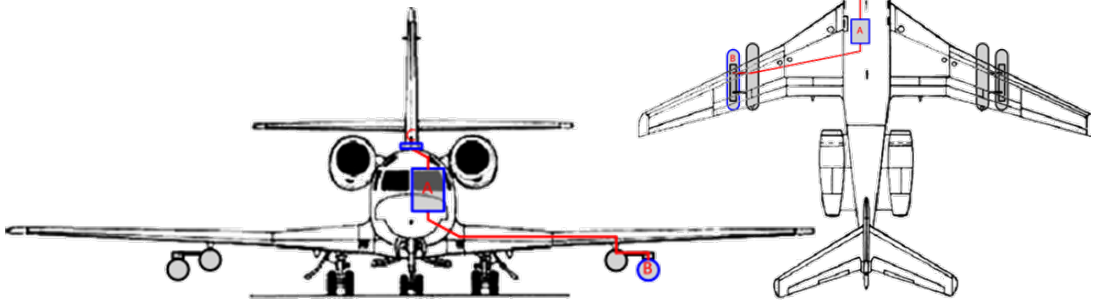
2016 Prototype

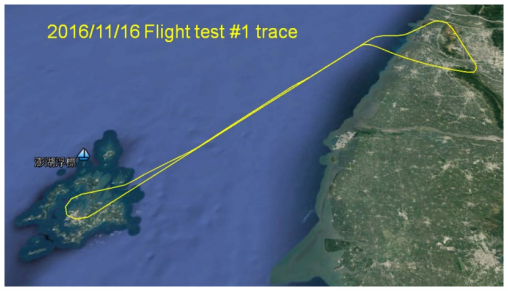


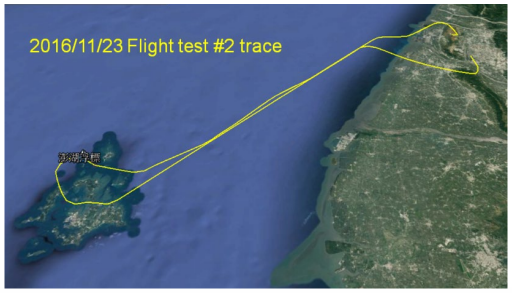
A: GNSS-R Prototype, a Laptop & a Power Supply on AIDC Console. 115V/60Hz power is required on console.

B: A Nadir Antenna mounted underneath a modified RTT-9 Tow Target. A RF Cable be routed from AIDC Console (through Pylon & Tow Winch Machine) to Nadir Antenna.

C: A Zenith Antenna & RF Cable ready for DOTSTAR Program.



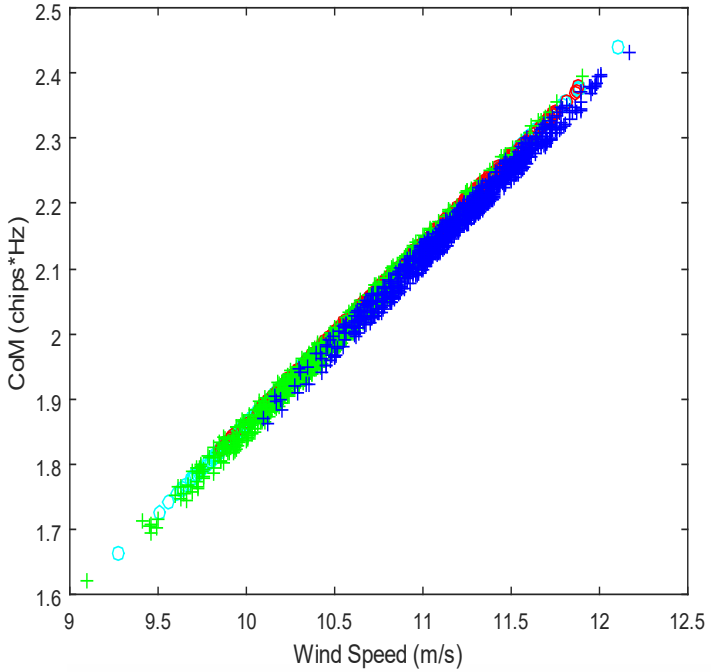




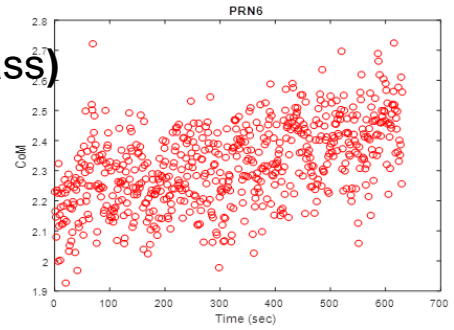
- **Wind Speed Truth Values**
  - **Buoy @ Penghu, wind speed ~ 10.4 m/s**
- **Wind Speed Observation**(Center of Mass)

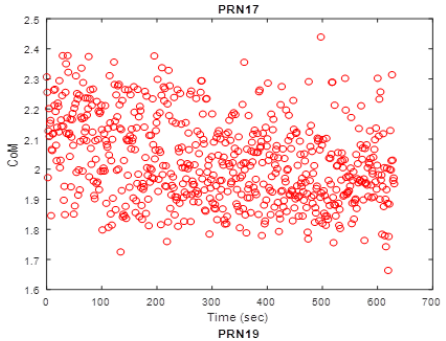
$$d = \Delta_\tau \Delta_{f_d} \sqrt{\left(\frac{MAX_\tau - CM_\tau}{\Delta_\tau}\right)^2 + \left(\frac{MAX_{f_d} - CM_\tau}{\Delta_{f_d}}\right)^2}$$

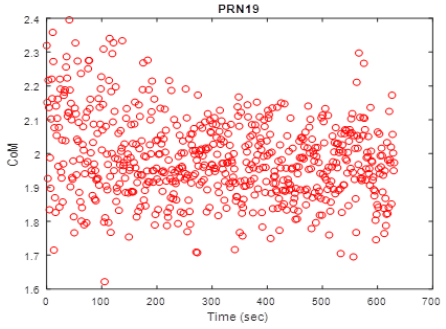
- **Linear Regression Relationships**



Data:2016/11/16







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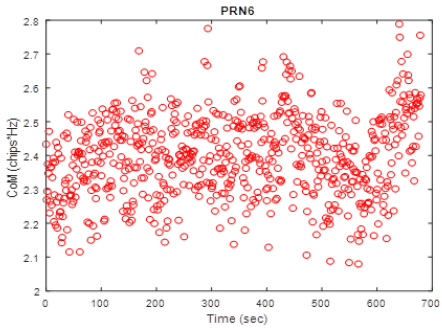

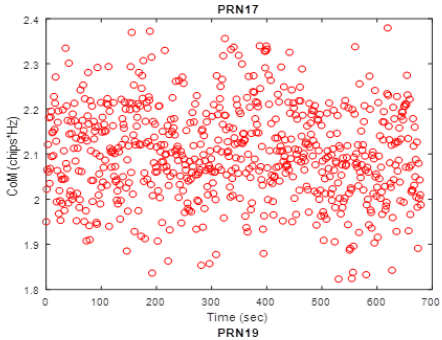

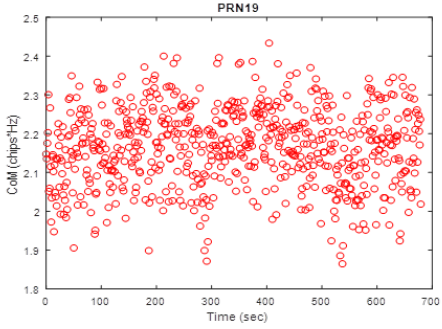

GNSS-R Payload Validation Status

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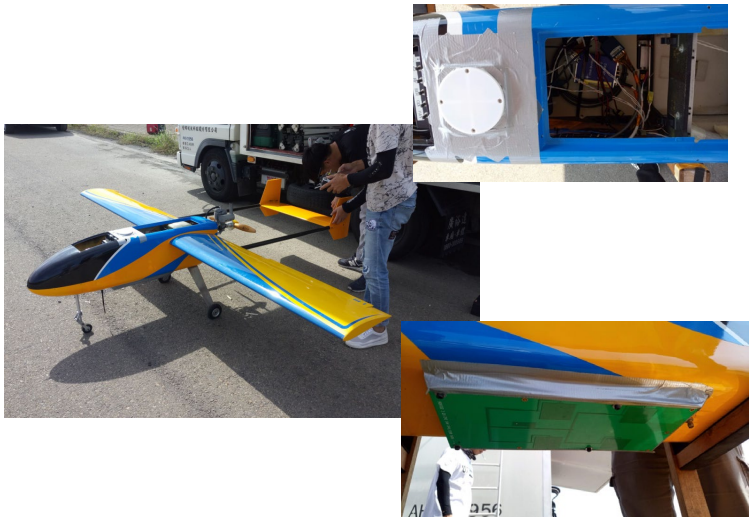
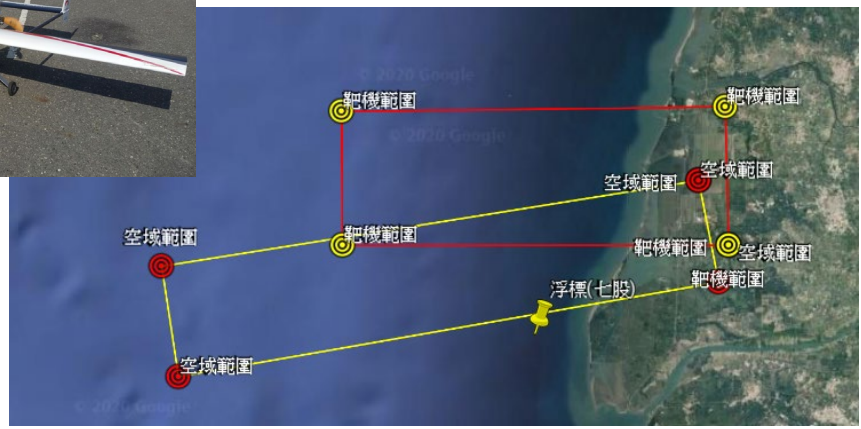
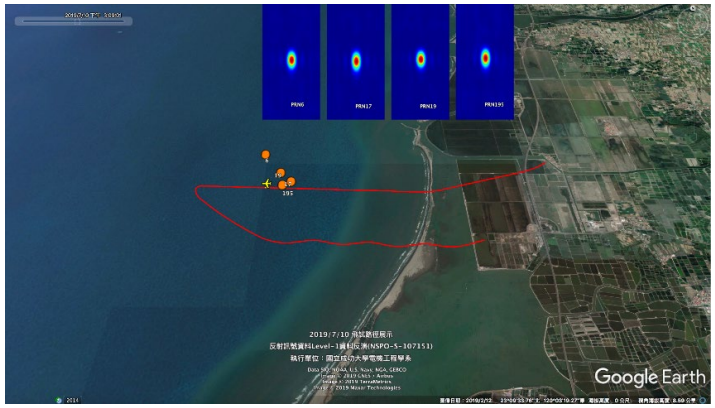
承諾·熱情·創新

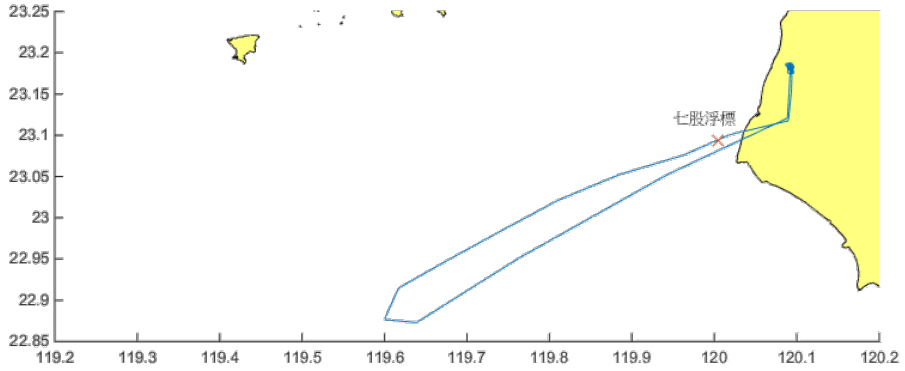
2016 Prototype

2017/2018/2019 EM/EQM/FM









Ongoing Validation Status

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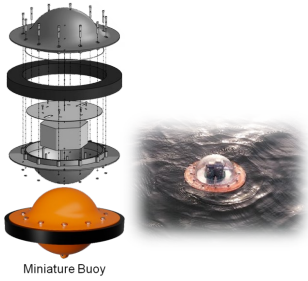
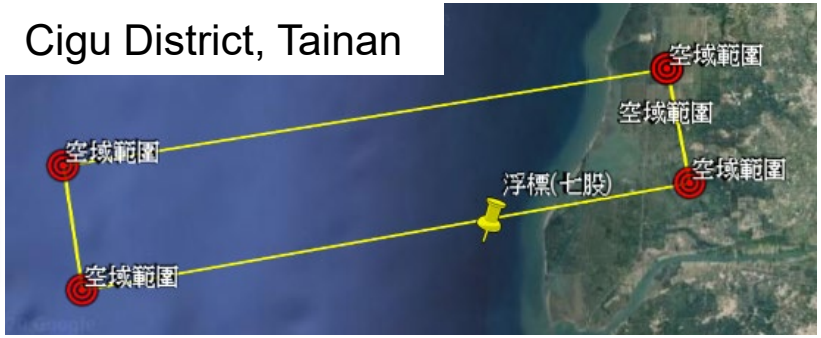
2016 Prototype	2017/2018/2019 EM/EQM/FM	2020/2021 FM

UAV

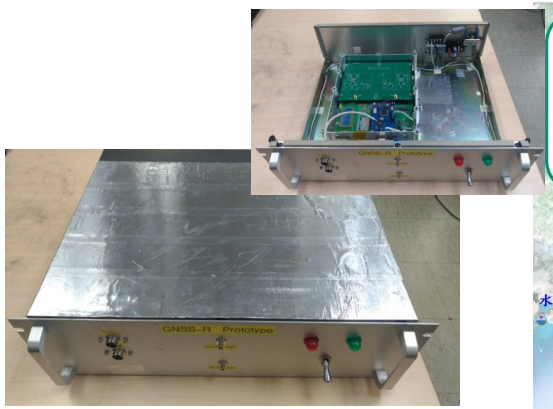
Gueishan Island, Yi-Lan

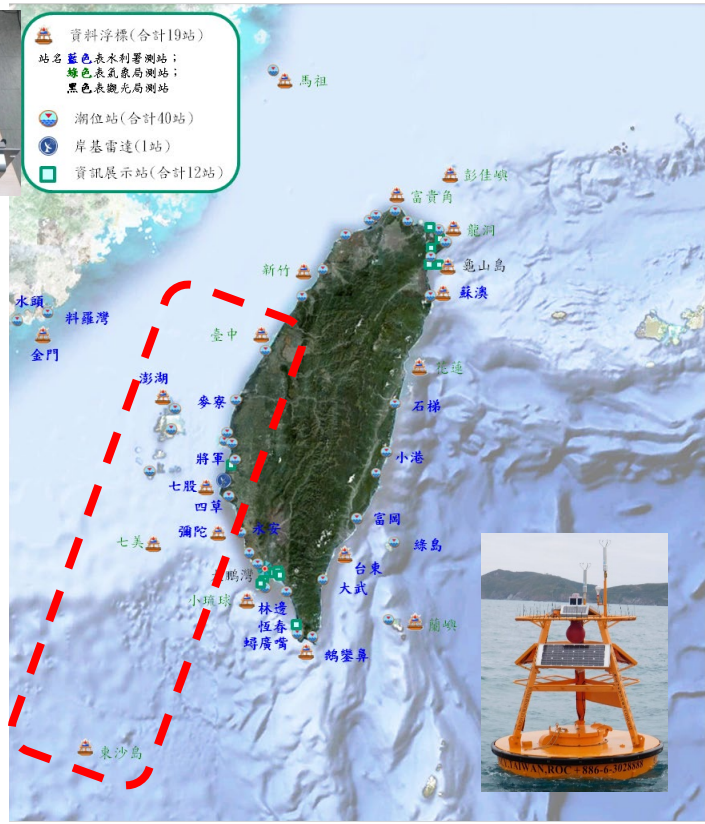


Cigu District, Tainan



AIDC airplane





Flight Test with AIDC Airplane

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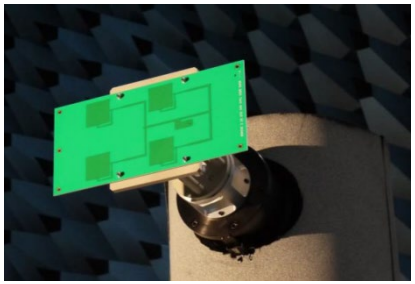
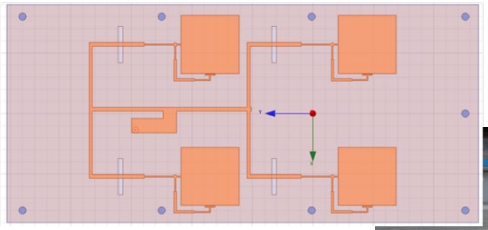
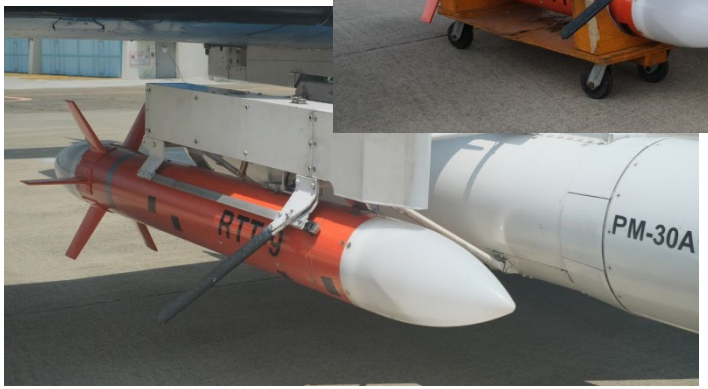
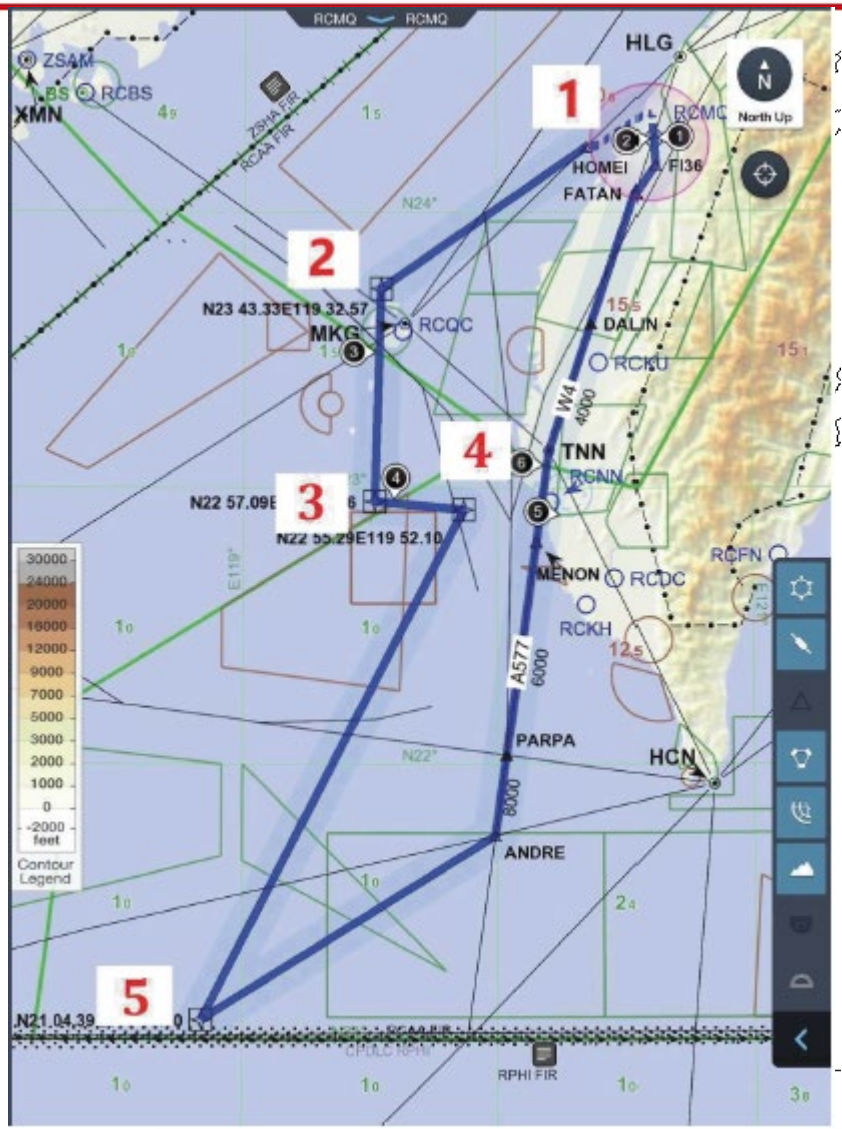


飛機前進方向







Drifter Observation

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Flight Path & Specular Points Distribution

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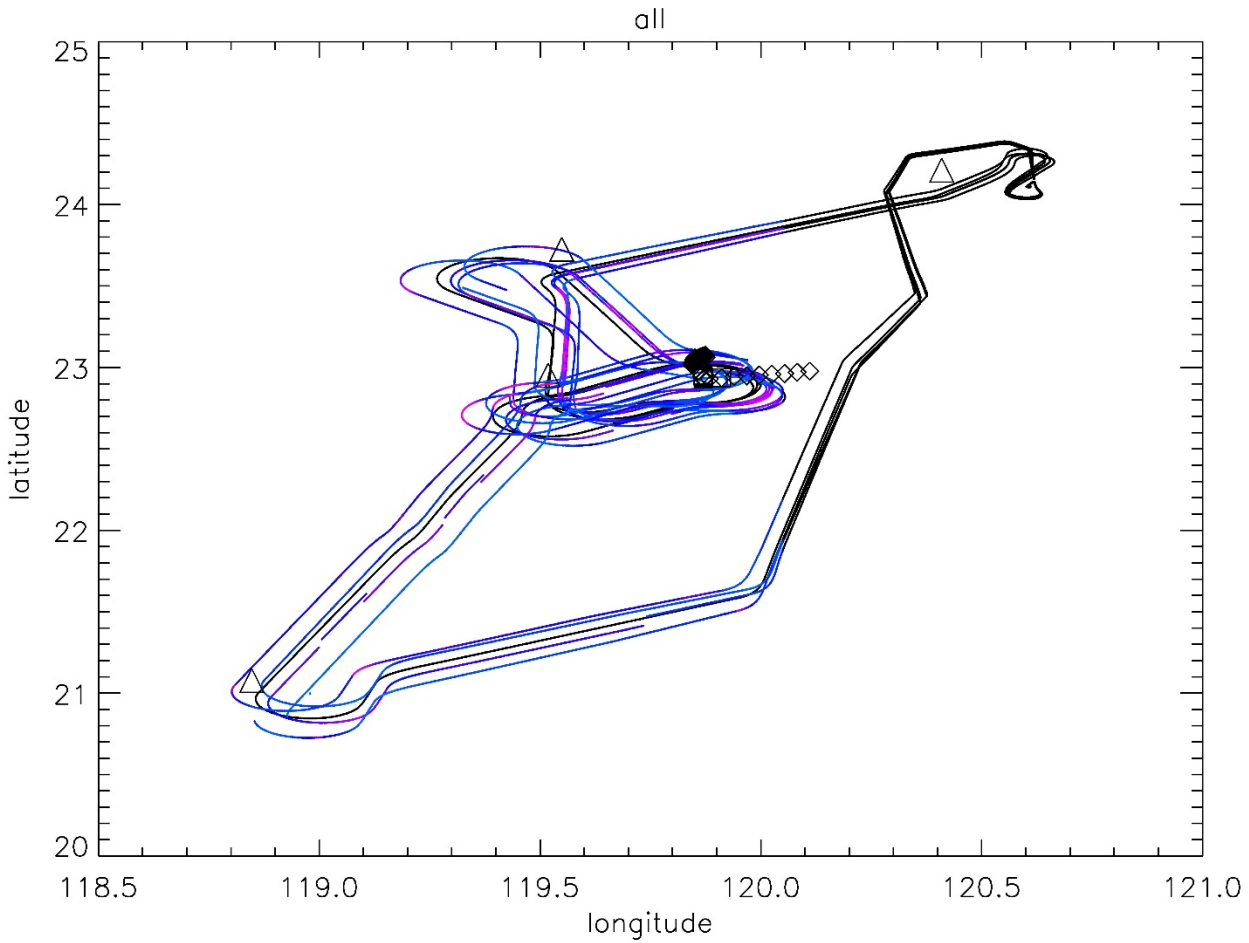
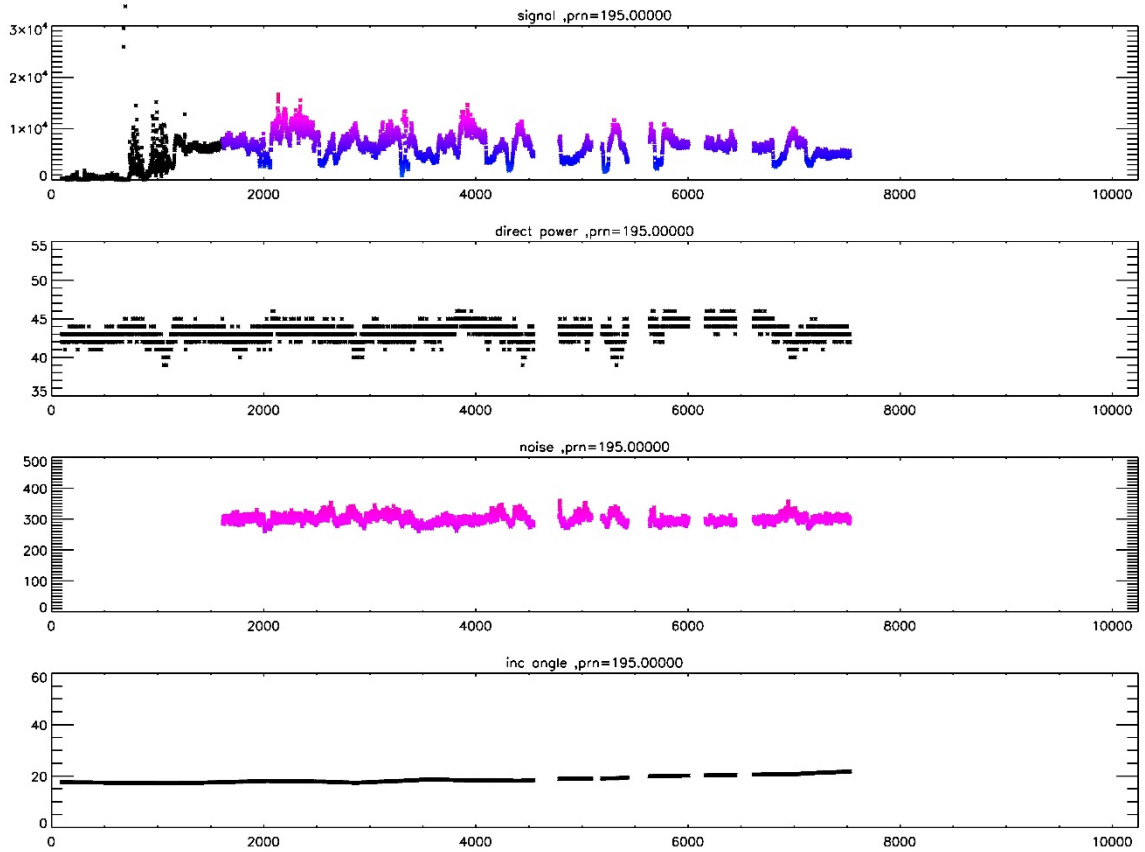


PRN 195 (QZSS)



Preliminary Analysis Results

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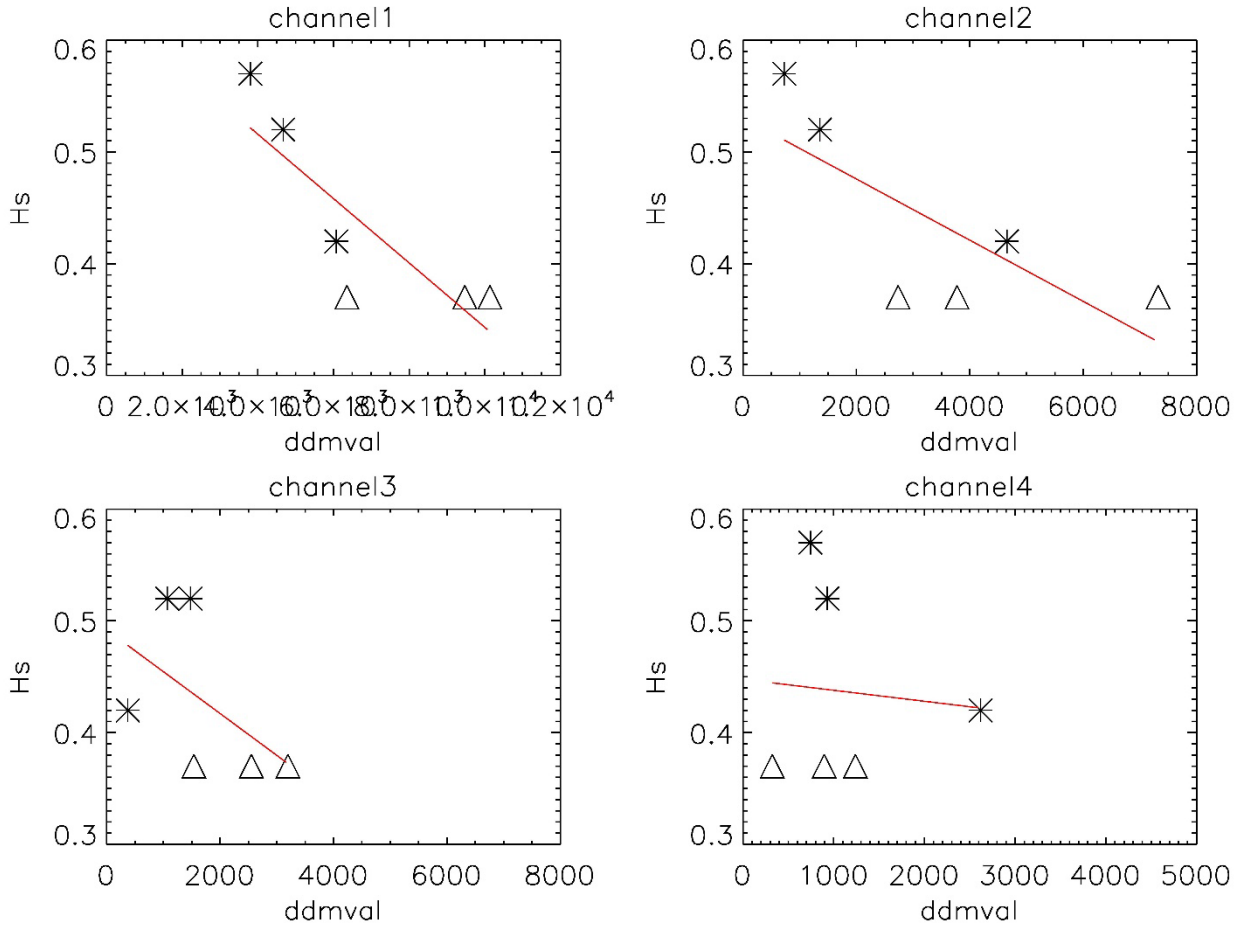


Thanks for Your Attention
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