NSPO

FORMOSAT-3

Status of FORMOSAT-3/COSMIC Project

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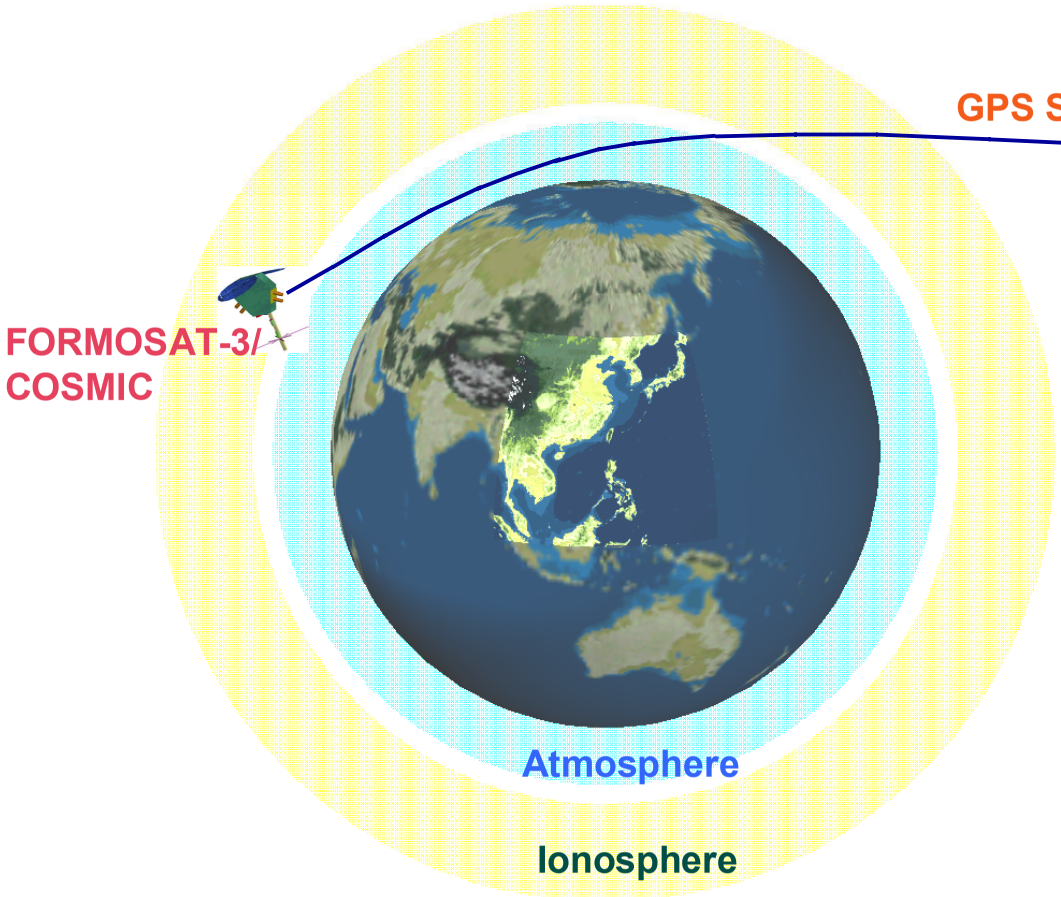
National Space Organization

May 30 2005

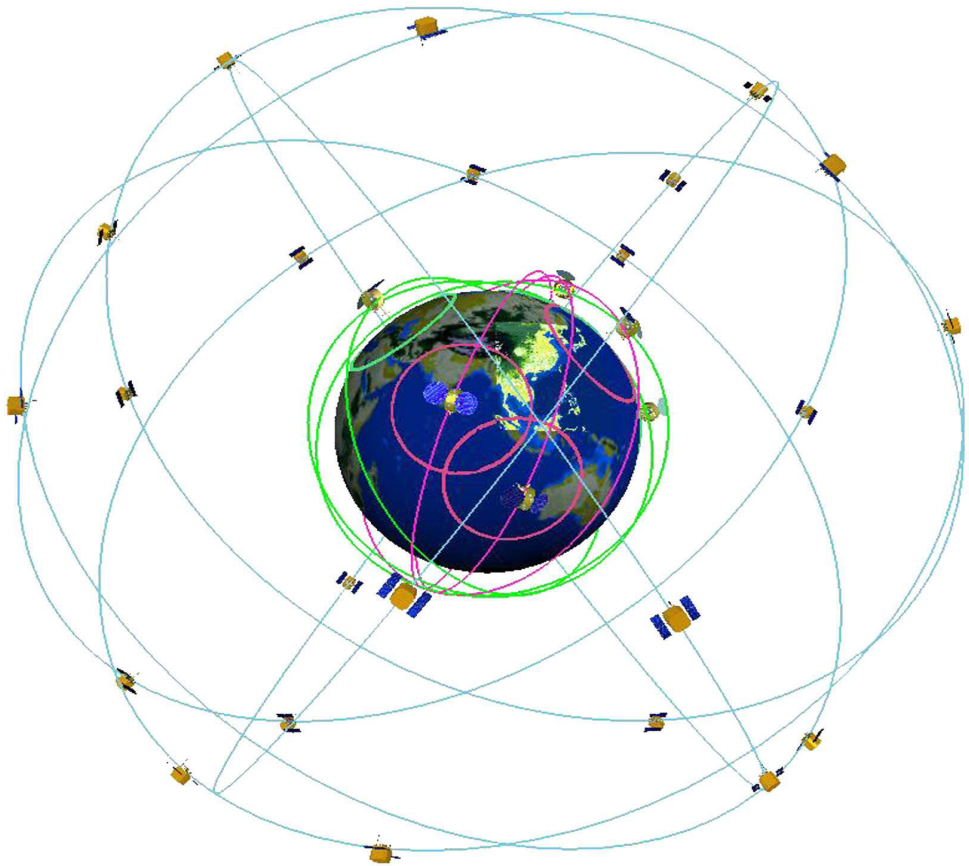
Mission Concept



- To obtain the temperature, pressure, and water vapor pressure from refractivity of the GPS signals to provide global weather forecasting (< 3 hrs latency)
- To provide space weather information, e.g. electron density profiles, horizontal & vertical TEC and CIT, scintillation, and communication outage maps

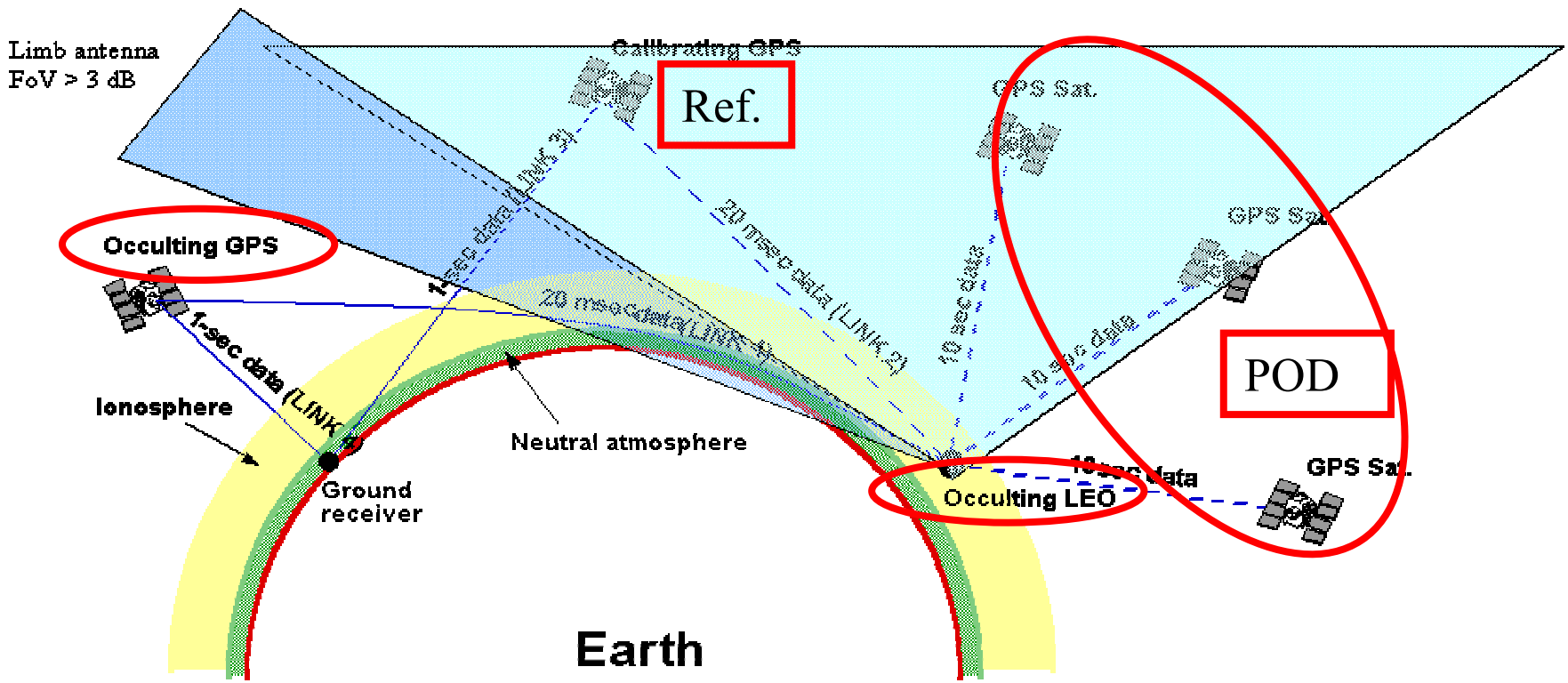
Constellation

- GPS constellation
  - 24-30 satellites in 6 orbit planes (55° inclination)
  - ~3km/s at 20,200km altitude
  - Orbit period ~12hr.
- FORMOSAT-3 Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC)
  - 6 satellites in 6 orbit planes (72° inclination)
  - ~7km/s at 700-800km altitude
  - Orbit period ~100min.



GOX Measurements

- GPS Occultation Experimental（GOX）Payload
  - Occultation (limb; high-gain) antenna (fore/aft)
  - POD antenna (fore/aft)
  - GPS receiver + Solid State Recorder/Payload Computer (SSR/PC)



GOX Measurements: 2500 Soundings Per Day

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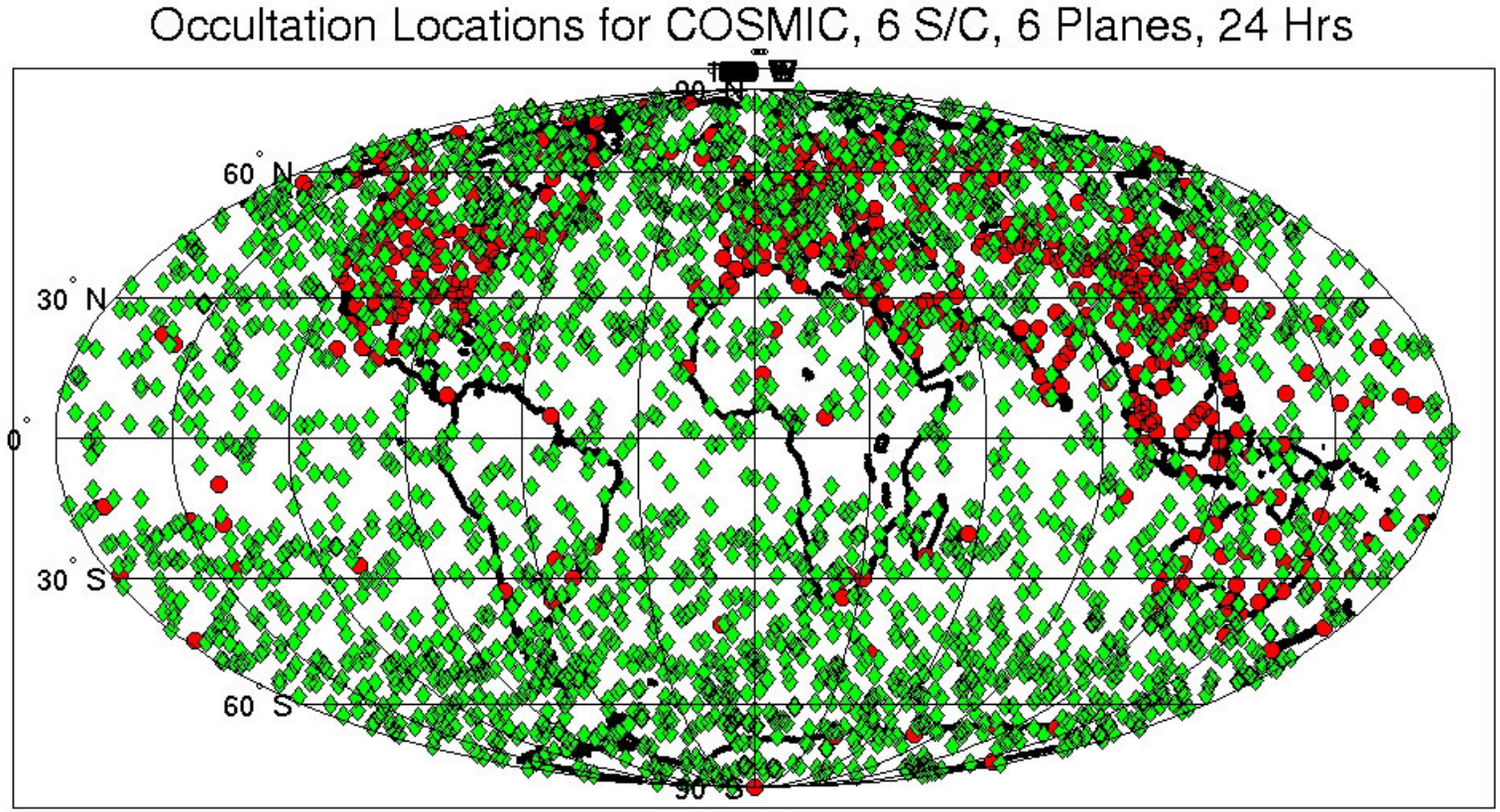
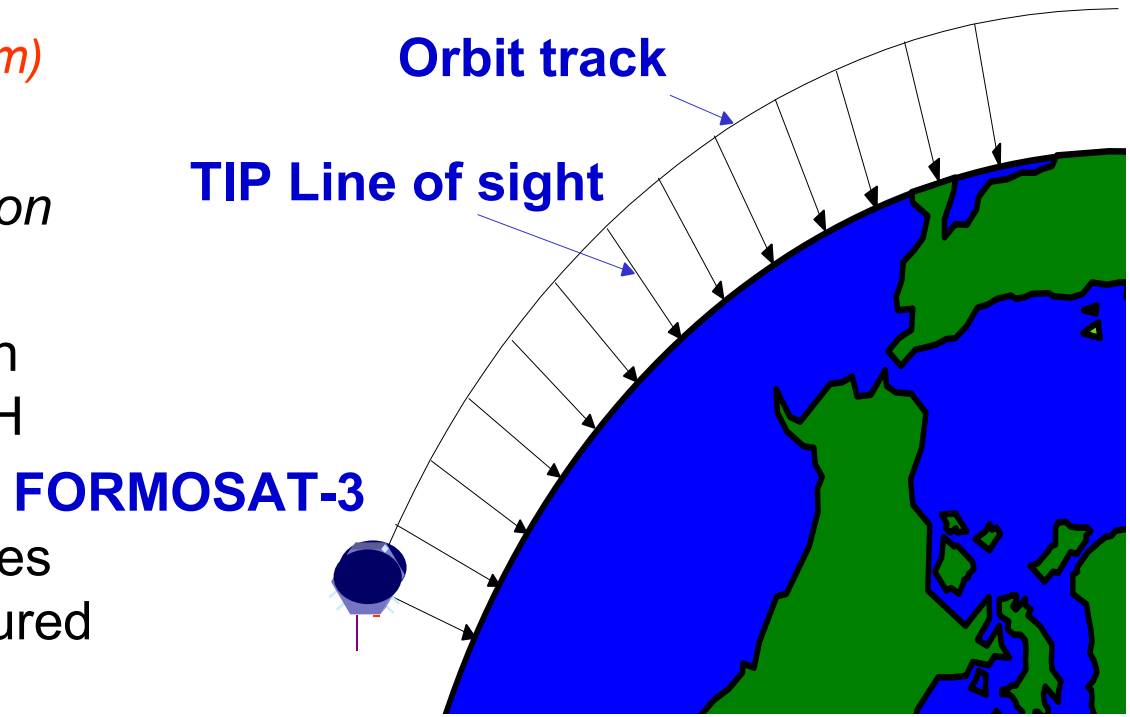
- **An average of 2500 globally distributed atmospheric soundings will be obtained each day.**



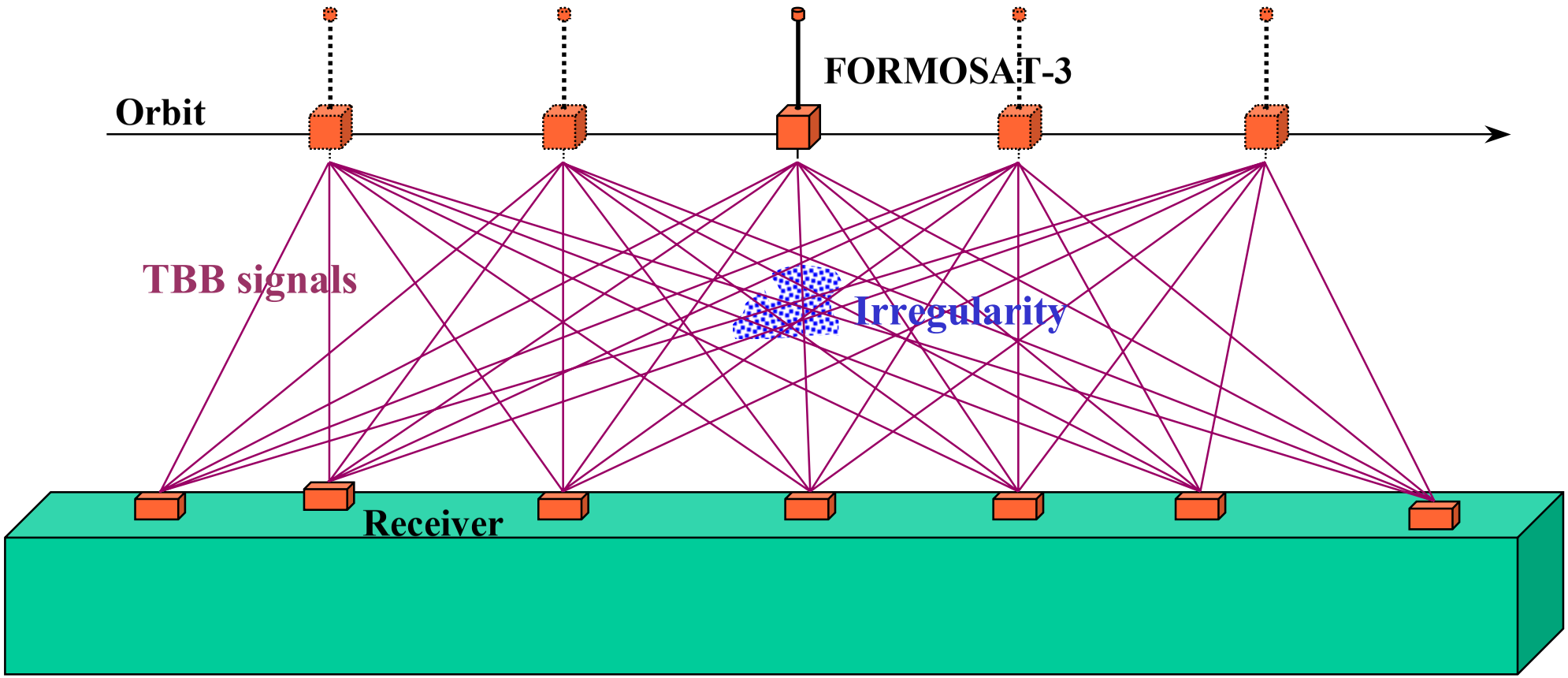
TIP Measurements

- Nighttime ionospheric TEC measurements (e^-)
  - *radiative recombination*
  - $O^+ + e^- \rightarrow O + h\nu$ *(135.6nm)*
- Map aurora boundaries (O)
  - *electron impact excitation*
  - $O + e^- \rightarrow O + e^- + h\nu$
- With the BaF2 filter, TIP can detect the molecular N_2 LBH emissions. (N_2)
- O & N_2 & e^- number densities are all retrieved from measured FUV radiance intensity (or photon counts, #/sec).



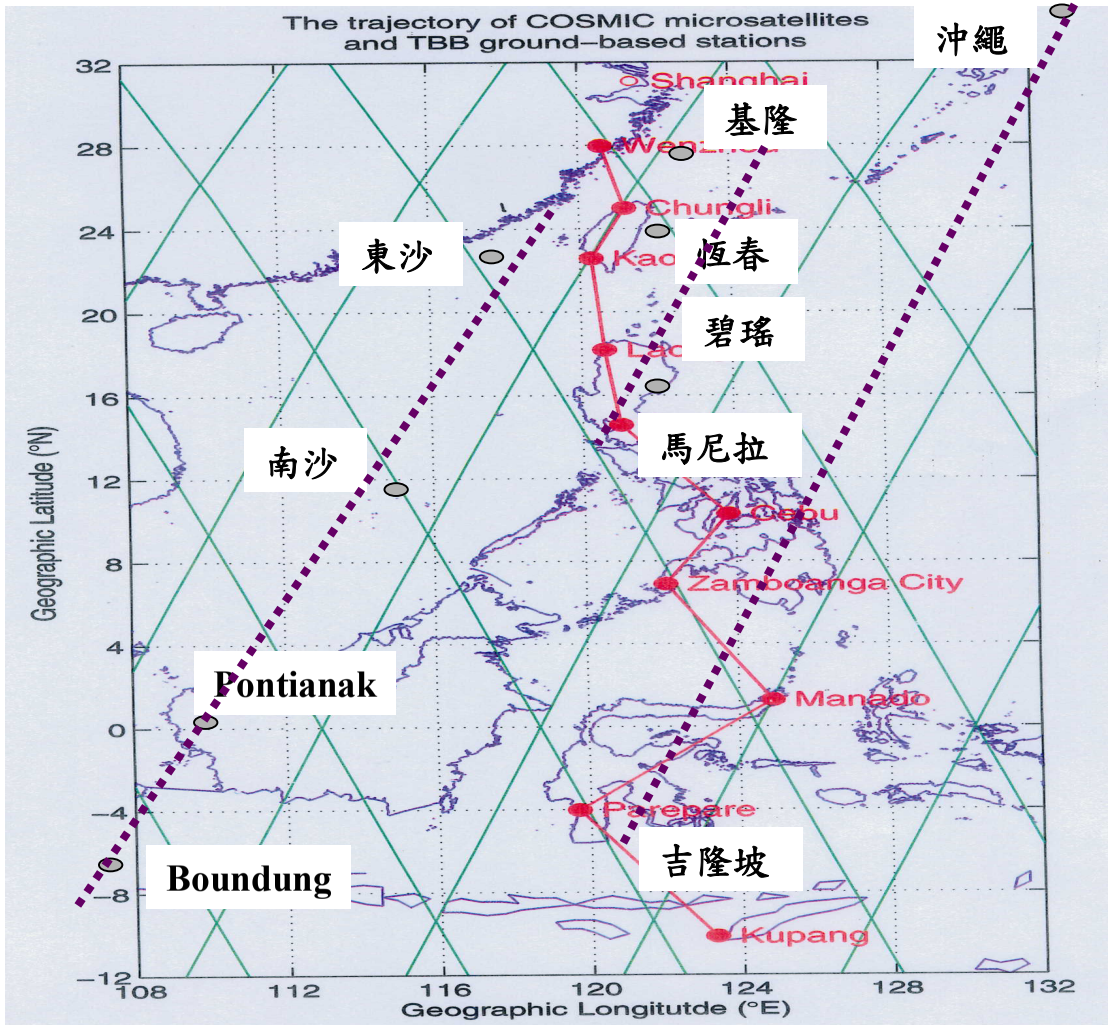
TBB Measurements

- **Signals measured by a chain of ground receivers will be used to**
  - *Retrieve electron density & 2-D Tomography*



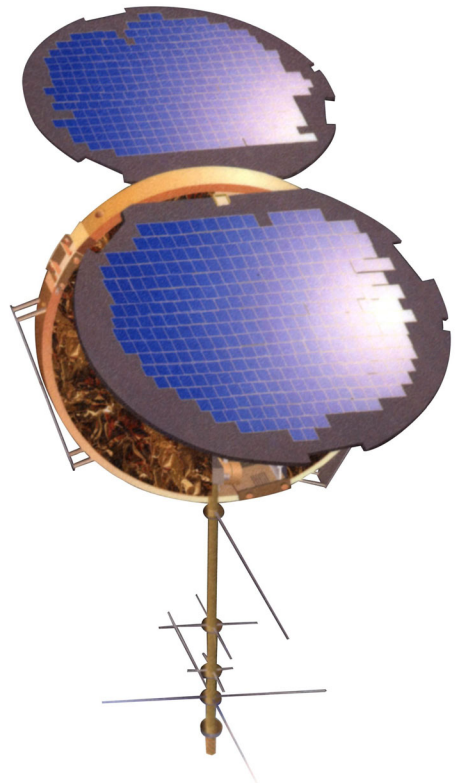
TBB Operations: Pacific Chain

- *10 stations along 3 strips which are nearly aligned with FS-3 orbit trajectory*



Description of FORMOSAT-3 Satellite

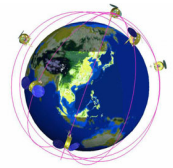
- Mission Life：2 years minimum.
- Design Life : 5 years.
- Constellation：consist of 6 satellites.
- Weight：70 Kg/each (including propellant).
- Dimension：diameter 103 cm，height 16 cm；with two circular solar panel separated by 121 degrees and 59 degrees.
- Orbit period：~100 minutes.
- Mission Orbit：circular orbit，altitude 700-800 Km，inclination 72 degree.



FORMOSAT-3 Satellite Development

- FM1 was assembled and tested, with participation of NSPO engineers, at Orbital and delivered to NSPO in July 2004.
- FM1 went through additional tests at NSPO.
- Kits for the remaining five satellites were shipped to Taiwan in summer 2005 for integration and test by NSPO team.
- NSPO started I&T work on June 1, 2004.

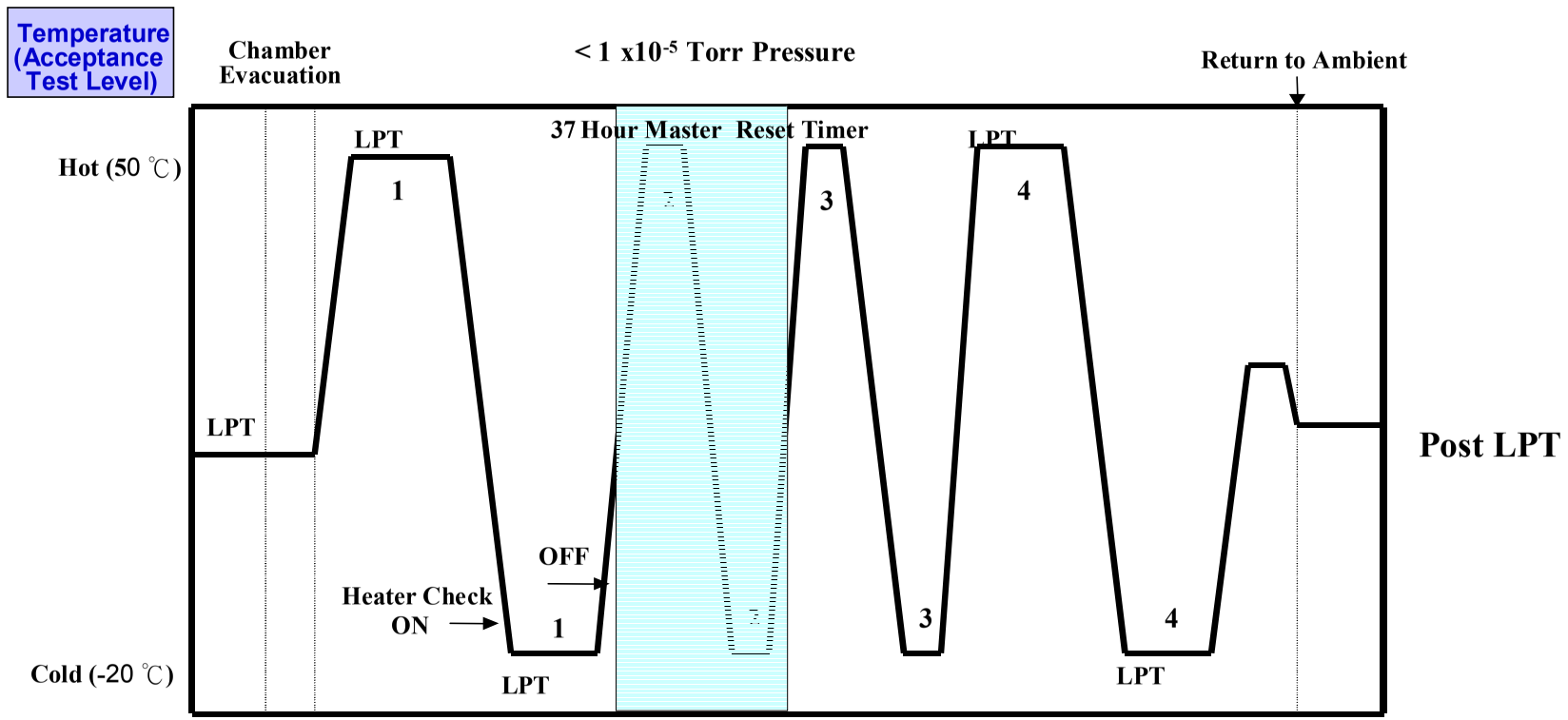
Satellite Integration & Testing at NSPO



- Mechanical Integration
- Electrical Integration
- Functional Test
- Environmental Test
  - Thermal Vacuum Test(TV Test)
  - Dynamic Test
  - Mass Property Test
  - Deployment Test
  - Alignment Test
  - Magnetic Calibration Test
- Interface Test

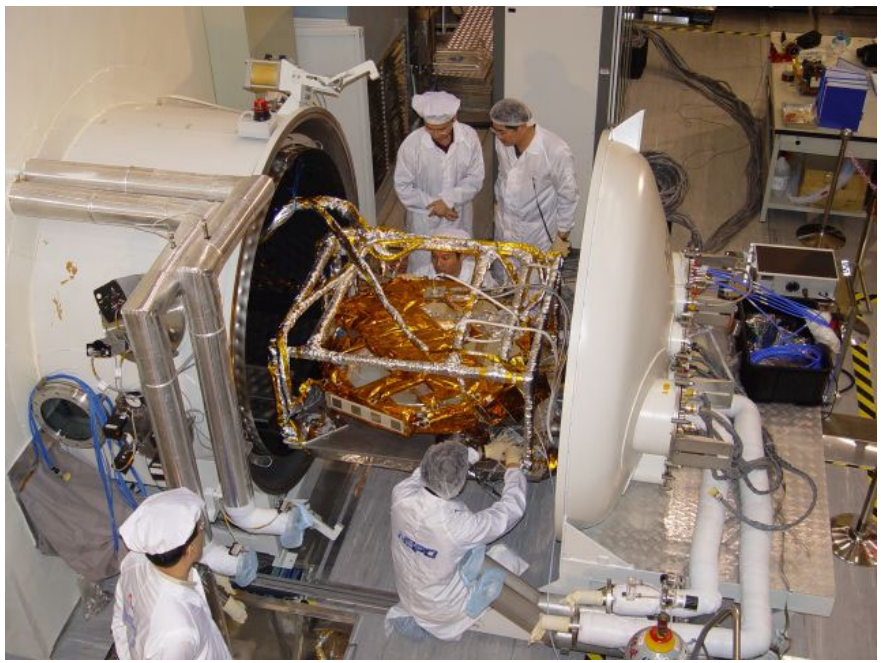
TV Test

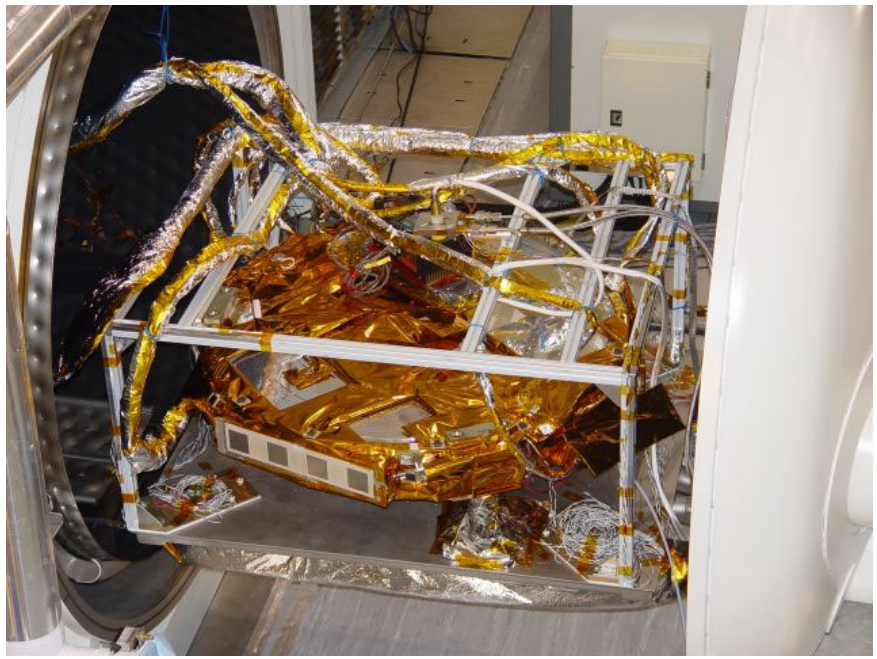
- Verify the spacecraft will operate satisfactorily when exposed to temperature cycling at temperature extremes beyond those predicted in flight environment.
- Obtain electrical performance data over the test temperature range.
- It takes about 8 days of continuous test for each satellite.



GOX unit

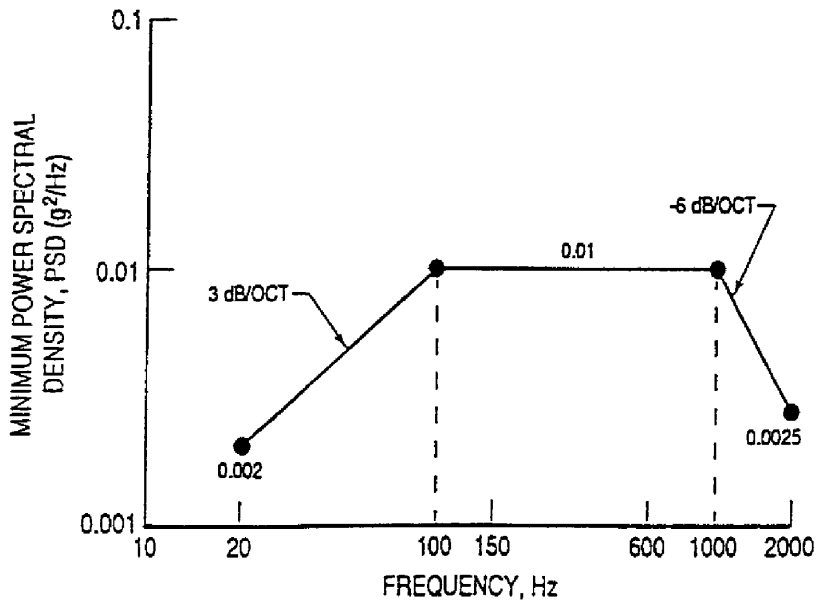
TV Test



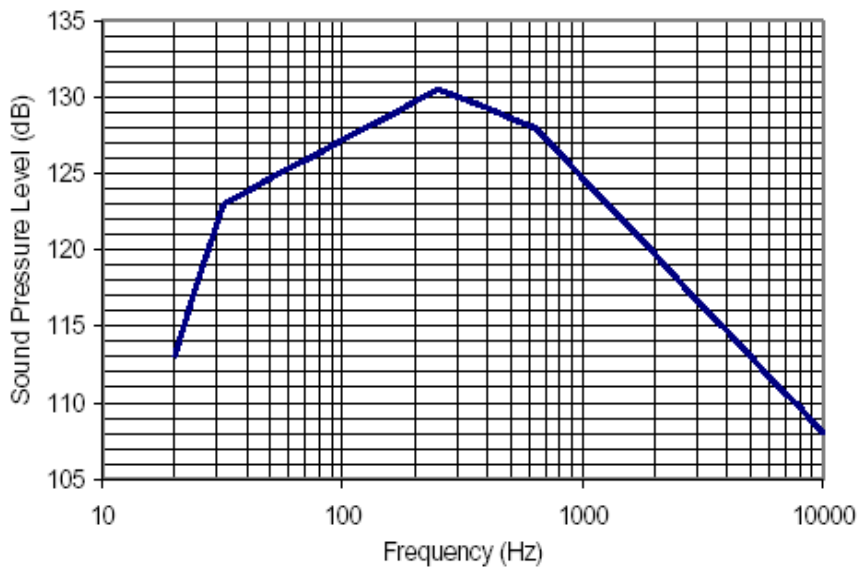


Dynamic Test

- Make sure that the satellites can survive the dynamic environment encountered during launching
- The test consists of the vibration and acoustic tests
- Some tests are performed at single satellite and some are performed at stack level

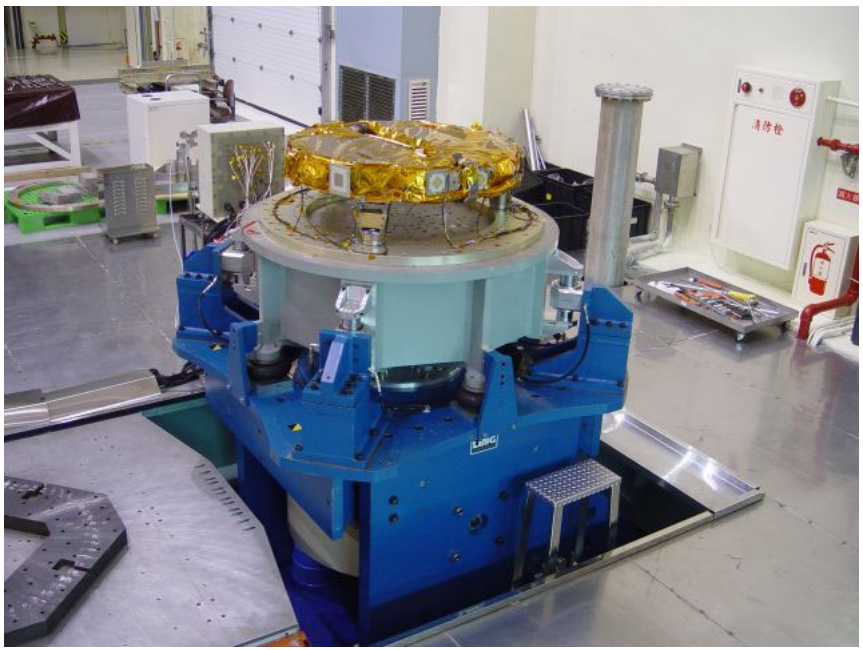


Vibration Test

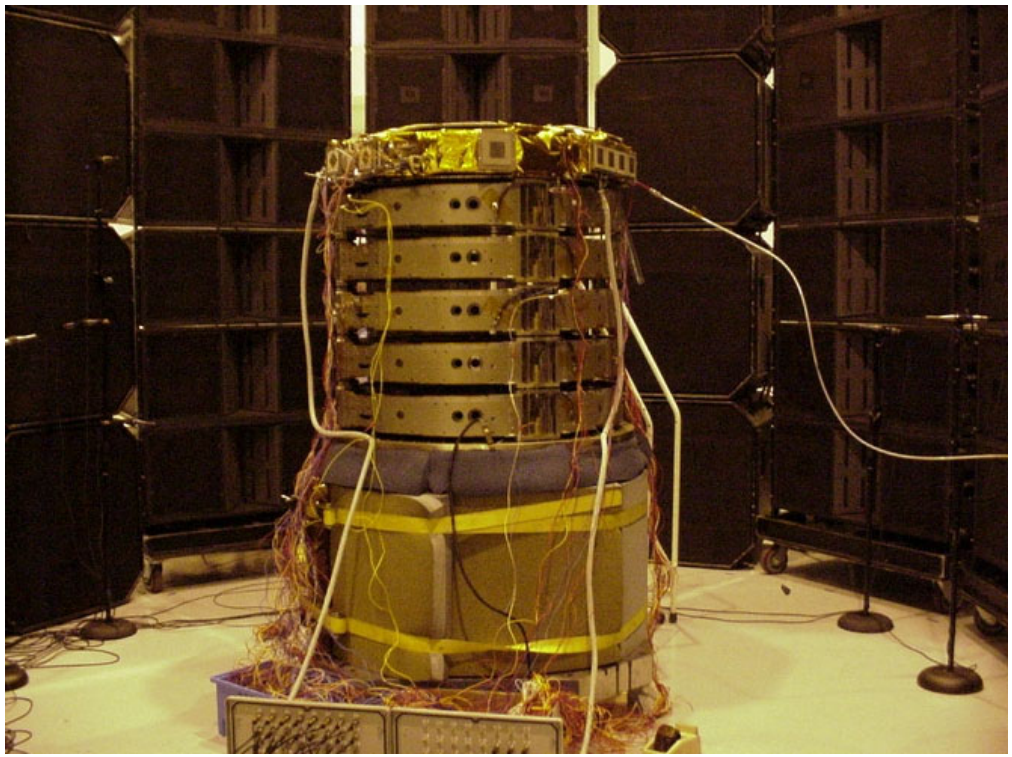


Acoustic Test

Dynamic Test
- Vibration Test

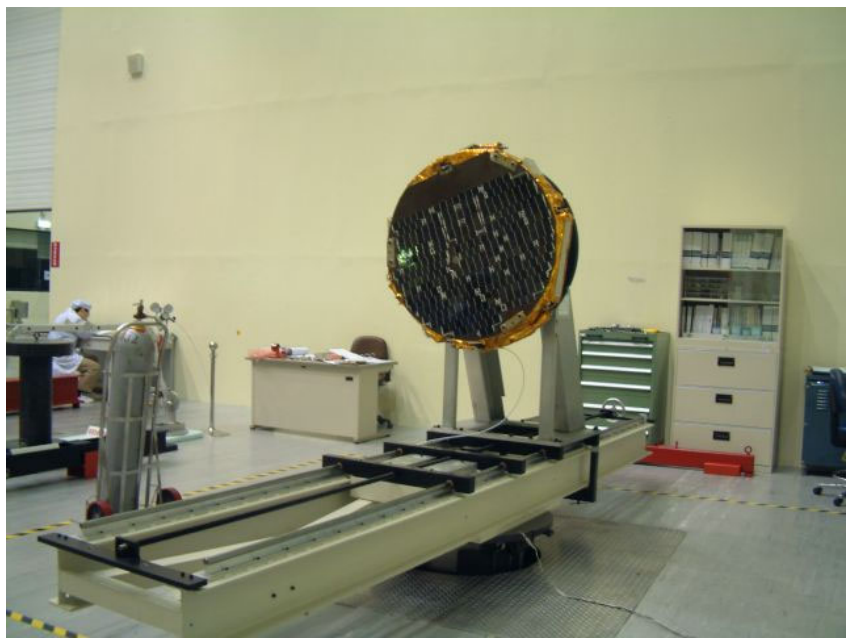


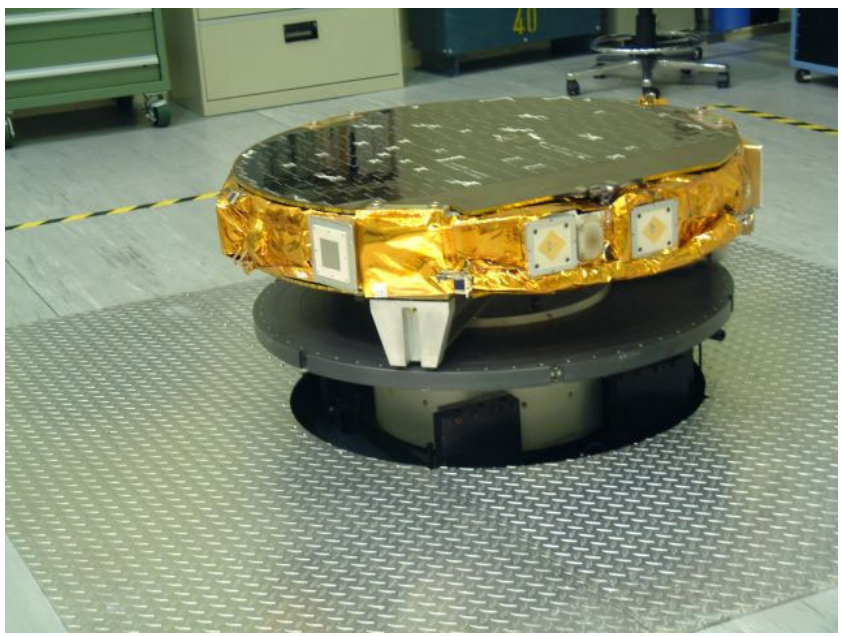
Dynamic Test
- Acoustic Test



Mass Property Test

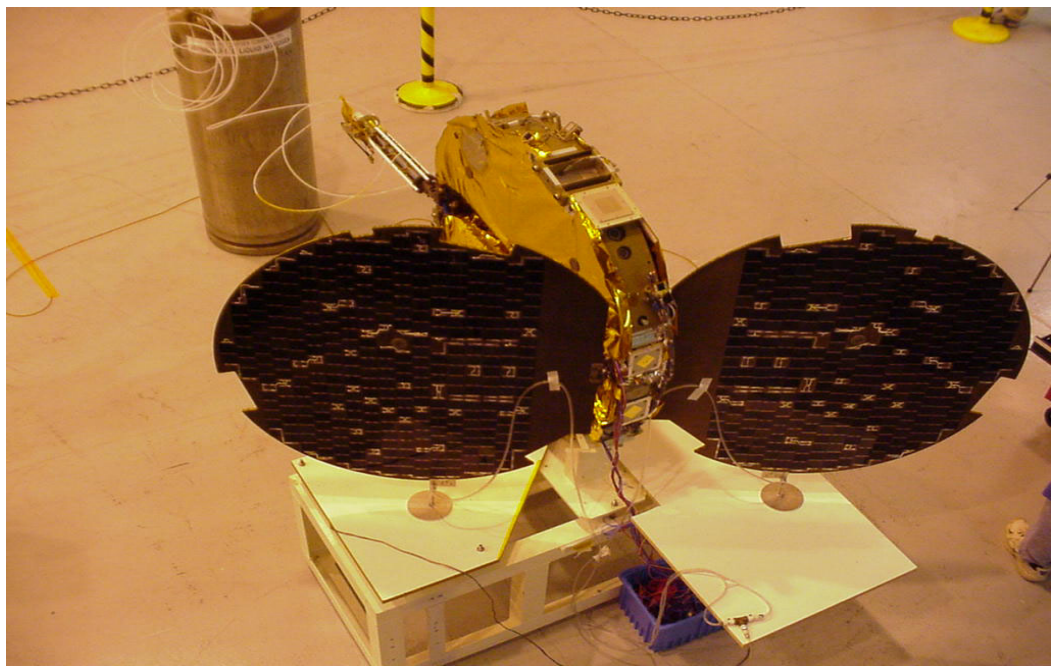
- Determine and verify the mass properties data of the satellites assembled in the various configuration during the launch and separation phases





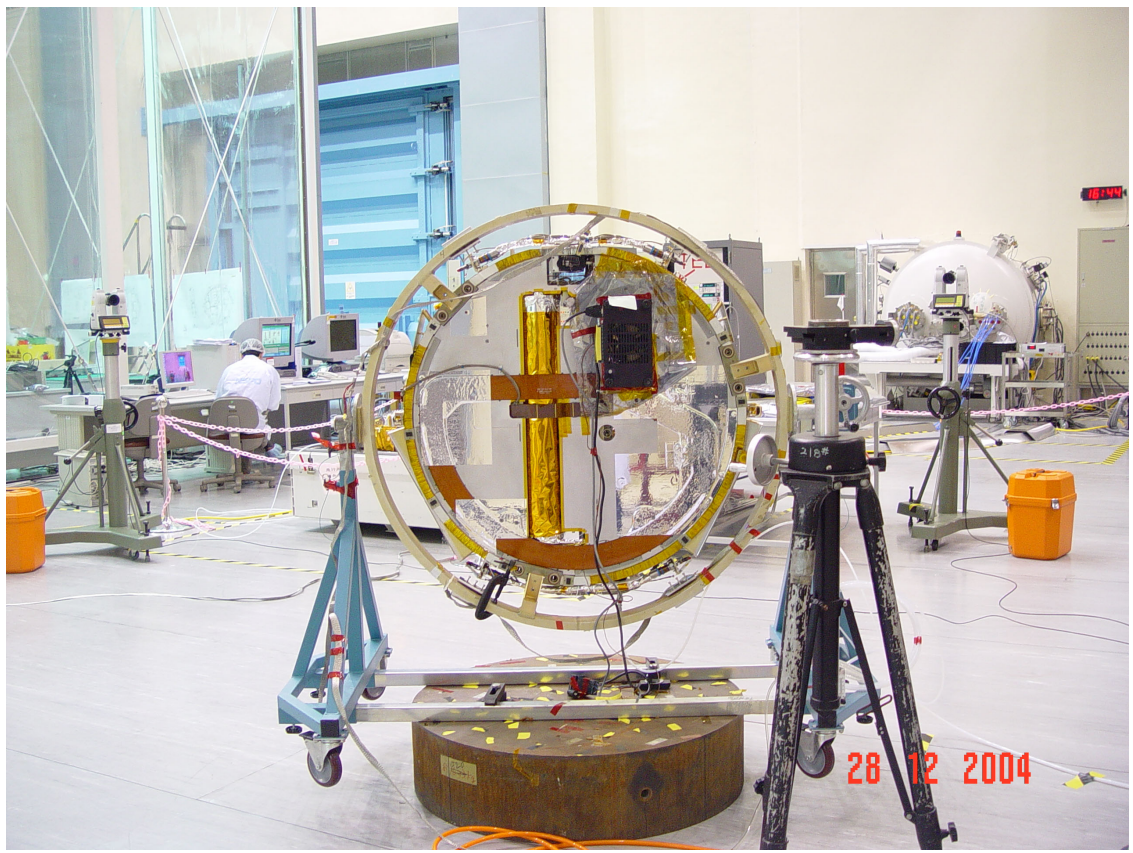
Deployment Test

- Verify the function of solar array and antenna boom release mechanism before and after the dynamic test.



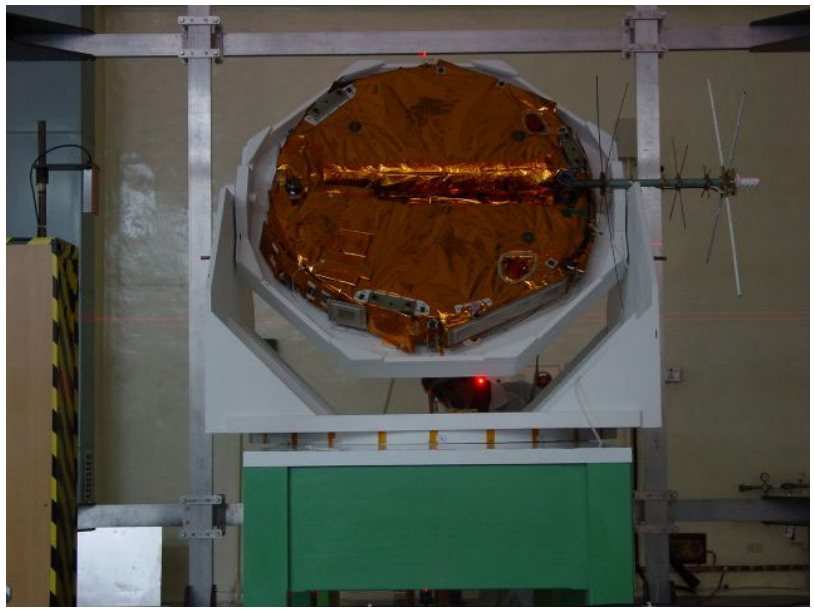
Alignment Test

- Determine the orientation and positional data for some specific flight hardware.
- Adjust flight hardware to meet the installation positioning requirement.

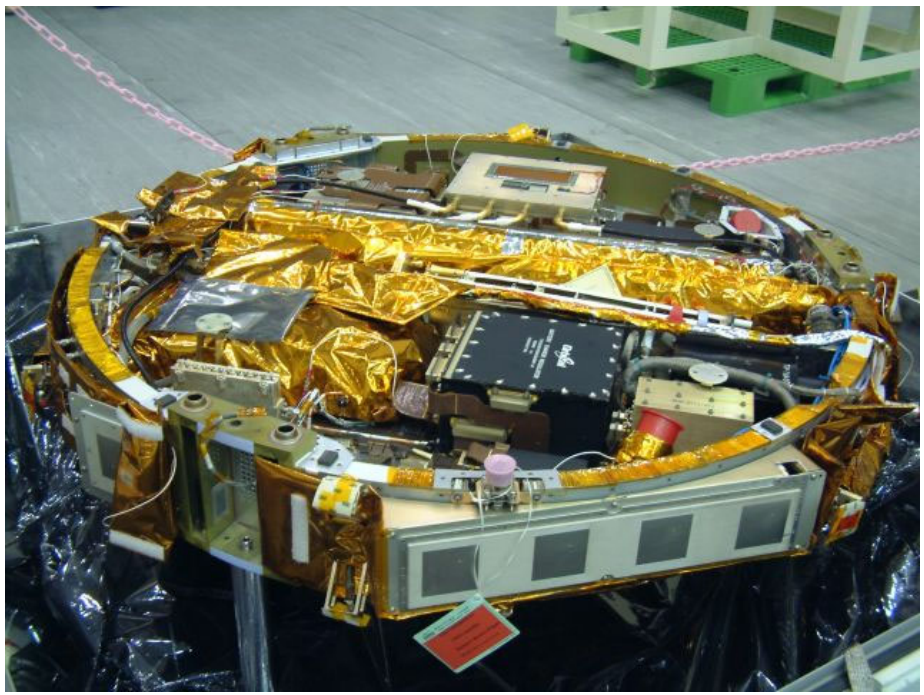


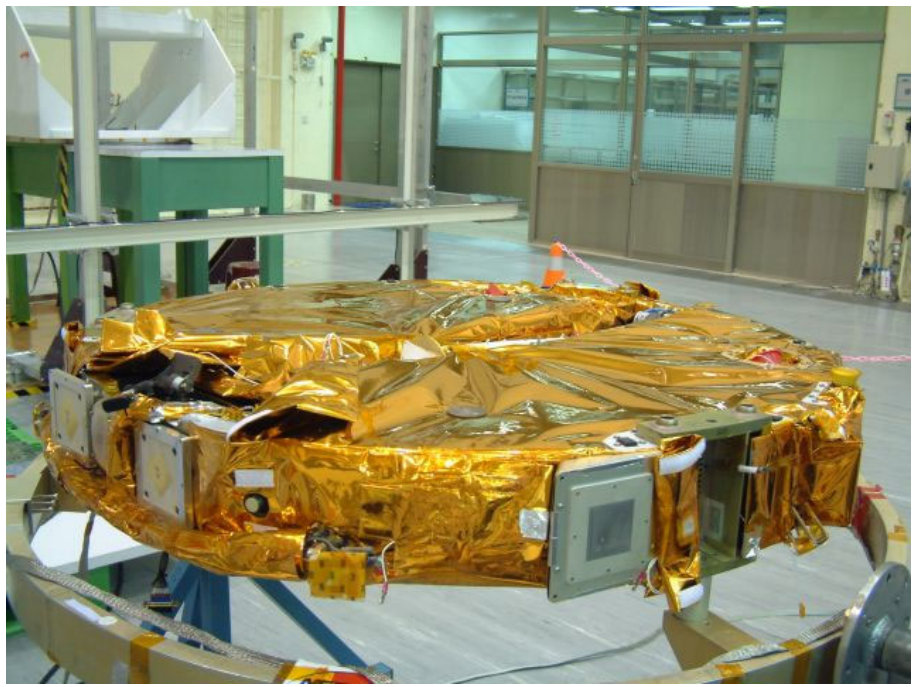
Magnetic Calibration Test

- Measure hard and soft dipoles of the spacecraft. Hard dipole compensation are performed as required.
- Calibrate the spacecraft magnetometer.



Final Configuration (w/o solar panel)





Satellite I&T Status at NSPO

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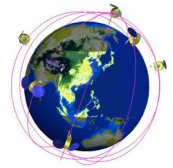
FORMOSAT-3

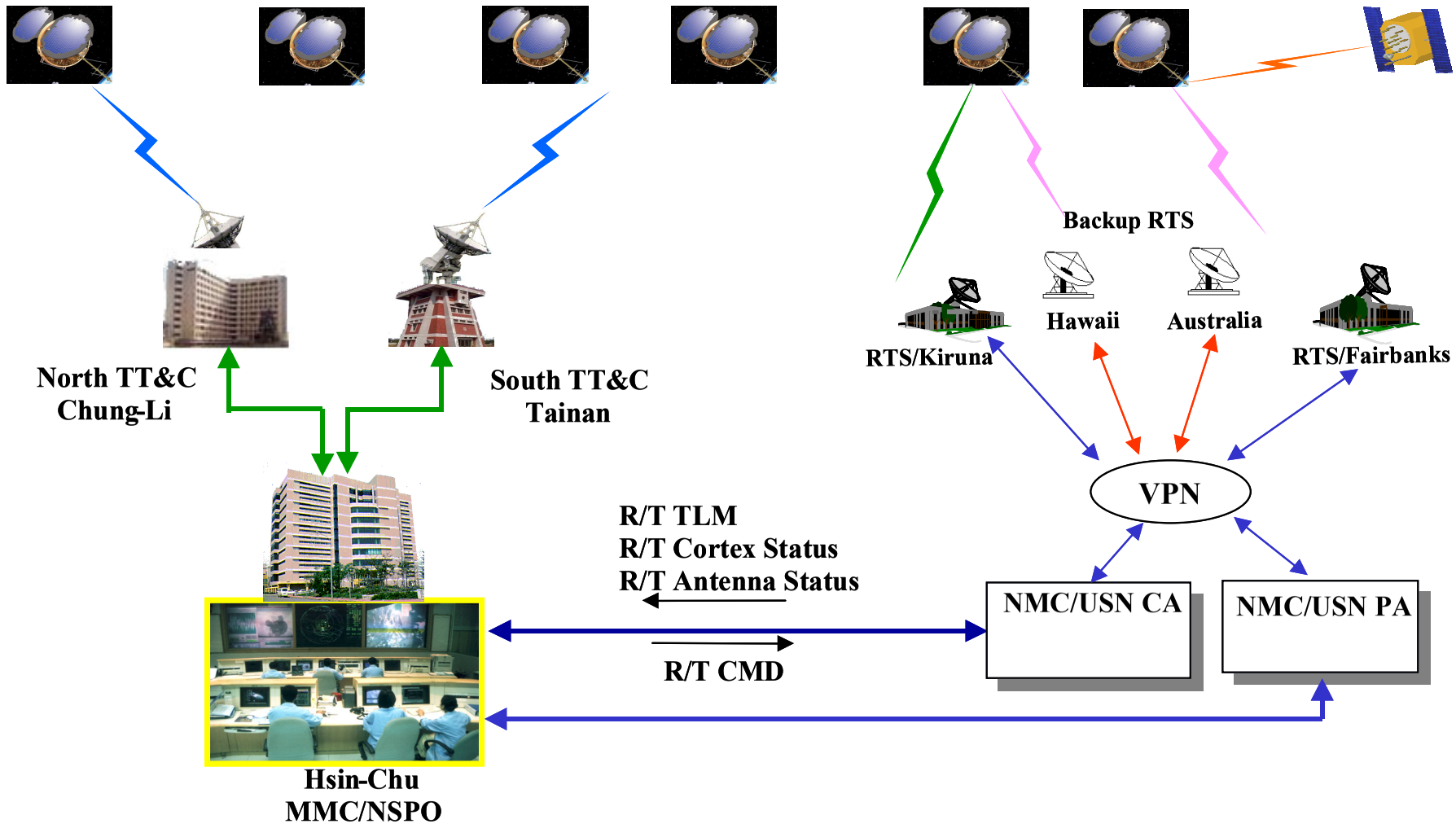
	I&T	Init. CPT	Mag. Cal.	TV	Vib.	Mass Prop.	Stack			Deployment		Final CPT
							Prep.	Test	Acoustic	Boom	SA	
FM1	NA	NA	✓	NA	NA	NA						
FM2	✓	✓	✓	✓	✓							
FM3	✓	✓		✓	✓	✓						
FM4	✓	✓	✓	✓	NA	✓						
FM5	✓	✓	✓	✓	NA							
FM6	✓	✓			NA							

Remaining Satellite I&T Activities at NSPO



- Preparation for the stack dynamic test is in progress.
  - The test is scheduled in July 2005.
- Post dynamic test will begin in August 2005.
- Send STx/SRx (FM3-5) to vendor for part replacement after dynamic test.
- Conduct FM6 TV test in September 2005.
- Complete all satellite I&T activities at the end of November 2005.
- Conduct roof-top GOX tracking test before shipment. (TBD)

FORMOSAT-3 Ground System



Ground System (1/2)

- Multi-Mission Center
  - To upgrade NSPO system to accommodate the mission operations of FORMOSAT-3.
    - » System integration and test completed in October 2004.
    - » Operation readiness review successfully conducted in March 2005.
- TT&C Stations Upgrade
  - Upgrade Taiwan TT&C stations with CORTEX, Up/Down Converters, and Monitor and Control Unit.
    - » System integration and test completed in October 2004.
    - » The systems have been operated since May 2005.

Ground System (2/2)

- Remote Tracking Stations
  - To construct RTS sites in Fairbanks, Alaska and Kiruna, Sweden.
    - » Complete system acceptance test in September 2004.
    - » Establish communication line (VPN/ADSL) between Mission Control Center and RTS.
    - » End-to-end test is on-going.

Multi-Mission Center

TT&C Stations at Northern/Southern Taiwan

S/S-Band TT&C Station
(NCU, Chung-Li)

S/S-Band TT&C Station
(NCKU, Tainan)

Remote Tracking Stations

RTS at Alaska

RTS at Kiruna

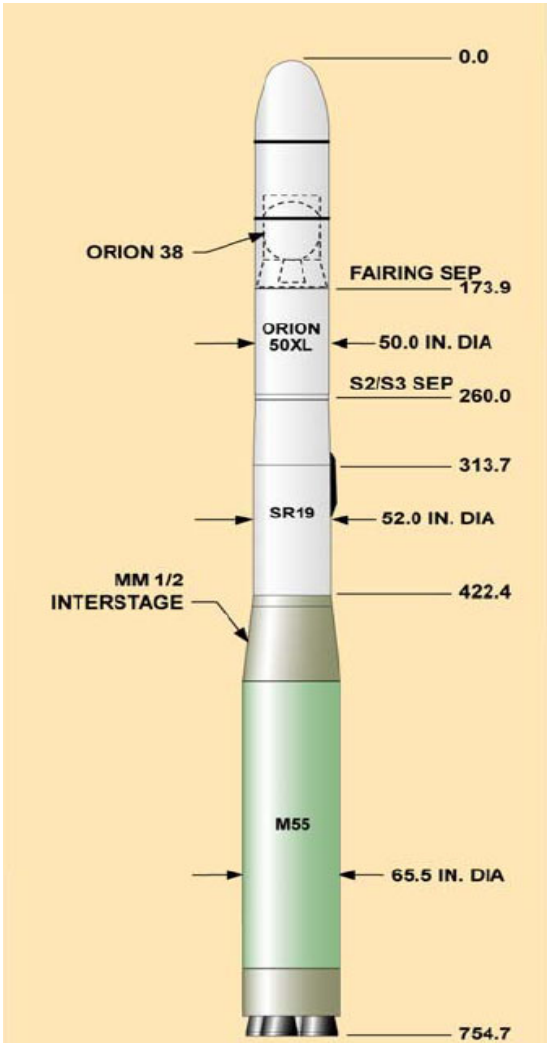
Mission Operation Development

- Mission operations are conducted from NSPO.
- Mission operation plan is nearly completed.
- In Orbit Checkout Plan is ready for final review.
- Dynamic Simulator is developed for training.
- Mission operation training
  - » Completed all major areas:

    Mission Overview, System/Sub-System Design, Mission Operations, Contingency Operations, MAESTRO, SWIL.
  - » Operation procedures training is on-going.

Launch Vehicle (1/2)

- USAF Minotaur LV
  - The LV consists of 4-stages solid fuel motor
  - Total height : 19.21 meter
  - Total weight : 36.2 tons
- Three successful launch since 2000.

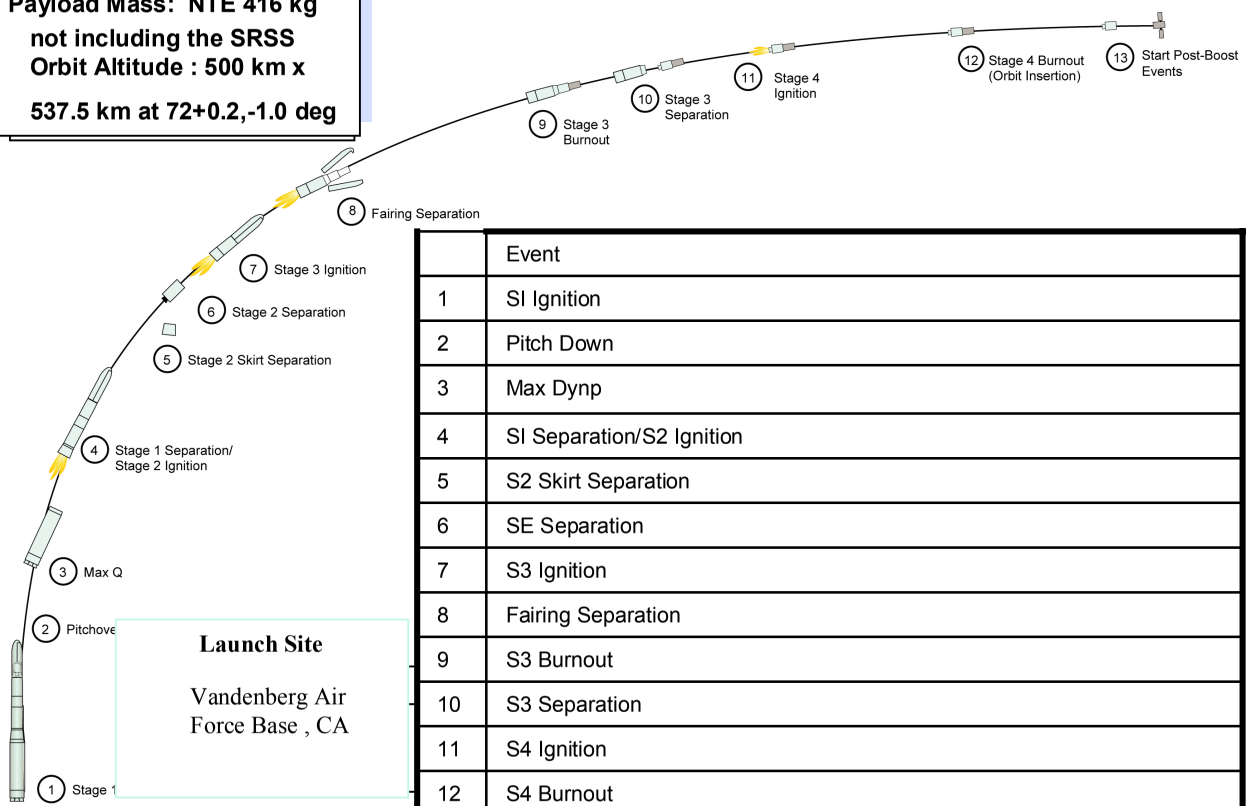


▲ *Minotaur Launch Vehicle*

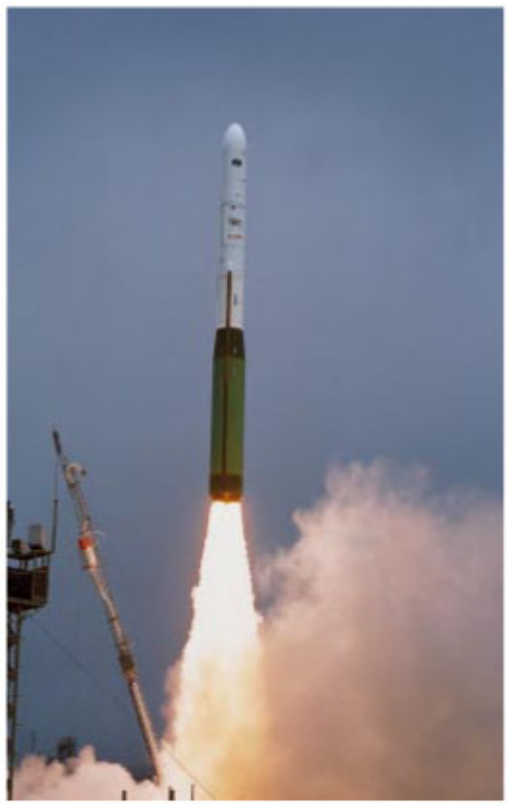
Launch Vehicle (2/2)

Mission Parameters

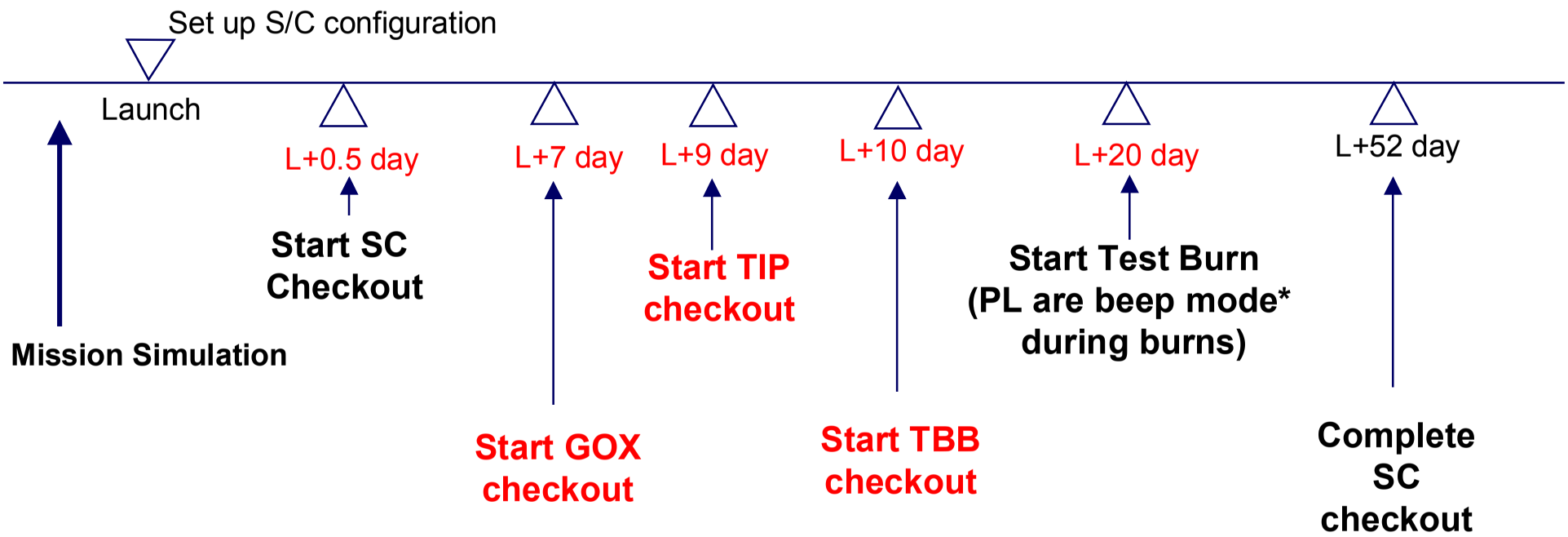
Payload Mass: NTE 416 kg not including the SRSS
Orbit Altitude : 500 km x 537.5 km at 72+0.2,-1.0 deg



	Event
1	SI Ignition
2	Pitch Down
3	Max Dynp
4	SI Separation/S2 Ignition
5	S2 Skirt Separation
6	SE Separation
7	S3 Ignition
8	Fairing Separation
9	S3 Burnout
10	S3 Separation
11	S4 Ignition
12	S4 Burnout
13	Payload Separation
14	CCAM



Payload Checkout Plan



*PL Beep mode:
GOX at Beep mode
TIP and TBB at Off mode

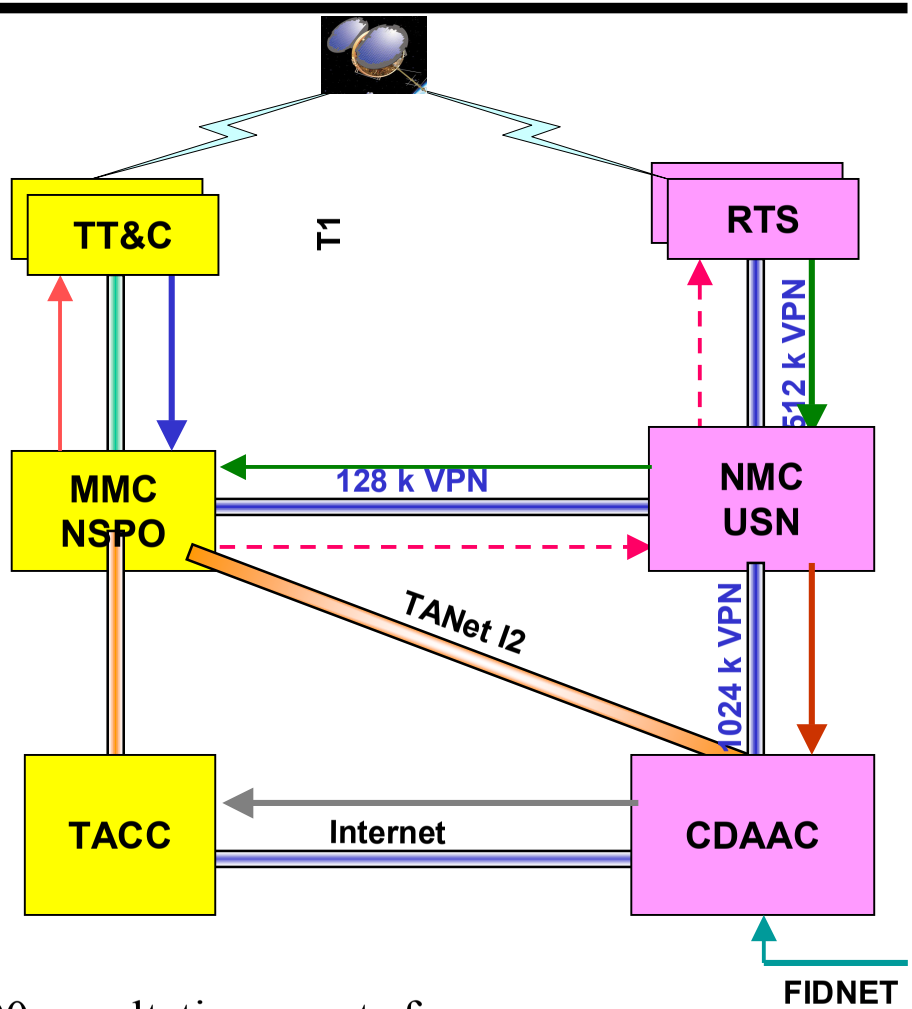
Ground Communication Network and Science Data Flow

NSPO

FORMOSAT-3

- Command:
  - Normal: MMC → TT&C → SC
  - Backup: MMC → NMC → RTS → SC
- Telemetry:
  - Real-time:
    - SC → TT&C → MMC
    - SC → RTS → NMC → MMC
  - Back Orbit
    - Normal: SC → TT&C → MMC
    - Backup/L&EO:

      SC→ RTS → NMC → MMC
- Payload science data (GOX & TIP)
  - SC → RTS → NMC → CDAAC
- Other science raw data (GPS FID, TBB)
  - FIDNET → CDAAC
- Science data Re-transmission
  - CDAAC → TACC



•The system is expected to receive ~200 occultation events for every orbit. The system will then process, archive, and transmit within 3-hours to weather forecasting models.

Data Policy (2006-2007)

- NSPO/UCAR/NSF is finalizing FORMOSAT-3/COSMIC data policy.
- FORMOSAT-3/COSMIC data will be provided at no cost or at the cost of reproduction and distribution.
- A “data use agreement” is required for the use of all FORMOSAT-3/COSMIC data. The review and approval are to be made by NSPO and UCAR.
- US users will register through UCAR (CDAAC) site; non-US users will register at Taiwan (TACC) site.

Taiwan Science Team

NSPO

FORMOSAT-3

- 氣象及氣候研究團隊
  - 中央大學：黃清勇教授、丘增杰教授
  - 台灣海洋大學：吳宗達教授
  - 文化大學：張忍成教授
- 電離層研究團隊
  - 中央大學：朱延祥教授、蔡偉雄教授、蔡龍志教授、陳明桂教授
  - 文化大學：王建亞教授
- 大地測量研究團隊
  - 成功大學：曾清涼教授、楊名教授、余騰鐸教授
  - 交通大學：黃金維教授

Conclusions

- Satellite I&T are progressing well.
- Ground system upgrade is completed.
  - Ground operation readiness review is scheduled in June 2005.
- Mission operation simulation and training are on-going.
  - Training will continue until launch.
- Launch vehicle development is on track.
- Range operation readiness will be reviewed in July- August 2005.
- Launch slot selection still needs coordination among all parties.
  - Need to consider range maintenance and other mission launch schedule.