Glenn Research Center
Space Communications Technology Program

Mid-year Technology Review for SOMO
Technology Working Group

March 30, 1999

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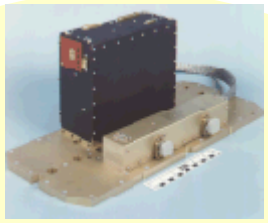
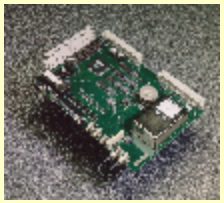
Space Communications Program

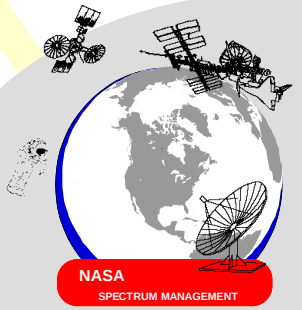
Enterprise Focused Projects

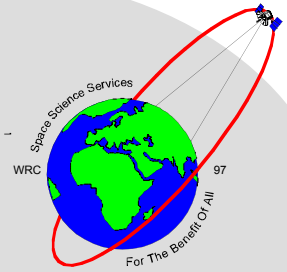
Communications Technologies





Agency Spectrum Management





Spectrum Management

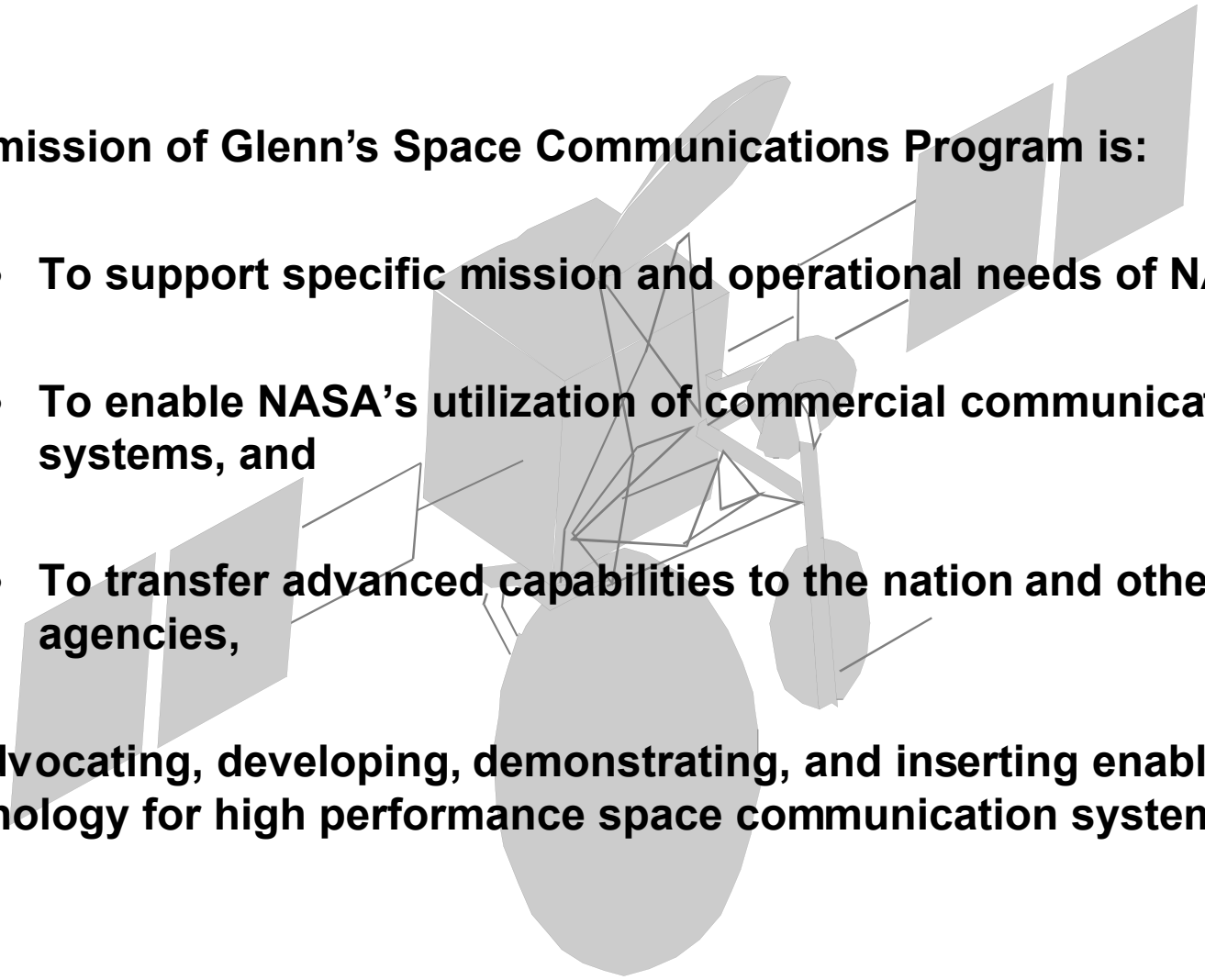
0.3	3	30	300 GHz

Agency Leader

Space Communications Program
Vision

Changing the way NASA and the Nation communicate through space

Space Communications Program
Mission



The mission of Glenn's Space Communications Program is:

- **To support specific mission and operational needs of NASA,**
- **To enable NASA's utilization of commercial communications systems, and**
- **To transfer advanced capabilities to the nation and other federal agencies,**

by advocating, developing, demonstrating, and inserting enabling technology for high performance space communication systems.

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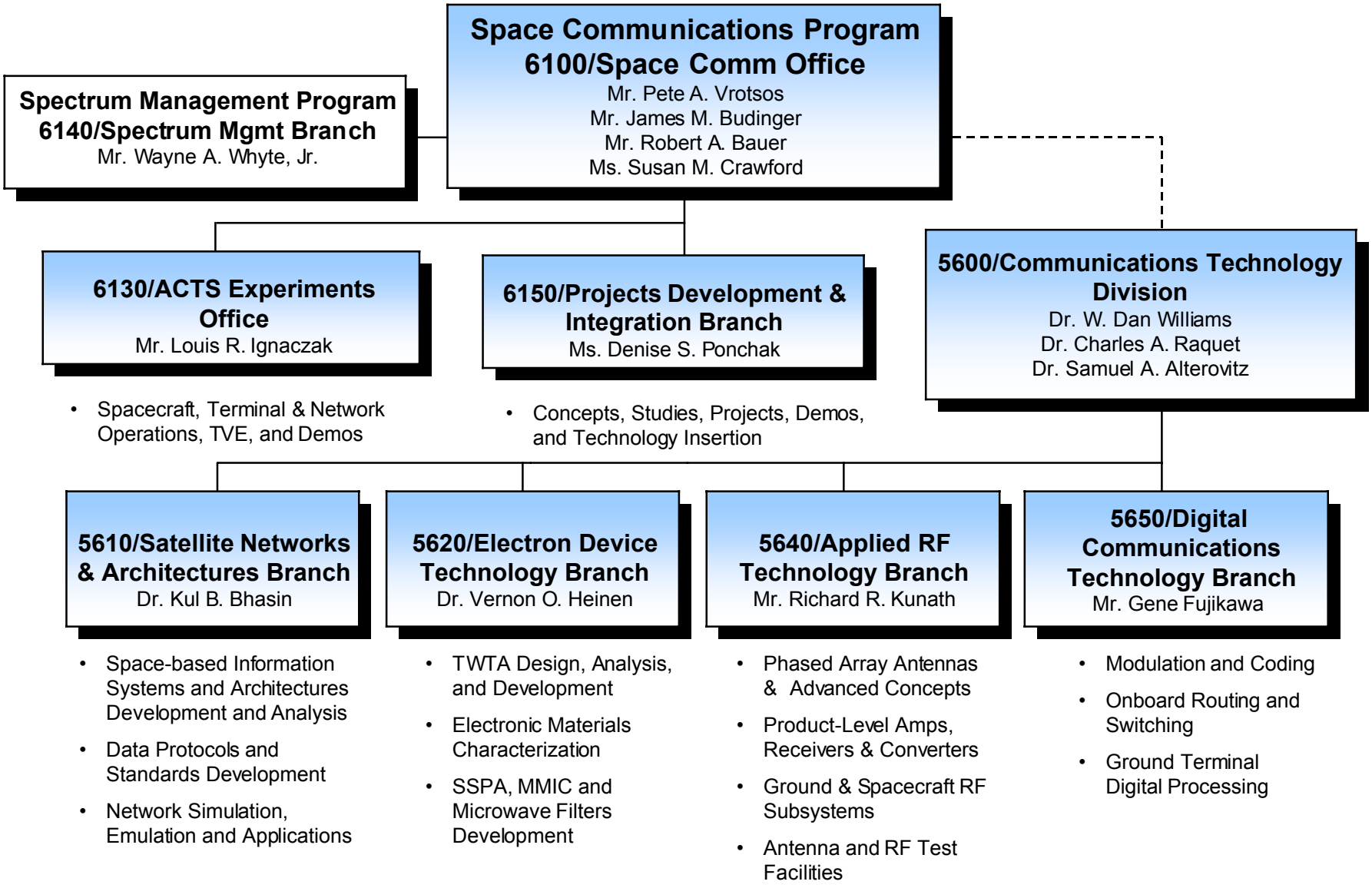
GRC Space Communications Program



Technology Program Review
Agenda & Overview

James M. Budinger

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Technology Review Agenda

10:45	**Opening Comments**	P. Vrotsos
10:55	**Technology Program Overview**	J. Budinger
11:15	**ACTS** Operations	L. Ignaczak
11:25	Technology Verification Experiments	R. Acosta
11:45	Networking Experiments	Z. Zernic
12:15	Closeout	R. Bauer
12:25	*Lunch Room 290 A&B*	
	Technology Insertion	
1:00	Technology Assessment & System Studies	D. Ponchak
1:15	Direct Data Distribution (D^3)	L. Wald
1:40	Ka-band TWTA for DSN	V. Heinen
1:55	Millimeter Wave Propagation Investigations	R. Acosta
2:10	**Space Internet Technology Overview**	J. Budinger
2:20	Network Simulation & Emulation	M. Zernic
2:40	Space Internet Router	P. Paulsen
3:00	*Break Room 290 B*	
3:15	Network Module	G. Fujikawa
3:45	RF Communications Module	C. Raquet
4:15	Integrated Space Internet Systems Demos	P. Paulsen
4:35	**Concluding Remarks and Discussion**	All
5:00	*Adjourn*	

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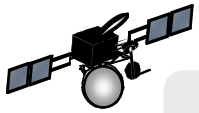
ACTS & Technology Insertion Elements



ACTS

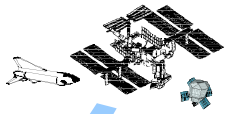
1A. ACTS Operations

1B. Technology Verification Experiments.

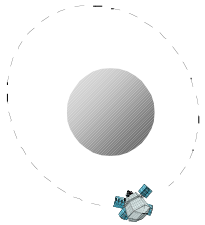
1C. Network Experiments

1D. ACTS Closeout

Near Earth



3. Direct Data Distribution (D^3)



Deep Space

4. Ka-band TWTA for DSN

5. Millimeter Wave Propagation

2. Technology Assessment/System Studies

Users Anywhere

Terrestrial Network

DSN

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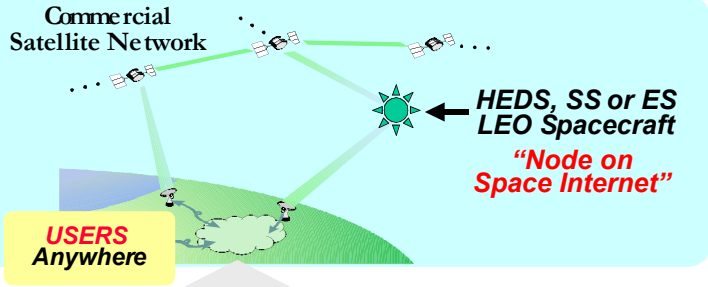
Technology Insertion - Space Internet

I. Reducing Cost of NASA Space Operations

II. Providing Enabling Data Services to NASA Enterprises



TRL 9

Mission Operations

Code S, M, Y

Flight Demo Projects

SOMO (M)

Gap Filling Technology

SOCTP (M)
[CETDP (SM)]

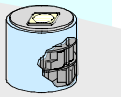
Res & Applied Technology

CETDP (SM)

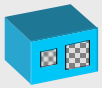
TRL 1

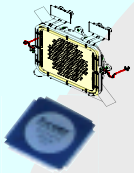
RF Link Technology

GASCAN



6D. RF Comm Module

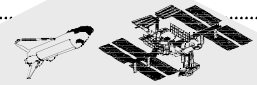




- Electronically Steered Arrays
- High Rate, Bandwidth & Power Efficient Modem/Codecs

2. System Studies

- Reflectarray
- Efficient Modulation
- Efficient RF Devices



Flight Demonstration

6E. Integrated Space Internet System Demos

Network Technology

6C. Network Module

6B. Space Internet Router

6A. Networking Simulation and Emulation

2. System Studies

- Internet Protocols
- Network Architectures
- Turbo Coding

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Technology Element Relevance

Relevance/Support
● Direct
○ Indirect

	SOMO ROADMAP								ENTERPRISES									
	PILLAR 1				PILLAR 2				HEDS				SSE				ESE	
	1	2	3	4	1	2	3	4	ISS/STS	Mars Infra.	SOMO	Comm'l.	CETDP	Mars	Ka-Band	Near Earth	Info. Web	ESTO Platform
ACTS																		
1A Operations	●	○			●			○			●							
1B Technology Verification Experiments	●				●			●			●	●						
1C Networking Experiments	●	●			○		○				●		●				○	○
1D ACTS Closeout	●				○						●	●						
Technology Insertion																		
2 Technology Assessment/System Studies	●	●			●				●	●	●	●	●	○		○	○	○
3 Direct Data Distribution (D^3)	●	○	○		●				○		●	●	●			●	○	○
4 Ka-Band TWTA for DSN					●						●		○		●			
5 Millimeter Wave Propagation	●				○			●			●	●	●	○	○	○		○
Space Internet Technology Development																		
6A Networking Simulation & Emulation	●	●					○		○	○	●	●	●	○		○	○	○
6B Space Internet Router	●	●			○	○	○		○	○	●	●	○			○	○	○
6C Network Module	●	●			○		○		○	○	●	●	●	○		○	○	○
6D RF Communications Module	●				●				○	○	●	●	●	○		○	○	○
6E Integrated Space Internet System Demos	●	●			●	○	○				●	●				○	○	○

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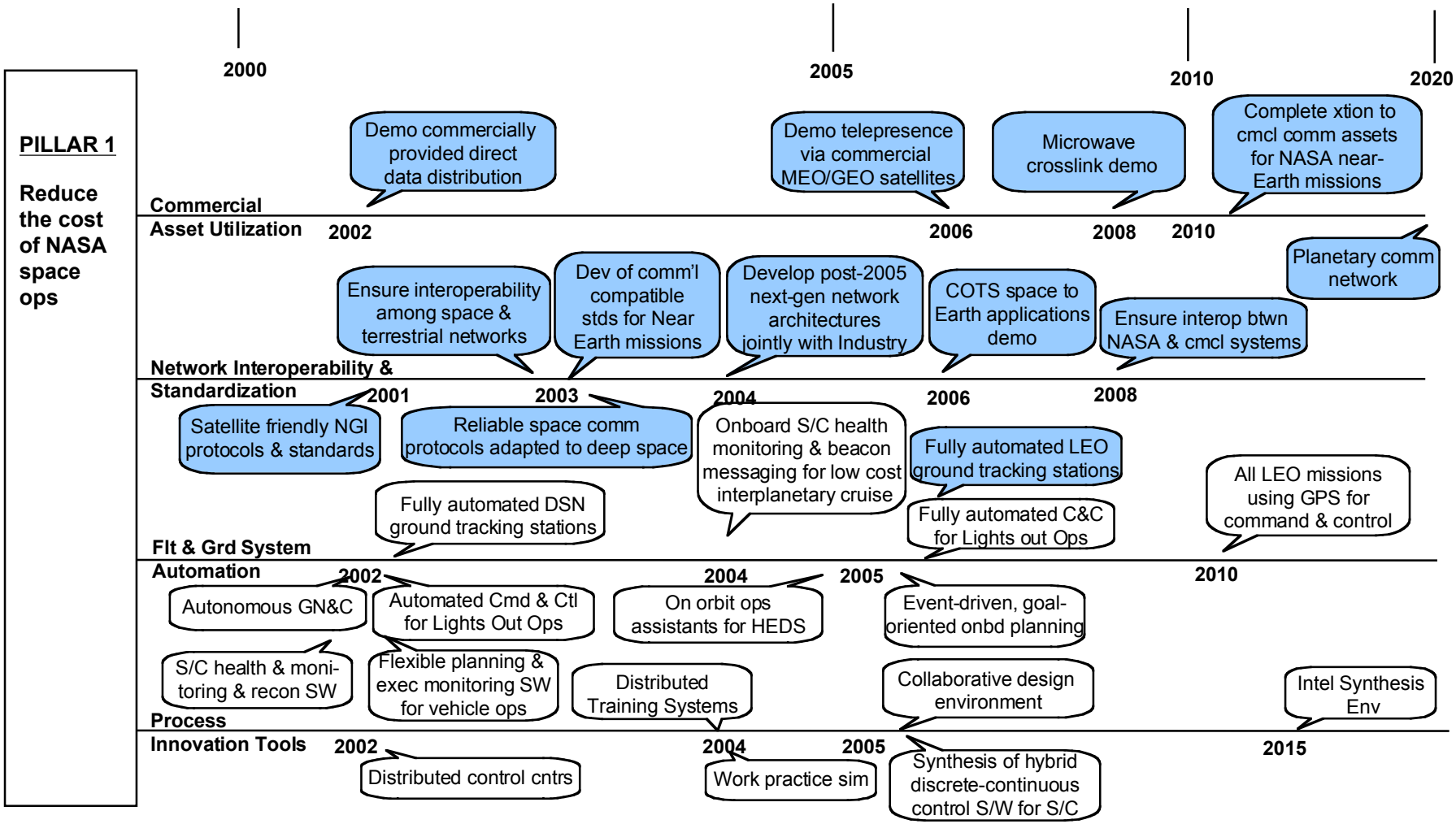
SOMO SOCTP Roadmap

GRC Milestone Contributions



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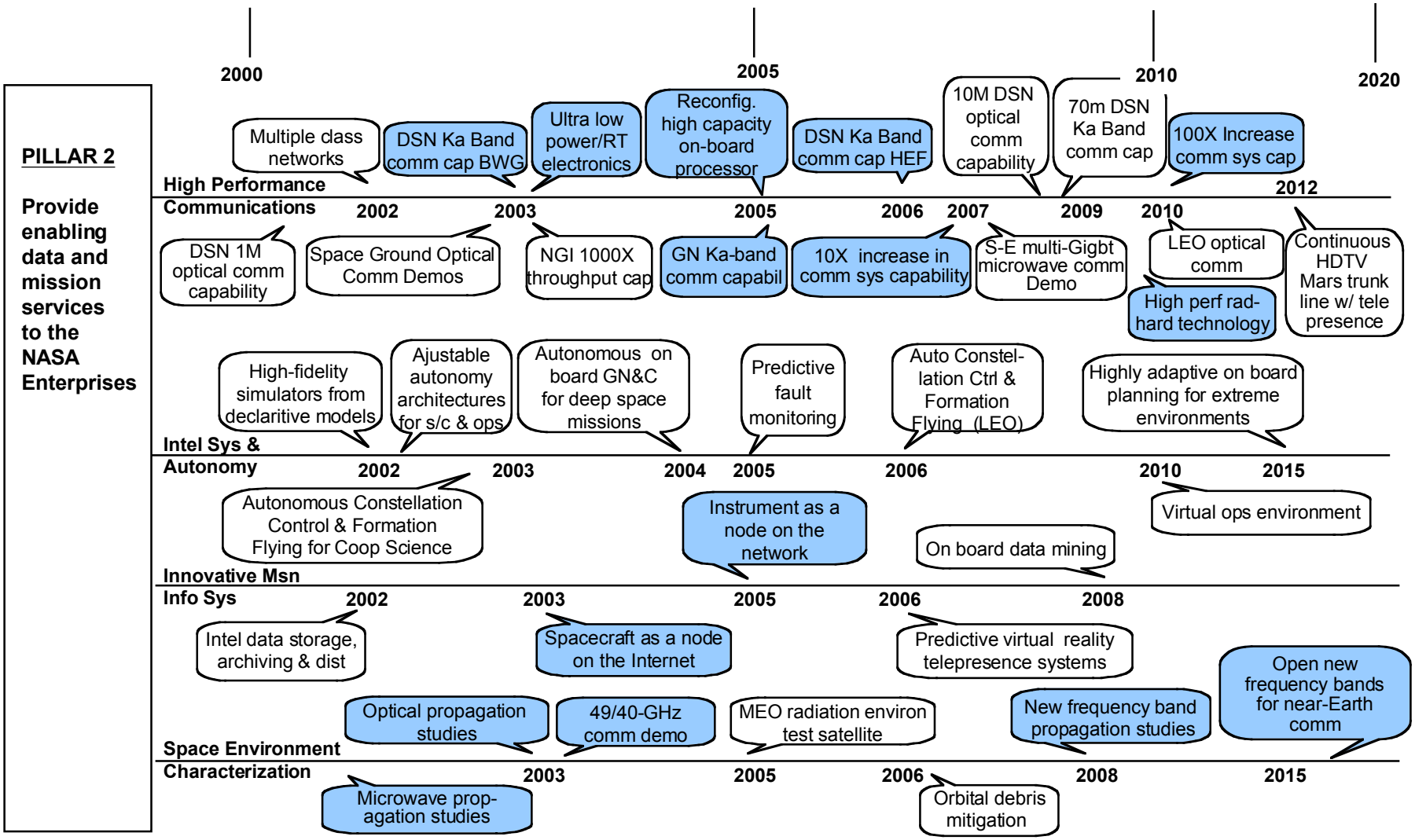
SOMO SOCTP Roadmap

GRC Milestone Contributions



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UPN & FY98 NTDIB Element Mapping

Technology Element		UPN	NTDIB	UPN	NTDIB
ACTS					
1A	ACTS Operations	315-90	447		
1B	Technology Verification Experiments	315-90	447		
1C	Networking Experiments	315-90	447	632-50	9462
1D	ACTS Closeout	315-90	447		
Technology Insertion					
2	Technology Assessment/Trade Studies	315-90	9448	632-50	1886
3	Direct Data Distribution	315-90	9456	632-50	9453, 9454, 9455
4	Ka-band TWTA for DSN	315-90	N/A	632-50	1881
5	Millimeter Wave Propagation	315-90	9448		
Space Internet Technology Development					
6A	Networking Simulation & Emulation			632-50	1885, 1886, 1888, 9462
6B	Space Internet Router			632-50	1885, 1888
6C	Network Module			632-50	1883
6D	RF Communications Module			632-50	1880, 1882, 1884, 9453, 9454, 9455
6E	Integrated Space internet System Demos				N/A

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Technology Element Support

Relevance/Support
- ● Direct
- ○ Indirect

	CURRENT DEVELOPMENT PHASE				SPONSORS		PARTNERS			
	CONCEPT/ STUDIES	TECHNOLOGY DEVELOPMENT	DEMON-STRATION	INSERTION/ TRANSFER	SOMO/ SOCTP	CODE SM/ CETDP	GSFC	JPL	LMSOC	INDUSTRY
ACTS										
1A Operations			●	●	●					
1B Technology Verification Experiments				●	●					●
1C Networking Experiments			●	●	●	○			●	●
1D ACTS Closeout	●				●				○	○
Technology Insertion										
2 Technology Assessment/System Studies	●				●	○		●	○	○
3 Direct Data Distribution (D^3)			●	●	●	●	○		○	●
4 Ka-Band TWTA for DSN		●			●	○		●		○
5 Millimeter Wave Propagation	●				●		○	○	○	●
Space Internet Technology Development										
6A Networking Simulation & Emulation		●			○	●	○	○	○	●
6B Space Internet Router		●			○	●	○		○	●
6C Network Module	●				○	●	○		○	●
6D RF Communications Module	●				○	●	○	○	○	●
6E Integrated Space Internet System Demos	●				○				●	○

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Significant NASA Collaboration

- **JPL/Code S**
  - Ka-band TWTA engineering model development (Laif Swanson)
  - Mars infrastructure technology trades in amplifiers, antennas & protocols (Shel Rosell)
  - CETDP High Rate Data Delivery thrust area (Pete Ulrich, Steve Prusha, Jim Lesh)
  - SCPS and TCP/IP assessment via ACTS (Adrian Hooke)

- **GSFC/Code Y**
  - High rate digital modem for Ka-band links to TDRS and ground (Mike Powers)
  - Interoperable protocol research and simulation (Julie Breed, Jim Rush)
  - Phased array antenna expertise & testing (Ken Perko)
  - Communications technology for ESTO and platform capabilities (Steve Smith)

- **JSC/Code M**
  - CSOC IOA network R&D and experiments via ACTS (Marty Skudlarek)
  - ISS commercial utilization studies (Jack Seyl, Ray Askew, Frank Buzzard)
  - ISS & STS communications upgrades and consultation on point solutions (Frank Buzzard, Ken Land)

Significant Industry Collaboration

- **Industry**
  - **Raytheon** K-band transmit array 50% cost share (Kurt Hollenbeck)
  - **SiCOM** space qualified modem development >50% cost share (Ron McCallister)
  - **CISCO** space internet router development (Dan Shell)
  - **Hughes** TWTA modeling & simulation tools (Jim Dayton)
  - **TIA, IETF & ATM Forum** interoperability and satellite interests (Prakash Chitre)

Background & Current Environment

- From 1978 to 1998 LeRC SCP primary responsibility was to open new frequency bands and provide enabling technology in direct support of US satellite industry competitiveness
- Following dissolution of Codes X, LeRC's commercial communications technology responsibility was transferred to Code S (CETDP), while the ACTS Project, studies and Spectrum Management functions were transferred to Code M (SOMO)
- Since late FY97, LeRC (now GRC) has worked successfully to re-direct both the communications technology and ACTS toward all 4 NASA Enterprises, and help enable NASA's transition to commercial communications (National Space Policy)
- ACTS (which accounts for ~65% of 315 funding) now in final 1-1/2 years of operation
- CETDP funding is being driven by metrics to lower TRL, when at least 5 years of past R&TD effort is now producing the higher TRL products in mid-term demand
- SOMO is facing increasing budget pressure on critical higher TRL technology investment to help reduce cost and enable new mission capabilities

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315-90 Budget 99-1 POP Guidelines

No.	Element	FY98	FY99	FY00	FY01	FY02	FY03
ACTS							
1A	Operations	4,190	4,385	3,820			
1B	Technology Verification Experiments	1,800	1,365	770	135		
1C	Networking Experiments	1,040	830	375			
1D	Closeout-E/S Conv		25	150	1,955		
	Subtotal - ACTS	7,030	6,605	5,115	2,090	-	-
Technology Insertion							
2	Technology Assessment/System Studies	240	350	375	370	610	610
3	Direct Data Distribution (D^3)	360	975	1,910	2,715	2,440	850
4	Ka-Band TWTA for DSN*		400*	1550*	900*	300*	
5	Millimeter Wave Propagation		165	185	210	365	365
Space Internet Technology Development							
6A	Networking Simulation & Emulation			310	615	730	730
6B	Space Internet Router			125	925	610	610
6C	Network Module			130	485	855	970
6D	RF Communications Module				430	1,830	2,435
6E	Integrated Space Internet System Demos				125	425	1,215
	Technology Insertion & Space Internet	600	1,490	3,035	5,875	7,865	7,785
TOTAL Guideline		**7,630**	**8,095**	**8,150**	**7,965**	**7,865**	**7,785**
	* SOMO Augmentation Needed		400*	1550*	900*	300*	