



# COSMIC-2



Pete Wilczynski  
U.S. COSMIC-2 Program Manager - NOAA

# COSMIC-2 Mission Overview

## Mission Objectives

- Follow-on to current COSMIC-1 satellite constellation
- Design concept meets L1RD requirements
  - System will provide 10,000+ worldwide soundings per day
  - All weather, uniform coverage over oceans and land with 30 min average latency
- 12 Satellite Constellation, 2 launches in different inclinations
  - 6 satellites to 24 degree orbit – carries USAF secondary payloads
  - 6 satellites (+ 1 optional spare) to 72 degree orbit – carries Taiwan secondary payloads (planned)



## Mission Overview

- Launch Dates: 1<sup>st</sup>: May 15, 2016; 2<sup>nd</sup>: CY2018 (FY2019)
- Launch Vehicle: 1<sup>st</sup>: Falcon Heavy [STP-2 Mission]; 2<sup>nd</sup> – TBD (Falcon-9, Falcon Heavy, or EELV rideshare)
- Design Life: 5 years
- Mission: 5 years (on orbit)
- Orbits: 1<sup>st</sup> launch - 24 deg inclination, 2<sup>nd</sup> launch - 72 deg (or 108 deg) inclination

## Instruments

- First Launch:
  - TriG GNSS-RO receiver (TGRS)
  - Ion Velocity Meter (IVM)
  - RF Beacon
- Second Launch:
  - TGRS
  - Taiwan-procured Scientific Payloads for second launch are TBD

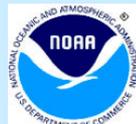


# COSMIC-2 Mission Roles



- **NOAA activities:**

- Manage all U.S. activities as Lead U.S. agency
- Arrangement for and oversight of the remote ground receiving stations
- Acquisition and management of the data processing center in the U.S.
- Overall management of the data analysis, application, and distribution segment
- Responsible for 6 primary payloads for the second launch [TBD]



- **U.S. Air Force activities:**

- Acquisition and management of the mission payload for the first 6 satellites
- Acquisition and management of the launch service for the first launch
- Acquisition and mission support of the scientific payloads for first six satellites
- Acquisition and management of the launch service for the second launch [TBD]



- **NSPO activities:**

- Acquisition and management of 12 spacecraft + 1 optional spare
- Acquisition, management, I&T, and deployment of satellite constellations
- Development and management of mission operation
- Modification and operations of Satellite Operations Command and Control (SOCC) station and Taiwan's TT&C station
- Acquisition and management of Taiwan data processing center
- Acquisition and management of the secondary scientific payloads for second six satellites

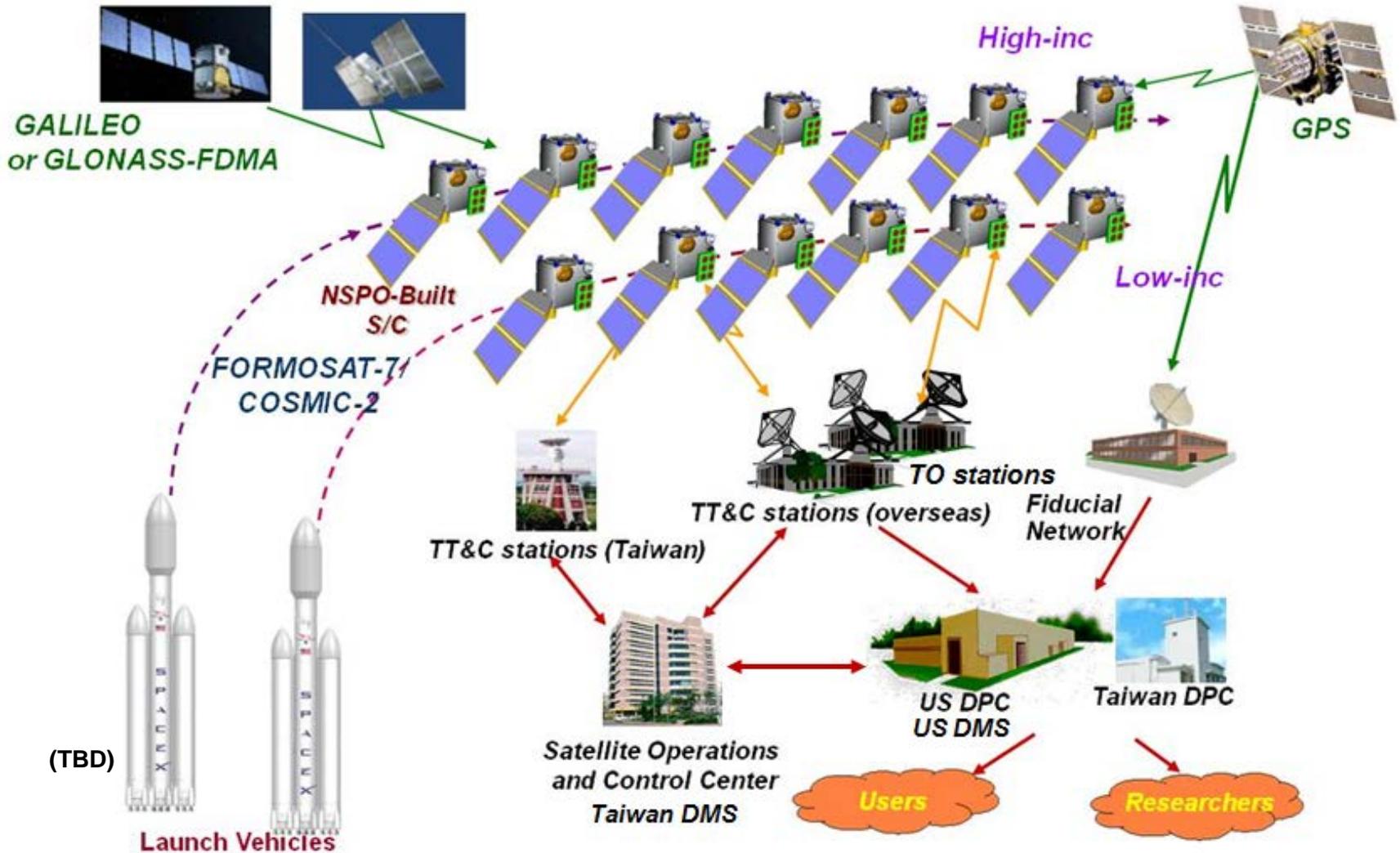


- **NASA/JPL activities:**

- Non Recurring Engineering (NRE) for new sensor design for TGRS
- Provide mission support for mission payload



# CONOPS / COSMIC-2 System Architecture



# C-2a Instrument Development Status

- All first flight units for TGRS, IVM, and RF Beacon were delivered to SSTL and successfully powered through the spacecraft
- **TGRS**
  - Software updates enabling loads through spacecraft
  - Units #2-4 completed and in storage
  - Completion of development, I&T, and software efforts for #2-6 through UCAR – JPL contract
  - Delivery of partial EIDP for Units #2-6 February 6th
  - TGRS Pre-Ship Review (PSR) for #2-6 March 24th
  - Near term focus is to complete flight software V2.0 (GPS only), and complete the test software update



## TGRS Description

- Radio Occultation (RO) receiver that tracks GNSS signals across Earth's limb
- Weather prediction models, severe weather forecasting, and space weather monitoring
- Meteorological, ionosphere and climate research
- Provides global observations of refractivity, pressure, temperature, humidity, total electron content, ionospheric electron density, and ionospheric scintillation

# C-2a Instrument Development Status

- **IVM (USAF)**

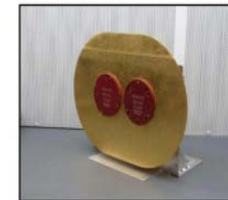
- Pre-Ship Review (PSR) for Units #2-6 completed January 27th
- JPL shipped units #2-6 to Taiwan April 3rd
- There is an issue of IVM contamination in the STP-2 stack that the USAF leadership (SMC/RS and SMC/AD are working to address)

- **RF Beacon (USAF)**

- Completion of development and I&T efforts for #2-6 will be through a UCAR - SMI contract
- All Antenna Units completed assembly
- BEU delivery schedule successfully optimized to meet S/C need date
- Delivery of RF Beacon Unit #2 occurred in March 2015

## IVM Description

- Measures the in-situ plasma density, ion temperature and composition, and drift velocity
- Used for modeling the ionosphere to determine electric fields that could impact other systems (e.g. GPS radio signals)

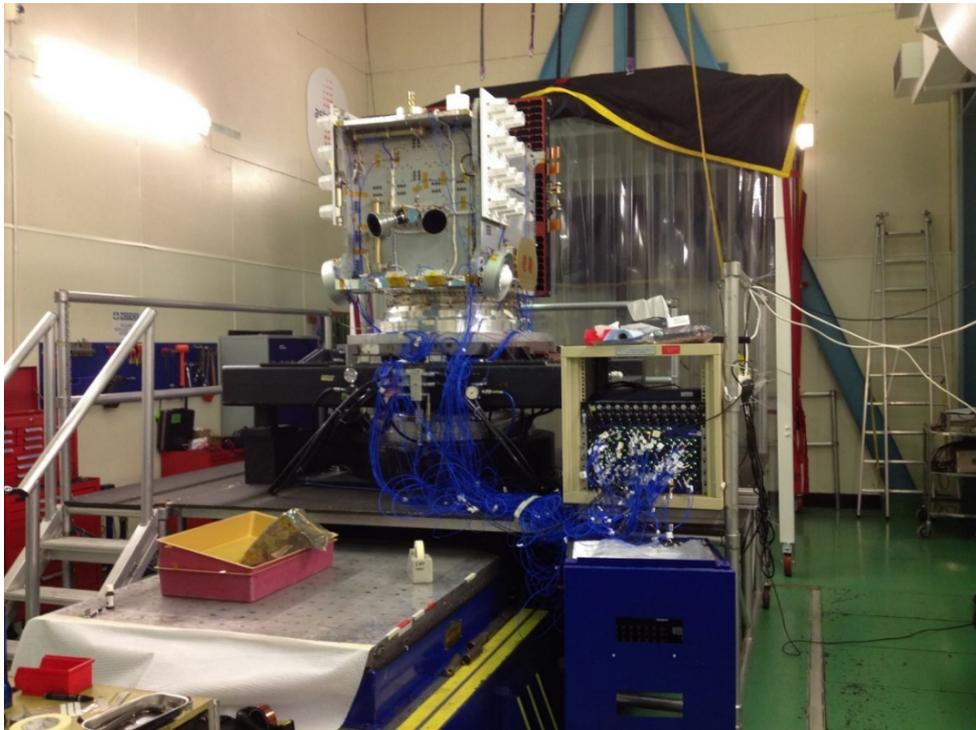


## RF Beacon Description

- Transmitter that enables ground-based measurement of ionospheric scintillation and ionospheric total electron content (TEC)
- Critical to the understanding of the impacts of space weather on satellite communication systems and GPS

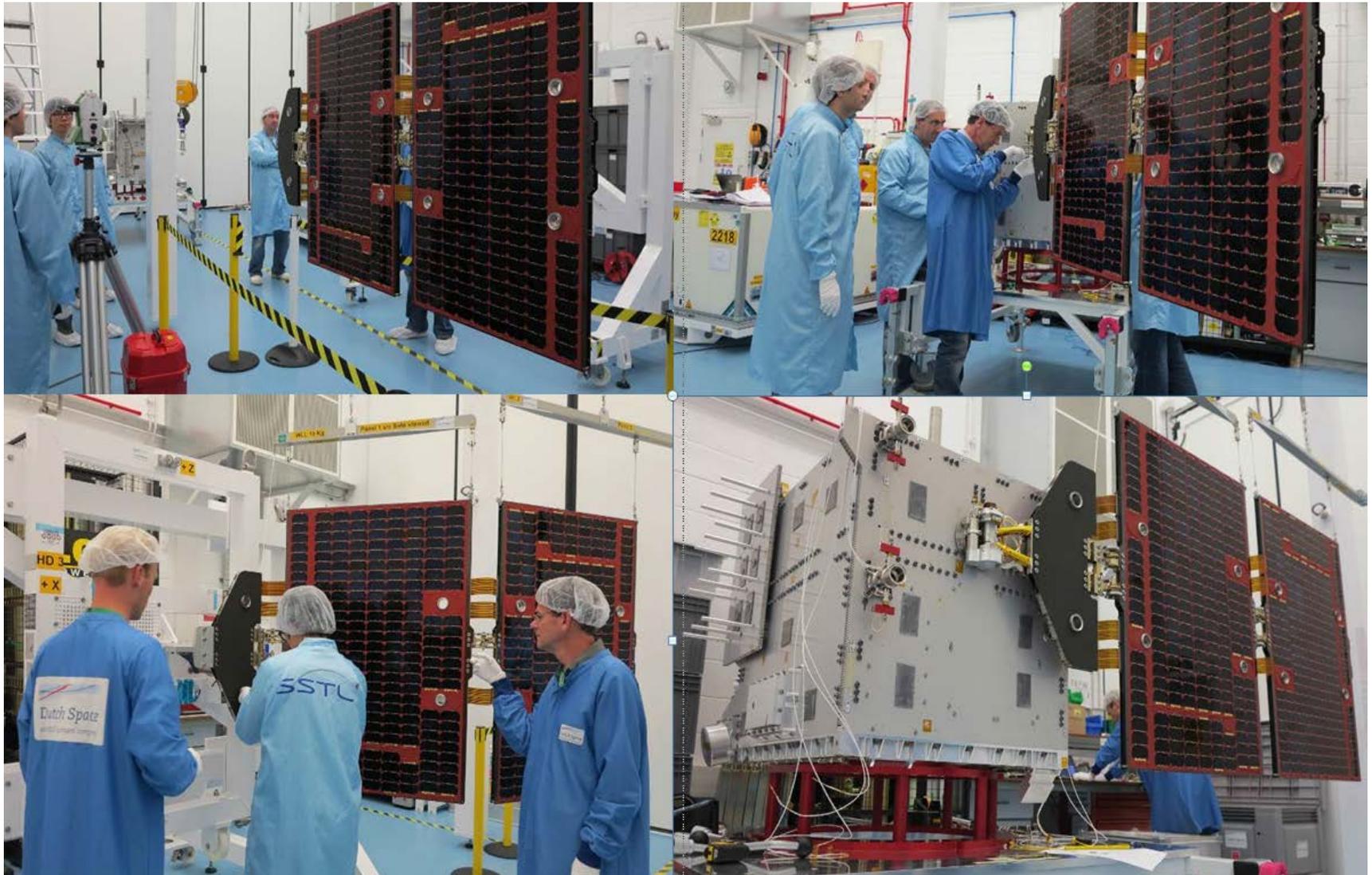
# Satellite Development Status

- The first satellite has been assembled and has gone through testing in the UK.
- System End-to-End Test (SEET) occurred at the end of February, Flight Acceptance Review the was the first week of March, and the delivery of the first satellite to Taiwan occurred at the end of March
- The picture below was taken with the spacecraft on the table for Z axis testing in December 2014
  - Two star trackers are visible in front and the white square RO antennas on either side
  - The lower round white antennas are for positional determination (or POD)
  - The blue cables are the numerous connections to the accelerometers attached to the spacecraft that provided test data
- The top of the Flight Unit in this picture is the earth facing nadir side



Dimensions (stowed)	1000 x 1250 x 1250 mm
Launch Mass (wet)	277.8 kg
Total Power Peak / OAP	229.8 (orbit average)
Battery Capacity	> 22.5A-hr
Attitude	3-axis Knowledge <0.07deg (3-sigma) Control <1deg (3-sigma)
Propulsion	Hydrazine monoprop ~141 m/s
Communications	S-band TM/TC, 32kbps uplink, up to 2Mbps downlink
Navigation	GPS
Design Life	5 years, >66%
Availability	>95%
Launch compatibility	EELV (ESPA Grande Adaptor)
Payload support	>2Gbits data storage 39.4kg mass, 95W OAP
Design Features	<input checked="" type="checkbox"/> dual redundant avionics <input checked="" type="checkbox"/> Batch launch compatible <input checked="" type="checkbox"/> Constellation compatible

# C-2 Flight Unit #1 Solar Panels are Undergoing Deployment Test and Fit Check on the Structure Demonstration Model Spacecraft Bus at SSTL in the UK

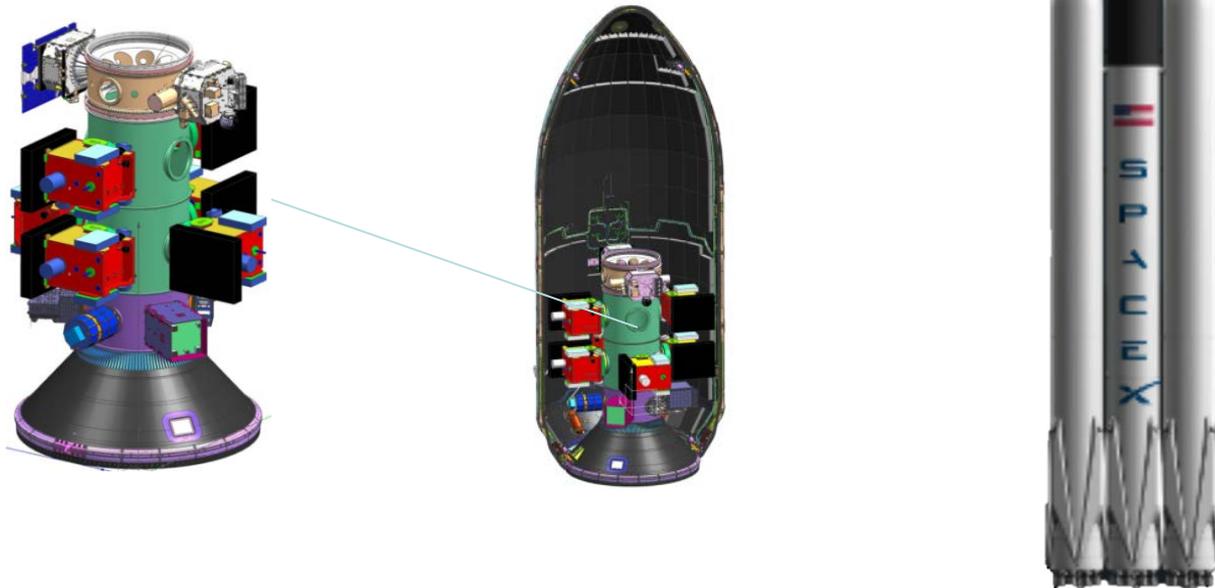


# Spacecraft #1 in Taiwan at NSPO



# C-2a Launch Status

- USAF awarded a launch vehicle contract to SpaceX in January 2013, to launch COSMIC-2 on the STP-2 Mission on a Falcon Heavy launch vehicle
  - Launch currently planned for May 2016
  - Scheduled to be a demonstration flight, not a certified launch
- Falcon Heavy in development
  - Demo mission to fly 4<sup>th</sup> quarter CY15





# Ground Status Update

- Successfully completed NOAA-UCAR System Requirements Review (SRR) for the Data Processing Center (DPC) Segment on Oct 22, 2014
- INPE (Brazil's Space Agency) successfully conducted Factory Acceptance Testing (FAT), successfully ingested COSMIC-1 data. Antenna being shipped from the factory in France to the ground site in Brazil. Initial UCAR quality analysis indicates good performance in FAT.
- Active dialogue with Australia's Bureau of Meteorology (BoM) – they are willing to host a ground station at their site in Darwin
- The USAF Mark IVB support:
  - Contract modifications pending, expect readiness by Nov/Dec 2015
  - Working on Pass Schedule coordination ConOp based upon GS ICD schedule definition
- Upcoming Activities
  - Meetings with Australia's BoM and Darwin Site Survey are planned for April 21-25
  - Ground and DPC Segment Critical Design Review (CDR) planned for summer/fall 2015 in Boulder, CO



# Mark IV-B Ground Stations



**3m Tracking  
X/L/S-Band**



**Signal Processing  
Racks**

- The USAF agreed to pay for the modifications and O&M costs associated with incorporating COSMIC-2 data collection and dissemination into the MARK IV-B baseline
- MARK IV-B capabilities
  - MARK IV-B utilizes S-band (e.g. 3m XLS-band polar antenna) in the current hardware architecture allowing it to capture COSMIC-2 data
  - MARK IV-B footprint at Guam, Hawaii and Honduras locations can help in the COSMIC-2 ground collection footprint
- Schedule
  - Work effort is in planned in CY 2015 to support COSMIC-2 launches planned in 2016 and 2018



# COSMIC-2 Equatorial Ground Stations (Planned)

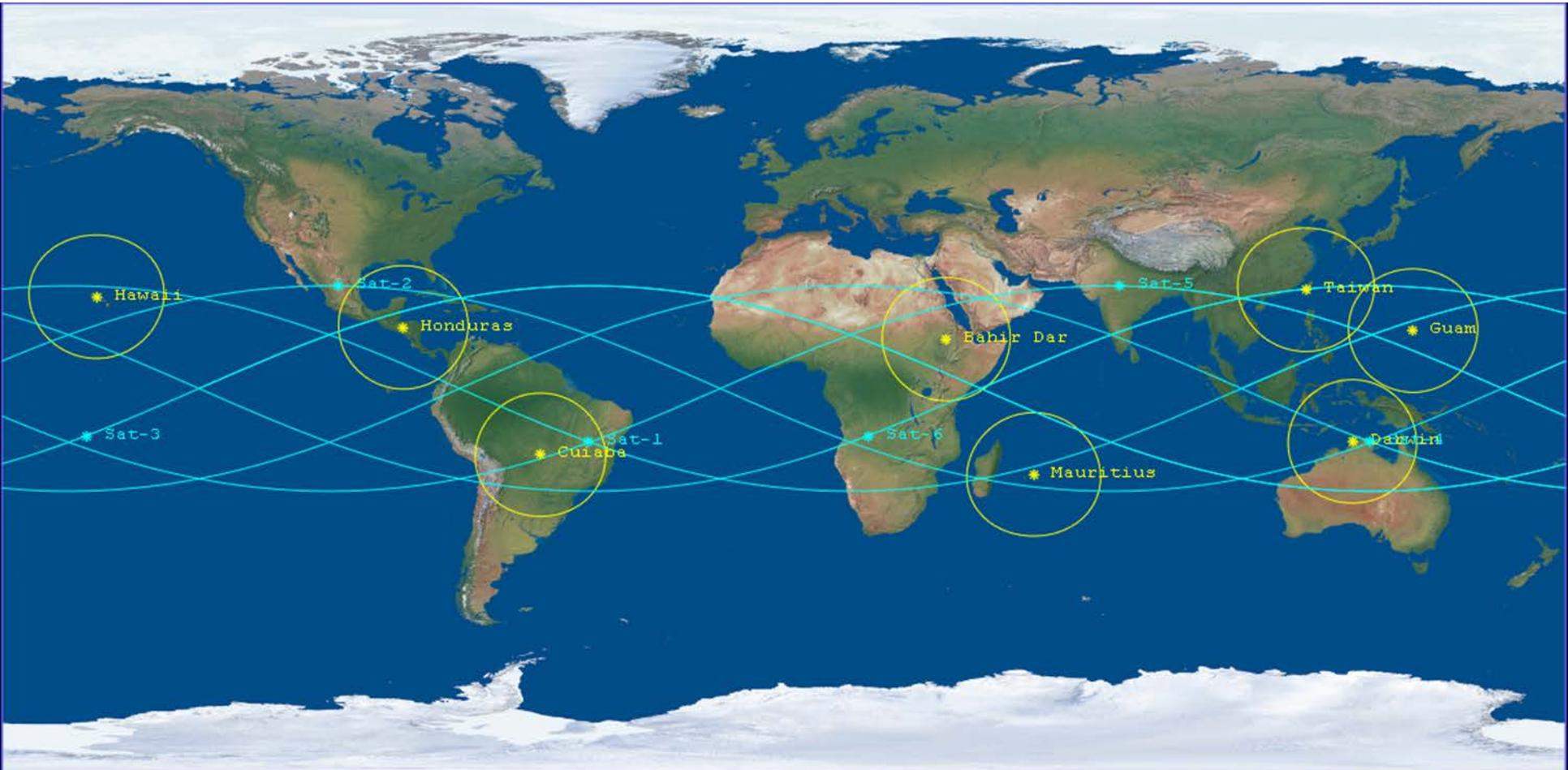
Ground Station Location	Partner / Sponsor	Level of Commitment	Notes
Taiwan	NSPO	100%	Uses existing Capability
Cuiaba, Brazil	INPE	100%	INPE awarded contract for GS in Jan 2014, MOU with NOAA in final Coordination
Mark IV-B – Hawaii	USAF	100%	Working with USAF to establish compatibility with COSMIC-2 downlink
Mark IV-B – Guam	USAF	100%	Working with USAF to establish compatibility with COSMIC-2 downlink
Mark IV-B – Honduras	USAF	100%	Working with USAF to establish compatibility with COSMIC-2 downlink
Darwin, Australia	BoM	~90%	BoM Australia discussing path forward to provide dedicated support
North Africa (TBD)	Commercial Service	0%	Subject of a FY15 solicitation for Data Services from commercial providers
Mauritius (TBD)	Commercial Service	0%	Subject of a FY15 solicitation for Data Services from commercial providers



NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION



# Ground Station Architecture (Planned First Phase)



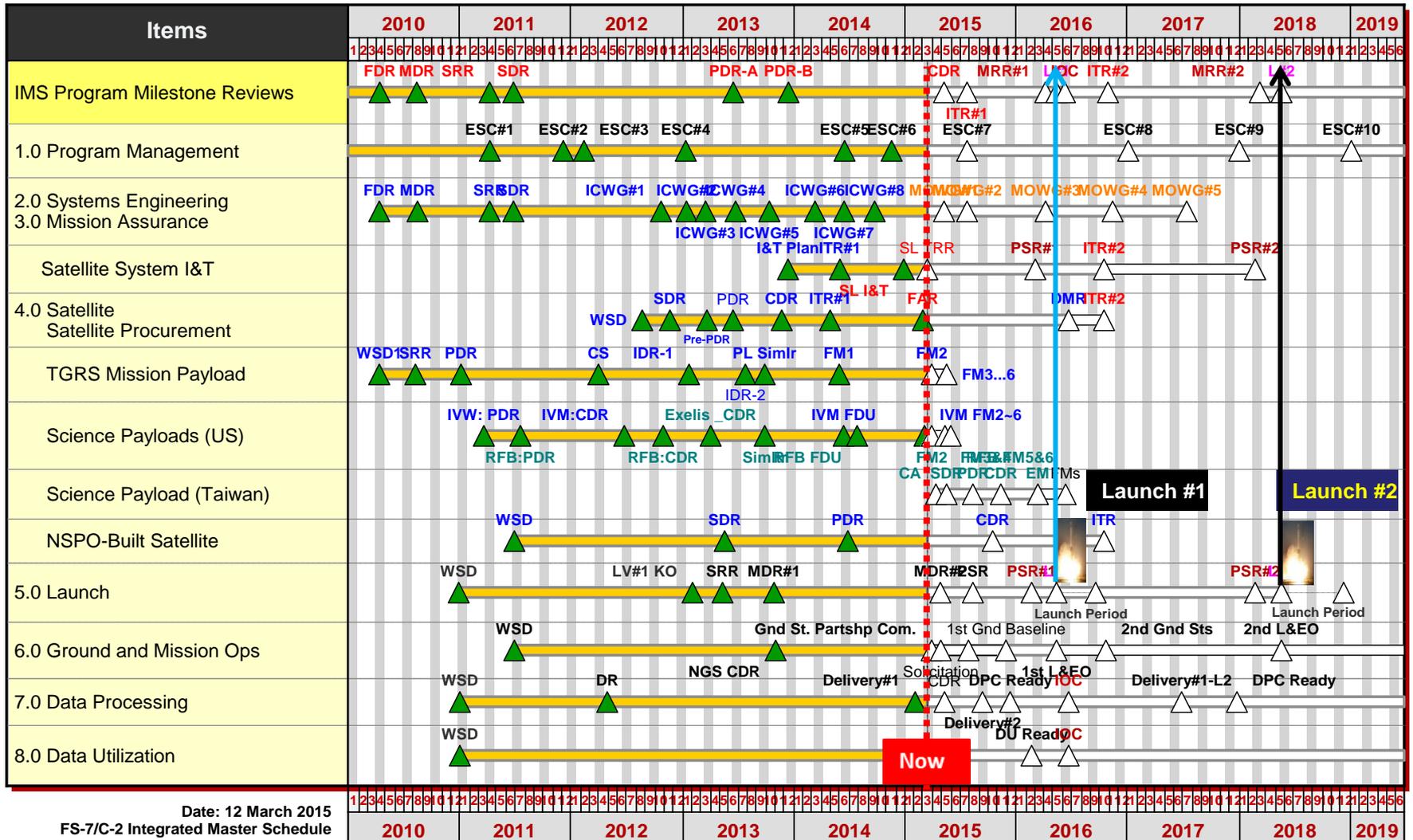


# DPC Status Update

- NOAA provided FY14 funds to UCAR in August 2014 to begin UCAR upgrades
- COSMIC-2 development hardware procured/installed and running beta COSMIC-2 SW at UCAR
- COSMIC-2 operational Ground-IO hardware purchased/installed and running
- UCAR delivered SW version #1 to Taiwan's data center Feb 5, 2015
- UCAR and NSPO conducted successful initial connectivity and data flow tests
- UCAR and NOAA working IT Security upgrades for COSMIC-2
- Summer/Fall 2015 – US DPC segment CDR
- May-Sept 2015 planned system I&T
- December 2015 planned UCAR Readiness Review

# Joint Program Integrated Master Schedule

## FORMOSAT-7 / COSMIC-2 Program Integrated Master Schedule



Date: 12 March 2015  
FS-7/C-2 Integrated Master Schedule



# Summary

- Looking forward to an exciting 12 months ahead!!