Space Network

Near Earth Networks Conference

June, 2003

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Agenda

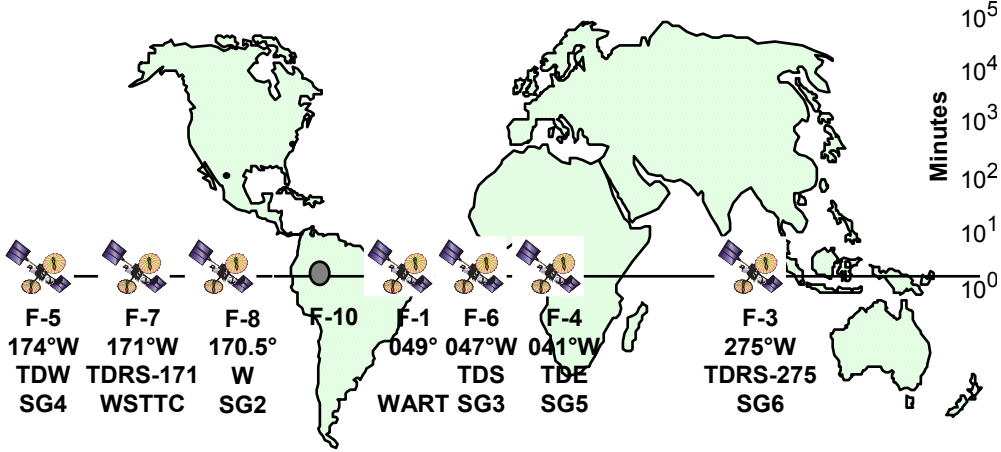
- Overview
- TDRS I and J Operations Transition
- SN Support Type by Mission
- New Capabilities

Overview

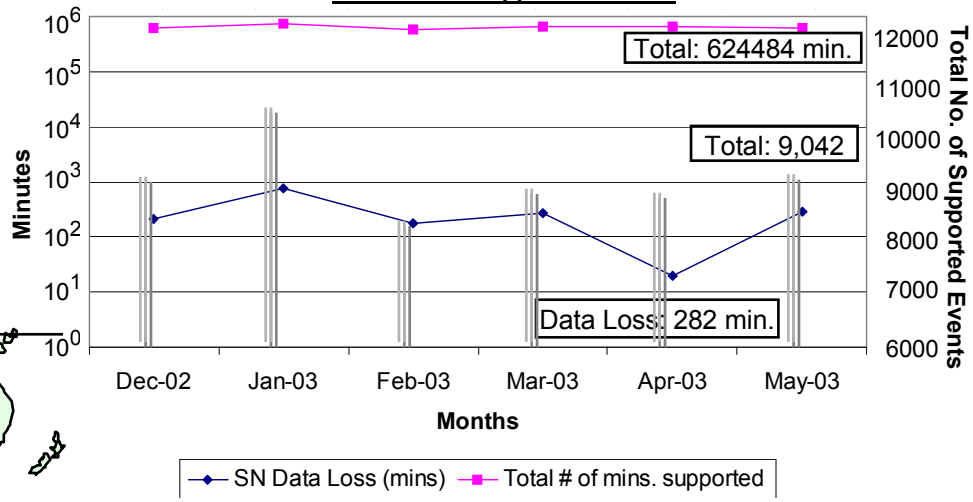
- **The Space Network (SN) provides highly reliable Tracking and Data Acquisition services to NASA and non-NASA missions.**
- **The Space Network consists of two major segments:**
  - Space Segment (TDRS Constellation)
  - Ground Segment (WSC, Guam, Network Integration Center (NIC), BRTS)
- **NASA customers are not charged for SN services, but mission-unique capabilities must be funded by each mission.**
- **The current fleet of TDRS's must remain operational through 2012.**

SPACE NETWORK AT A GLANCE

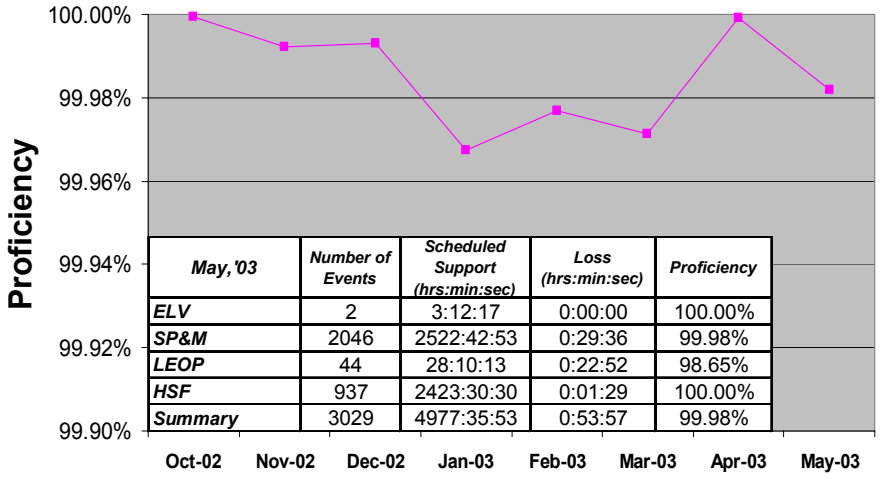
- **Operations and Maintenance**
  - **Space Network**



Minutes of Support and Minutes of Data Loss
Total No. of Supported Events

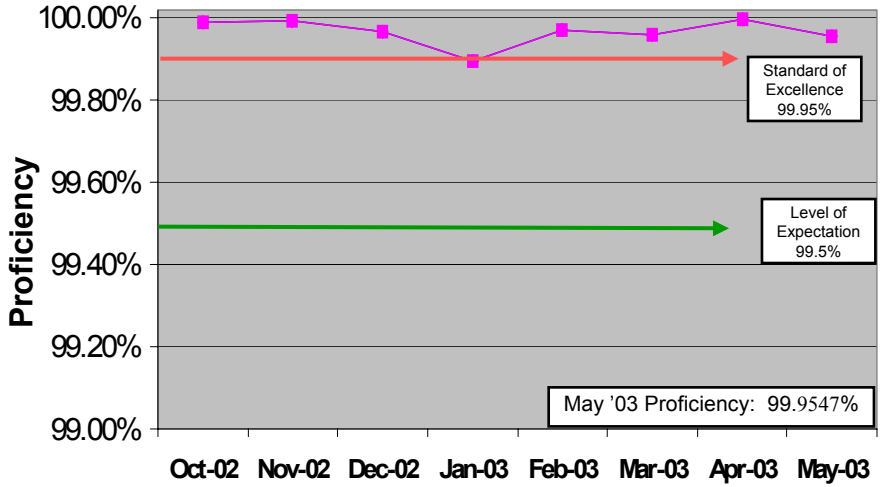


SN Critical Support Proficiency Trend



May, '03	Number of Events	Scheduled Support (hrs:min:sec)	Loss (hrs:min:sec)	Proficiency
ELV	2	3:12:17	0:00:00	100.00%
SP&M	2046	2522:42:53	0:29:36	99.98%
LEOP	44	28:10:13	0:22:52	98.65%
HSF	937	2423:30:30	0:01:29	100.00%
Summary	3029	4977:35:53	0:53:57	99.98%

SN Proficiency Trend



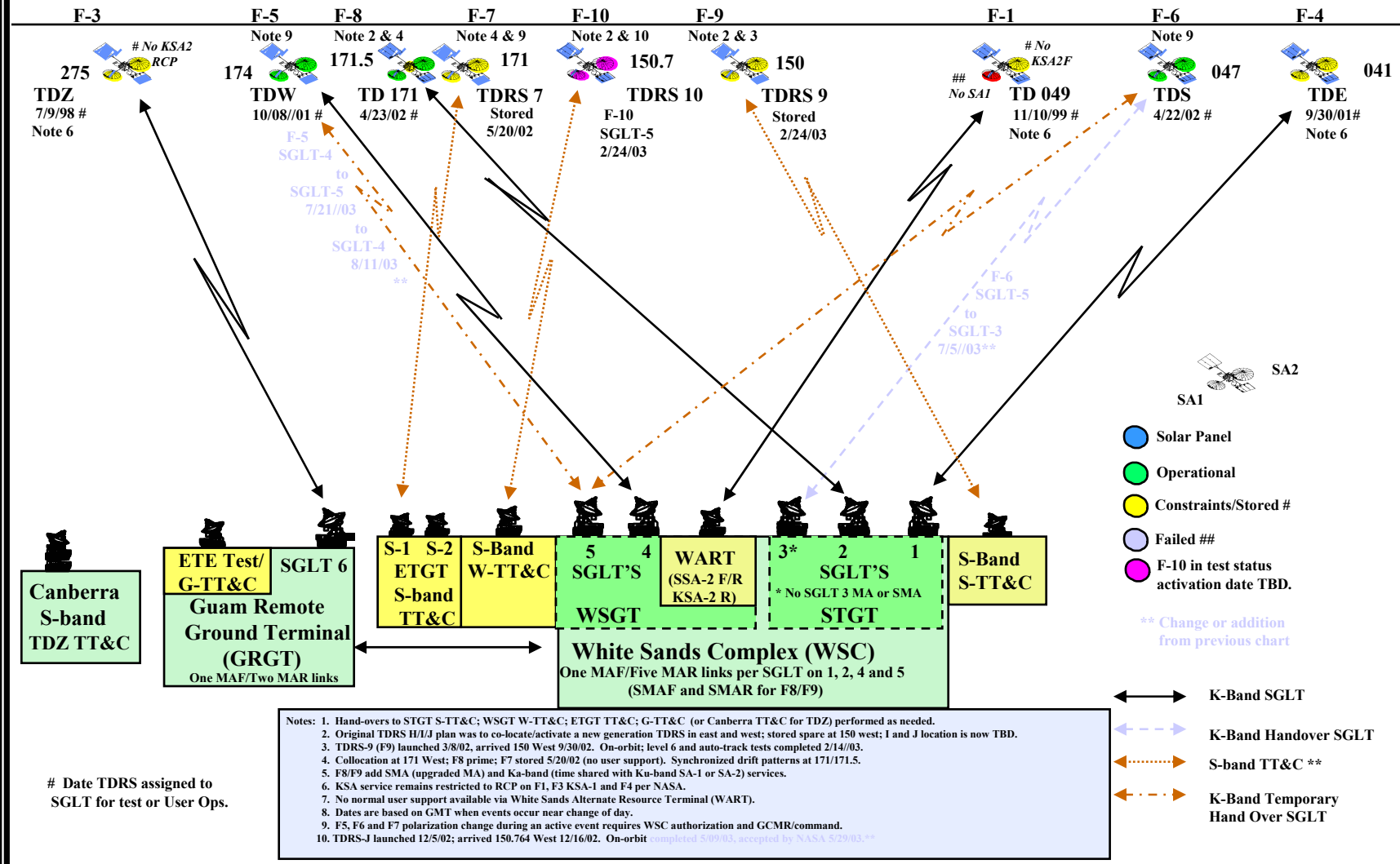
Missions	Total No. of Supported Events	Anomalies	Service Stat.	Proficiency (%)	Standard of Excellence (%)
Aqua, ERBS, FUSE, HST, ISS, L-7, SP&M, TERRA, TOPEX, TRMM, UARS, XTE, EO-1,TITAN, ATLAS, GALEX, LDBP	9,042	TBD	10,412 hrs. sched 10,408 hrs. actual 4 hrs. 42 min. lost	99.952%	99.95%

Overview
Ground Segment

- Two geographically separated Ground Stations at White Sands, NM with five Space-to-Ground Link Terminals (SGLT's).
- A sixth SGLT has been installed at the Guam Remote Ground Terminal
- The Data Services Management Center (DSMC) at White Sands is the focal point for scheduling and control of the Space Network.
- Network Integration Center (NIC) tests and monitors network data flow.
- Simulation and Testing Facility performs RF and data compatibility testing prior to mission.

Space Network Configuration – June – Aug. 2003

(5/30/03 Version per WSC SN Daily Forecast, Friday, 30 May 2003)



Notes:
1. Hand-overs to STGT S-TT&C; WSGT W-TT&C; ETGT TT&C; G-TT&C (or Canberra TT&C for TDZ) performed as needed.
2. Original TDRS H/I/J plan was to co-locate/activate a new generation TDRS in east and west; stored spare at 150 west; I and J location is now TBD.
3. TDRS-9 (F9) launched 3/8/02, arrived 150 West 9/30/02. On-orbit; level 6 and auto-track tests completed 2/14//03.
4. Collocation at 171 West; F8 prime; F7 stored 5/20/02 (no user support). Synchronized drift patterns at 171/171.5.
5. F8/F9 add SMA (upgraded MA) and Ka-band (time shared with Ku-band SA-1 or SA-2) services.
6. KSA service remains restricted to RCP on F1, F3 KSA-1 and F4 per NASA.
7. No normal user support available via White Sands Alternate Resource Terminal (WART).
8. Dates are based on GMT when events occur near change of day.
9. F5, F6 and F7 polarization change during an active event requires WSC authorization and GCMR/command.
10. TDRS-J launched 12/5/02; arrived 150.764 West 12/16/02. On-orbit completed 5/09/03, accepted by NASA 5/29/03.**

Date TDRS assigned to SGLT for test or User Ops.

TDRS-H, -I & -J STATUS

- **TDRS-H was launched in June 2000 and became operational on April 2002 at the 171° West location**
- **TDRS-I was launched in March 2002 and is located at the 150° West location.On Orbit testing proceeding well**
  - On Orbit Test Review at Boeing Space Systems on 27 Jun 03
  - NASA acceptance anticipated in early July (DD250)
- **TDRS-J was launched in December 2002**
  - Resolved issues regarding the turbo pump used in the Atlas RL-10.
  - Successfully conducted Vector Verification. on 20 Nov 02
  - NASA accepted the spacecraft in May 03.
- **Plan being finalized for transition to operations**

Current SN Service Type Per Code/Mission

			SN Support Type				
Current	Code	Primary	Routine	TT&C	DAS	MA	SA
FUSE	S		X	X			X
HST	S	X		X		X	X
LDBP	S	X				X	X
RXTE	S	X		X		X	X
TIMED	S		X	X			X
AQUA	Y				X	X	X
ERBS	Y	X		X		X	X
TOMS-EP	Y						
TERRA	Y		X	X			X
TOPEX	Y	X		X			X
TRMM	Y	X		X			X
UARS	Y	X		X		X	X
SORCE	Y					X	X
STS	M	X				X	
ISS	M	X				X	

Future SN Service Types Per Code/Mission

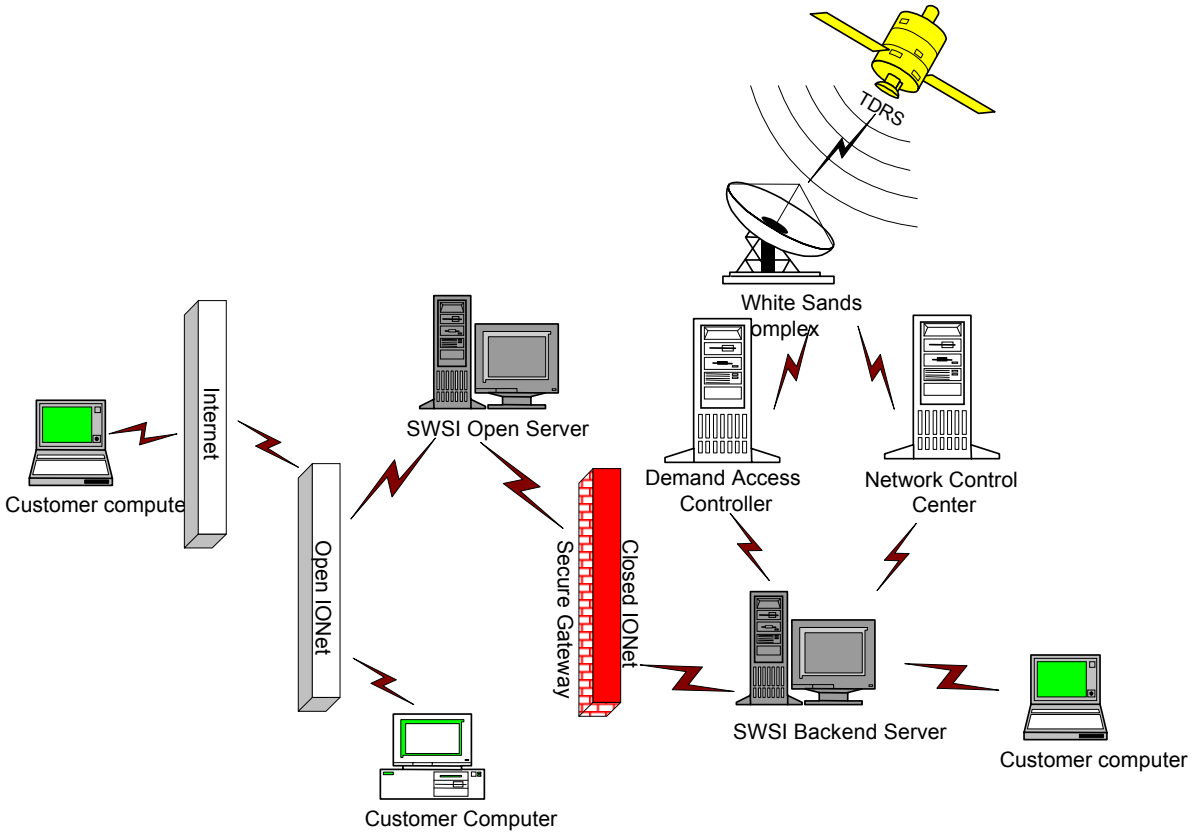
			SN Support Type				
Future	Code	Primary	Routine	TT&C	DAS	MA	SA
CNOFS	S/USAF		**X**		**X**	**X**	
GALEX	S	**LEOP**					
GLAST	S		**X**		**X**		
GP-B	S	**X**			**X**	**X**	**X**
ULDBP	S	**X**		**X**	**X**	**X**	**X**
SWIFT	S		**X**		**X**	**X**	
AURA	Y	**X**			**X**	**X**	**X**
GPM-1					**X**		
GPM-2					**X**		
ESA-GPM					**X**		
HTV	M	**X**				**X**	**X**
ATV	M	**X**				**X**	**X**

New SN Capabilities

- **SWSI – SN Web Services Interface: A Java based platform independent customer interface for submitting SN service requests and real-time monitoring and control of on-going service, via desktop computer to the NISN Open and/or Closed IOnet**
  - SWSI Release 1.0 (SN Legacy services only): July 2003
  - SWSI Release 1.1 (New DAS MAR services): August 2003
- **WDISC - White Sands Complex (WSC) Transmission Control Protocol (TCP)/Internet Protocol (IP) Data Interface Service Capability: Provides direct TCP/IP based telemetry and command services on the closed IOnet from the WSC.**
  - Scheduling automation: **Dec 02**
  - Capacity expansion: **July 03**
- **DAS – Demand Access Services: Multiple Access Return services on demand.**
  - Site Acceptance Testing Completed: June 03
  - Interim Operational Capability (IOC) Review: June 03
  - Final Operational Capability (FOC) Review Nov. 03
- **Ka-Band Ultra-High Rate User Services: To provide a full data relay capability at >1Gbps using the 650MHz BW channel associated with F8, TDRS-I and –J at Ka-Band by 2006**
  - Sys. Requirements, Ops. con., Proj. Mgnmt Plan, PCD's, etc. to be completed by 9/30/03.
  - Separate the Ground Segment from the Space Segment effort, but maintain consistency.

Space Network Web Services Interface

- **<u>SWSI</u> – SN Web Services Interface: A Java based platform independent customer interface to the NCCDS for performing TDRSS scheduling and real-time monitoring and control, via desktop computer to the NISN Open and/or Closed IOnet**



SWSI
Customers

- **Current**
  - Communications and Navigation Demonstrations on Shuttle (CANDOS)/Low Power Transceiver (LPT)
  - Long Duration Balloon Program (LDBP) Program
  - Solar Radiation and Climate Experiment (SORCE)
- **Future**
  - Swift Gamma Ray Burst Explorer (SWIFT)
  - Communications/Navigations Outage Forecasting System C/NOFS
  - Global Precipitation-B (GP-B)

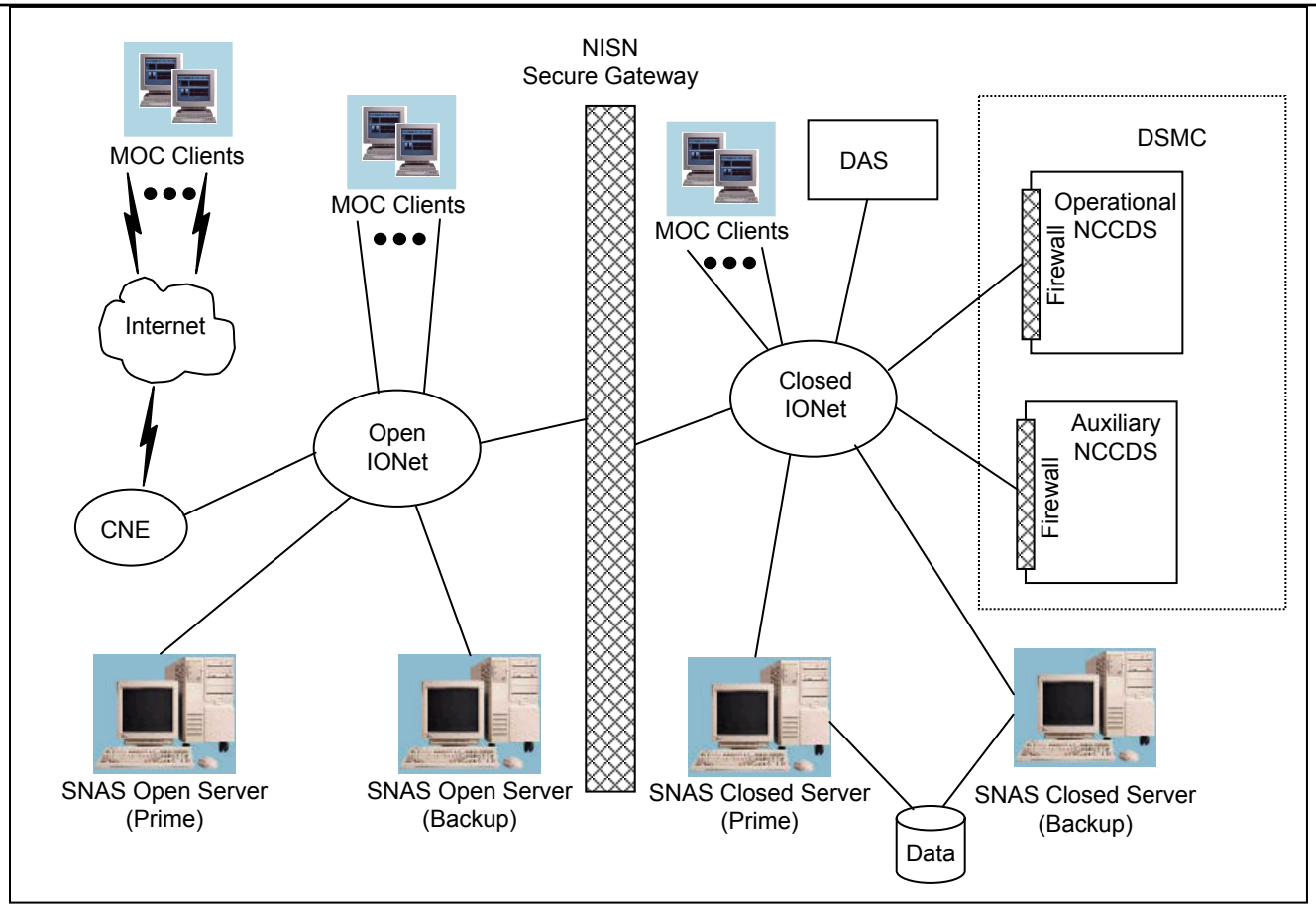
Demand Access Service (DAS)

- **DAS is an MA return service that utilizes 3 TDRS (F-3 – F-7) nodes (041°W, 174°W, 275°W) to provide continuous global coverage.**
  - A single user schedule can provide multi-year support
  - DAS automatically hands over from TDRS node to node for orbiting users
  - Data Rate from 1-150kbps/channel (subject to approval by MSP)
  - Customers use TCP/IP interface
    - » Customers interface to DAS for scheduling and status monitoring through Space Network Web Services Interface (SWSI)
  - Low Cost based on node usage (subscription fee)
- **DAS Applications**
  - Emergency/Contingency (911 service) customer transmits when problem occurs. DAS is always "listening"
  - Science Alerts; Transmit when significant observations occur

Space Network Access System (SNAS)

- **Purpose**
  - Provides a single, standards-based customer interface for performing (TDRSS) scheduling and real-time service monitoring and control.
  - Provides for secure message exchange on all NISN and open networks and will implement the complete NCCDS and DAS customer interfaces.
  - Consolidates the functionalities of the SN Web Services Interface (SWSI) system and the User Planning System (UPS) into a single system, and will replace the UPS and SWSI as the primary scheduling interface between the SN customer and the SN.
- **Developed to support all current SN customers**
    - » Scientific robotic missions
    - » STS
    - » ISS
    - » Special Project
- **SNAS will replace SWSI and User Planning System (UPS).**

SNAS Architecture

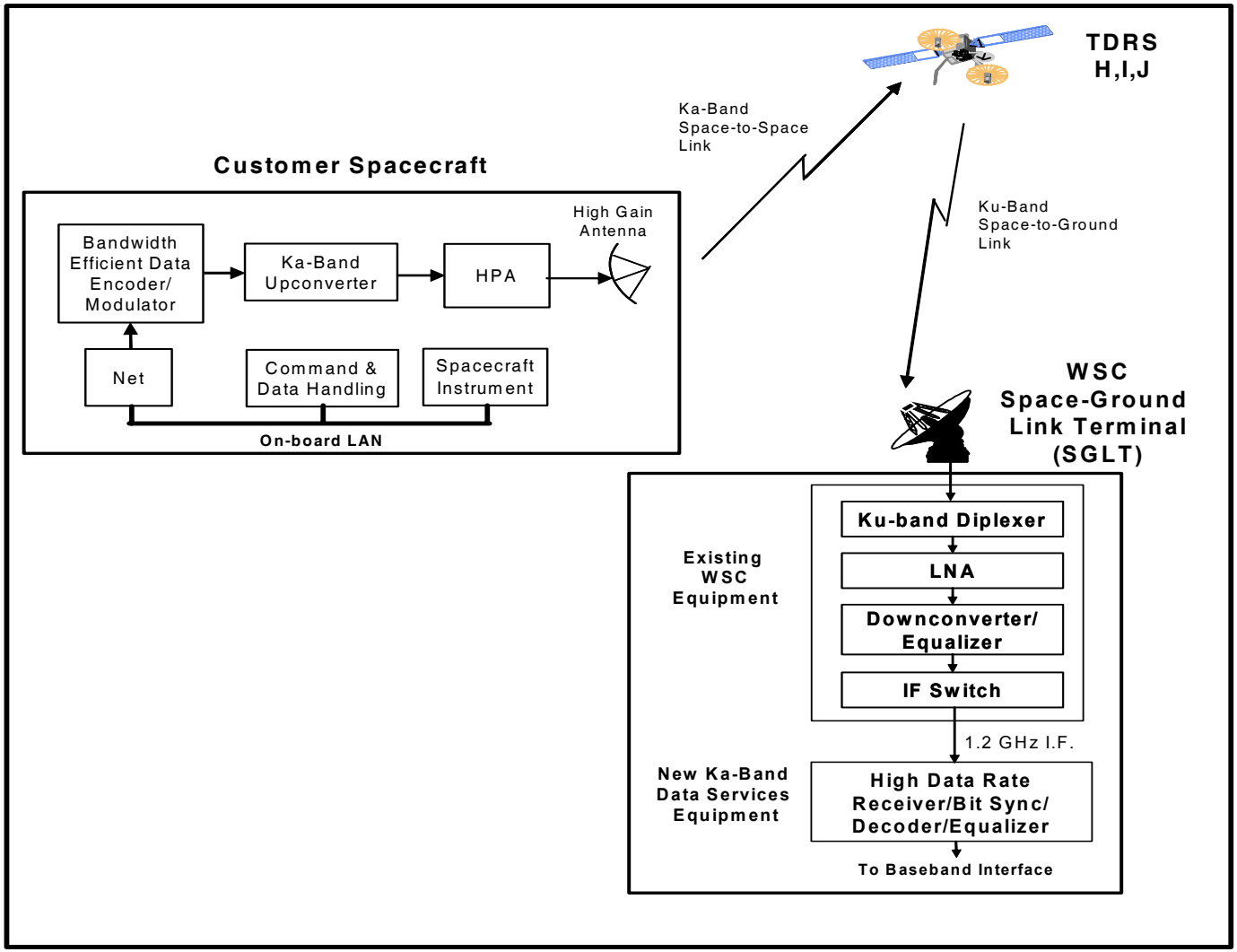


Ka-Band Ultra High Rate Development

- **In early 2000, NASA/GSFC initiated the Ka-band Transition Project as a first step in transitioning the SN and GN to Ka-band operations.**
  - Develop new SN high rate telemetry service using TDRS H,I,J 650 MHz wide channel
  - Develop a GN station to demonstrate direct to earth Ka-band operations
  - Provide test bed within the SN and GN to demonstrate new communication technologies
  - High data rate demonstrations scheduled for fall 2002
  - Upgrade SGLTs to take advantage of TDRS H,I,J 650 MHz wide Ka-band channel.
  - Add new Downconverters, Equalizers, and IF switching.
  - Modify network control software for automated control and monitoring of new equipment.
  - Provide Ka-band return signals at a 1200 MHz IF compatible with the GN IF interface.
  - Accommodate SNIP space to space Ka-band frequency plan for both 225 MHz wide channel and the 650 MHz wide channel.

Ka-Band Ultra High Rate Development

SN Ka-Band Data Services Customer Spacecraft and WSC Receive Segments



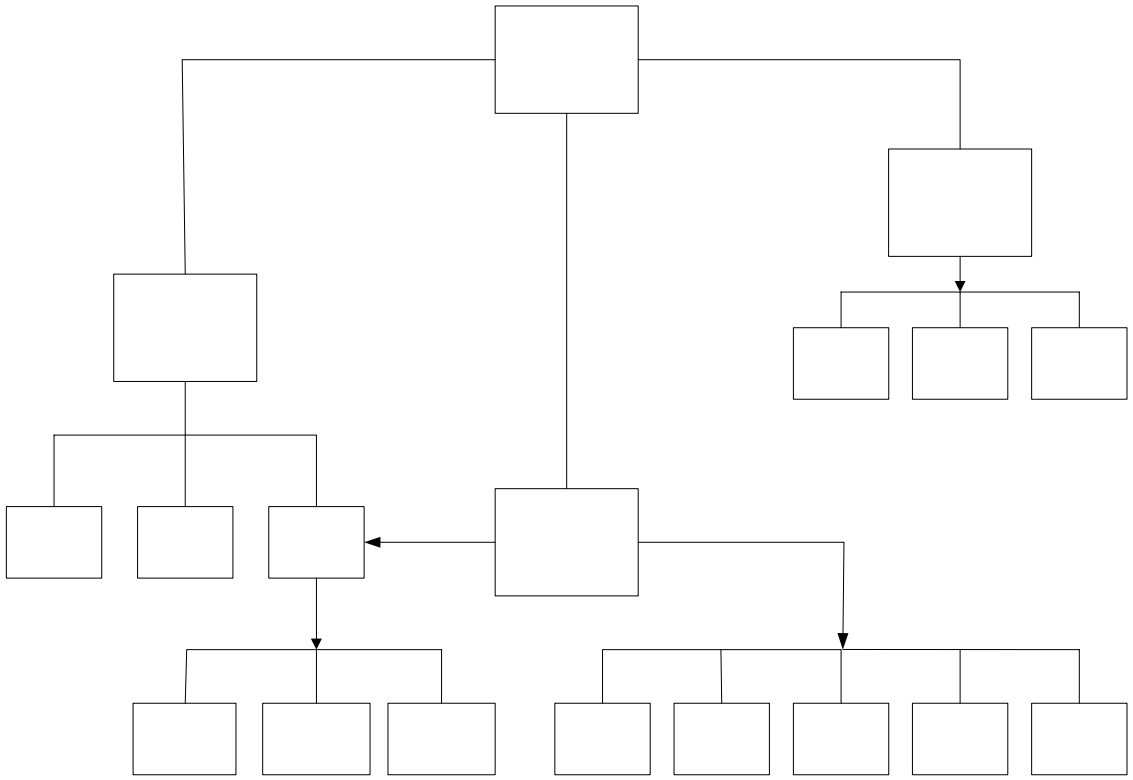
Ka-Band Ultra High Rate Development

- **Space Network Ka-Band Ultra High Rate Development Plan**
  - Fiscal Year 2003
    - » Complete system requirements
    - » Complete Ops Concept
    - » Complete System Spec
  - Fiscal Years 2004-2005
    - » Hardware Development and Testing
    - » Demonstrations
  - Fiscal Year 2006
    - » Establish Ka-band user services capability

Ka-Band Ultra High Rate Development

Space Network Ka-Band Ultra High Rate Service Work Breakdown Structure

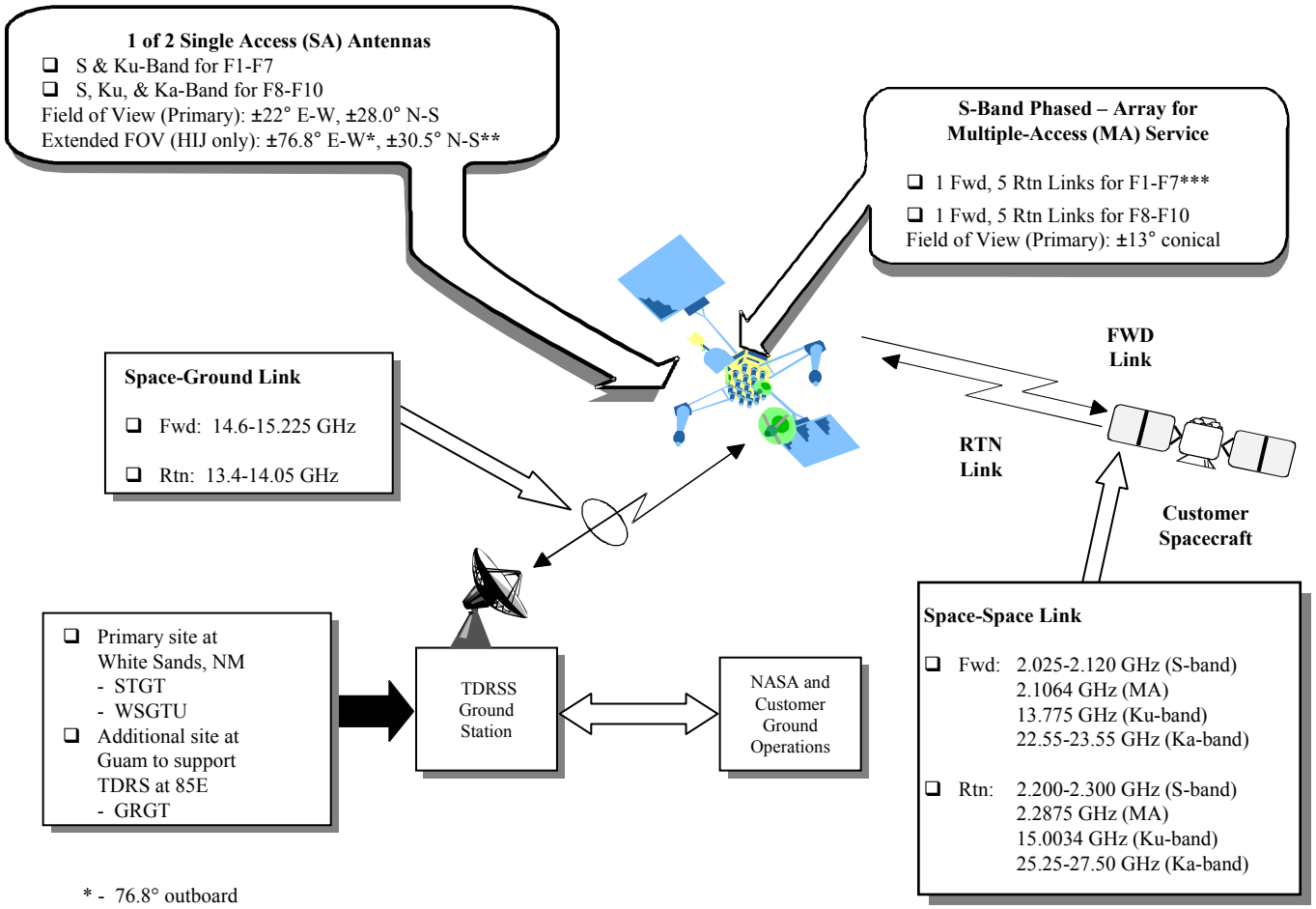
- **System engineering and trade studies** to develop operations concept & system requirements documents by Sept 2003
- **Characterization** of maximum SN data rate capability
  - **Drives WSC ground system specifications and customer support system capabilities**
  - **Driven by technology, such as bandwidth efficient modulation**.
- **End-to-end data flow architecture** development for handling high rate data
- **Partnership Outreach**
  - **Exploration of needs of future SN Ka-Band customers (at low, medium & high data rates)**
  - **Assessment of flight hardware availability & identification of technology/product gaps**



BACK-UP CHARTS

Overview

Space Segment:
Tracking and Data Relay Satellites



* - 76.8° outboard
** - 24°E-W (inboard)
*** - Demand Access Service allows large expansion on the number of non-coherent return link services available through F1 – F7

Data Rates Associated with Space Network Services

Service			WSC & TDRS F1-F7 Capabilities[3]	WSC & TDRS F8-F10 Capabilities
Single Access	S-Band	Forward	Up to 7MBps; EIRP = 43.6 dBW (normal); 48.5 dBW (high)	Up to 7 MBps; EIRP = 43.6 dBW (normal); 48.5 dBW (high)
		Return	Up to 6 Mbps; G/T (min) = 9.0 dB/K	Up to 6 Mbps; G/T (min) = 9.0 dB/K
	Ku-Band	Forward	Up to 25 Mbps[4]; Autotrack EIRP = 46.5 dBW (normal); 48.5 dBW (high)	Up to 25 Mbps[4]; Autotrack EIRP = 46.5 dBW (normal); 48.5 dBW (high)
		Return	Up to 300 Mbps; Autotrack G/T = 24.4 dB/K	Up to 300 Mbps; Autotrack G/T = 24.4 dB/K
	Ka-Band	Forward	N/A	Up to 25 Mbps[5]; Autotrack EIRP = 63 dBW
		Return	N/A	Up to 300 Mbps/800 Mbps[1]; Autotrack G/T = 26.5 dB/K
Number of Single Access Links			SSA: 2/TDRS; 10/WSC; 2/GRGT KuSA: 2/TDRS; 10 KuSA/WSC; 2/GRGT	SSA: 2/TDRS; 10/WSC; 2/GRGT[5] KuSA: 2/TDRS [2]; 10/WSC; 2/GRGT[5] KaSA: 2/TDRS [2]; 8/WSC[5]
Multiple Access		Forward	1/TDRS @ up to 300 kbps; 4/WSC; 1/GRGT EIRP = 34 dBW	1/TDRS @ up to 300 kbps; 4/WSC[5] EIRP = 42 dBW (LEOFOV)
		Return	5/TDRS @ up to 300 kbps; 20/WSC; 2/GRGT; Formed Beam G/T= 3.1 dB/K (Does not include DAS)	5/TDRS @ up to 3 Mbps; 20/WSC[5] G/T = 4.5 dB/K (LEOFOV) [6]
User Tracking			Range, 1&2 way Doppler	Range, 1&2 way Doppler (No Ka-band Tracking)

Notes:

1. Spacecraft only
2. The SN can simultaneously support S-band or Ku/Ka-band (F8-F10 only) forward and/or return services through 1 SA antenna to the same ephemeris. F8-F10 cannot simultaneously support Ku/Ka-band services through 1 SA antenna.
3. For customer data configurations, see 450-SNUG, Space Network Users' Guide
4. Current WSC configuration supports 7 Mbps
5. Guam Remote Ground Terminal (GRGT) is not currently configured to support TDRS F8-F10
6. F8 may experience lower G/T performance less than 12 hrs per day

TDRSS Service Summary/System Capacity

Service			WSC & TDRS F1-F7 Capabilities[3]	WSC & TDRS F8-F10 Capabilities
Single Access	S-Band	Forward	Up to 7MBps; EIRP = 43.6 dBW (normal); 48.5 dBW (high)	Up to 7 MBps; EIRP = 43.6 dBW (normal); 48.5 dBW (high)
		Return	Up to 6 Mbps; G/T (min) = 9.0 dB/K	Up to 6 Mbps; G/T (min) = 9.0 dB/K
	Ku-Band	Forward	Up to 25 Mbps[4]; Autotrack EIRP = 46.5 dBW (normal); 48.5 dBW (high)	Up to 25 Mbps[4]; Autotrack EIRP = 46.5 dBW (normal); 48.5 dBW (high)
		Return	Up to 300 Mbps; Autotrack G/T = 24.4 dB/K	Up to 300 Mbps; Autotrack G/T = 24.4 dB/K
	Ka-Band	Forward	N/A	Up to 25 Mbps[5]; Autotrack EIRP = 63 dBW
		Return	N/A	Up to 300 Mbps/800 Mbps[1]; Autotrack G/T = 26.5 dB/K
Number of Single Access Links			SSA: 2/TDRS; 10/WSC; 2/GRGT KuSA: 2/TDRS; 10 KuSA/WSC; 2/GRGT	SSA: 2/TDRS; 10/WSC; 2/GRGT[5] KuSA: 2/TDRS[2]; 10/WSC; 2/GRGT[5] KaSA: 2/TDRS [2]; 8/WSC[5]
Multiple Access		Forward	1/TDRS @ up to 300 kbps; 4/WSC; 1/GRGT EIRP = 34 dBW	1/TDRS @ up to 300 kbps; 4/WSC[5] EIRP = 42 dBW (LEOFOV)
		Return	5/TDRS @ up to 300 kbps; 20/WSC; 2/GRGT; Formed Beam G/T= 3.1 dB/K (Does not include DAS)	5/TDRS @ up to 3 Mbps; 20/WSC[5] G/T = 4.5 dB/K (LEOFOV) [6]
User Tracking			Range, 1&2 way Doppler	Range, 1&2 way Doppler (No Ka-band Tracking)

Notes:

1. Spacecraft only
2. Ku- or Ka-band; Ka-band and Ku-band space-to-space link (SSL) services are not available simultaneously through the same SA antenna.
3. For user data configurations, see 450-SNUG, Space Network Users' Guide
4. Current WSC configuration supports 7 Mbps
5. Guam Remote Ground Terminal (GRGT) is not currently configured to support TDRS F8-F10
6. F8 may experience lower G/T performance less than 12 hrs per day

TDRSS Current Status

• TDRS-1	WART	49W	
• TDRS-3	SGLT-6	275W	
• TDRS-4	SGLT-1	41W	
• TDRS-5	SGLT-4	174W	
• TDRS-6	SGLT-3	46W	
• TDRS-7	STTC-W	171W	no operations support
• TDRS-8	SGLT-2	171W	
• TDRS-10	STTC-S	150W	no operations support
• TDRS-9	SGLT-5	150W	no operations support
• available	ETGT		

TDRSS Timeline (past)

TDRS-9 Launch	March 8, 2002
TDRS-9 Propulsion System Anomaly	March 12, 2002
TDRS-9 Geosynchronous Orbit Achieved	September 30, 2002
TDRS-10 Launch	December 5, 2002
TDRS-10 Geosynchronous Orbit Achieved	December 16, 2002
TDRS-10 SCP-1 Anomaly	December 30, 2002
TDRS-9 On-Orbit Testing Finished	January 3, 2003

TDRSS Timeline (future)

assumes TDRS-10 accepted before TDRS-9

TDRS-10 On-Orbit Testing Finished

TDRS-10 Acceptance

TDRS-7 Initiate Drift to 79W

TDRS-10 Initiate Drift to 171W

TDRS-10 On Station at 171W

TDRS-10 Transition to Operations (from TDRS-8)

TDRS-7 On Station at 79W

TDRS-8 Initiate Drift to 62W

TDRS-9 Acceptance

TDRS-9 Initiate Drift to 171W

TDRS-9 On Station at 171W

TDRS-9 Transition to Operations (from TDRS-10)

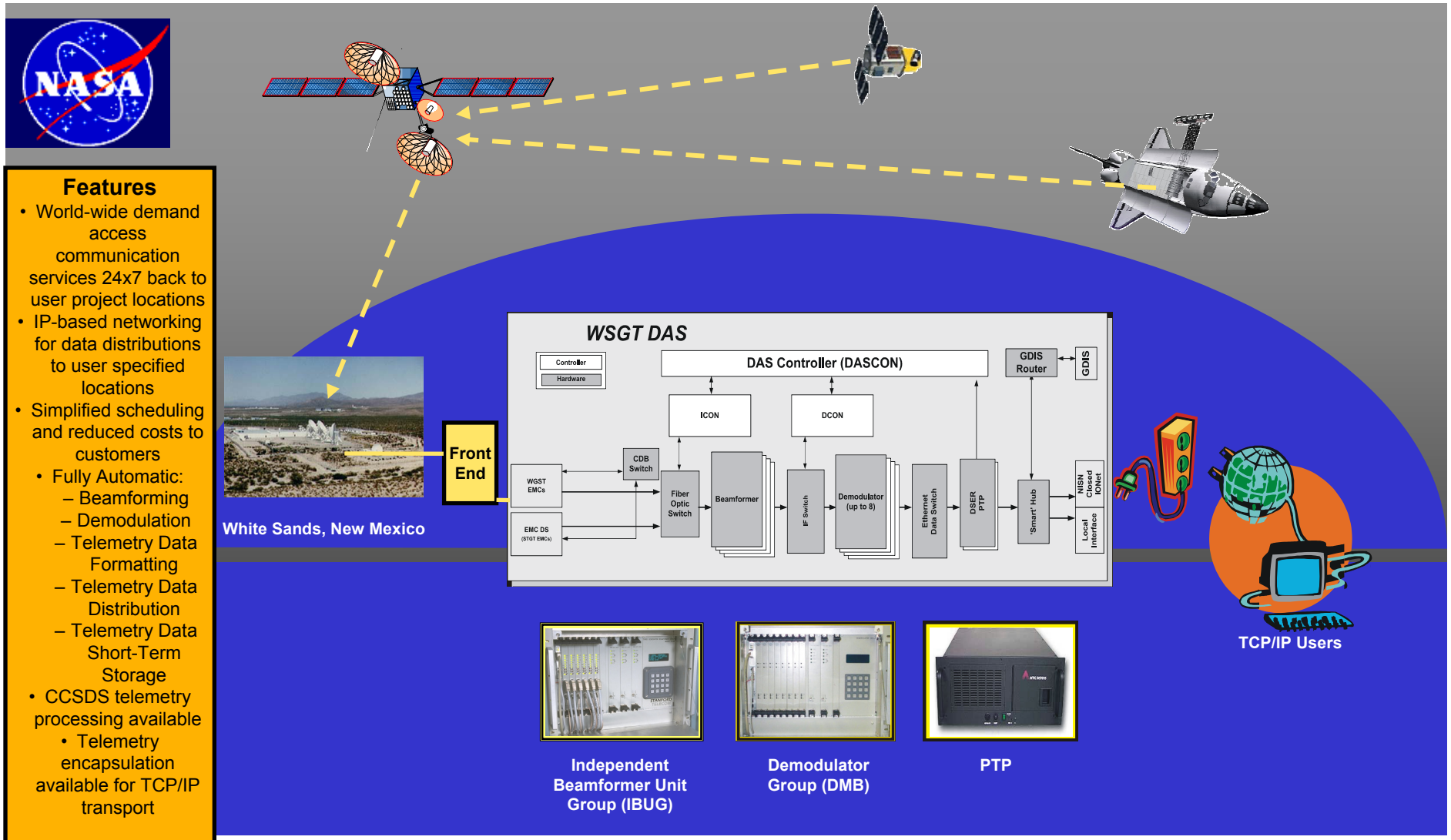
TDRS-10 Drift to 46W

TDRS-7 Drift to 171W

TDRS-7 On Station at 171W

TDRS-10 On Station at 46W

Demand Access System (DAS)



DAS Customer Matrix (1 of 2)

As of 3/21/03

Project	AQUA	Swift	LDBP	ULDBP	AURA
Launch Date	Launched 5/4/02	Tests Begin 4/2/03 12/5/03	Tests Begin July 03 12/10/03-01/10/04	Tests Begin July 03 12/10/03-02/10/04	1/1/04
Inclination/Altitude (Km)	98.2°/705	22°/600	Antarctica/120K Feet	Antarctica/120K Feet	98.2°/705
PN Code	63	84	7,8,82,83,85	7,8,82,83,85	73
Antenna Type	Omni	Omni (2.2 dBW)	Omni	Steer Dish-.46M	Omni
Srvc Type (#of TDRSs)	All (TBD) (3)	Any (3)	Spec (1 TDRS at a time)	Spec (1 TDRS at a time)	All (TBD) (3)
Service Duration *	24x7 (911)	24x7 (911)	24x7 (cont ~30d)	24x7 (cont ~60d)	24x7 (911)
PTP Setup:					
Header	Async	LEO-T	Async	Async	Async
Frame Sync	N/A	Yes	N/A	N/A	N/A
VC Processing	N/A	Yes	N/A	N/A	N/A
Reed-Solomon	N/A	No	N/A	N/A	N/A
Tx Modulation Scheme	SQPN-Single	SQPN-Single	SQPN-Single	SQPN-Single	SQPN-Single
Data Rate - I Chnl	1 KB	1 KB	6 KB	150 KB	1.024 KB
Data Rate - Q Chnl	1 KB	1 KB	6 KB	150 KB	1.024 KB
I/Q Power Ratio	1:1	1:1	1:1	1:1	1:1
Symbol Format - I Chnl	NRZ	NRZ	NRZ	NRZ	NRZ
Symbol Format - Q Chnl	NRZ	NRZ	NRZ	NRZ	NRZ
Data Format - I Chnl	L	M	M	M	L
Data Format - Q Chnl	L	M	M	M	L
Acq Mode (700/3000)	700 Hz	700 Hz	3000 Hz	3000 Hz	700 Hz

* 911 = Occasional RF Transmission
cont = Continuous RF Transmission

DAS Customer Matrix (cont'd)

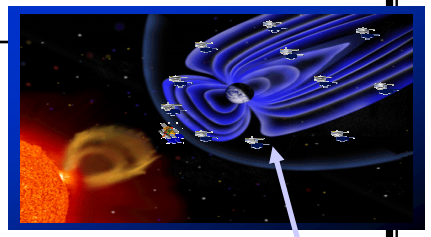
As of 3/21/03

Project	C/NOFS	GLAST	GPM-1	GPM-2	ESA-GPM
Launch Date	Tests Begin 6/10/03 1/14/2000	3/1/06	11/1/07	8/1/08	2008 (TBD)
Inclination/Altitude (Km)	13°/400-710	28.5°/550	65°/400	98.2°/400-635	(TBD)
PN Code	9		32		
Antenna Type	Patch Ants (14.5 dBW)	Omni	Steer Dish- .76M	Steerable Dish (TBD)	Steerable Dish (TBD)
Srvc Type (#of TDRSs)	All (3)	All (3)	Any (TBD) (3)	Any (TBD) (3)	Any (TBD) (3)
Service Duration *	24x7 (cont)	24x7 (911)	24x7 (cont)	24x7 (cont)	24x7 (cont)
PTP Setup: Header Frame Sync VC Processing Reed-Solomon	 LEO-T No N/A N/A	 LEO-T Yes Yes No (TBD)	(TBD)	(TBD)	(TBD)
Tx Modulation Scheme	SQPN-Single	SQPN-Dual, or SQPN-Single (TBD)	SQPN-Dual	SQPN-Dual (TBD)	SQPN-Dual (TBD)
Data Rate - I Chnl	20 KB	1 KB	150 and 25 KB	? 50 KB (TBD)	(TBD)
Data Rate - Q Chnl	20 KB	1 KB	150 and 25 KB	? 50 KB (TBD)	(TBD)
I/Q Power Ratio	1:1	1:1	1:1	1:1	(TBD)
Symbol Format - I Chnl	NRZ	NRZ	NRZ	NRZ	(TBD)
Symbol Format - Q Chnl	NRZ	NRZ	NRZ	NRZ	(TBD)
Data Format - I Chnl	M	L (TBD)	L	L	(TBD)
Data Format - Q Chnl	M	L (TBD)	L	L	(TBD)
Acq Mode (700/3000)	700 Hz	700 Hz	3000 Hz (TBD)	3000 Hz (TBD)	(TBD)

* 911 = Occasional RF Transmission
cont = Continuous RF Transmission

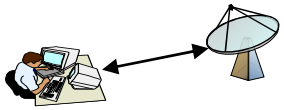
GSFC Space Operations Technology Development Strategic Roadmap

Space Network



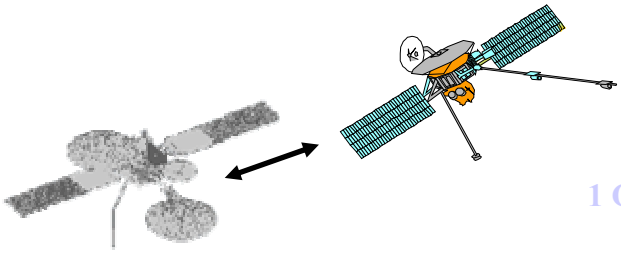
Reactive Mission Execution
Large Constellation Operations
Constellation Management Tools
Goal driven planning
FY05 | FY10 | FY15 | FY20
Synchronized Operations
Autonomous Mission Operations System
Automated Spacecraft Health and Safety
Constellation Visualization

Mission Services Timeline

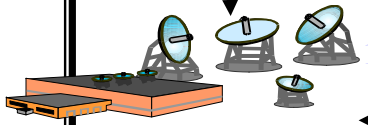


Intraplanetary GPS
4 Gbps data rates
Intraplanetary Internet
TDRSS Continuation Program - approved and funded
LPT Add-ons
Large Constellation Precision Formation Flying
Crosslink Communications for multiple S/C
Near Earth Internet
Bandwidth Efficient modulation schemes
Small Constellation Formation Flying

Data Services Timeline
FY05 | FY10 | FY15 | FY20



1 Gbps data rates
Ka-Band Services
600 Mbps data rates
High rate data compression
100 Mbps data rates



White Sands Complex