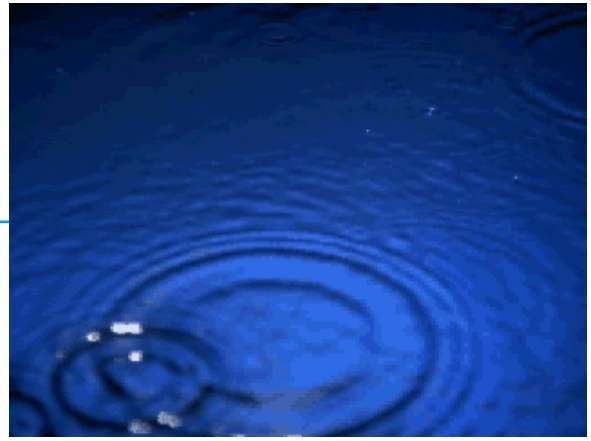
Global Precipitation Measurement

Ground Validation System
Systems Requirement Review



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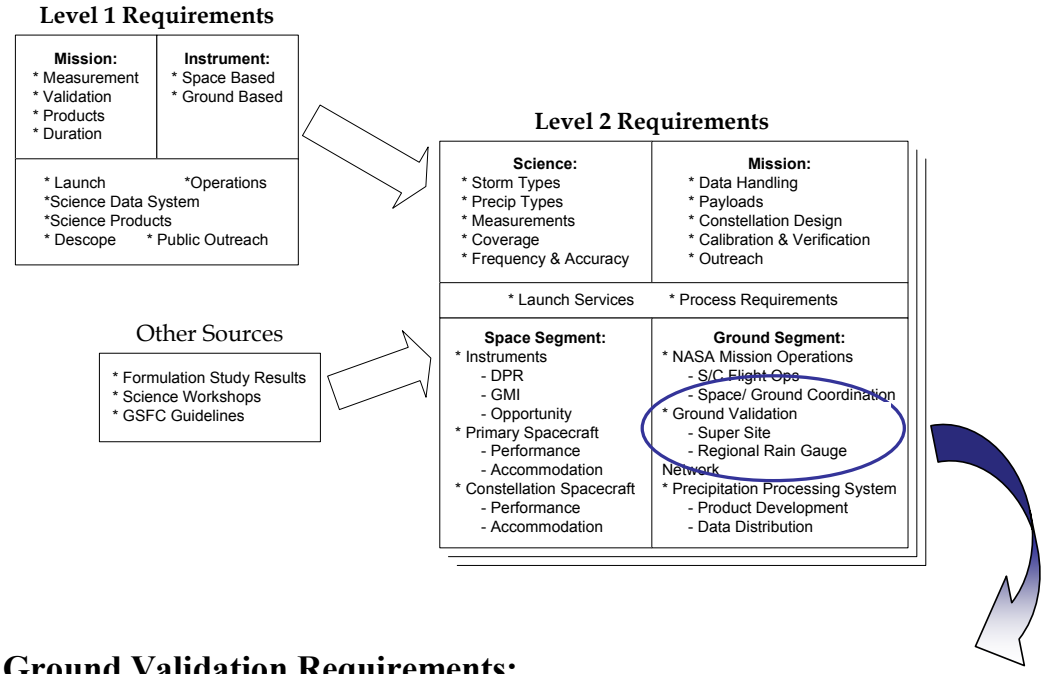
Ground Validation Level 2 Introduction



Ground Validation Requirements:

•Error Diagnosis and Characterization (Level 2)

•Routine Product Program (Level 1)

- Super Site – Location, Instrumentation
- Regional Rain Gauge Network – Location, Instrumentation

•Focused Measurement Program (Level 3)

- Specific Validation Needs

Level 2 Ground Validation Requirements

General
- Error Characterization [6.1.1]
- Error Diagnosis [6.1.2]

Supersites
- Local Area Supersite [6.1.3]
- Site Location [6.1.3.5]
- Site Instrumentation [6.1.3.4, 6.1.3.6]
- Regional Error Covariance Expansion Rules [6.1.3.3]
- Bias Reports [6.1.3.1, 6.1.3.2]

Regional Rain Gauge Networks [6.1.4]

Outline

I. Driving Requirements

II. Assumptions

III. Risk Assessment

IV. Future Trades

V. Schedule

Ground Validation Driving Requirements

Purpose of Ground Validation:

The purpose of the Ground Validation System is to provide credibility to the GPM measurement products and to provide quantized error–characterization information to the GV clients.

How is Credibility Provided?

Ground Validation provides an independent method of error-characterization to the satellite rainfall retrievals and provides evaluation to physical error models.

Ground Validation Clients:

(1) Algorithm Developers

(2) Data Assimilation Specialists

(3) Climate Researchers

(4) Ground Validation Scientists

Instrument Calibration: Distinct from GV

External Instrument Calibration includes…

1) **Ground-Based, Active Radar Calibration for the Dual-Precipitation Radar**

2) **Vicarious Radiometer Calibration (i.e. spacecraft intersections)**

3) **Stable Earth Surface, Ocean Surface, Ice Surface Conditions**

4) **Others?**

Broad Goals of Ground Validation

(in Draft Science Plan: 'Overall Goals of GV')

- Diagnosis to ascertain causes of errors within satellite products.
- Improvement of satellite products by refinement of physical assumptions, underlying cloud resolving models, and underlying radiative transfer calculations.
- Evaluation to estimate the quality of satellite precipitation products in terms of systematic and random error.

Ground Validation System Programs

Ground Validation is divided into two subordinate programs:

1) **Routine Product Program (RPP)**

2) **Focused Measurement Program (FMP)**

GLOBAL PRECIPITATION MEASUREMENT

Routine Product Program (RPP)

(Ref: GV Draft Science Plan)

Multi-year observation program overlapping with the satellite operational period that produces near real-time routine GV products on a regular schedule. Routine observations will be conducted from fixed GV sites located around the globe.

Focused Measurement Program (FMP)

(Ref: GV Draft Science Plan)

Observational program that produces data and derived products addressing GPM algorithm and model validation needs but does not produce GV products on a regular schedule. These experiments may involve aircraft and other observational platforms and may be co-located at a fixed GV site.

Driving Requirements on GV

Ground Validation and Calibration [Level 1: 3.1.2.2]

The GPM shall provide independent measurements of precipitation at pre-defined ground sites. These measurements shall be sufficient to permit:

(1) Determination of minimum detectable surface precipitation rate of the satellite instrumentation.

(2) Hydrometeor classification of precipitation in 3 dimensions into categories such as rain, snow, mixed, and graupel/hail.

(3) Determination of the spatial pattern of surface precipitation intensity.

(4) Generation of a quantitative estimate of surface precipitation rate.

Driving Requirements on the Routine Product Program (RPP):

Supersites and Regional Rain Gauge Networks [Level 1, 3.2.2.1, 3.2.2.2]

Physically, the Routine Product Program consists of pre-defined ground sites around the globe representing different geographic and climatological regimes.

These sites are classified as "Supersites" and "Regional Rain Gauge Networks". They will be instrumented to perform the four measurements of Level 1 Requirement 3.1.2.2.

- **Supersites [Level 1, 3.2.2.1] shall have the capability to meet all four measurements.**

- **Regional Rain Gauge Networks [Level 1, 3.2.2.2] will have the capability to provide measurement #3:**
"Determination of the spatial and temporal pattern of surface precipitation intensity"

Driving Requirements on Routine Product Program

Provision for Ground Validation Sites [Level 1, 3.1.2.2]

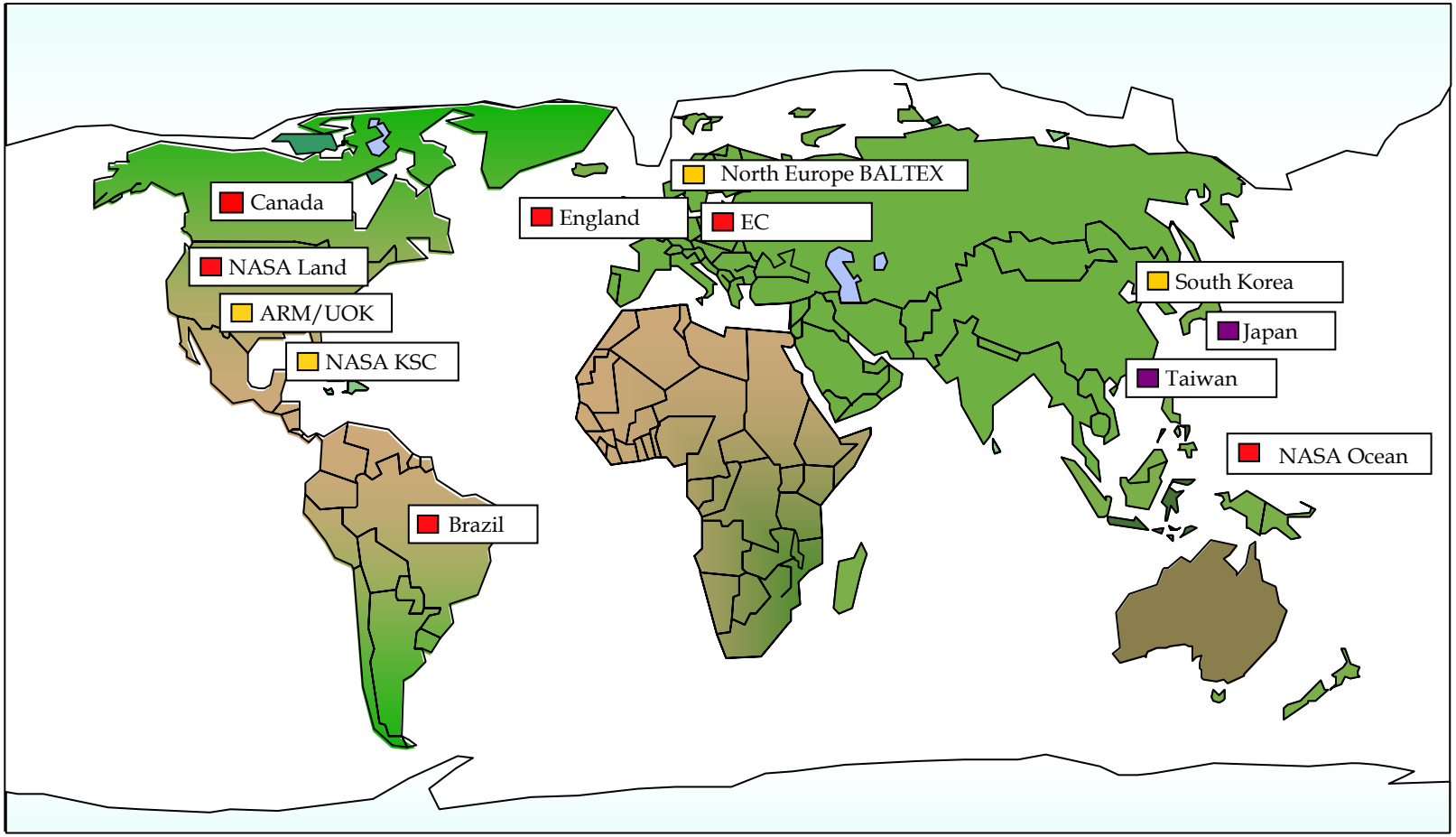
NASA shall provide two Supersites

NASA shall pursue partners for up to eight additional Supersites

NASA shall provide one Regional Rain Gauge Network

NASA shall pursue partners for up to five additional Regional Rain Gauge Networks

Potential Supersites and Regional Raingauge Networks



Supersite

Regional Raingauge Network

Supersite & Regional Raingauge Network

Routine Product Program (RPP)

The products of the Supersite will be three-fold:

(1) Local Products [Level 3]

(2) Regional Error Covariance Expansion Rules [Level 2]
(provides spatial and temporal error structure)

(3) Bias Reports [Level 2]
(provides systematic error estimates)

Routine Product Program (RPP)

Local Products:

Local Products are derived from observations and measurements at the Supersites.

Local Products are used for developing the primary Supersite products:

- **"Regional Error Covariance Expansion Rules" and "Bias Reports". Both are delivered to the Precipitation Processing System.**

Routine Product Program (RPP)

Regional Error Covariance Expansion Rules:

[Level 2, 6.1.3.3]

The Expansion Rules shall attach error covariance to the satellite rainfall retrievals. 'Error covariance' expresses the underlying spatial and temporal error structure within the satellite rainfall retrievals.

The Expansion Rules will be developed at the processing and analysis facility associated with each Supersite.

The Expansion Rules will be representative of the geographic and climatological regime of the specific site.

Routine Product Program (RPP)

Regional Error Covariance Expansion Rules (cont.):

[Level 2, 6.1.3.3]

The Expansion Rules shall be delivered to the Precipitation Processing System where the Rules are combined with those from other sites and where the error covariance is automatically generated and attached to the satellite rainfall retrievals.

The refinement of the Expansion Rules and their long-term evaluation involves overpass subsets of satellite rainfall retrievals and the Local Products.

Routine Product Program (RPP)

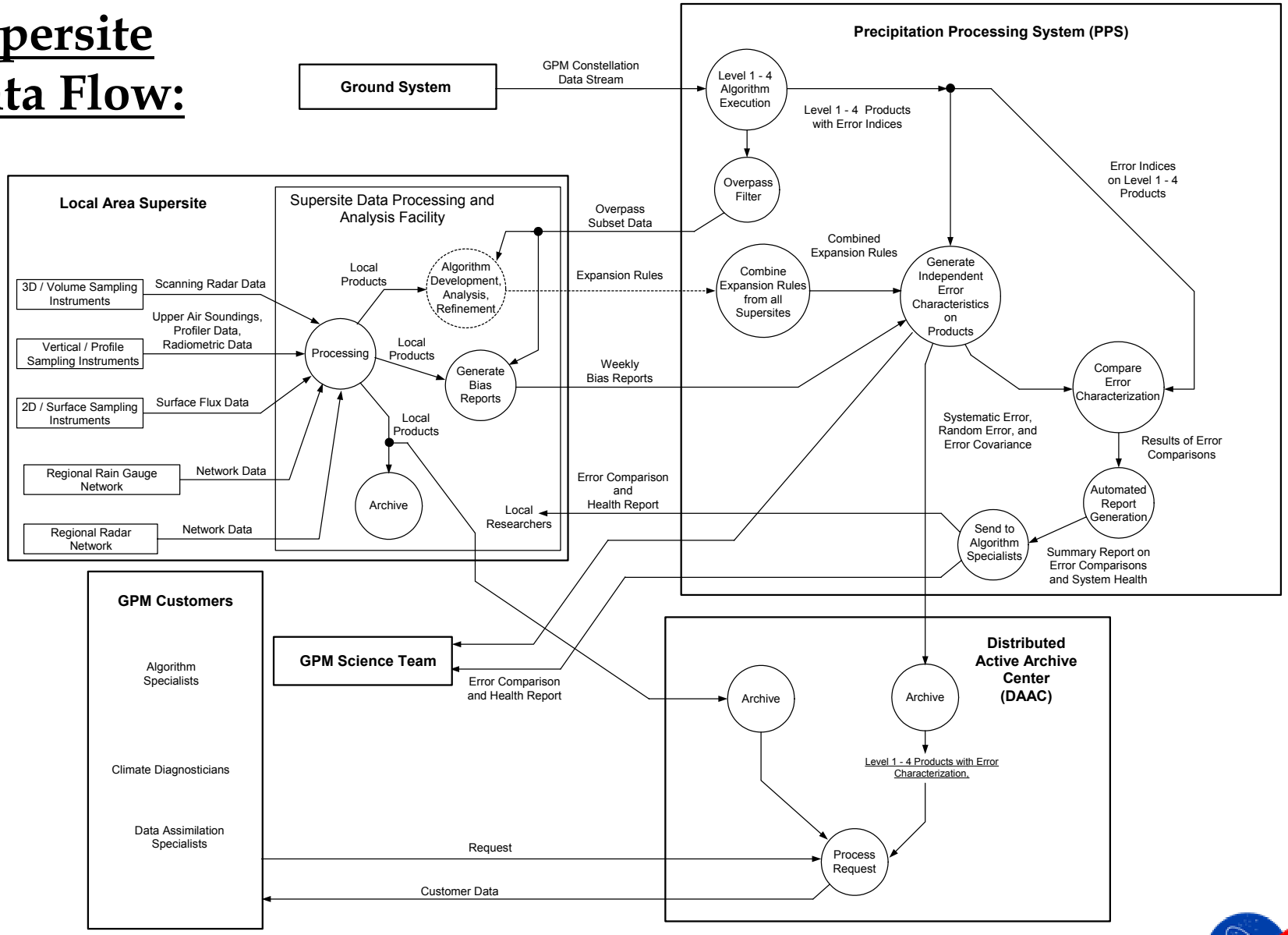
Bias Reports: [*6.1.3.1*]

Each Supersite shall deliver bias reports on a weekly basis to the Precipitation Processing System (PPS).

Bias reports shall provide systematic error characterization on the satellite-rainfall retrievals. The reports will include an uncertainty on the systematic error estimate.

Bias report generation requires the PPS to deliver a subset of satellite rainfall retrievals during overpass events for comparison purposes. Bias reports require observations during satellite overpass events with ground-based instrumentation equivalent to the spaceborne radiometer and dual-frequency radar.

Supersite Data Flow:



Driving Requirements:

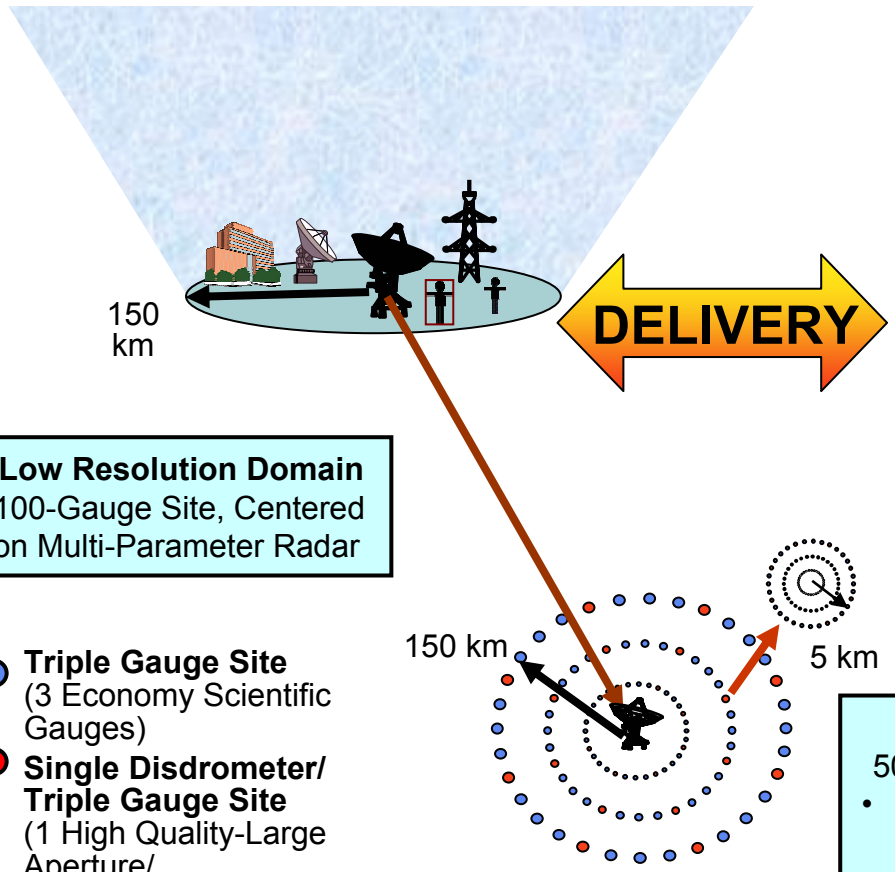
Adequate Precipitation at Site Locations [6.1.3.5]

The Supersites shall be sited in locations where monthly precipitation totals exceed TBD cm at least six months of the year.

Rationale:

A minimum number of productive months during the wet season is required to justify the infrastructure expenses associated with a Supersite.

Supersite Template



Legend

- Data Analysis Facility
- Multi-Parameter Radar
- Matched Dual Freq. Radar & Multi-Channel Radiometer
  S-/X- Band Radars / Profilers
  Cloud Radar Profiler
- Meteorological Tower & Sounding System
- Site Scientist (3)
- Technician (3)

Low Resolution Domain
100-Gauge Site, Centered on Multi-Parameter Radar

- **Triple Gauge Site** (3 Economy Scientific Gauges)
- **Single Disdrometer/ Triple Gauge Site** (1 High Quality-Large Aperture/ 2 Economy Scientific Gauges)

GV Products
(1) Error Biases & Bias Uncertainties
(2) Error Structures / Error Covariances

GV Product Customers
(1) Data Assimilation Specialists
(2) Climate Diagnosticians
(3) Algorithm Specialists

High Resolution Domain
50-Gauge Site, Center-Displaced with
- Matched Radar / Radiometer
  [14, 35 / 10, 19, 22, 37, 85 GHz]
- S-/X-band Doppler Radar Profilers
- Cloud Radar Profiler

Driving Requirement:

Supersite Instrument Complement [6.1.3.6]

The Supersites shall include as a minimum a:

- **Scanning, research-quality, Doppler radar.**
- **Dense network of research-quality rain gauges and various disdrometers.**
- **Combined radar / radiometer equivalent to the GMI and DPR.**
- **Upward-looking Doppler precipitation and cloud profiling radar.**
- **Meteorological tower equipped for measurement of surface properties.**

Rationale:

Error characterization involves analysis of both error structure and error bias with respect to the satellite retrievals. A scanning Doppler radar and a rain gauge network will enable spatial and temporal error structure. A combined radar / radiometer enables error bias estimation.

A vertical profiling radar provides information to cloud resolving models and for estimating Ka band radar attenuation.

A meteorological tower provides surface information critical for boundary conditions to the satellite instrumentation.

Driving Requirement:

Sounding Near Site Location [6.1.3.4]

A 12-hour upper air sounding station shall be located within 125 km of the Supersite scanning Doppler radar.

Rationale:

A 12-hour operational upper air station within the coverage area of the Doppler radar is the minimum requirement associated with initializing cloud resolving models.

Scientific Goals of the Focused Measurement Program:

(Ref: GV Draft Science Plan)

Refinement of specific physical and scaling assumptions within satellite algorithms, cloud models, and radiative transfer calculations.

Observations for cloud models, regional models, radiative transfer calculations at climatologically important locations distinct from the Supersite.

Program Planning and Risk Reduction Goals of the FMP

Experiments involving new instrument performance and new measurement techniques. Results of these experiments will aid in planning the Supersites, and in a broader sense, provide program risk reduction.

For example, the Pilot Experiment(s) will study the performance of a dual-frequency radar and a radiometer in a ground-based setting. These instruments are being evaluated for use at the Supersites for providing the bias errors.

Assumptions

Assumptions (Requirements to the International Supersites and Regional Rain Gauge Networks)

Requirements are not applicable to the internationally provided Supersites and Regional Rain Gauge Networks. Requirements to the international sites and networks are better termed recommendations.

Assumptions (Focused Measurement Program)

The Science Office will plan and manage the experiments of the FMP. The exception are those experiments involving planning and risk mitigation for the Supersites for which the Project Office will be involved.

Requirements will not be defined by the Project Office for the FMP. The nature of the FMP does not lend itself to advance specificity.

Risk Assessment

Risk Assessment: Expansion Rules and Bias Techniques

The Ground Validation System represents a new, but unproven, approach. There is little heritage for the Regional Error Covariance Expansion Rule and Bias Report technique. This is a large advancement beyond the TRMM heritage.

Mitigation:

Sites required functional two years prior to core spacecraft launch will allow time for resolving problems and optimizing techniques.

Risk Assessment: Radar / Radiometer Instrument Suite for Bias Reports

There is risk that the dual-frequency radar / radiometer bias estimation technique will not meet expectations for bias report generation.

Mitigation:

The ground-based dual-frequency radar / radiometer instrument technique is in evaluation both theoretically and experimentally.

The Pilot Experiment(s) are intended to investigate the instrument operation as well as the bias estimation technique.

Risk Assessment: Two Year Advance Operation Requirement

The schedule represents a challenge to meet a fully operational requirement on Supersite operation two years prior to core satellite launch (i.e. November 2005) [Level 1: 3.1.4.3]

Mitigating Factors:

The Supersites may have different status at time of site selection. For example, Kwajalein, as a tropical open-ocean site, is already a TRMM GV location and may be more rapidly developed for GPM than a yet, unspecified, continental U.S. site.

Future Trades

GLOBAL PRECIPITATION MEASUREMENT

Future Trades: NASA Supersite Selection Process

NASA Supersite Selection Options:

(1) Formal Competition including Peer Review

(2) Informal Competition with decision from Science / Project Office

Important Factor:

Synergism with facilities and resources of domestic agencies

Future Trades: Supersite Instrumentation

Level 2 [6.1.3.6] governs minimum instrument complement for the NASA Supersites (i.e. governs type of required instruments)

Instrumentation Options:

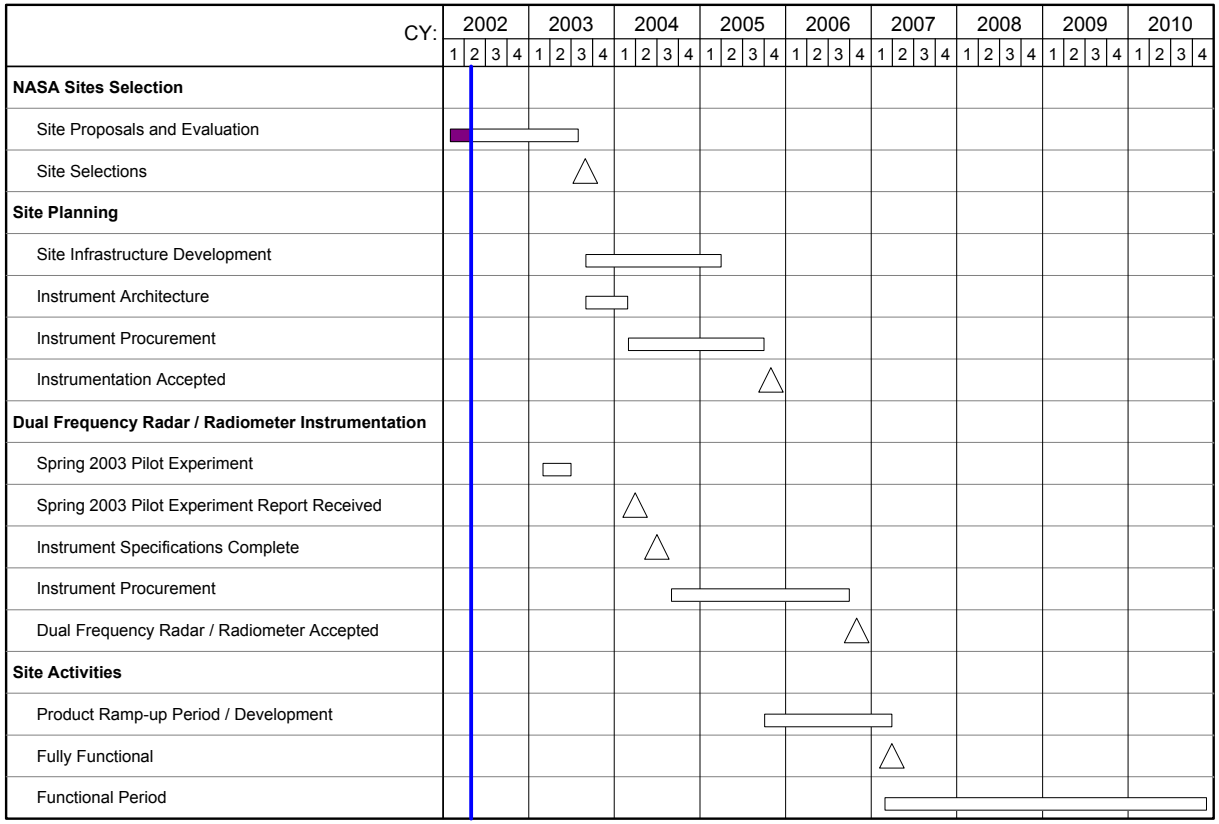
(1) Identical instruments for minimum complement or

(2) Specific instrument selection authority to the local Supersite experts

Important Factor:

Different geography and precipitation characteristics of the two Supersites

Schedule

GV Routine Product Site
Schedule

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