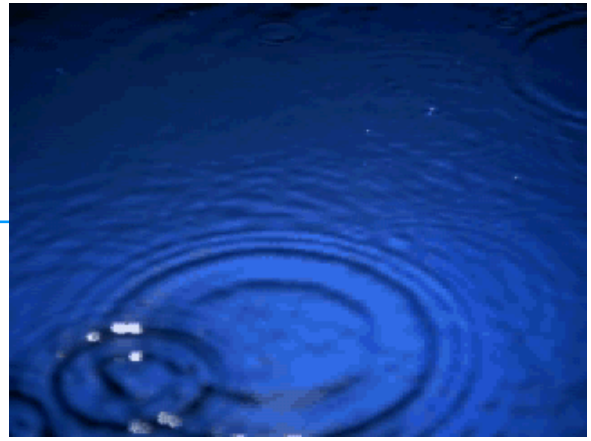
Global Precipitation Measurement



System Requirements Review

GMI -

GPM Microwave Imager

June 4 - 5, 2002

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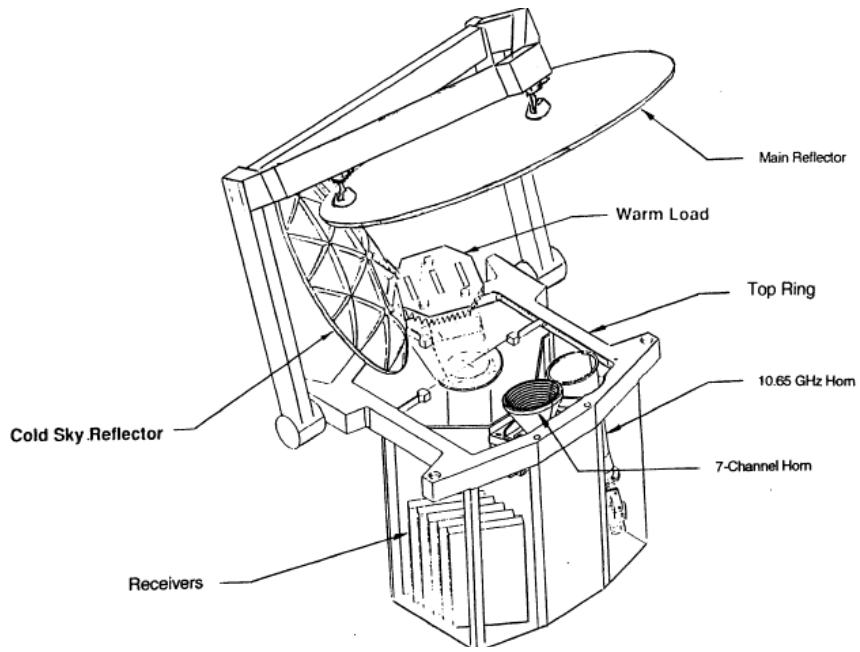
Goddard Space Flight Center

Background

The TRMM Program successfully used a conical scan, multi-channel microwave radiometer to make passive rainfall measurements.

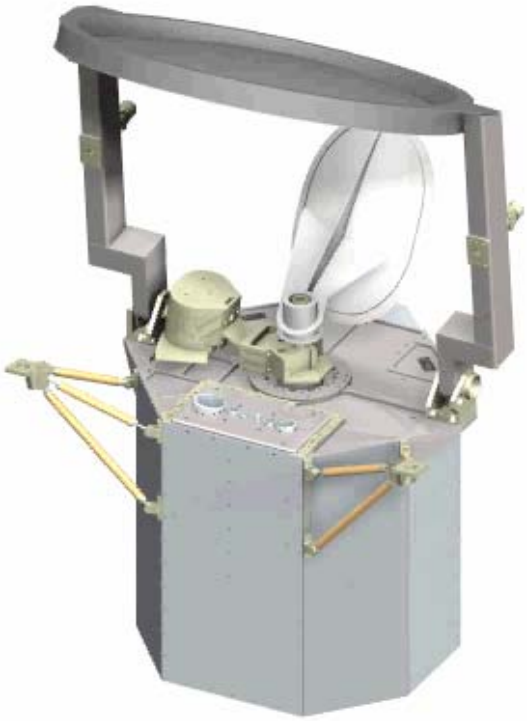
Conical scan radiometers have the following characteristics:

- *Simultaneous measurements at multiple microwave frequencies*
- *Constant Earth Incidence Angle*
- *Constant ground spot size*
- *Calibration during each scan*
- *Broad measurement swath*
- *Mature technology*



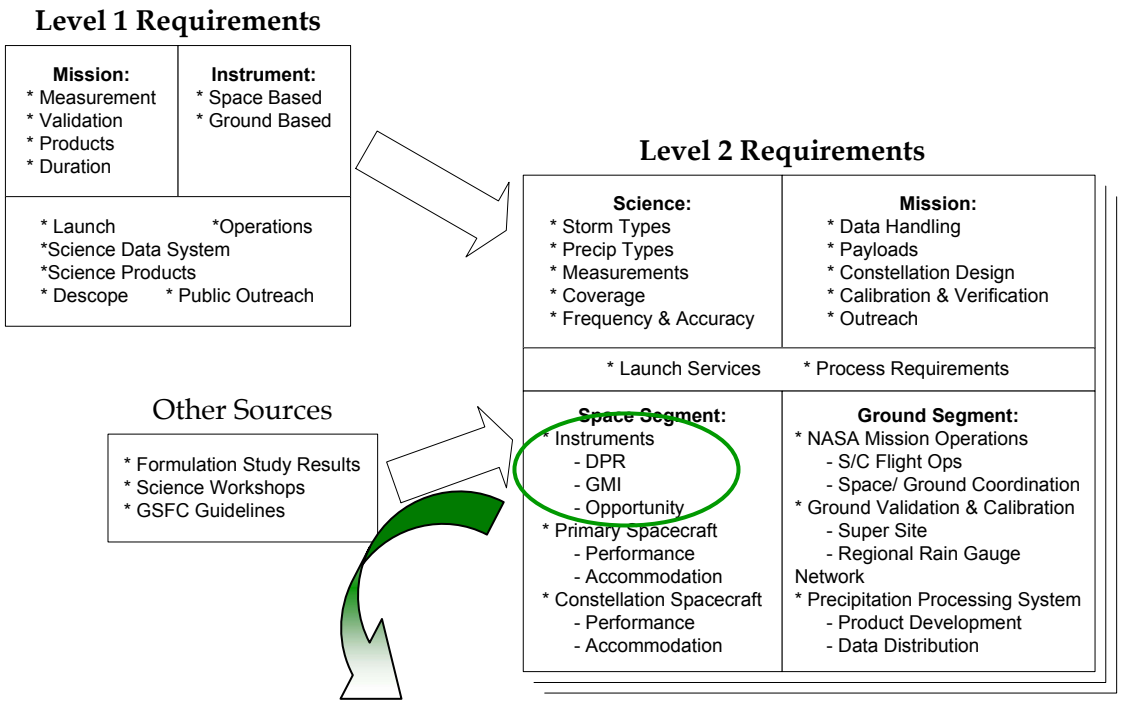
TRMM Microwave Imager (TMI)

Example of Conical Scan Microwave Radiometer



SSMIS

Instrument Level 2 Requirements



Instrument Requirements:

- Lifetime
- Operating Bands
- Resolution
- Scan/ Swath
- Physical Allocations

GMI Level 2 Requirements

The following are the GMI Level 2 Requirements:

5.1.2 GPM Microwave Imager

5.1.2.1 GMI Lifetime

5.1.2.2 Reliability

5.1.2.3 GMI Mass Allocation

5.1.2.4 GMI Power Allocation

5.1.2.5 GMI Volume Allocation

5.1.2.6 GMI Data Allocation

5.1.2.7 GMI Earth Incidence Angle

5.1.2.8 GMI Contiguous Coverage

5.1.2.9 GMI Resolution

5.1.2.10 GMI Swath Width

5.1.2.11 GMI Observing Channels

GMI Level 2 Requirements

The first six, and the tenth, Level 2 Requirements relate primarily to instrument design and accommodation characteristics. The assignment of values have been/will be established during discussions with GPM Systems Engineering Team:

5.1.2.1 GMI Lifetime → 3 years, goal of 5 years

5.1.2.2 Reliability → TBD

5.1.2.3 GMI Mass Allocation → 88 kg, NTE

5.1.2.4 GMI Power Allocation → 101 W, NTE

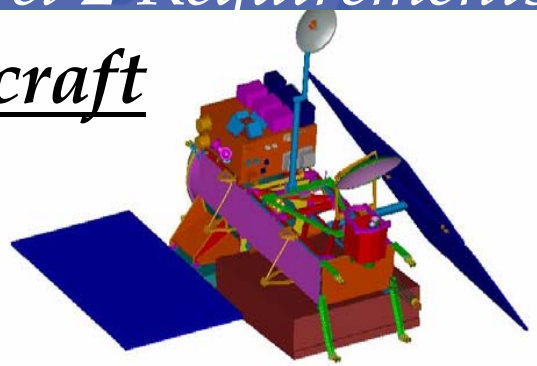
5.1.2.5 GMI Volume Allocation → TBD

5.1.2.6 GMI Data Allocation → 15 kbps, NTE

5.1.2.10 GMI Swath Width → 850 km

Accommodation on Primary Spacecraft

Rationale



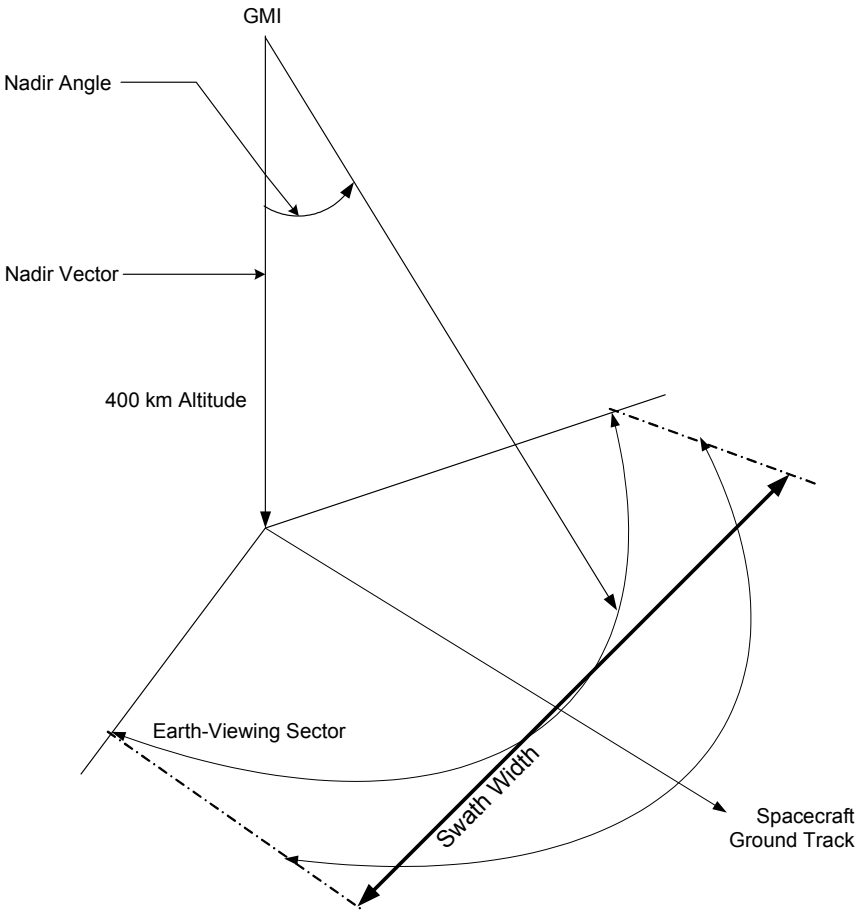
Allocations are based upon a compromise between the assignment of limited spacecraft resources and the anticipated requirements for the instrument

Characteristic	SSM/I	TMI	**GMI**	SSMIS	CMIS	AMSR-E
Antenna Diameter	0.61 m	0.61 m	**0.61 – 1.2 m**	0.61 m	2.35 m	1.6 m
Number of Channels	7	9	**9 - 15**	24	61	12
Mass	48 kg	54 kg	**88 kg NTE**	96 kg	~250 kg	324 kg
Power	45 W	50 W	**101 W NTE**	135 W	340 W	350 w
Data Rate	3.3 kbps	8.8 kbps	**15 kbps NTE**	13.7 kbps	300 kbps	87.4 kbps

5.1.2.10 GMI Swath Width → 850 km

Swath width is a design characteristic of the instrument. A broad swath is preferred in order to maximize the surface of the Earth measured each orbit.

A spacecraft altitude of 400 km, an Earth Incidence angle of 52.8 °, and a scan sector of 130° provides the required swath width.



GMI Level 2 Requirements

The remaining four Level 2 requirements relate primarily to instrument performance.

5.1.2.7 GMI Earth Incidence Angle

5.1.2.8 GMI Contiguous Coverage

5.1.2.9 GMI Resolution

5.1.2.11 GMI Observing Channels

GMI Level 2 Requirements

The values for these requirements were formulated over a period of time based upon discussions and recommendations obtained from the scientific community:

- ***Experience with the TRMM Microwave Imager (TMI) on the TRMM Program***

  TRMM Scientists have been very satisfied with the measurements obtained from TMI

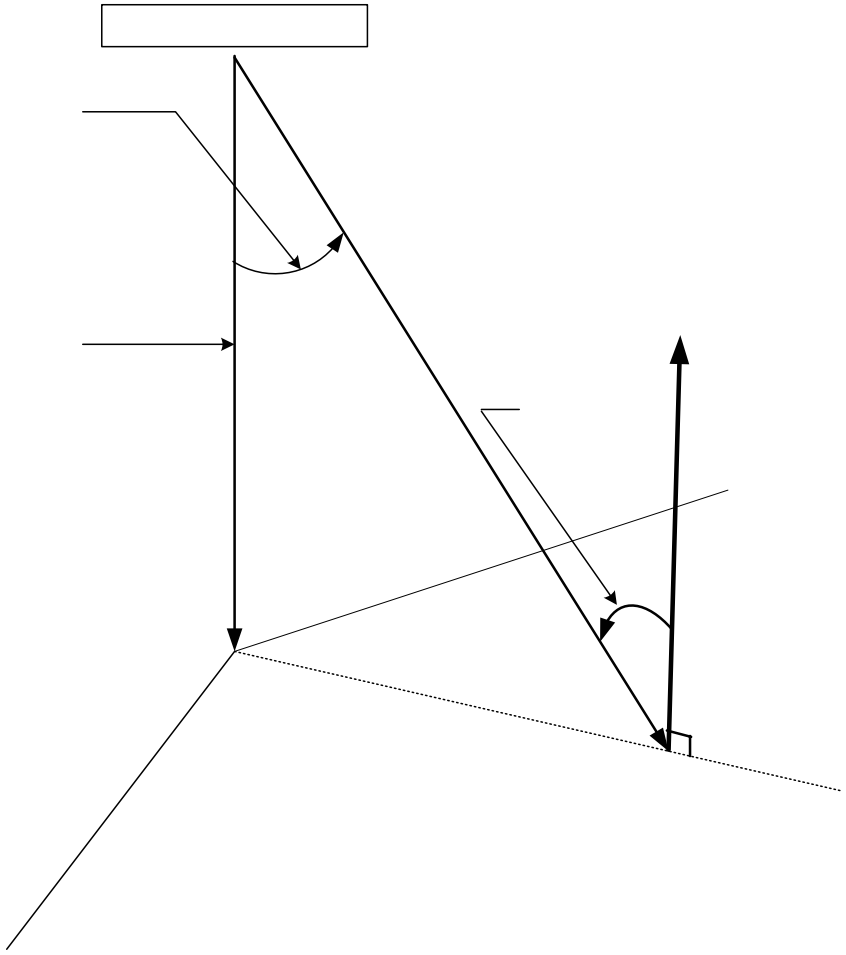
- ***GPM Science Workshops***
  - *NASA Workshop on GPM Core Satellite Radiometer Improvements, August 30-31, 2001*
  - *Algorithm Workshop for Global Precipitation Measurement, March 12, 2002*

- ***Discussions with the GPM Project Scientist and his supporting team***

5.1.2.7 GMI Earth Incidence Angle → 52.8°

Rationale:

Two predecessor instruments to GMI, the SSM/I and the TMI, each had an Earth Incidence Angle (EIA) of 52.8°. The scientist have expressed a preference that the same EAI be maintained for GMI.



5.1.2.8 GMI Contiguous Coverage

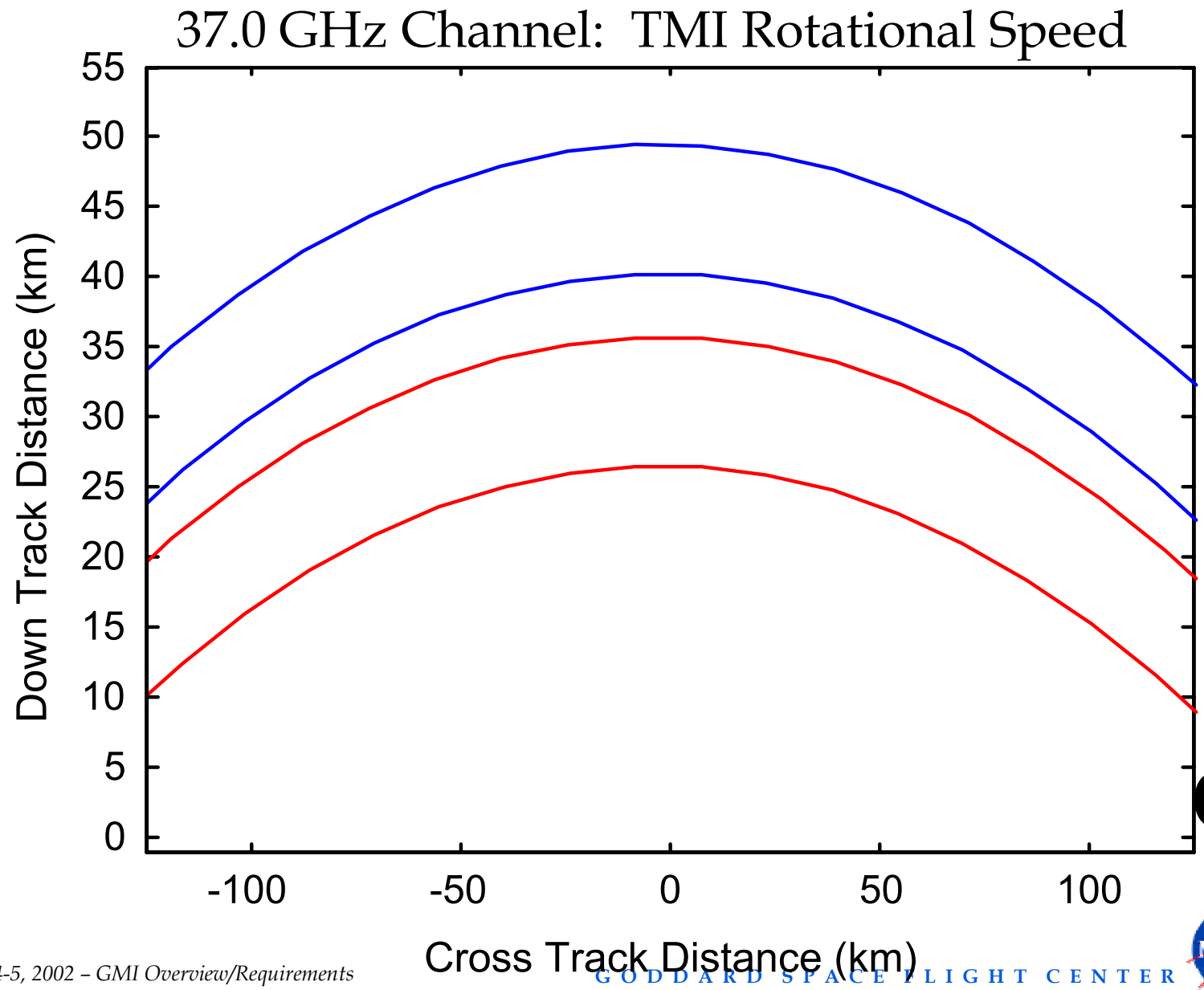
No measurement gaps *between successive ground scans at frequencies of 89 GHz and lower (see following charts)*

Rationale

Gaps between measurement swaths result in incomplete measurements of precipitation. This introduces uncertainty into the precipitation events being observed, and into the calibration standards which will be transferred from the Primary Spacecraft to other members of the GPM constellation.

This requirement was discussed and approved by the attendees at the GPM Algorithm Workshop on March 12, 2002

GMI Contiguous Coverage



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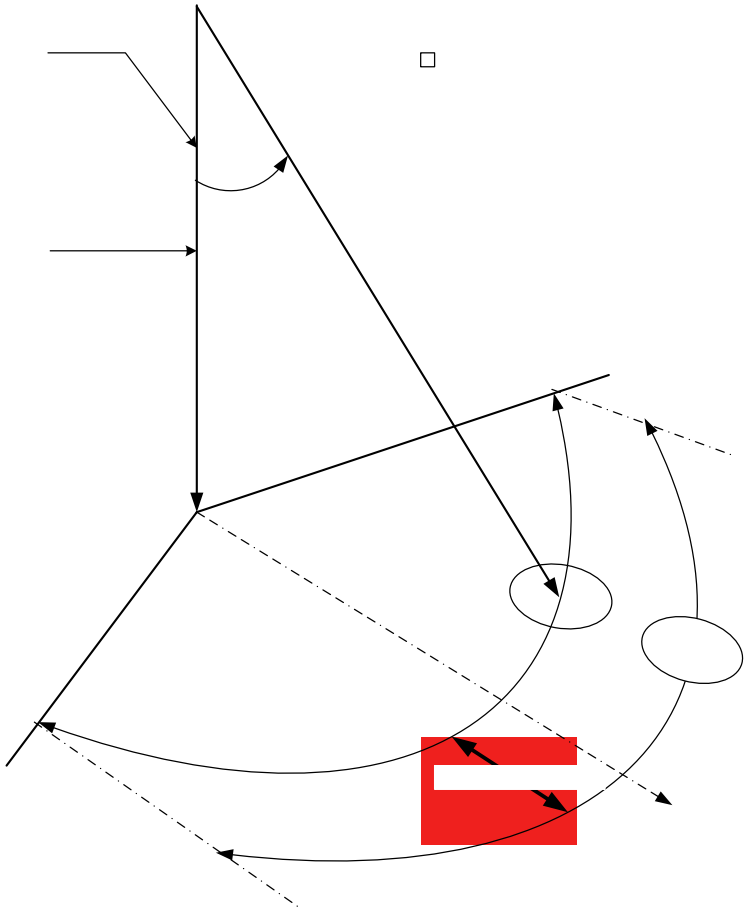
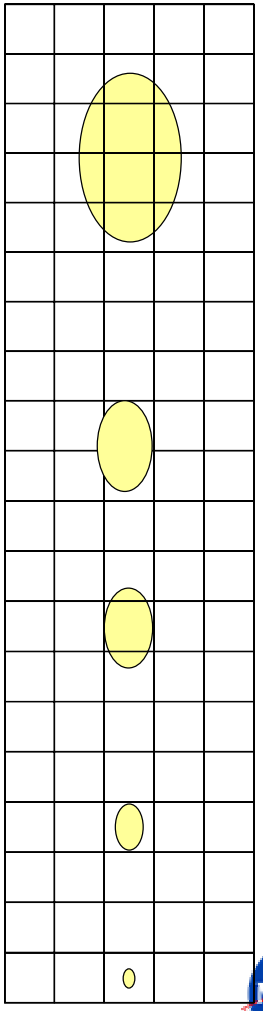
Measurement swath scan geometry

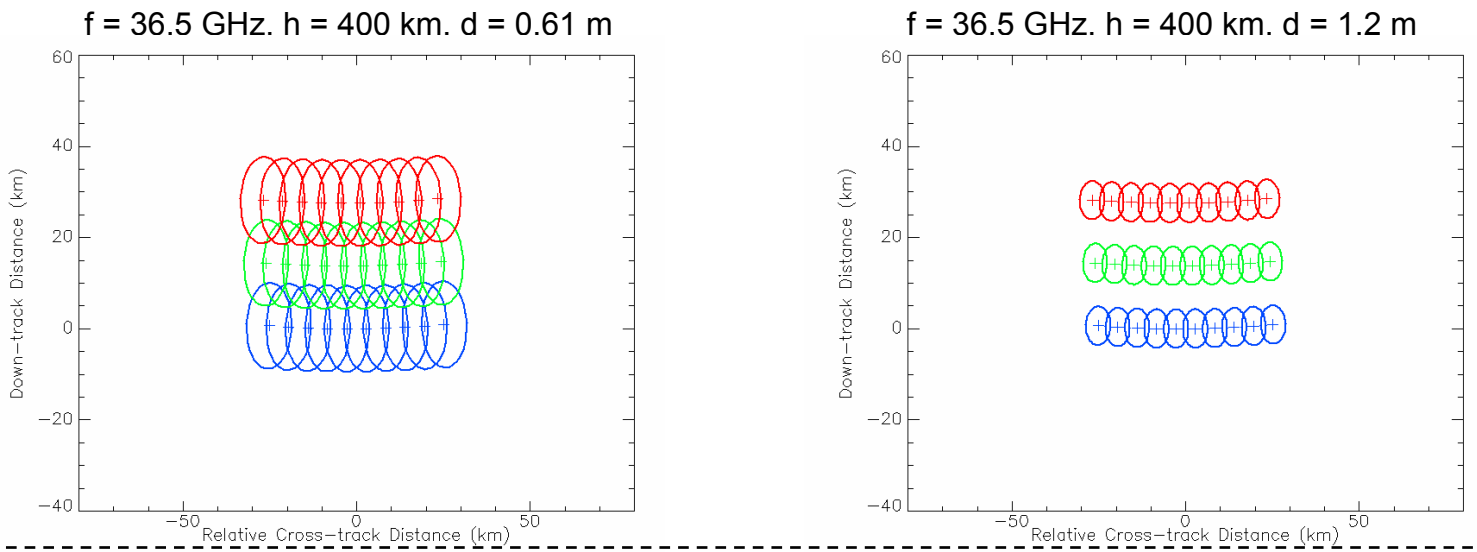


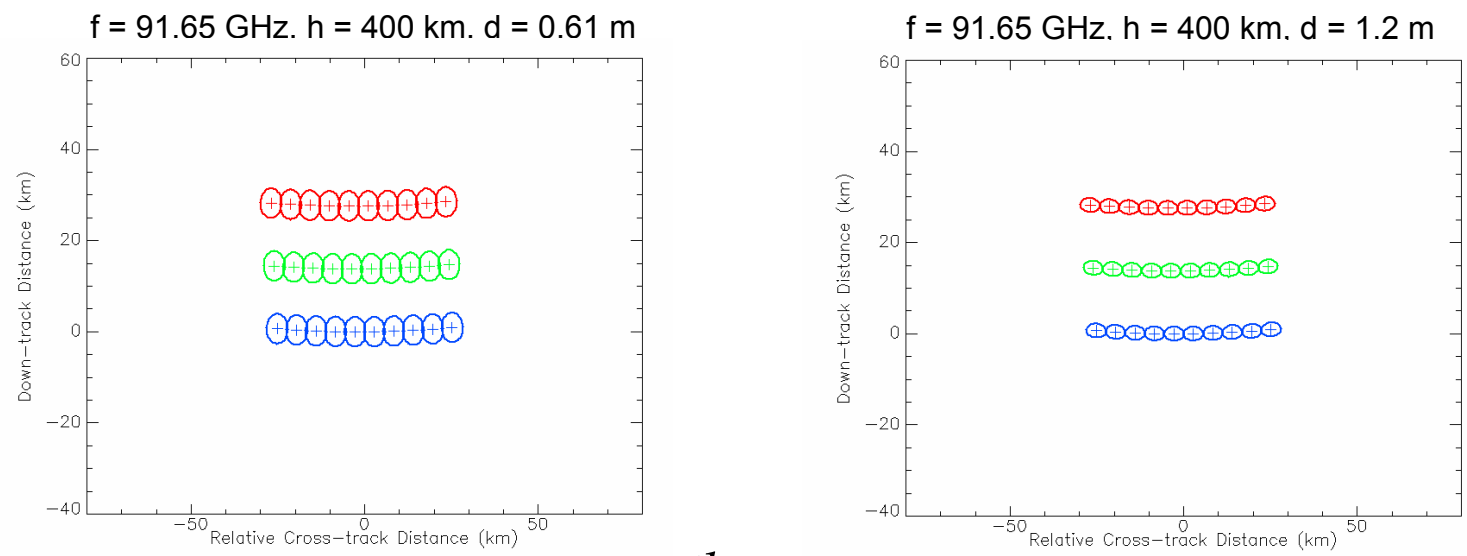
1.2 m Antenna



GMI Contiguous Coverage

Examples of measurement swath overlap and gaps between successive swaths





Material obtained from Northrop Grumman - Asuza

GMI Contiguous Coverage

Provide contiguous measurement scans to 89 GHz

Approach for reaching a solution:

A strawman GMI concept is in development which will be used to perform a series of trades. These will provide GPM a good understanding of the hardware issues, and may suggest an optimum implementation approach. If an optimum approach is not identified, this will be a trade which the GMI contractor will be required to perform.

The trades for the GMI concept will be performed in the GSFC Instrument Synthesis and Analysis Lab (ISAL) during the last two weeks of June 2002.

5.1.2.9 GMI Resolution → TBD

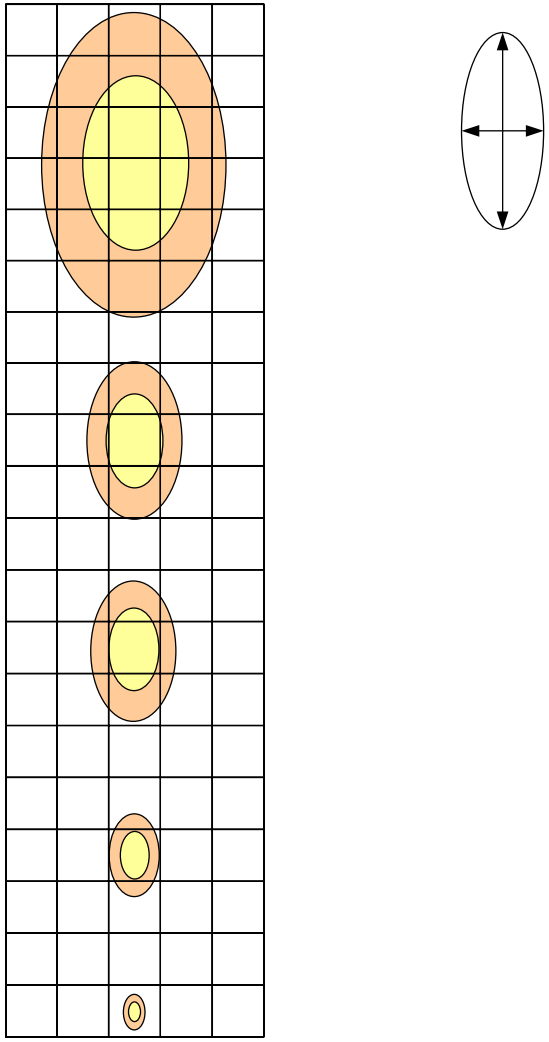
Provide sufficient resolution so that the convective core of a storm entirely fills the measurement beam (i.e. the measurement is not contaminated due to only partial beam-filling). This requires ground spatial resolution on the order of 5-to-10 km.

Increased resolution requires in a smaller footprint. A smaller footprint will reduce scan over-lap, or result in larger gaps between successive scans.

Increased ground spatial resolution is achieved by increasing the size of the antenna.

GMI Resolution

The GPM Scientists have expressed the desire that GMI have ground spatial resolution equivalent to TMI, as a minimum.



GMI Resolution

Required Analyses:

Identify the appropriate size antenna which provides good ground spatial resolution and while also providing contiguous scans.

Approach for reaching a solution:

A strawman GMI concept is in development which will be used to perform a series of trades. These will provide GPM a good understanding of the hardware issues, and may suggest an optimum implementation approach. If an optimum approach is not identified, this will be a trade which the GMI contractor will be required to perform.

The trades for the GMI concept will be performed in the GSFC Instrument Synthesis and Analysis Lab (ISAL) during the last two weeks of June 2002.

5.1.2.11 GMI Observing Channels → TBS

The channel set used by TMI was selected based upon a scientific understanding of the capabilities of the selected channels. The satisfaction expressed by the TRMM Scientists with the measurements obtained from TMI provides confirmation that the selection was well made. It is anticipated that GMI will utilize a similar channel set to provide comparable capabilities. The inclusion of additional channels for enhanced capabilities is under consideration.

GMI Channel Set

The minimum recommended set of measurement channels are as follows:

10.65 GHz, V&H Pol

18.7[1] GHz, V&H Pol

21.3[2]GHz, H Pol

37.0 GHz, V&H Pol

89.0[1] GHz, V&H Pol

[1] *The recommended channels has been moved from 19.35 GHz to 18.7 GHz, and from 85.5 to 89.0 GHz in order to use frequency bands reserved for Passive Earth Remote Sensing*

[2] *TMI utilized V-Polarization, scientists have expressed a preference for H-polarization*

Trades

Trades

Improved measurement capability for light rains, and a desire to measure snowfall

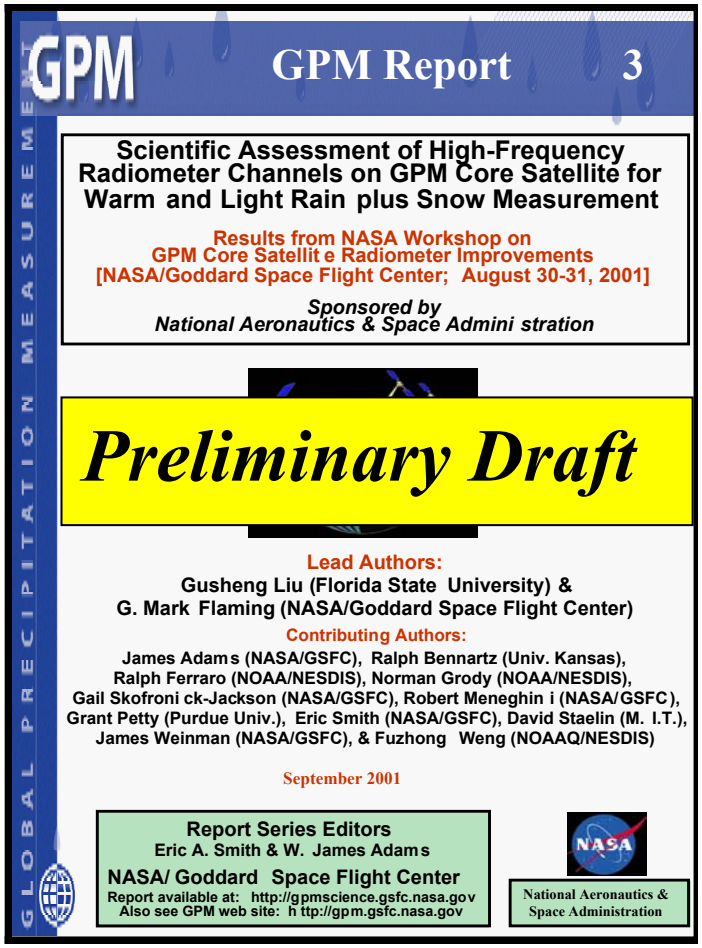
Rationale for desired capability:

- ***Substantial amount of the precipitation which falls in the higher latitudes is in the form of light rain and snow***
- ***Inability to measure this precipitation will introduce uncertainty and error***

Improved measurement capability for light rains and other precipitation

- *Topic of Discussion at the "GPM Core Satellite Radiometer Improvements Workshop", Aug 30-31, 2001*

- *Addition of High Frequency Channels was the recommended approach*
  - *Provides increased sensitivity for measurements of light rain*
  - *Use of Multiple Channels at 150-166 GHz and 183 GHz recommended*
  - *Implementation of fewer channels provides a reduced capability at a reduced cost*


GPM Report 3

Scientific Assessment of High-Frequency Radiometer Channels on GPM Core Satellite for Warm and Light Rain plus Snow Measurement

Results from NASA Workshop on GPM Core Satellit e Radiometer Improvements [NASA/Goddard Space Flight Center; August 30-31, 2001]

Sponsored by National Aeronautics & Space Admini stration

Preliminary Draft

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September 2001

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Also see GPM web site: h ttp://gpm.gsfc.nasa.gov

National Aeronautics & Space Administration

Report available at the GPM Science website: gpmscience.gsfc.nasa.gov

Procurement Status

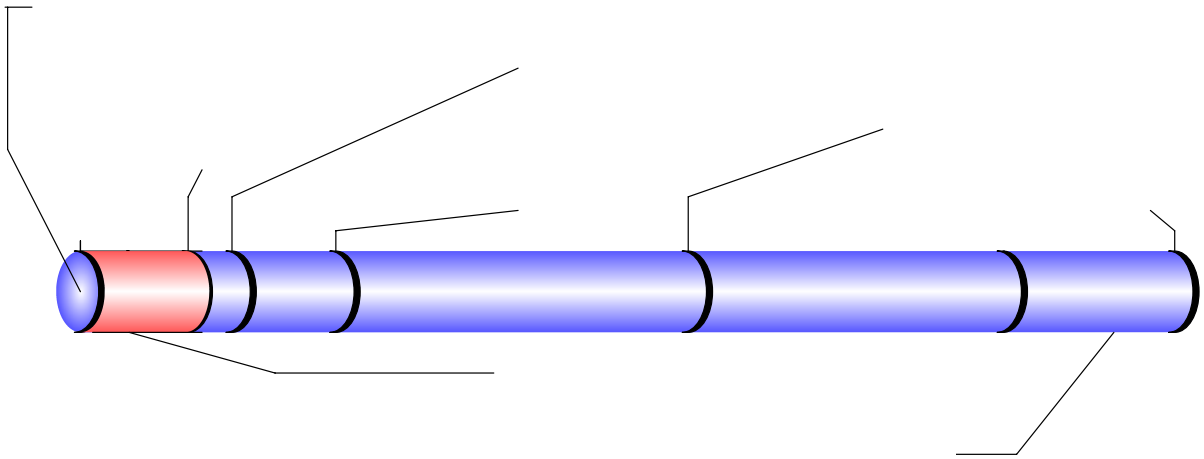
Instrument Acquisition

- ***Two GMIs will be Procured from industry***
  - *One for the Core Spacecraft*
  - *One for the NASA Constellation Spacecraft*

- ***Contract type:***

  CPIF or CPAF

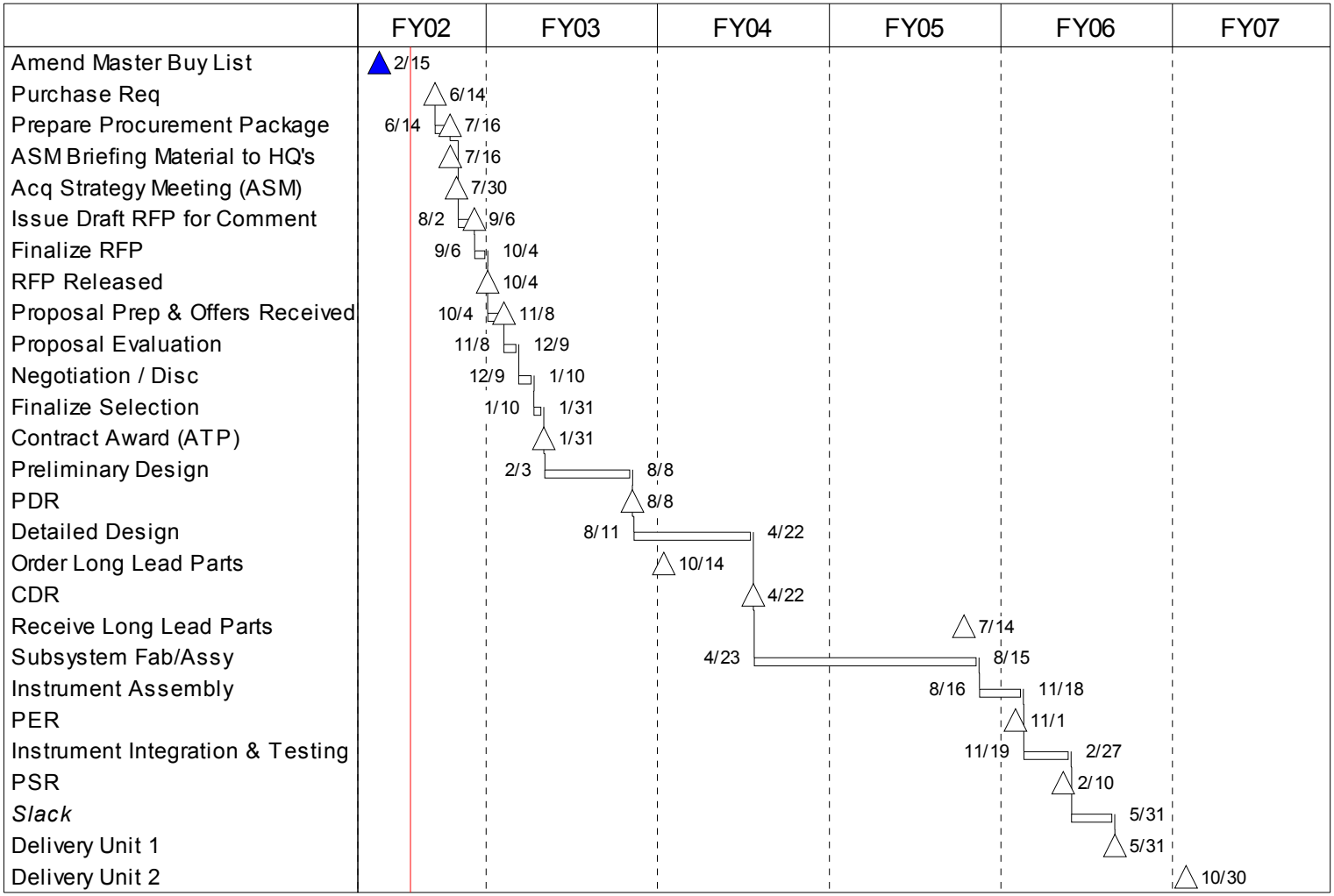
Acquisition Timeline



Detail GMI Acquisition Schedule

GMI
Schedule

4/22/02



Risk

Technical Risk –

Substantial experience exists with the design and fabrication of similar conical scan radiometers

- *SSM/I – 7 instruments*
- *TMI – 1 instruments*

} ***Currently more than 45 years of on-orbit operation***

- *SSMIS - 5 instruments built, none launched yet*

Technologies

All technologies anticipated for use on GMI have been used previously, or are being incorporated into current microwave radiometer developments