IGARSS 2008 Special Session: Global Precipitation Mission

The Global Precipitation Measurement (GPM) Project

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The Global Precipitation Measurement (GPM) mission is an international cooperative effort to advance weather, climate, and hydrological predictions through space-based precipitation measurements. The **Core Observatory** will be a reference standard to uniformly calibrate data from a **constellation** of spacecraft with passive microwave sensors. GPM mission data will be used for scientific research as well as societal applications. GPM is being developed under a partnership between the United States (US) National Aeronautics and Space Administration (NASA) and the Japanese Aerospace and Exploration Agency (JAXA). NASA is developing the Core Observatory, a Low-Inclination Constellation Observatory, two GPM Microwave Imager (GMI) instruments, Ground Validation System and Precipitation Processing System for the GPM mission. JAXA will provide a Dual-frequency Precipitation Radar (DPR) for installation on the Core satellite and launch services for the Core Observatory. Other US agencies and international partners contribute to the GPM mission by providing precipitation measurements obtained from their own spacecraft and/or providing ground-based precipitation measurements to support ground validation activities.

The GPM Core Observatory will be placed in a low earth orbit (~400 km) with 65-degree inclination, in order to calibrate partner instruments in a variety of orbits. The Core Observatory accommodates 3 instruments. The GMI instrument provides measurements of precipitation intensity and distribution. The DPR consists of Ka and Ku band instruments, and provides three-dimensional measurements of cloud structure, precipitation particle size distribution and precipitation intensity and distribution. The instruments are key drivers for GPM Core Observatory overall size (11.6m x 6.5m x 5.0m) and mass (3500kg), as well as the significant (~1950W) power requirement.

The Core Spacecraft is being built in-house at Goddard Space Flight Center. The spacecraft structure consists of an aluminum lower bus structure, composite upper bus structure, 2-axis steerable High Gain Antenna System on a dual-hinged boom, and two deployable solar arrays. The propulsion system features twelve thrusters and a single Composite Overwrap Pressure Vessel tank. The GPM Core spacecraft is one of the first large spacecraft developed to be demiseable (i.e. burn up upon atmospheric reentry). The spacecraft demiseable components--structure, propulsion tank, lithium-ion battery, solar array and reaction wheels, are a unique feature.

The spacecraft will have a fully redundant avionics integrated in a separable module, to optimize integration and test operations. The heart of the avionics is the Central Avionics Box (CAB), which provides command and data handling, guidance, navigation and control, communications processing, as well as control electronics for the spacecraft propulsion system and mechanisms. The CAB integrated avionics architecture is a modular design, providing all flight software on a single processor card.

The spacecraft is being designed to be highly reliable over a 3-year mission life, with 5 years capacity for consumables (e.g. propellant, battery end-of-life capacity). The Core Observatory will be launched on an HII-A from Tanegashima, Japan in the summer of 2013. It will be controlled from a Mission Operations Center at Goddard Space Flight Center in Greenbelt, MD.

The GPM Project team is currently refining requirements and performing spacecraft design activities, working toward a Preliminary Design Review in late 2008. This paper will present an overview of the GPM Project development status, as well as technical challenges in developing the Core Observatory.

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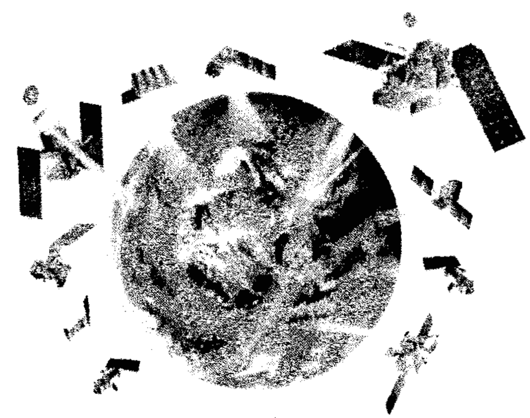

IGARSS 2008

Global Precipitation Mission Session I

July 10, 2008

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Project Manager
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Deputy Project Manager
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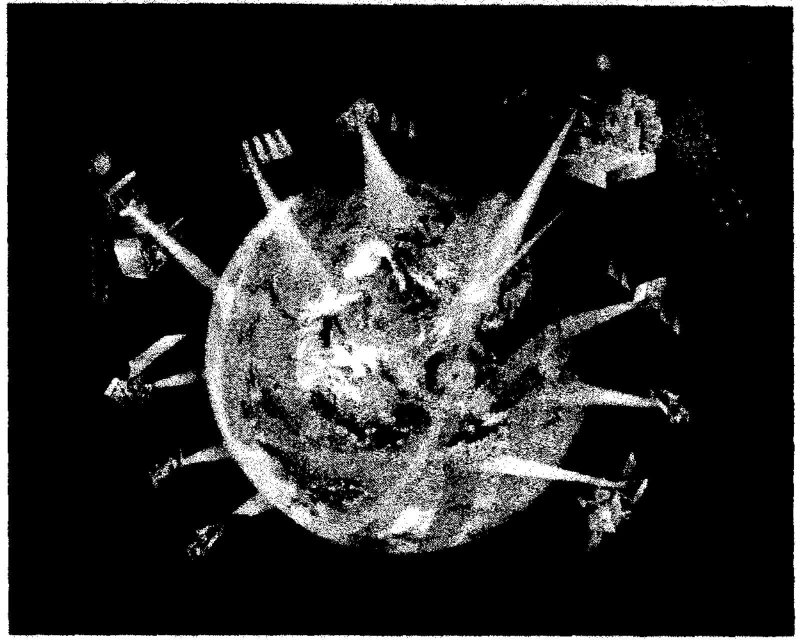
Global Precipitation Measurement Overview

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***

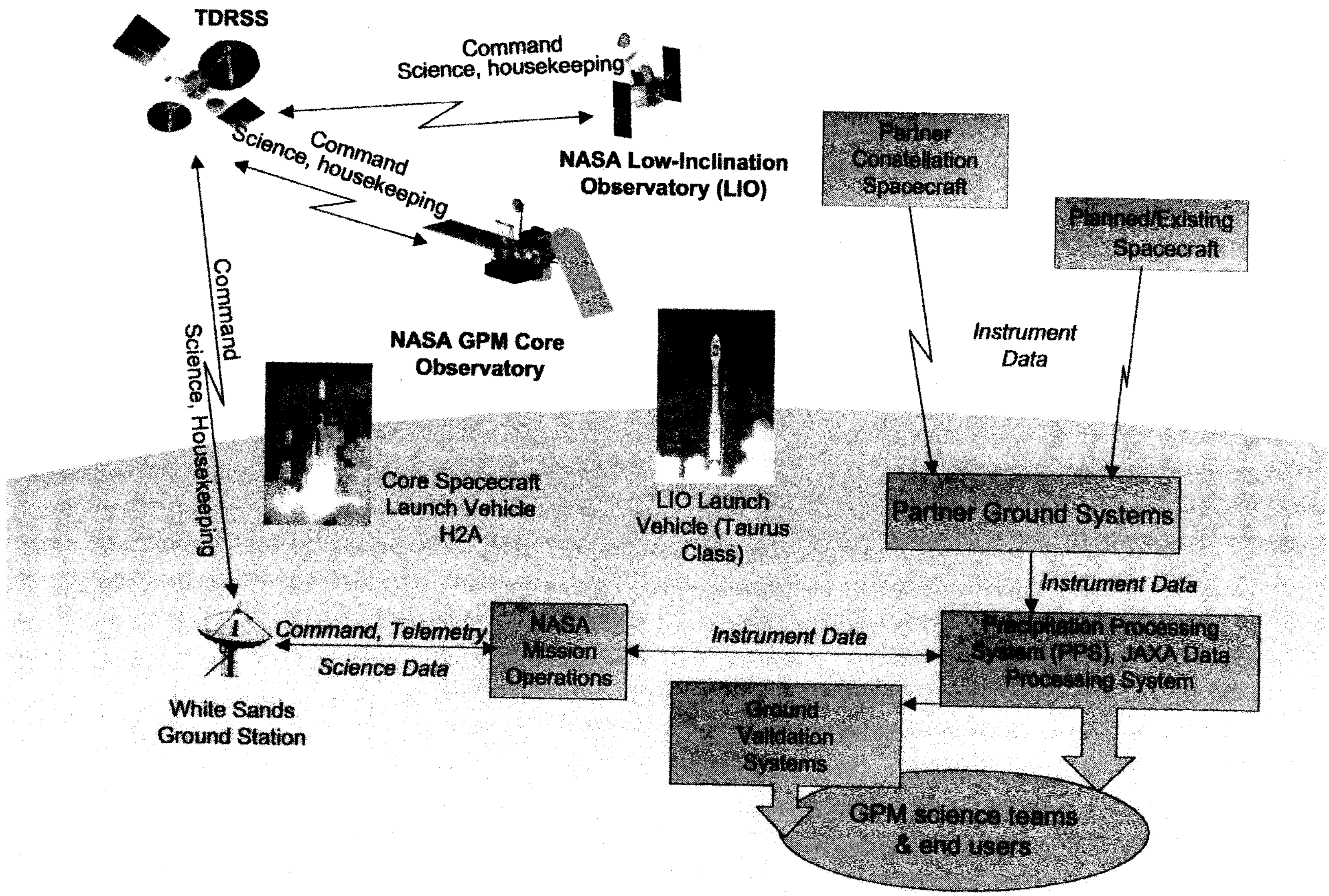
Mission Description:

- ***Constellation of spacecraft provide global precipitation measurement coverage***
  - *NASA 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*
  - *NASA Low-Inclination spacecraft: Complements Core spacecraft and partner assets*
    - *~40° inclination, ~600 km altitude*
    - *Launch November 2014 on Taurus XL-class*
  - *3 year mission (5 year consumables)*
  - *Partner constellation spacecraft: Provided by JAXA, Air Force, 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 NASA spacecraft*



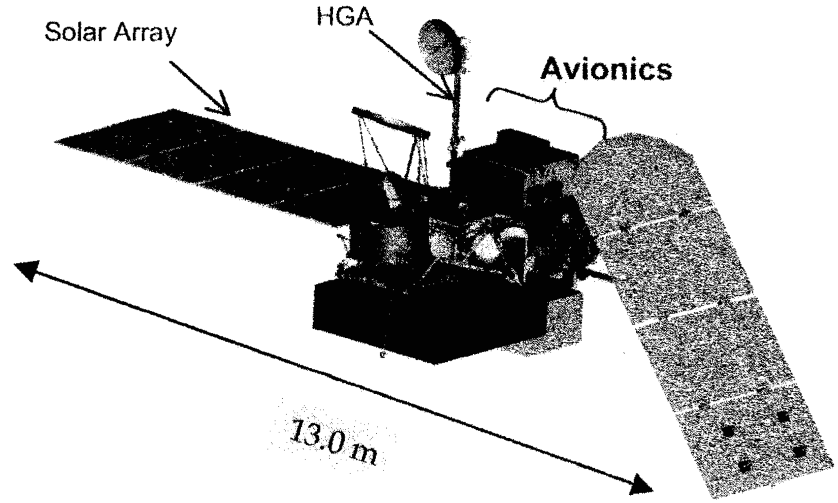
- ***Partners***
  - *Japanese Aerospace and Exploration (JAXA)*
    - *DPR instruments for Core spacecraft*
    - *Launch service for Core spacecraft*
  - *Other U.S. and international agencies*
    - *Data from radiometers (e.g. IPO NPP, DOD DMSP, JAXA GCOM-W)*
    - *Ground validation partnerships*
  - *Ball Aerospace Corp.*
    - *GPM Microwave Imager (GMI) instrument*
  - *Universities*
    - *Ground validation partnerships*
    - *Science team participation*

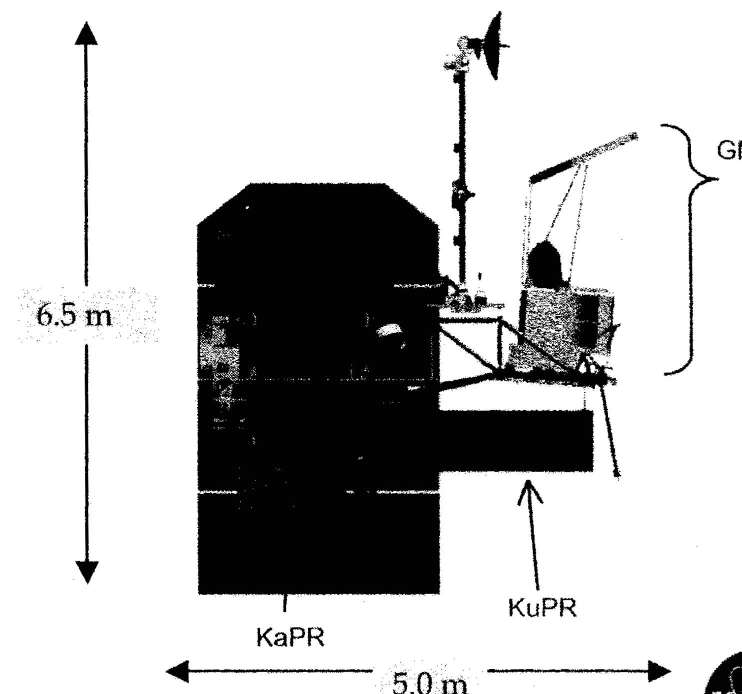
GPM Mission Architecture



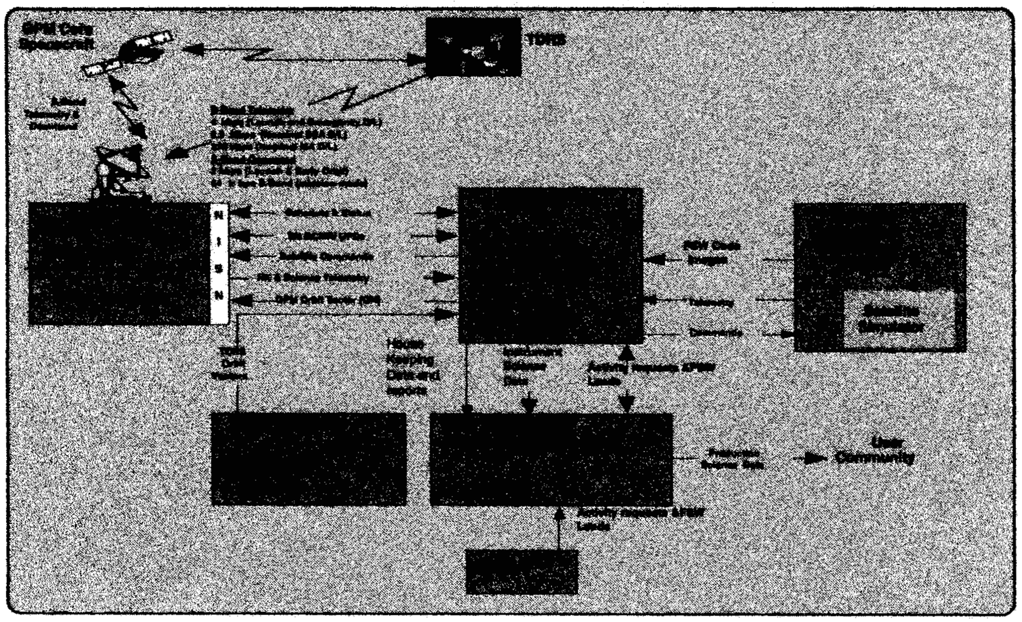
GPM Core Observatory

- *In-house GSFC spacecraft*
- *Dual-Frequency Precipitation Radar (DPR = KaPR + KuPR): JAXA*
- *GPM Microwave Imager (GMI): Ball Aerospace*
- *Spacecraft bus: 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*
- *Orbit: 407 km; 65 degree inclination*
- *Power ~1950W*
- *3 year design life with 5 years consumables (e.g. battery, propellant)*





GPM Ground System Architecture

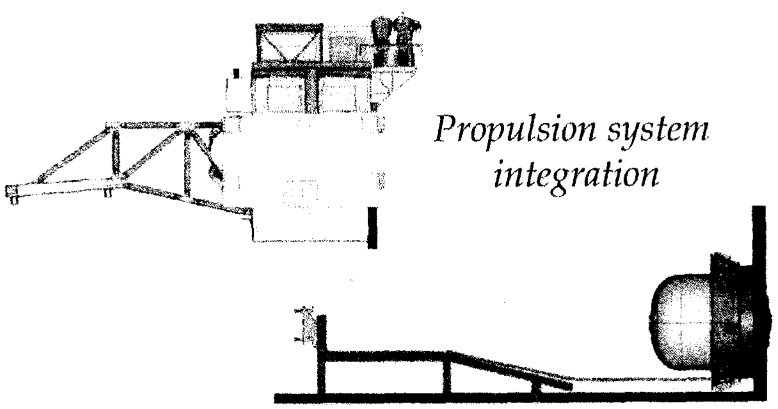


Ground system supports:
- Radiometer precipitation products from GMI within 1 hour of observation
- Combined radar/radiometer swath products within 3 hours of observation

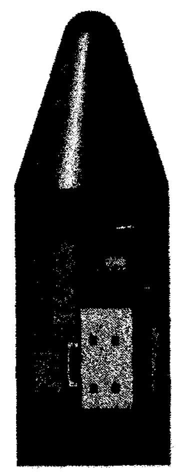
- ***Mission Operations Center (MOC)***
  - *Largely automated, staffed 8x5*
    - *Instruments operate in survey mode, require very little commanding from ground*
  - *Interfaces with Precipitation Processing System (PPS) to deliver:*
    - *5-minute duration science instrument files*
    - *5-minute 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*

GPM Core Observatory Design Challenges

- ***Spacecraft "demiseable," designed to burn up on uncontrolled atmospheric re-entry***
  - *Li-Ion battery*
  - *Minimize use of titanium parts*
  - *Unique-design demiseable propulsion tank and reaction wheels*
- ***Spacecraft bus designed to accommodate fully welded propulsion system integration***
- ***Deployable solar arrays, high-gain antenna system and GMI instrument to fit within HII-A fairing***
- ***Designed to preclude interference between GMI and DPR instruments***
  - *Filters on both instruments*
  - *"Blanking" capability for on-orbit mitigation if needed*
- ***Designed to preclude "jitter" between GMI rotation and solar array***
  - *Fundamental frequency design constraints*
  - *GMI balancing*
  - *Potential on-orbit mitigation for separating resonant frequencies by changing GMI spin rate*



Propulsion system integration

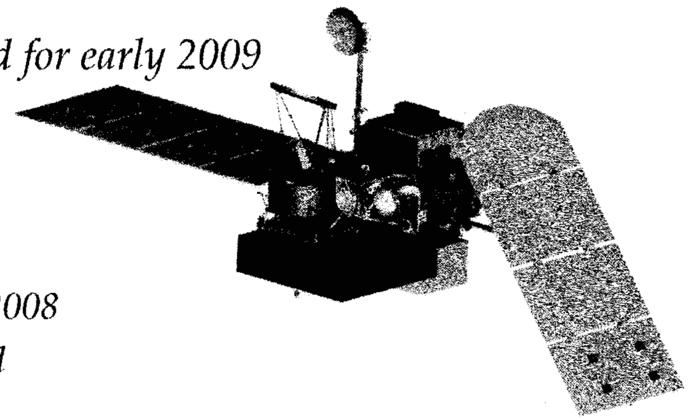


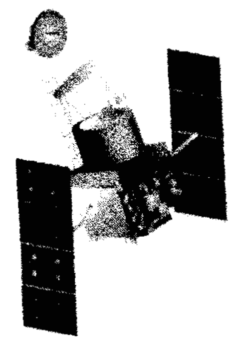
HII-A accommodation

GPM Project Status

GPM

- *Mission*
  - GPM Project funded by President's budget supporting
    - Core Observatory Launch Readiness Date of July 2013
    - NASA Low-Inclination (Constellation) Observatory Launch Readiness Date of November 2014
  - Mission Confirmation Review (at NASA HQ) planned for early 2009
- *Core Observatory*
  - Spacecraft bus is being developed in-house at GSFC
  - Phase B design of the Core Observatory on schedule
    - Mission Preliminary Design Review (PDR) - November 2008
    - Many hardware procurement activities have been initiated
    - Peer reviews of all subsystems in progress
- *NASA Low-Inclination (Constellation) Spacecraft*
  - Completed initial conceptual design
  - Implementation study will begin mid-2010

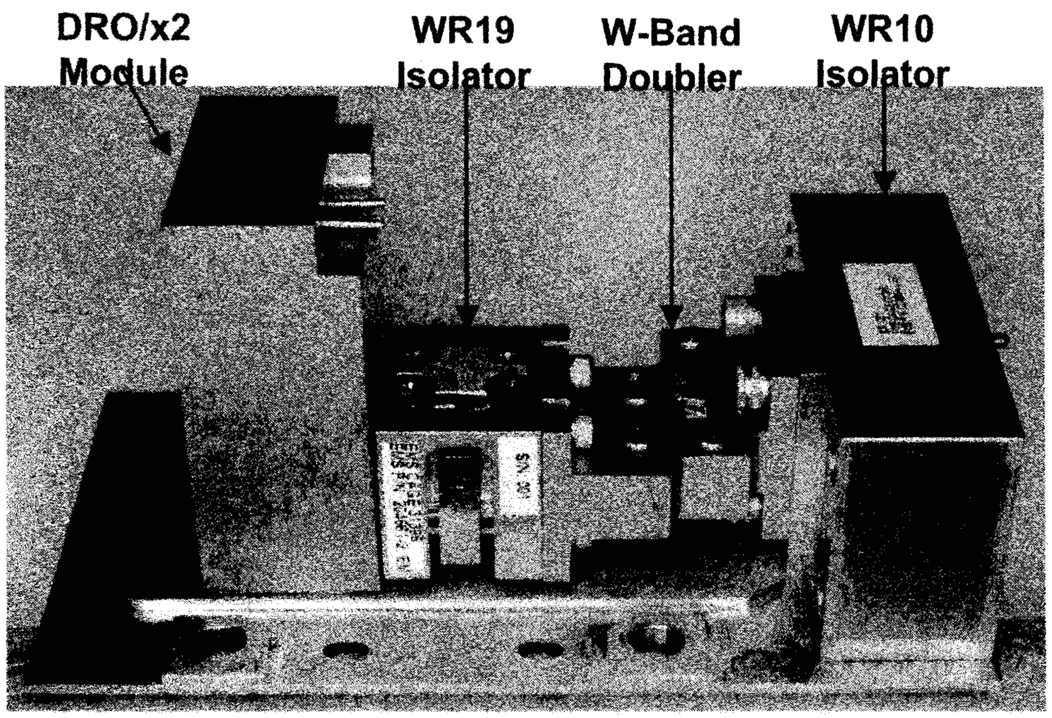


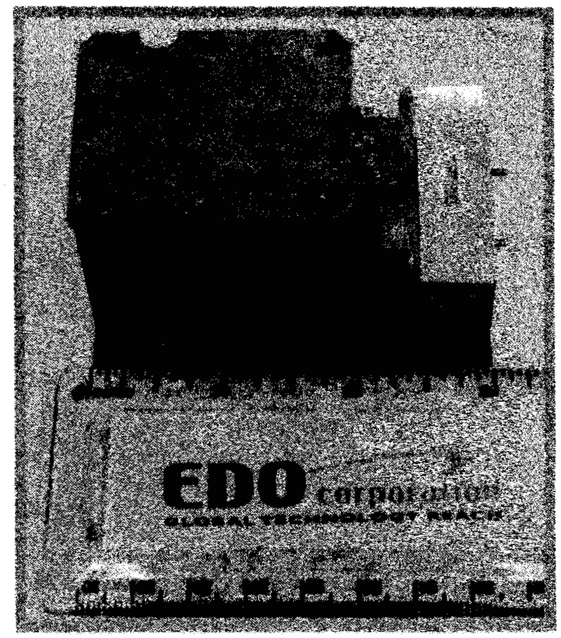


GLOBAL PRECIPITATION MEASUREMENT

GPM Microwave Imager (GMI) Status

- GMI Critical Design Review (CDR) scheduled for May 2009
  - Preliminary Design Review (PDR) held November 13-17, 2006 at Ball
  - Technical Status Review (design updates since PDR) was held May 12-13, 2008
- RF High Frequency PDR Held Dec 2007
  - Dielectric Resonant Oscillator (DRO) CDR held Oct 2007
- GMI development on track for April 2011 delivery
  - Many critical Engineering Model Units (EMUs) for subsystems have been built and under test

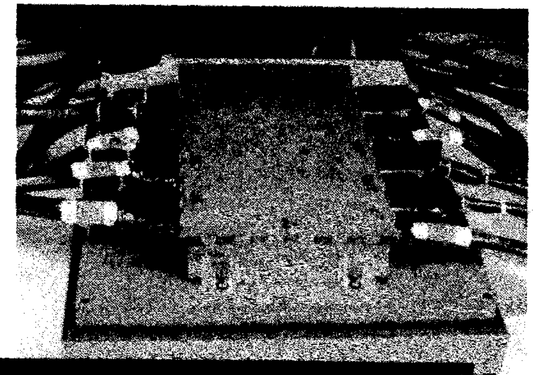


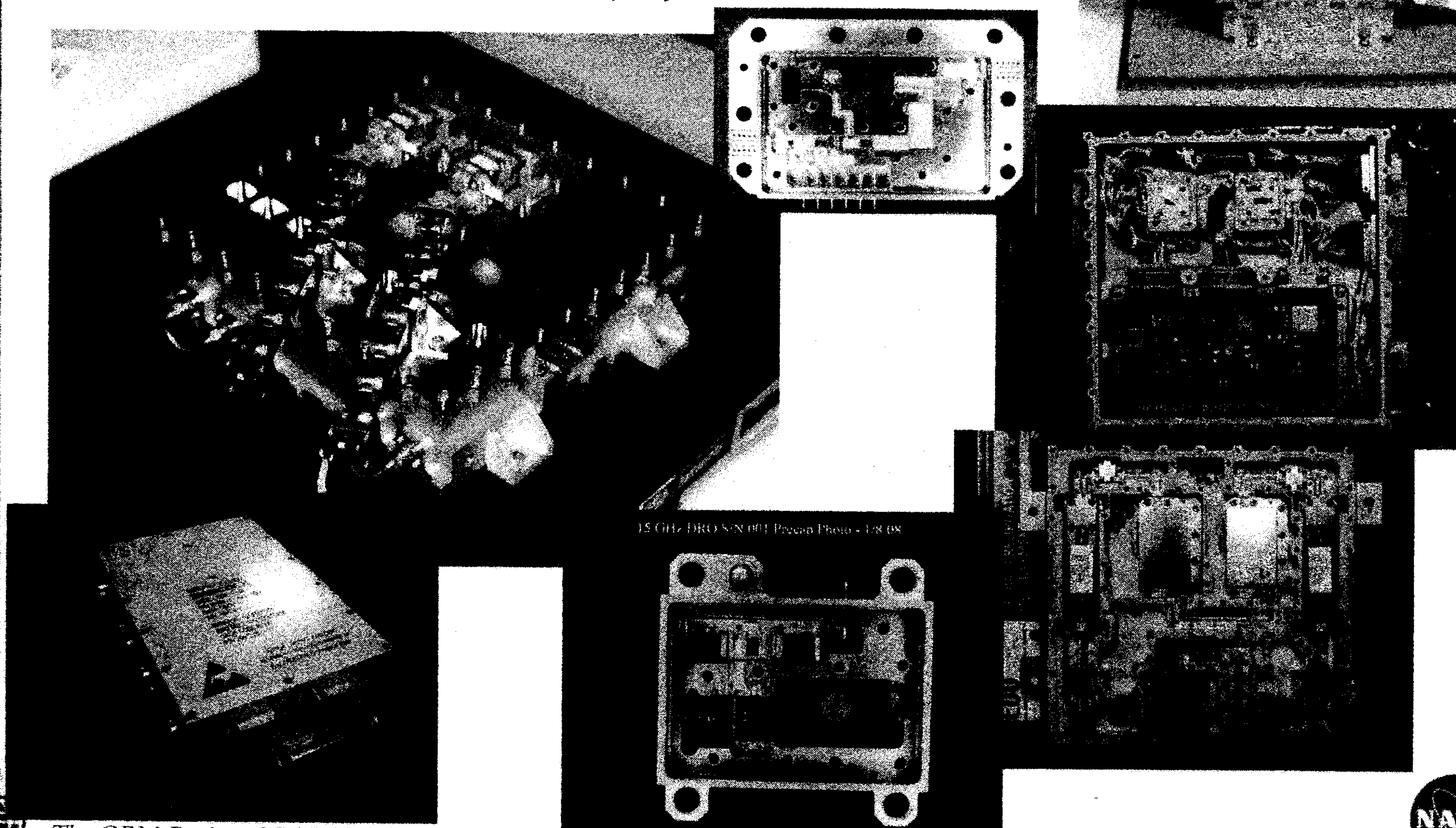


Flight-Like DRO LO 82.75 GHz EMU Hardware

GPM Microwave Imager (GMI) Status

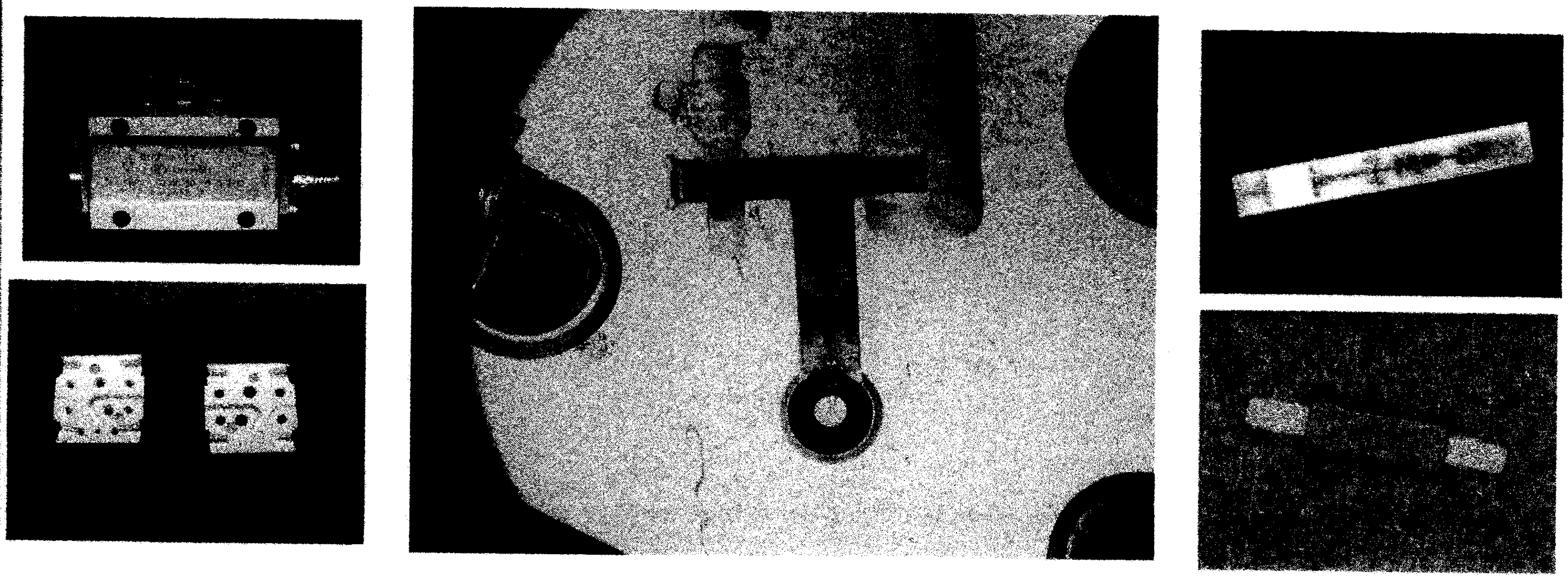
- ***GMI RF Development status***
  - *Fully assembled the 36 GHz Flight-Like end-to-end (including filters), completed performance testing and system in EMI testing*
    - *"Delta T" data better than specification*





GPM Microwave Imager (GMI) Status

- ***GMI RF Development status***
  - *Finished building mixers for all other frequencies*
    - *Will be down selecting for flight build by September 2008*
  - *In the process of assembling the 10 GHz system to perform end-to-end test*

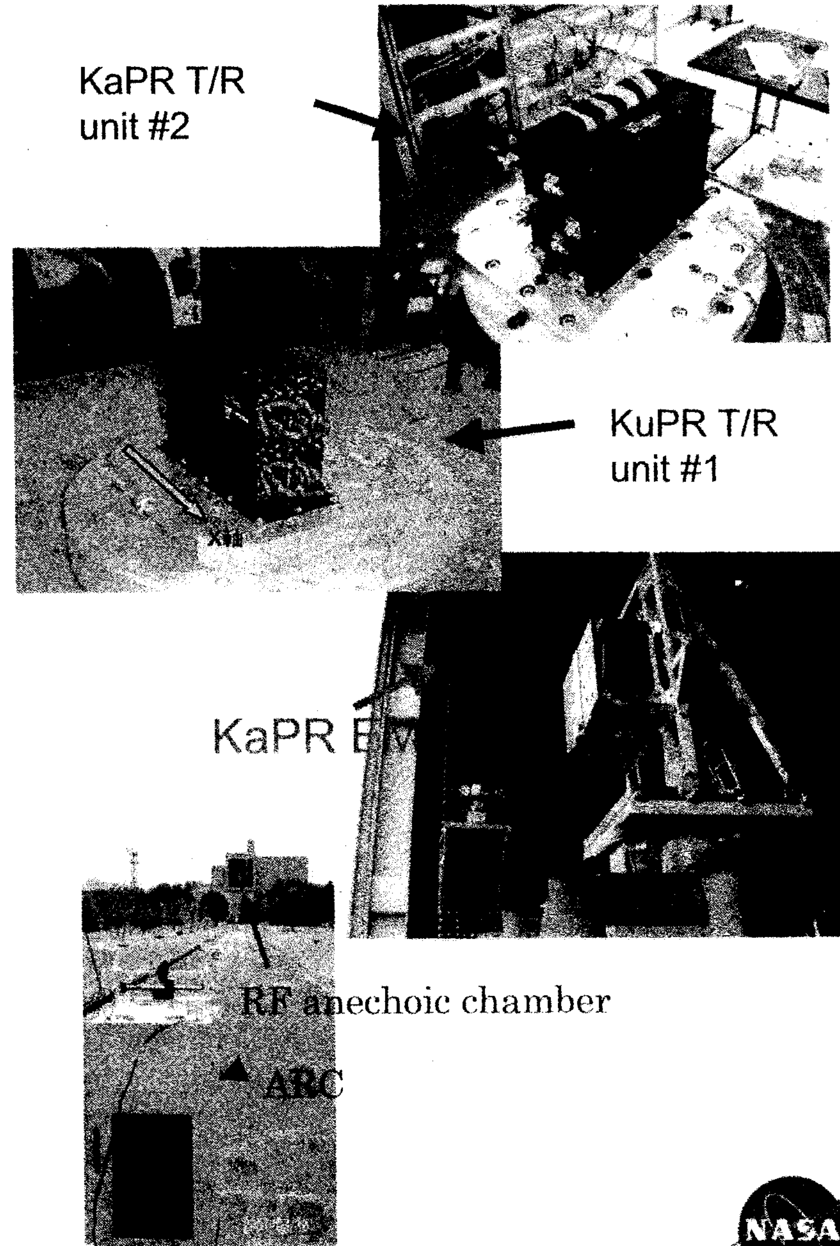


166 GHz Mixer/Preamp Flight-Like EMU Hardware

GPM Dual-Frequency Precipitation Radar (DPR) Status

GLOBAL PRECIPITATION MEASUREMENT

- NASA-JAXA DPR/Core Observatory Interface PDR held September 25 - 28, 2007 in Japan
- NASA-JAXA DPR/Core Observatory Interface CDR scheduled for 2009
- DPR schedule on track to support integration to Core Observatory in early July 2011
- KuPR
  - Engineering Model Unit (EMU) testing in progress
  - Structural/thermal model manufacturing near completion
- KaPR
  - Engineering Model Unit has undergone RF testing
  - Transmit/Receive (T/R) unit in qualification testing
  - Manufacturing structural/thermal model



GLOBAL PRECIPITATION MEASUREMENT

Global Precipitation Measurement

Master Schedule

(PPBE 2010 - Core LRD 7/21/2013; Low-Inclination LRD 11/2014)

Baseline: 5/30/08 Rev: -

Status as of: 6/30/08