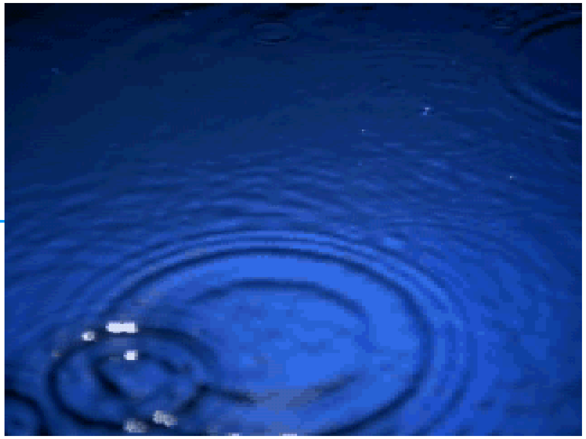
GPM

GLOBAL PRECIPITATION MEASUREMENT

Global Precipitation Measurement

System Requirements Review
System Architecture & Concept



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Outline

- *Driving Level 1 Requirements*
- *Architecture Overview*
- *Trades Performed*
- *Functional Allocation*
- *Operations Concept*
- *Remaining Trades*
- *Technologies*

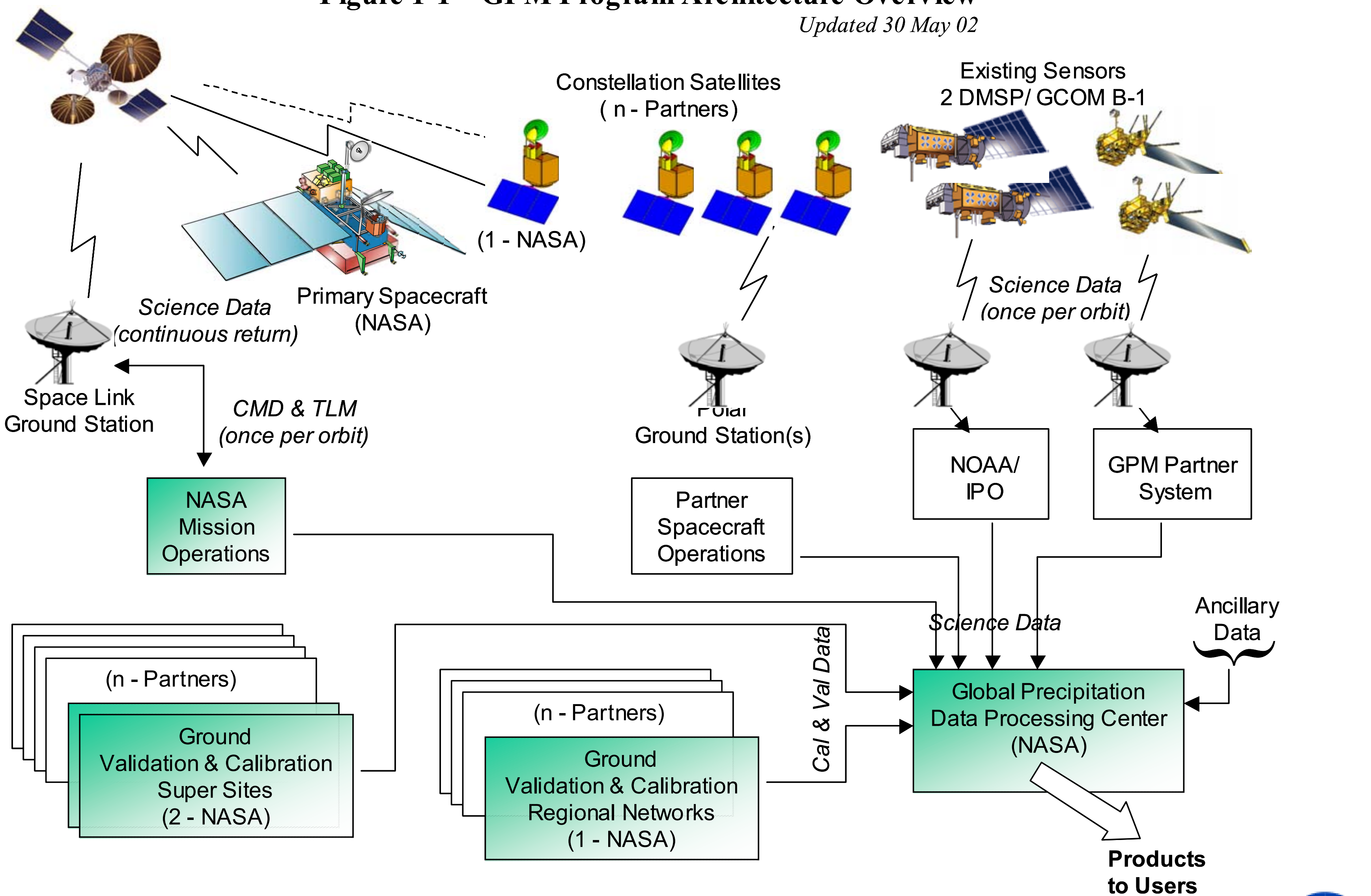
Driving Level 1 Requirements

- ***Precipitation sampling***
  - *Resolve diurnal cycle*
  - *Ingest multiple data streams from NASA and domestic and foreign partners*
- ***Drop size distribution measurement***
  - *Fundamental feature of precipitation*
  - *Enabled by dual-frequency precipitation radar (DPR)*
  - *5km horizontal and 500m vertical resolution*
- ***Error estimates***
  - *Critical to users*
  - *Drives GV and algorithm efforts*
- ***NASA/NASDA partnership***
  - *DPR*
  - *H2A-202 launch vehicle*
- ***Latency and Completeness***
  - *3 hours for 90% of data*
  - *72 hours for 98% of data*
- ***Lifetime: 3 years with a goal of 5***
- ***End-of-Life disposal***

GPM Mission Architecture Overview

Figure 1-1 GPM Program Architecture Overview

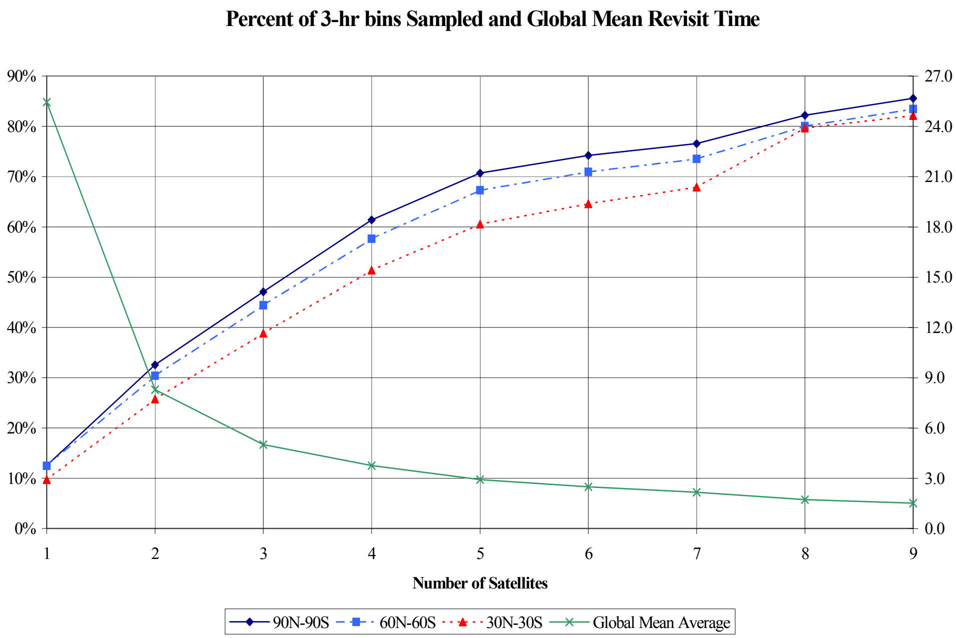
Updated 30 May 02



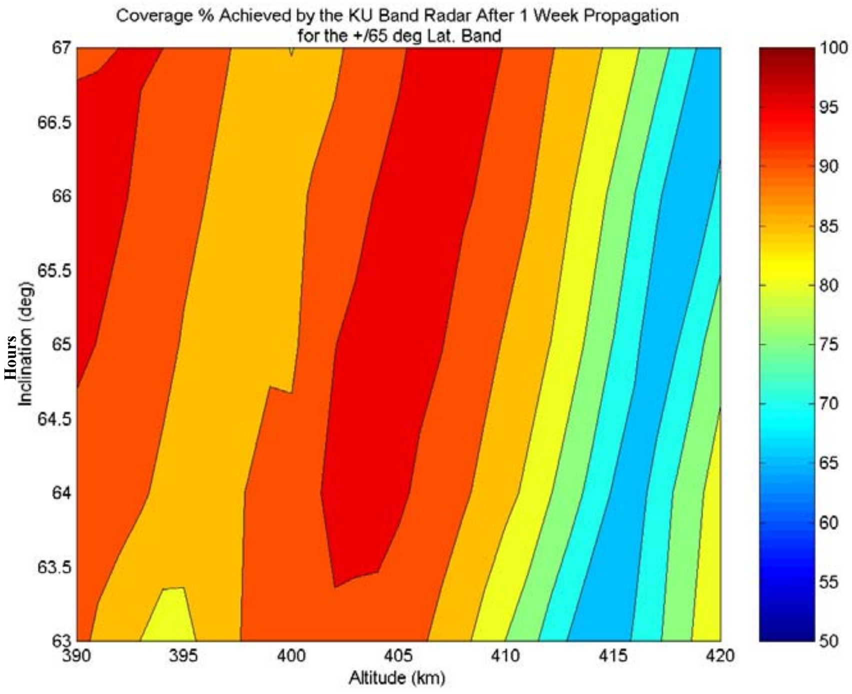
Trades Performed

- *Orbit Studies*
- *Current CCSDS Standards vs. Internet Protocol*
- *Ground Network vs. TDRSS*
- *Direct Broadcast Options*
- *Two TDRSS Antennas vs. GN Backup*
- *Constellation Configuration*
- *Other Trades*

- ***Constellation orbit analysis***
  - *Revisit time*
  - *Binning statistics*
  - *% coverage in 3 hours*



- ***Core orbit analysis***
  - *Drag make-up*
  - *Time to cover total area*



- ***More details to follow in Chad Mendelsohn's Presentation***

Current CCSDS Standards vs. Internet Protocol

- *Internet Protocol (IP) is an international standard with tremendous commercial technology investment.*
- *NASA and the Consultative Committee for Space Data Systems (CCSDS) are working toward the use of standard commercial interface standards.*
- *With a launch in 2007 and operations continuing past 2010, GPM must look toward compatibility with future missions, not past missions.*
- *IP has been successfully demonstrated between orbiting spacecraft and the ground.*

- *GPM will use Internet Protocol for the Space-to-Ground link.*

- *Steve Tompkins will discuss more details and implications of IP.*

Ground Network vs. TDRSS

- ***Five stations required for core spacecraft to meet 3 hour latency due to 65° inclination***
- ***GN solution may be practical for polar orbiter***
- ***Tim Rykowski will present more information on this trade during the Mission Operations System presentation.***

Direct Broadcast Options

- ***Compared Direct Broadcast Transmitter to using TDRSS Demand Access Service Continuously***
  - *Direct broadcast requires extra flight hardware*
  - *Direct broadcast only available to users in view of spacecraft*
  - *Direct broadcast requires special ground equipment to receive*
  - *TDRSS DAS allows us to get science data to the PPS with very little latency – improves the 3-hour products*
- ***Selected TDRSS Demand Access Service***

Two TDRSS Antennas vs. GN Backup

- ***Advantages of GN Backup***
  - *Spacecraft will fly omni antennas anyway*
  - *Significant cost associated with second antenna*
    - *Drag*
    - *cp/cg offset*
    - *Hardware costs*
    - *Integration and testing costs*
    - *Extra mass*
  - *GN cost not incurred unless failure occurs, but some data will be lost while GN contracts are established*
  - *Antenna is fairly high reliability – low probability of incurring GN costs*
- ***Advantages of two TDRSS antennas***
  - *Two HGA's would enable make before break handovers*
  - *GN solution is costly*
  - *GN solution makes meeting 3 hour latency requirement difficult*
- ***Baselined a single TDRSS antenna on the primary spacecraft, with GN used as backup.***

Constellation Configuration

- ***Orthodox constellation vs. collection of existing data streams***
  - *Cost of launching nine spacecraft into different orbital planes is prohibitive*
  - *Low data volume and advancing computer and network capability and standardization makes sensor fusion from partners practical*
  - *TRMM Data System capabilities are being extended to demonstrate this concept*
- ***GPM will use a collection of data streams from various spacecraft microwave radiometers, with NASA providing only two spacecraft.***

Other Trades

- ***Element trades to be described tomorrow***

GLOBAL PRECIPITATION MEASUREMENT

SPACE SEGMENT:

* Measurement:

* **Global Coverage** - instantaneous rain rate measurements sufficiently frequent to avoid diurnal aliasing, and with 10 km resolution.
* **Measure** 4-D structure of rainfall rates and drop size distribution.

Primary Spacecraft
* Carry a multi-instrument payload
* Obtain Precipitation Measurements
* Obtain Latent Heat Release Measurements
* Obtain Drop Size Distribution Measurements

Constellation Spacecraft

Dedicated Spacecraft
* Carry a dedicated passive microwave radiometer
* Obtain Precipitation Measurements
* Obtain Global Coverage
* Obtain Temporal Coverage

Partner Spacecraft
* Carry a suitable passive microwave radiometer
* Obtain Precipitation Measurements
* Contribute to Global Coverage
*Contribute to Temporal Coverage

GPM Science Drivers

* **Climate Observation** - to accurately measure global/regional variability of precipitation to improve global climate models.
* **Weather Prediction** - to improve the accuracy of global and regional weather prediction models.
* **Global Water Cycle** - to improve the understanding and predictability of relevant components of the water cycle.

Mission Operations Center
* Manage NASA Space Assets
* Co-ordinate NASA/ Partner S/C Operations
* Co-ordinate S/C- Ground Site Overflights
* Co-ordinate Primary-Constellation Coincident Observations

GROUND SEGMENT:

* Validation:

* **Accuracy Threshold** - Bias error<5%
* **Precision Threshold** - <25%

* Science Products:

* **Latency** - Deliver near-real-time and 3-hour products.
* **Climate Products -**
* **Outreach Data Access -**

Ground Validation & Calibration

Super Site
* Collect Precipitation, Cloud and DSD data
* Obtain atmospheric temperature and moisture profile measurements
* Obtain radiation, heat and water fluxes
* Develop data quality estimates
* Develop error characterization data

Regional Network
* Collect Precipitation Data over a scale greater than 250 km.
* Develop data quality estimates

Precipitation Data Processing Center
* Generate Science Products
* Provide Outreach Data Access
* Develop Cal/ Val Parameters

- ***Mission-level operations concept describes high-level interaction among elements***
  - *Primary spacecraft (also called Core Spacecraft)*
  - *Constellation spacecraft*
  - *Mission Operations System*
  - *Precipitation Processing System (PPS)*
  - *Ground Validation System*
- ***Primary Spacecraft***
  - *Carries DPR and GMI*
  - *Provides reference standard for constellation*
  - *Makes DSD and latent heat measurements*
  - *Launches on H2A-202*
  - *Downlinks science data continuously via TDRSS-MA*
  - *Uses IP for space-to-ground link*
  - *On-board MIL-STD-1553 for instrument interface, Ethernet under study*
  - *Autonomous navigation for orbit control*
  - *Design for demise*

Operations Concept (continued)

- ***Constellation Spacecraft***
  - *Carries only a radiometer (copy of GMI)*
  - *Enhances coverage provided by partners ⇒ improves sampling*
  - *Uses TDRSS-MA continuously*
- ***Mission Operations System***
  - *Controls the spacecraft*
- ***Precipitation Processing System***
  - *Ingests data streams from core, constellation, and partner spacecraft*
  - *Ingests data from GV sites*
  - *Ingests ancillary data (such as IR)*
  - *Sends overpass info to GV sites*
  - *Output products*
    - *Outreach rain map via web server*
    - *3-hour products*
    - *Climate products*
- ***Ground Validation System***
  - *Collects data and produces algorithms needed to characterize errors*
  - *Provides products to PPS on a regular basis*
  - *Runs targeted campaigns to resolve specific issues in the precipitation retrieval algorithms*

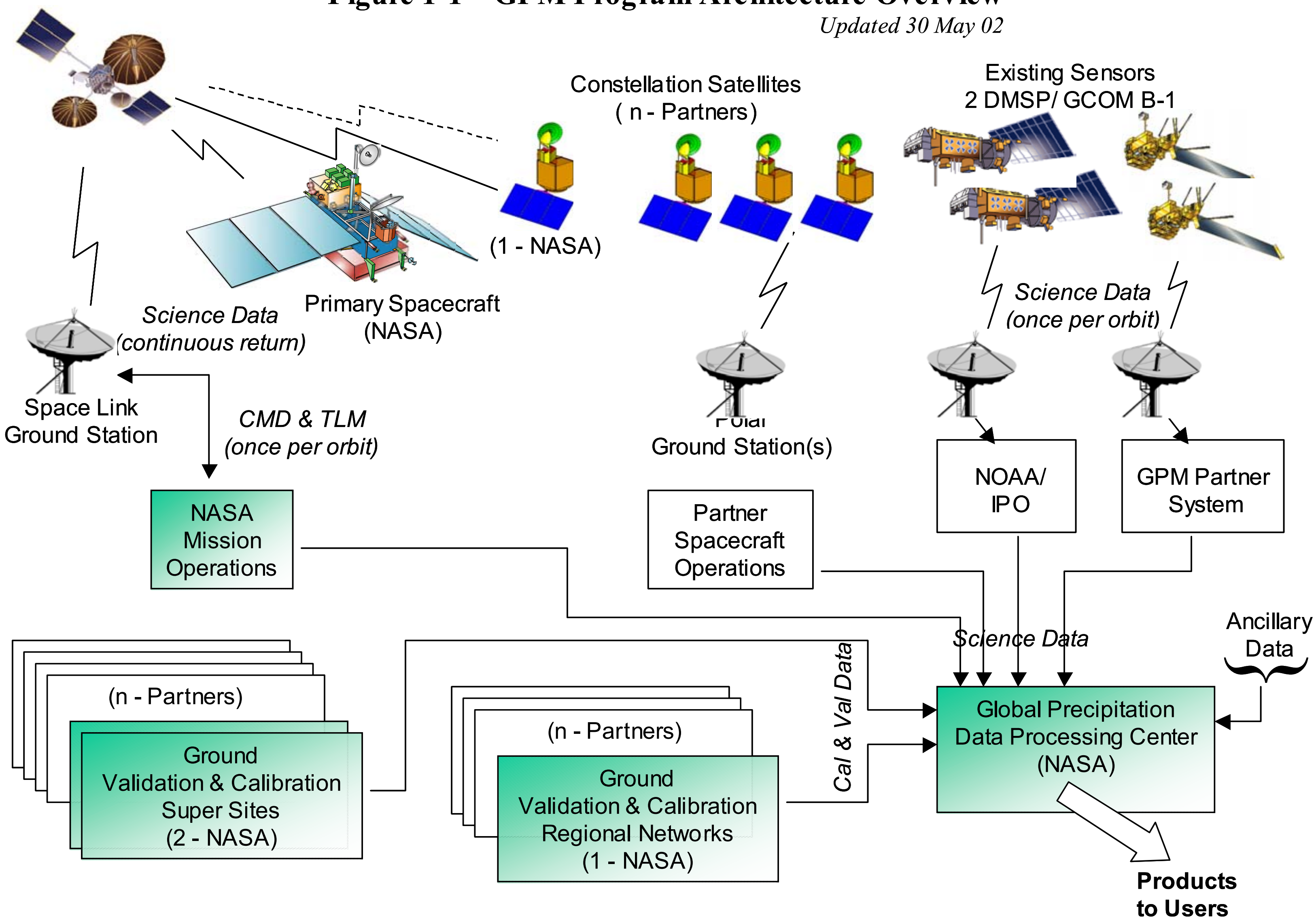
Operations Concept (continued)

- *More detailed operation of each element will be described by element engineers*
- *Draft operations concept document on DocuShare*

GPM Mission Architecture Overview

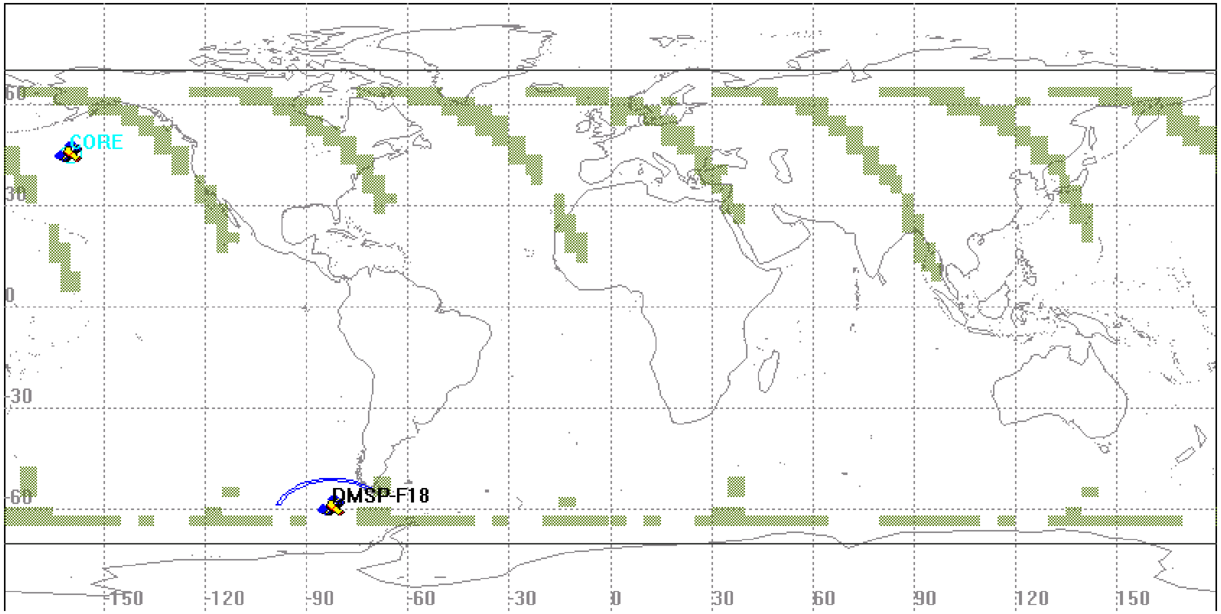
Figure 1-1 GPM Program Architecture Overview

Updated 30 May 02



Remaining Trades

- ***Using core/constellation crossings vs. using GV over-flights to calibrate across the constellation***
  - *Core/constellation crossings are infrequent*



One month of crossings

  - *TRMM has shown that absolute accuracy of GV measurements is difficult to achieve*
- ***Finalizing constellation spacecraft orbit***
- ***Finalizing constellation spacecraft launch vehicle***
- ***Many trades at the element level***

Technologies

- ***GPM will utilize technology, not develop it.***
  - *Functional capability by PDR, design specific by CDR*
  - *Standard techniques carried in design until new technology is ready*
- ***Autonomous navigation***
  - *Demonstrated by EO-1*
  - *Provides finer orbit control*
  - *Reduces operations cost*
- ***Design for demise***
  - *Reduces fuel by 40%*
  - *Inherently safer*
- ***Internet Protocol***
  - *Demonstrated on UOSAT-12 by OMNI*
  - *International standard with tremendous commercial investment in technology*
  - *Simplifies autonomous data delivery*
- ***Additional technologies under consideration by element managers***