NASA's Ground Network (GN) Space Communications and Data Transport

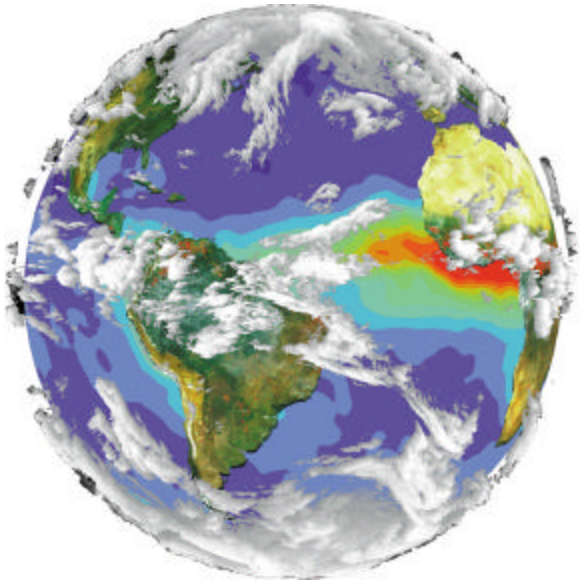
McMurdo Ground Station (MGS)

Bill Watson, NASA HQ

March 9, 2004

Overview

The Earth Science Enterprise (ESE) of the National Aeronautics and Space Administration is responding to the Agency vision to "understand and protect our home planet" with a shift in emphasis from missions to measurements



Aqua MODIS 21:05 UTC

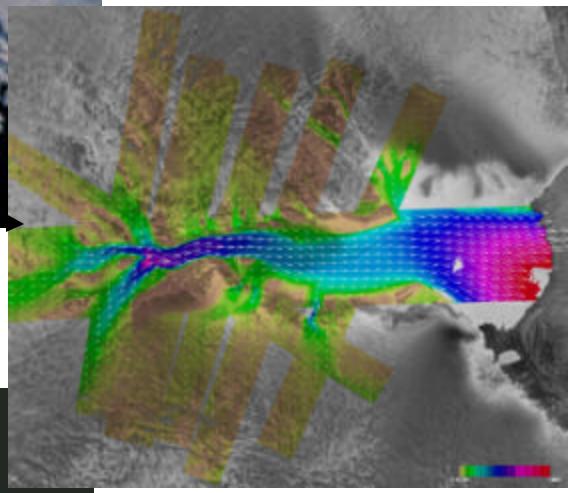
Aspen Fires, Coronado National Forest, AZ

Image taken June 19, 2003

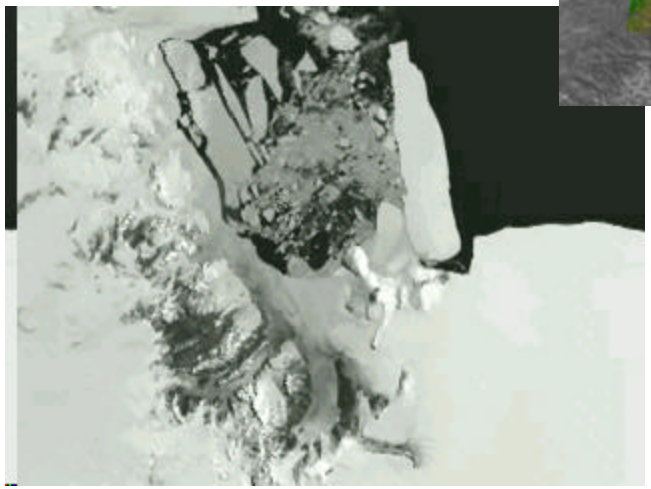
NASA's Ice Research Made the News

NASA reports on surface melting and ice-sheet flow in Greenland, July 12, 2002.

Terra MISR image of calving of Pine Island iceberg, Nov. 12, 2001.

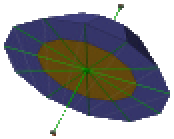


NASA measures the velocity of ice flow on the Lambert Glacier



NASA discovers massive icebergs' affect on Antarctic food chain.

GEO

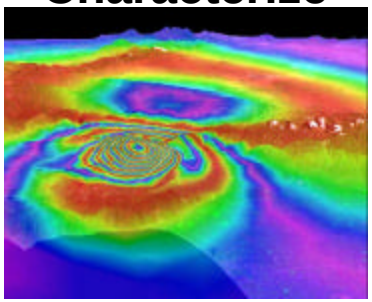


MEO

LEO

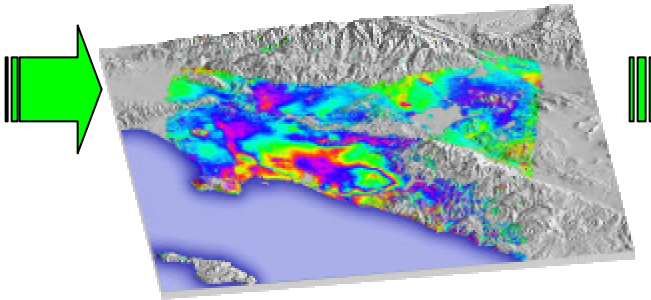
Telecommunications in support of Science Data acquisition and characterization

Characterize



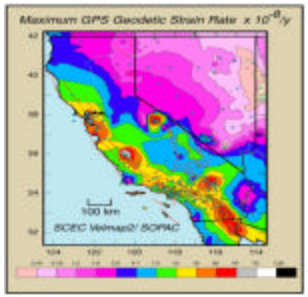
InSAR missions

Understand



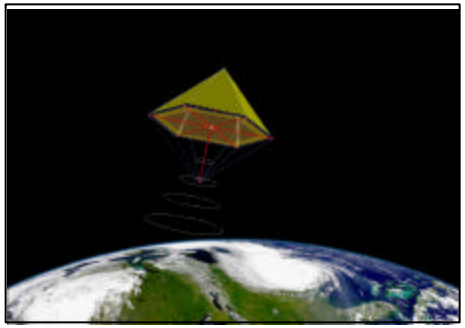
Solid Earth modeling

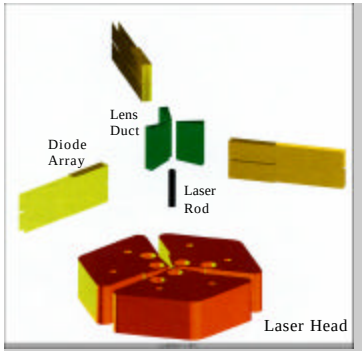
Predict



Event forecasting

Advancing radar and lidar technologies for the decade beyond

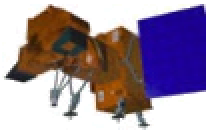




In Operation

In Implementation

The Earth Observing System -- systematic measurement of interactions among land, oceans, atmosphere, ice & life



Landsat

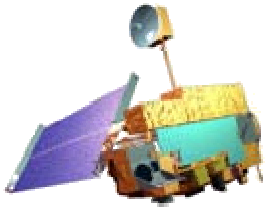
Aqua

Research missions to probe key Earth system processes globally for the first time

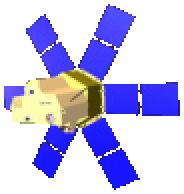
TRMM

GRACE

Jason



Terra



SORCE

Calipso

Cloudsat

ICESat

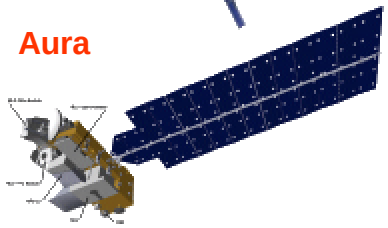
SeaWiFS

EO-3: GIFTS

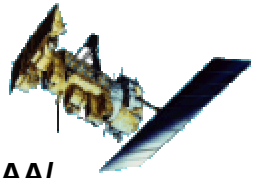
EO-1: ALI & Hyperion

Operational precursor / Technology demos

Aura



NOAA/ GOES



Operational weather services missions for NOAA

NOAA/ POES

Next Generation

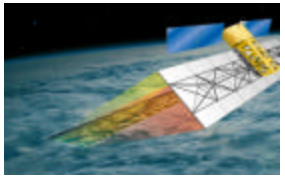
Next generation systematic measurement missions to extend / enhance the record of science-quality global change data.

In Formulation

Candidate Future Missions

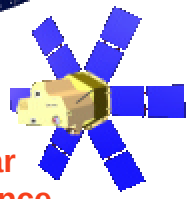
Research missions to probe key Earth system processes globally for the first time

Synthetic Aperture Radar

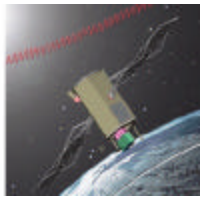


Cryosphere Monitoring Mission

Chemistry / Climate Mission



Solar Irradiance Measurement



Orbiting Carbon Observatory

AQUARIUS

Global Precipitation Measurement

Total Column Ozone

Future research measurements:

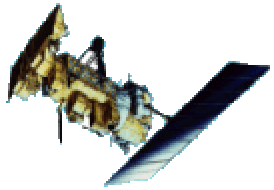
- Soil moisture
- Advanced gravity
- Ocean carbon
- Cold climate processes
- Vegetation recovery

Landsat Data Continuity Mission

Ocean Surface Topography Mission

NPOESS Preparatory Project

NOAA/GOES-R



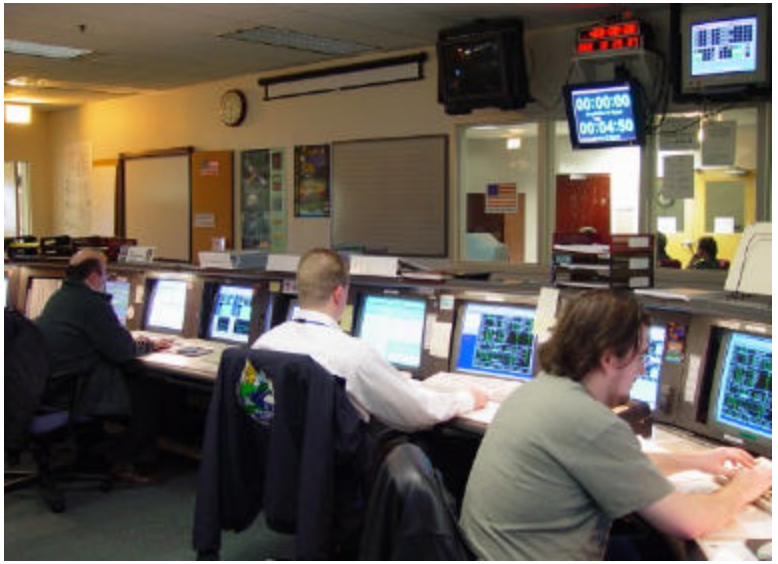
Operational weather services missions with NOAA

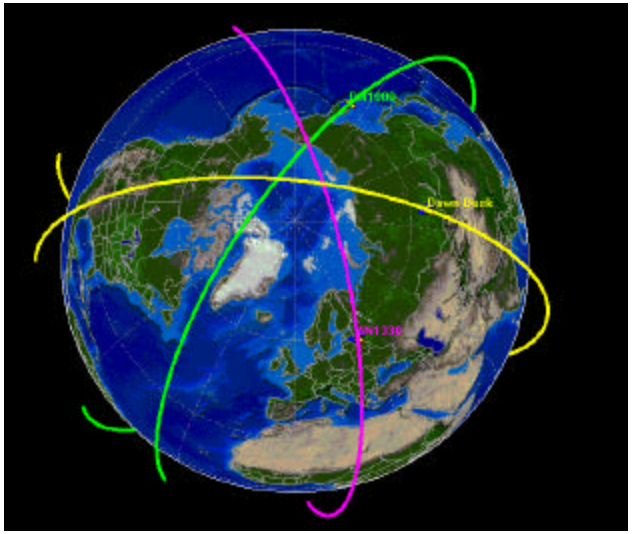
NOAA / NPOESS

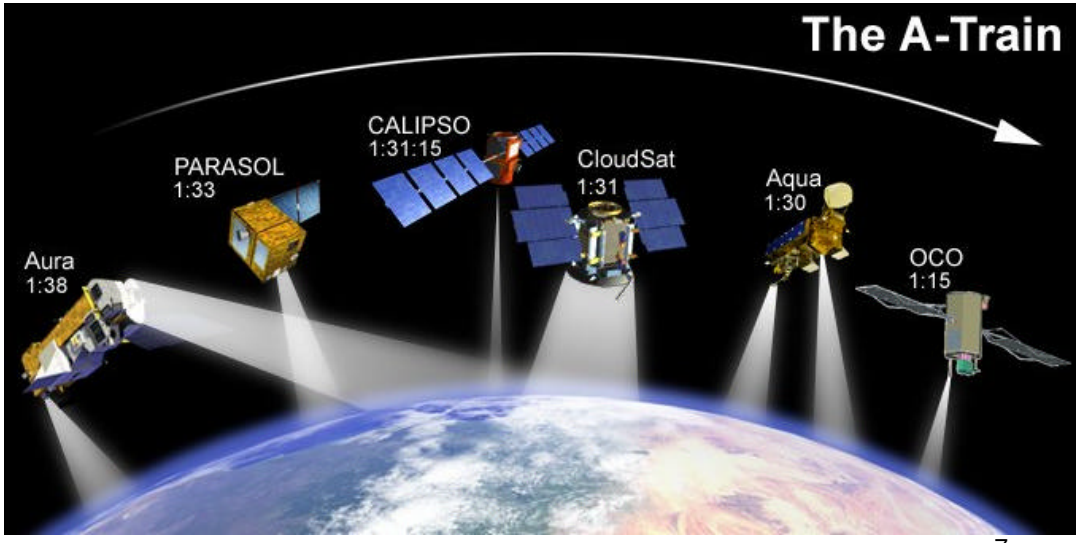
EOS mission control

Earth Science Mission Operations

- Manage command and control spacecraft power, dynamics,
- Monitor instrument operations, build composite observation schedule
- Manage spacecraft recorder dumps and schedule retrieval with ground stations and space network



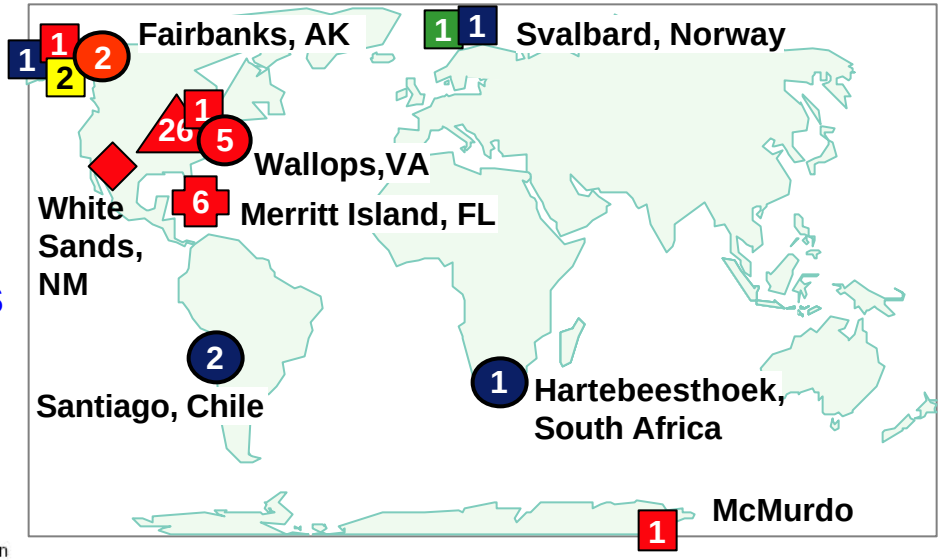




NASA's Ground Network

- 50 ground station antennas;
  30 unique antenna systems
- 7 geographic antenna locations
- 4 different owner/operator models
  - 14 contracts for commercial services

GN Antenna Map (Number of Antennas)

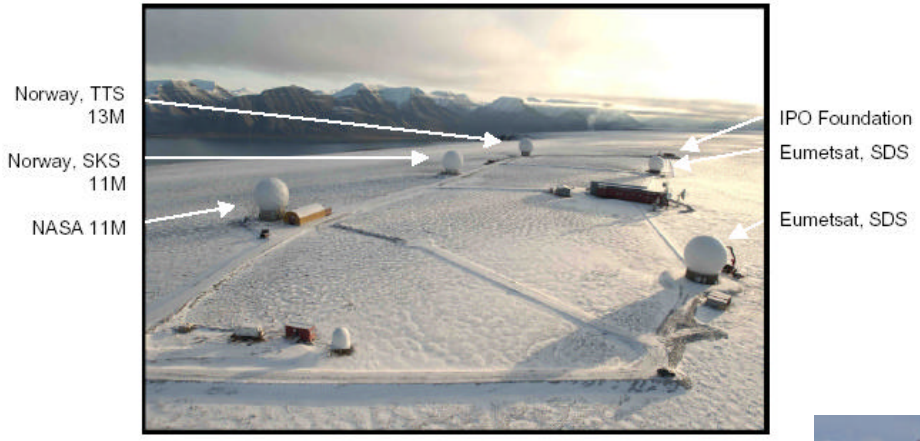


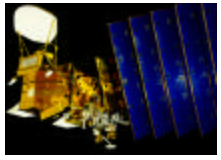
Primary Support Category

- Orbital S-Band @ 3 mbps
- Orbital X-Band @ 150 mbps
- Range
- Shuttle
- Scheduling

Owner/Operator Model

- NASA/NENS
- NASA/university
- NASA/commercial
- Commercial





EOS Aqua

Shuttle Launch

Ultra Long Duration Balloon

Ground Network Program Framework

- **On-going dynamic to maintain balance:**
  - Backward compatibility in space communications systems-service continuity
  - Increasingly complex and higher resolution measurements are achieved
- **Paradigms in space communication:**
  - In principle, measurement and mission needs drive space communication system changes; however,
  - In practice the communication system technology, spectrum regulation and signals standards become enablers for the specific mission design.
- **Effort invested in using existing systems for new spacecraft missions**
  - Adoption of space link extension standards for remote control of ground tracking station configuration
  - Demonstrations of Internet protocols for routing information through heterogeneous ground tracking stations

MGS

1993 MOA Between National Science Foundation and NASA For Spacecraft Tracking and Data Acquisition at McMurdo Station, Antarctica
1994 MGS Supports Radarsat And ERS
1996 Feb MTRS Supports FAST
1997-8 SPTR Demonstrations
2000 MOA Between NASA's GSFC And NSFs Office of Polar Programs Concerning Support Via the TDRSS
2000 MOA Among the Air Force Space Command, NASA, and National Science Foundation Concerning an Interagency Partnership For a Joint Spacecraft Operations Center at McMurdo Station, Antarctica
2003 MGS/WSC RAID demo

George Iwanaga

MGS in GN

Recent Day (Feb 27) in the life of the Ground Networks

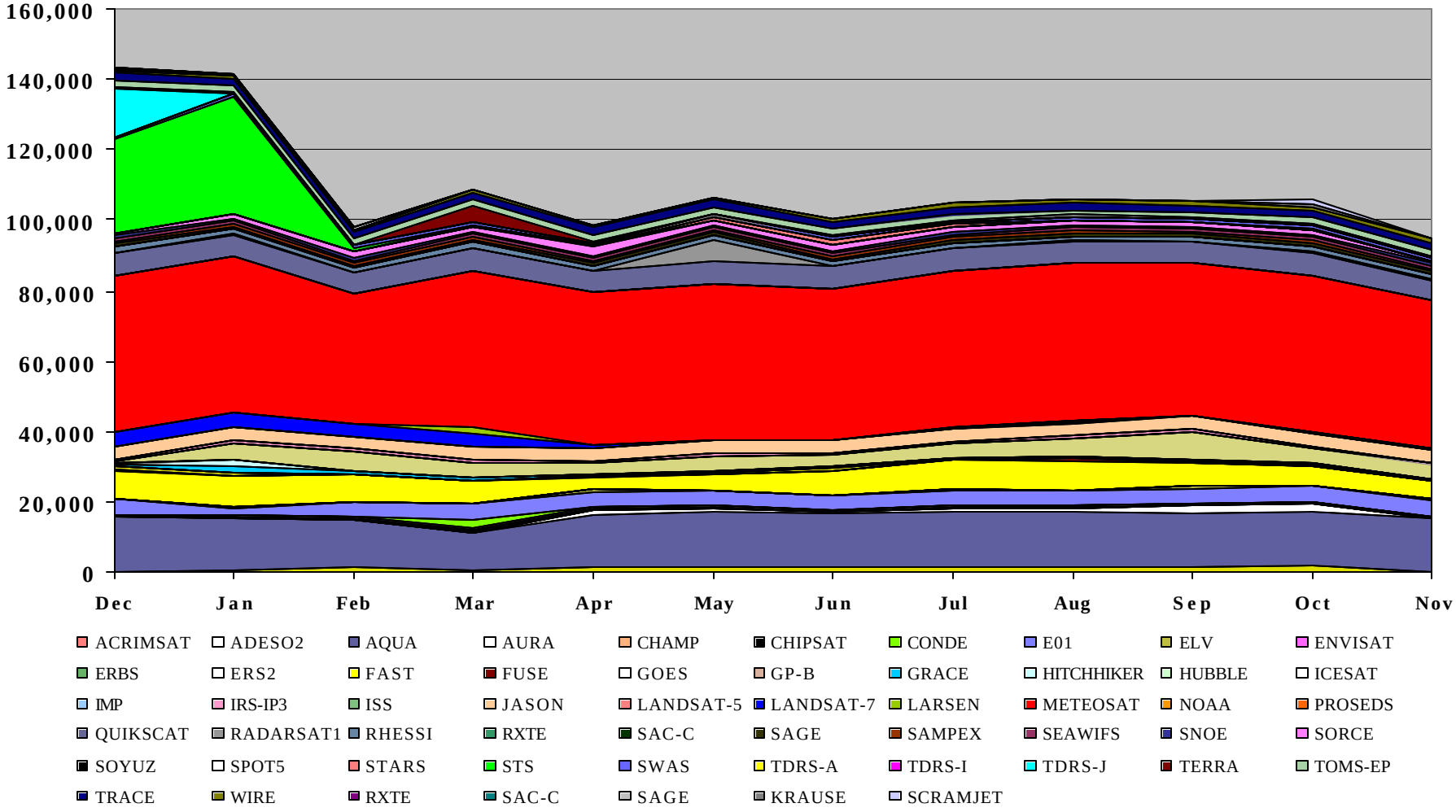
Ground Network Customer Support

CUSTOMER	AGS	MGS	SGS	WGS	PF1	SKS	WPS	PKR	AGO	MIL	DRY	WSC	DSN	ASF	TOTAL
AQUA	10		8			4									22
CHIPSAT							2								2
EOI	3		4												7
FAST							3	8							11
GRACE1				2											2
HESSI				3											3
ICESAT	1		3			1									5
JASON							1	4							5
METEOSAT							1								1
QUIKSCAT			3	1		1								9	14
RADARSAT		1													1
SM3							2								2
SAMPEX							2								2
SEAWIFS				1			1								2
SORCE				1					1						2
SWAS							2								2
TOMS EP				2			1	2							5
TRACE		1					2	5							8
WIRE							2	4							6
TOTALS	14	2	18	10	0	6	19	23	1	0	0	0	0	9	102

GP-B	055/22:10:00Z	MGS	10 Meter	Loss 0:06:00	CDS ID# 35252
GPB NOC lost telemetry connections approximately nine minutes into test support. No indications were found at MGS of a problem. No errors or socket connection problems were found. MGS suggests that problem may be at GPB NOC or NISN issue. MGS has not had any other occurrences of same problem since test.					

GN Minutes of Support By Customer

December 2002 - November 2003



MGS Capabilities

http://www.wff.nasa.gov/%7Ecode452/mcmurdo.html

- S-Band and X-Band Receive and Tracking
  S-band commanding
- TDRS Relay (150 Mbps)
- Virtual channel stripping
- Tape Recording (up to 150 Mbps)
- Near real-time, & post pass data delivery
- Primary antenna systems
  - 10-meter S and X-Band
  - 7.2-meter and 4.6-meter TDRS Relay

MGS S-Band Command Characteristics

Characteristic	Value
Frequency	2025 – 2120 MHz
EIRP	≥ 63 dBWi
Polarization	RHC or LHC
Antenna Beamwidth	1.05°
Antenna Gain	44 dBi
Output Power	200 W
Carrier Modulation	PM, FM, or PSK
Modulation Index	FM: 50 kHz – 50 MHz deviation BPSK: ±90°
Carrier Data Rate	≤ 200 kbps
Subcarrier Frequency	≤ 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	≤ 32 kbps
Data Format	NRZ-L, M, or S; or Biφ-L, M, or S

MGS S-Band Telemetry Characteristics

Characteristic	Value
Frequency	2200 – 2400 MHz
G/T	≥ 21.1 dB/K
System Noise Temperature	245 K
Polarization	RHC or LHC
Antenna Beamwidth	0.91°
Antenna Gain	45 dBi
Carrier Modulation	PM, FM, AM, or BPSK
Modulation Index	PM: 0.2 – 2.8 radians (peak)
Carrier Data Rate	NRZ-L: 100 bps – 8 Mbps Biφ-L: 100 bps – 4 Mbps
Carrier Data Format	NRZ-L or Biφ-L
Subcarrier Frequency	≤ 2 MHz
Subcarrier Modulation	BPSK
Subcarrier Data Rate	≤ 1 Mbps
Subcarrier Data Format	NRZ-L, M, or S; Biφ-L, M, or S
Decoding	Viterbi and/or Reed-Solomon (CCSDS)

MGS X-Band Telemetry Characte

Characteristic	Value
Frequency	8025 – 8400 MHz
G/T	≥ 32.5 dB/K
System Noise Temperature	225 K
Polarization	RHC or LHC
Antenna Beamwidth	0.26°
Antenna Gain	56 dBi
Modulation Type	QPSK or UQPSK
Data Rate	QPSK: 6 – 110 Mbps UQPSK: 10 – 23 Mbps 75 – 90 Mbps
Data Format	NRZ-L, M, or S
Decoding	Viterbi and/or Reed-Solomon (CCSDS)