The Global Precipitation Measurement (GPM) Project Status (Instruments)

GPM NOAA workshop



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GPM Global Precipitation Measurement Overview

Mission Objective:

- **Improve scientific understanding of the global water cycle and fresh water availability**
- **Improve the accuracy of precipitation forecasts**
- **Provide frequent and complete sampling of the Earth's precipitation**

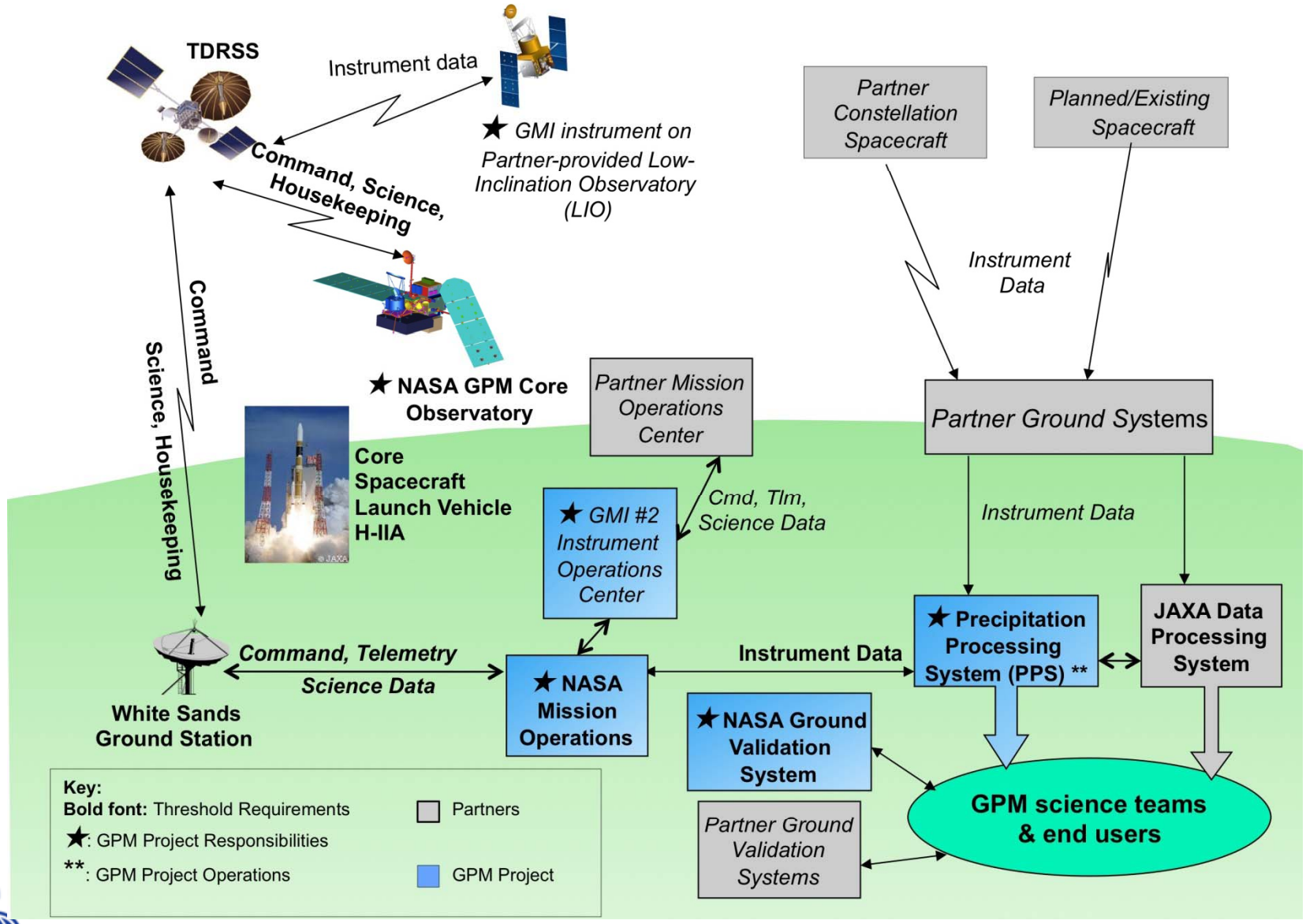
Mission Description (Class B, Category I):

- **Constellation of spacecraft provide global precipitation measurement coverage**
  - NASA/JAXA Core spacecraft: Provides a microwave radiometer (GMI) and dual-frequency precipitation radar (DPR) to cross-calibrate entire constellation
    - 65° inclination, 400 km altitude
    - Launch July 2013 on HII-A
    - 3 year mission (5 year propellant)
  - Second GMI instrument to be accommodated on a TBD partner-provided Low-Inclination spacecraft: Complements Core spacecraft and partner assets
    - ~40° inclination, ~600 km altitude
    - Launch late 2014 (TBR)
  - Partner constellation spacecraft: Provided by JAXA, DoD, NOAA, other space agencies
- **Ground assets**
  - Precipitation Processing System: Data processing, archive, distribution for the entire constellation of spacecraft
  - Ground validation system: Uses world-wide network of ground-based measurements to validate space measurements and algorithms
  - Mission Operations Center for Core Spacecraft
  - Instrument Operation Center for GMI #2



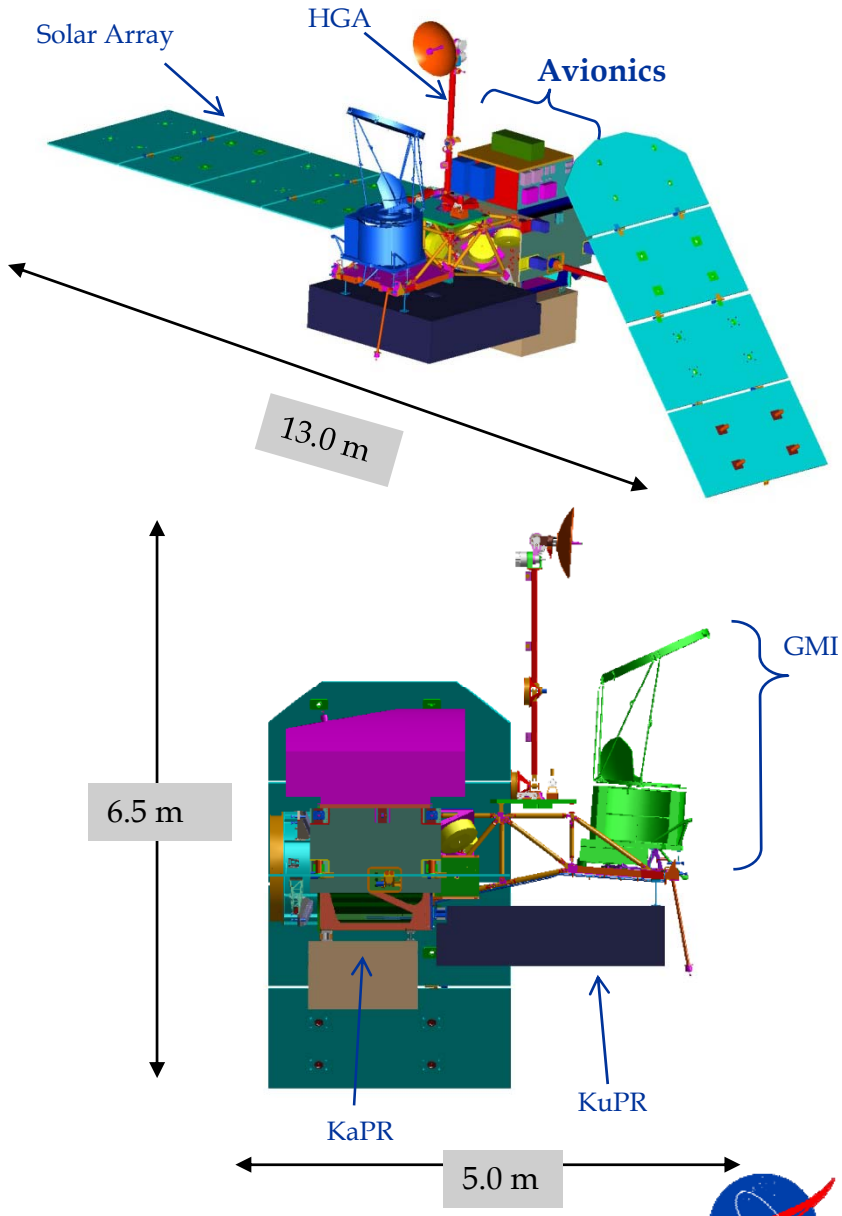
- **Partners**
  - Japanese Aerospace and Exploration (JAXA)
    - DPR instruments for Core spacecraft
    - Launch service for Core spacecraft
  - TBD, LIO Spacecraft and Launch Vehicle
  - Other U.S. and international agencies
    - Data from radiometers (e.g. IPO NPP, DOD DMSP, JAXA GCOM-W, Megha-Tropiques)
    - Ground validation partnerships
  - Universities
    - Ground validation partnerships
    - Science team participation

GPM Mission Architecture



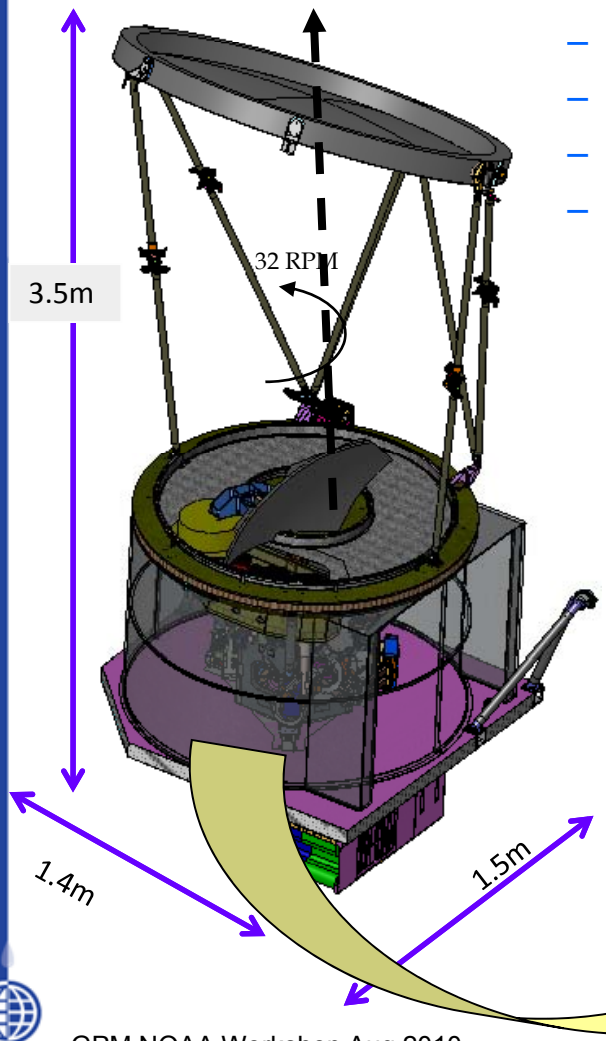
GPM Core Observatory

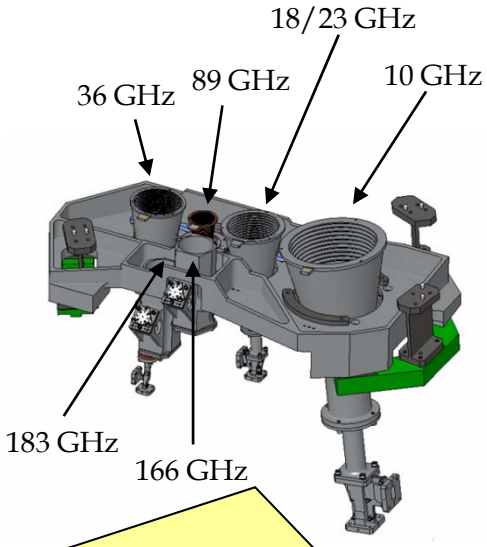
- **Orbit: 407 km; 65 degree inclination**
- **3 year design life with 5 years propellant**
- **Controlled re-entry at end of operational life**
- **GPM Microwave Imager (GMI) : Conically Scanned Radiometer (Ball Aerospace)**
  - 10.6,18.7,23.8,36.5,89,166 & 183 GHz
- **Dual-Frequency Precipitation Radar (DPR = KuPR + KaPR): JAXA**
  - 13.6,35.5 GHz
- **Spacecraft bus: GSFC in-house design**
  - Aluminum and Composite
  - Modular, fully-redundant avionics
  - Steerable high-gain antenna on dual-hinged boom
  - Solar arrays track the sun
  - 12 thrusters (4 forward, 8 aft)
  - 200 Amp-hour Lithium Ion Battery
  - Size: 13.0m x 6.5m x 5.0m
  - Mass: 3850 kg
  - Power: ~1950W
  - Data Rate:~ 300 Kbs (with onboard storage)



GMI Overview

- **GMI is a passive microwave radiometer with hot and cold calibration**
  - 166 Kg, 162 W, 34.9 Kbs Science (4 Kbs Engineering data) 1.2 m diameter reflector
- **Conically scanned Main Reflector @ 32 RPM**
  - Clear view enables high beam efficiency with low cross-pol coupling
  - Swath width 885 km
  - Resolution: 19.4km x 32.2km (10 GHz) – 4.4km x 7.3km (183 GHz)
  - Incorporates a 166/183 GHz subreflector
    - Allows for single aperture
    - Enables critical frequencies to be located near the focal point while optimizing competing efficiency, beamwidth, and loss requirements

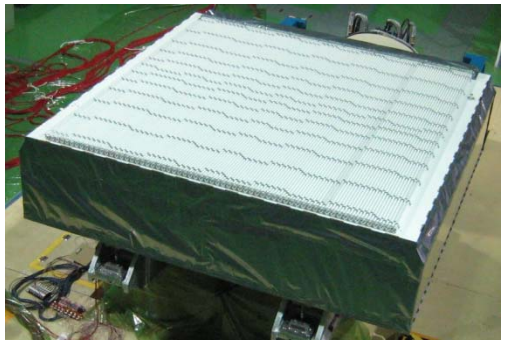




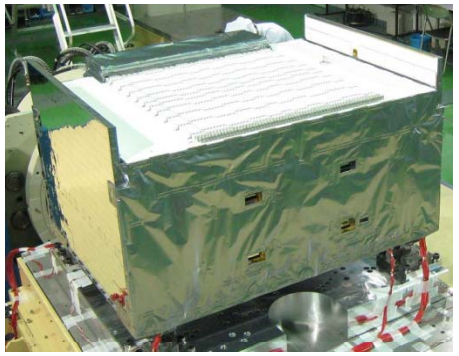
Frequencies	Polarizations
10.65 GHz	V/H
18.7 GHz	V/H
23.8 GHz	V
36.5 GHz	V/H
89 GHz	V/H
166 GHz	V/H
183 GHz	Va/Vb

JAXA-Provided Dual-frequency Precipitation Radar (DPR) Instrument Overview

	KuPR (similar to TRMM PR)	KaPR (new for GPM)
Frequency	**13.597 , 13.603 GHz**	**35.547 , 35.553 GHz**
Horizontal Resolution	**5.2 km (at nadir)**	**5.2 km (at nadir)**
Swath Width	**245 km**	**120 km**
Scan period	**0.7 sec**	**0.7 sec**
Range Resolution	**250 m**	**250 m / 500 m**
Observation altitude	**Up to 19 km**	**Up to 19 km**
Minimum Detectable Rainfall Rate	**0.5 mm/hr**	**0.2 mm/hr**
Measurement Accuracy	**within ± 1 dB**	**within ± 1dB**
Beam-matching Accuracy	**< 1000 m**	
Data Rate	**< 109 kbps**	**< 81 kbps**
Mass	**< 472 kg**	**< 336kg**
Power Consumption	**< 446 W**	**< 344 W**
Size	**2.5 × 2.4 × 0.6 m**	**1.2 × 1.4 × 0.7 m**



KuPR STM



KaPR STM

GPM Project Status

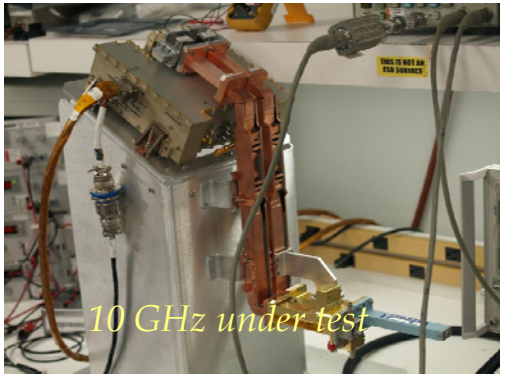
- **Programmatic**
  - GPM Mission was "Confirmed" by NASA HQ December 2, 2009 to proceed with the implementation phase
    - Launch Readiness Date July 2013
  - Mission CDR held Dec 14-17, 2009
  - Low-Inclination Observatory (LIO) implementation via partnership
    - GMI#2 development (copy of GMI #1) started October 2009
    - Spacecraft Bus for LIO will be acquired through international partnership
- **Core Observatory**
  - Flight Structure being assembled in preparation for Qualification Test Program and delivery to I&T
  - Flight avionics unit manufacturing has started
  - Observatory Integration & Test (I&T) targeted to start in Dec 2010
  - Flight Solar Array cell lay down process has begun
  - All other spacecraft procurements in place
- **Ground Systems**
  - Ground System CDR completed July 28-29, 2010

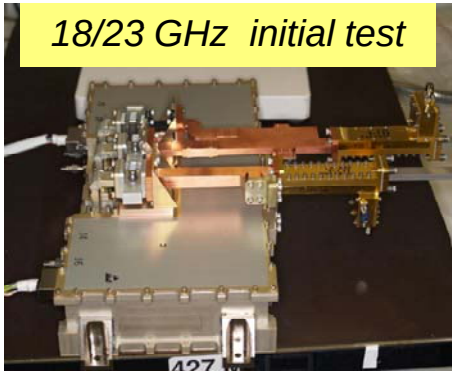
GPM Project Status

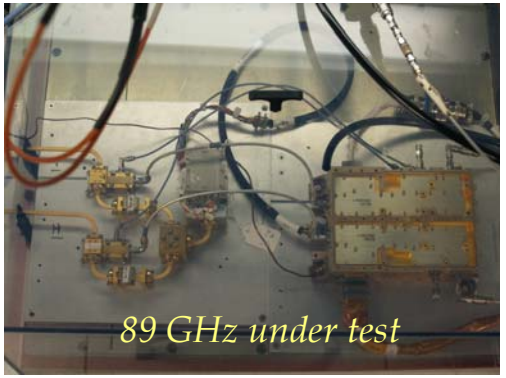
- **GPM Core Observatory Instruments**
  - GMI (#1) Development at Ball/Subcontractors continues
    - Delivery targeted for July 2011
    - Cold Sky Reflector #1 coating completed
    - Flight Main Reflector #1 coating is complete
    - Receiver testing progressing through box-level alignment/ATP process – Deliveries Oct thru Nov
      - 10 GHz environmental testing
      - 18/23 GHz completed alignment test
      - 36 GHz testing complete
      - 89 GHz environmental testing
      - 166 GHz started test program
      - 183 GHz started test program

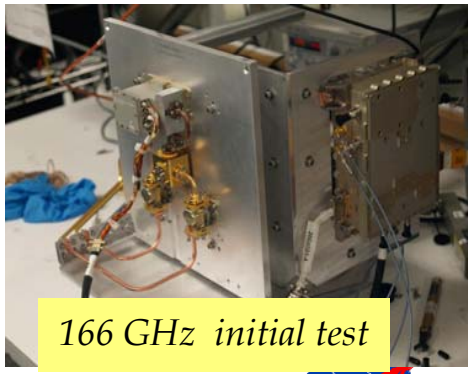












GPM Project Status

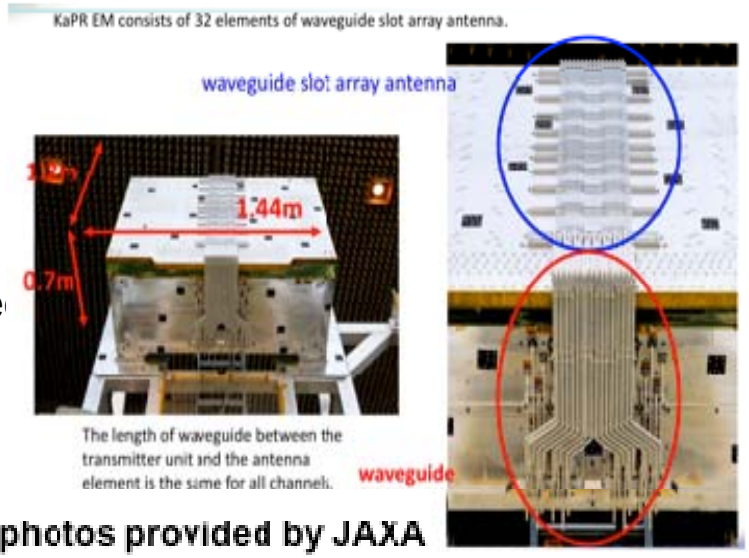
- **GPM Core Observatory Instruments**
  - GMI (#1) Development at Ball/Subcontractors continues – Delivery targeted for July 2011
    - Flight Reflector Deployment Assembly (RDA) tested with flight Main Reflector
      - Verified repeatability of main reflector deployments
    - GMI Spin Mechanism Assembly (SMA) complete
      - Awaiting slipring delivery in mid September
    - Instrument Controller Assembly (ICA) boards continue final assembly and test
    - 166,183 , 10 & 36 GHz feed horns aligned to tray assembly


RDA Deployment


Feedhorns

GPM Project Status

- **GPM Core Observatory Instruments, cont'd**
  - DPR (KuPR & KaPR) Instruments (JAXA)
    - Ku & Ka assembly and test continues
    - DPR Pre-Environmental Review (PER) targete for November 2010
    - DPR targeted delivery - July 2011

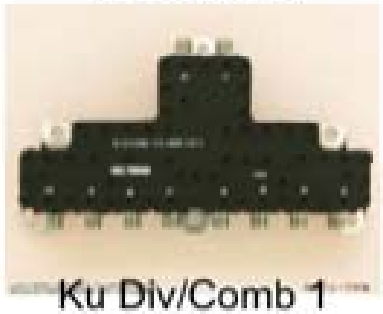


DPR photos provided by JAXA


Ku T/R unit


Ka T/R unit


Interface box


Ku Div/Comb 1


Ka Div/Comb 1


Ku RX BPF

GPM Project Status

- **GMI #2 development underway - delivery of the instrument is targeted for Dec 2012**
  - Main Reflector #2 completed environmental testing and delivered to Ball
    - Vapor deposited aluminum (VDA) coating is planned for early September 2010
  - Cold Sky Reflector is complete and ready for VDA coating
    - VDA coating planned the week of Aug 16
  - Reflector Deployment Assembly (RDA) completed testing and ready for delivery
  - Spin Mechanism Assembly will begin early 2011
  - Receiver assembly in progress

Next Steps

- **Prepare to start Core Observatory Integration &Test phase in Dec 2010**
  - Complete flight hardware fabrication
- **Establish partnership for the Low Inclination Observatory**
  - Continue with GMI #2 development
  - Targeted Delivery Date Dec 2012

Back-up charts

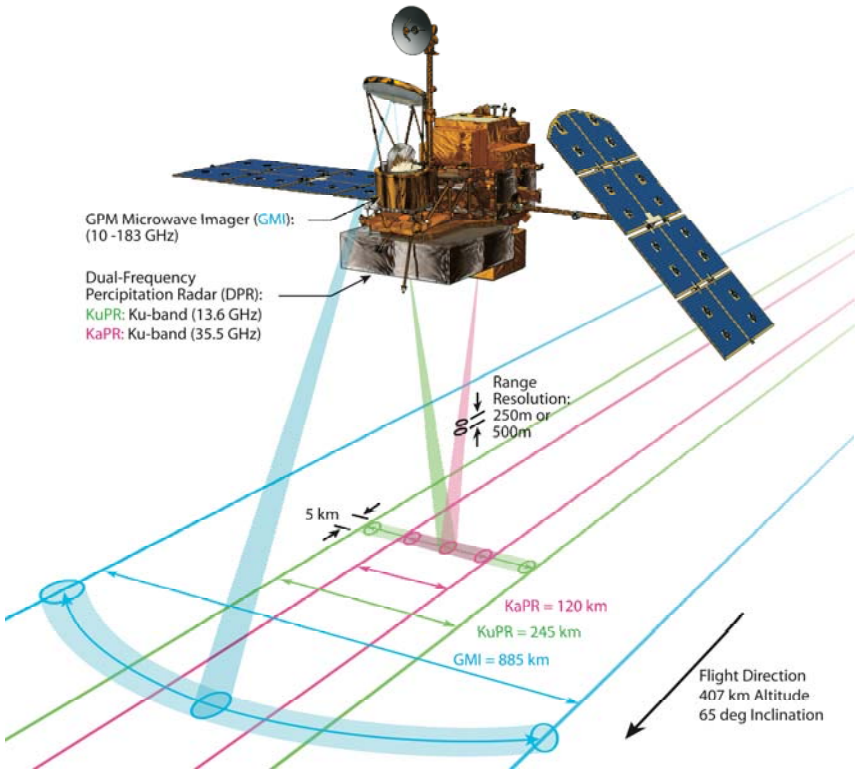
GPM Instrument Observation Geometry

GPM Microwave Imager (GMI)
10-183 GHz

- Passive microwave radiometer with hot and cold calibration
- 4-point calibration to serve as a radiometeric reference for constellation radiometers
- High spatial resolution
- Improved light rain & snow detection
- Improved signals of solid precipitation over land (especially over snow-covered surfaces)

Dual Precipitation Radar (DPR) Ku-Ka band:

- KuPR similar to TRMM, KaPR added for GPM
- Provides three-dimensional measurements of cloud structure, precipitation particle size distribution (PSD) and precipitation intensity and distribution
- Increased sensitivity (~11 dBZ) for light rain and snow detection

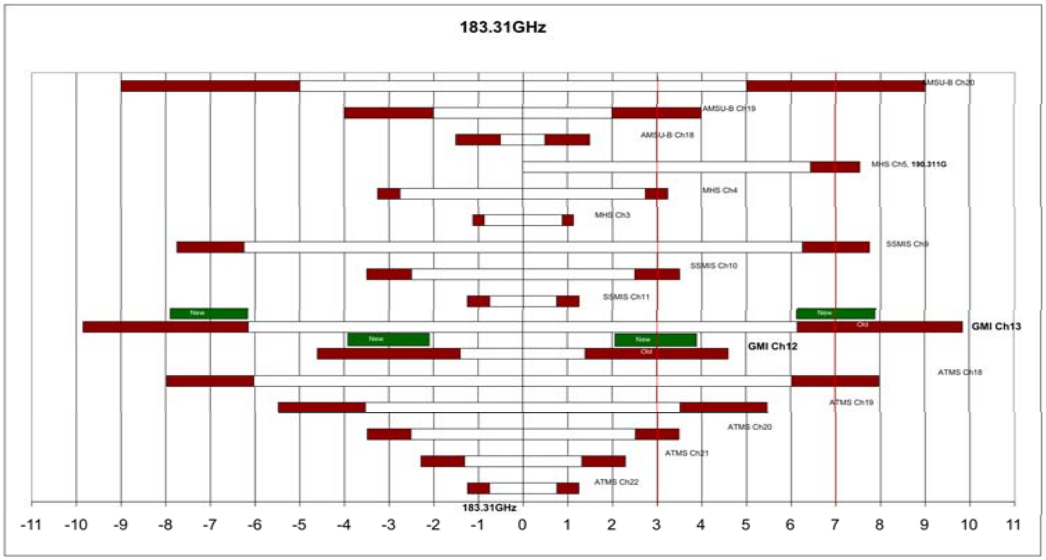


Combined Radar-Radiometer Cloud Database

- DPR & GMI together provide greater constraints on possible solutions to improve retrieval accuracy
- Improved a-priori cloud database for constellation Radiometer retrievals

GPM Enhancements to GMI 166 & 183 GHz channels

- **Enhancements to GMI 166 GHz (channels 10 &11) and 183 GHz (channels 12 &13) have been implemented**
  - 166 GHz (channels 10 & 11) – improved NEΔT (Higher performance mixers)
  - 183 GHz (channel 12) – improved NEΔT (Higher performance mixers) and changed bandwidth
    - Bandwidth change from 3GHz to <1.5GHz
  - 183 (channel 13) – improved NEΔT (Higher performance mixers) and changed center frequency and bandwidth
    - Center Frequency change from183.31± 8 GHz to 183.31± 7
    - Bandwidth change from 4.5 GHz to <2 GHz

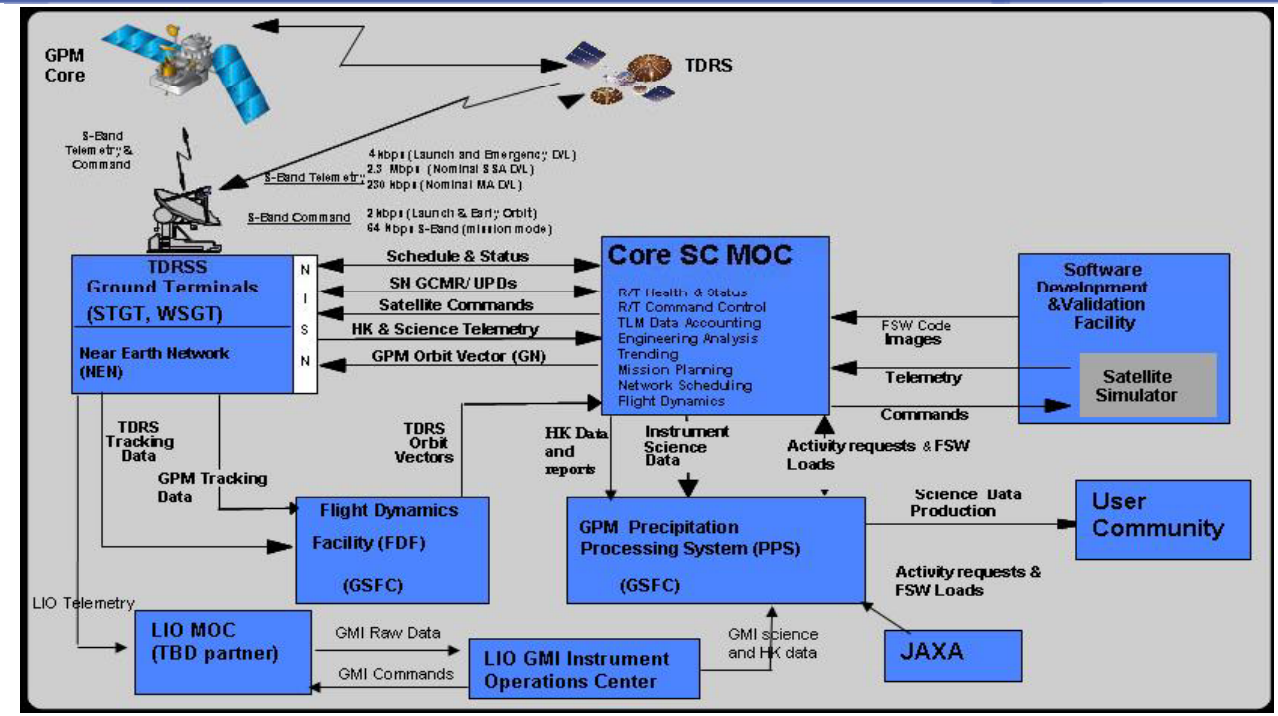


Channels 10 &11 NEΔT req: 1.5K
Previous prediction: 1.47K
Current prediction with new mixers: 0.81K

Ch 12 NEΔT req 1.5K
Previous prediction of NEΔT 1.18K with 3.0GHZ BW
Current prediction with new mixer and 1.5 GHz BW ; 0.87K

Ch 13 NEΔT req 1.5K
Previous prediction of NEΔT 1.21K with 3.78GHz BW
Current prediction with new mixer and 1.80GHz BW ; 0.81K

Ground System Architecture Builds on TRMM Experience



Ground system supports:
- Radiometer precipitation products from GMI within 1 hour of observation
- Combined radar/radiometer swath products within 3 hours of observation

- **Mission Operations Center (MOC)**
  - Largely automated, staffed 8x5
    - Instruments operate in survey mode, require very little commanding from ground
  - Interfaces with Precipitation Processing System (PPS) to deliver:
    - 5-minute duration science instrument files
    - 5-minute duration housekeeping data files
    - Metadata associated with data processing and delivery
    - Ancillary data to support science product generation
  - Interfaces with PPS to receive instrument commands and command requests as needed

- **Precipitation Processing System (PPS)**
  - Creates higher-level science data products
  - Delivers science data products to user community
  - Provides interface to instrument science teams
  - Delivers instrument commands, instrument team command requests to MOC
- **LIO GMI Instrument Operations Center**
  - Interfaces with partner-provided MOC (TBD)
  - Provides LIO GMI data to PPS

GPM Ground Validation Builds on TRMM Experience

- **GPM Level-1 Requirements call for a Ground Validation System to**
  - Support the PMM Science Team in pre-launch science algorithm development and post-launch product evaluation
- **The framework for the GPM-GVS is based on the GPM GVS Science Implementation Plan; it calls for 3 approaches to validation:**
  - Surface: compare satellite data to US and International Networks of radars and gauges
  - Vertical Column: physical process studies and field campaigns test and refine physically-based retrieval algorithms
  - 4-Dimensional: field validation of satellite precipitation products integrated with meteorological and hydrological prediction models
- **Ground validation program partnerships**
  - Inter-agency and international partnerships improve the fidelity of ground validation
  - Putting partnerships in place through workshops and working group meetings



- **Five (5) field campaigns planned, starting in 2011**
- **~18 month intervals between campaigns**
- **Campaigns held in different climatic regimes**