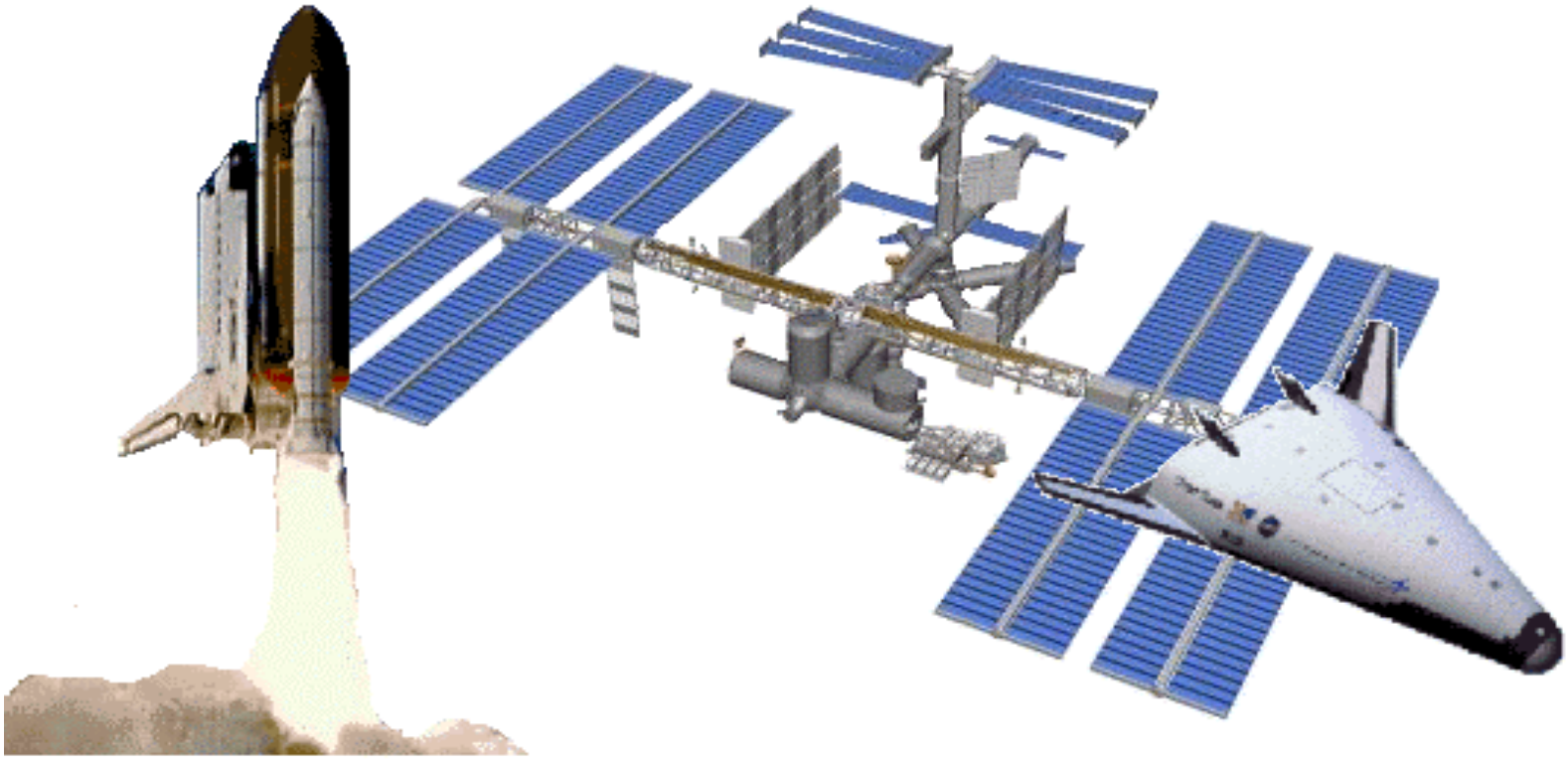
GSFC Human Spaceflight Mission Support Overview

GSFC Human Spaceflight Introduction

GSFC HUMAN SPACEFLIGHT MISSION SUPPORT OVERVIEW

GSFC HUMAN SPACEFLIGHT

THE MISSIONS



1981

1997

2000

CONTRACTS CONSOLIDATION

Service-based Contracts

- Network & Mission Operations Support (NMOS)
- Systems Engineering & Analysis Support (SEAS)
- Wallops Operations Contract

Performance-based Contract

Consolidated Network & Mission Operations Support (CNMOS)

SLAs & GSAs

CNMOS Objectives:

- Consolidate Service Contracts to Eliminate Duplication and Overlaps
- Reduce NASA'S Involvement in Daily Operations
- Provide Significant Cost Reduction to NASA
- Develop a Strategy for Continuous Cost Reduction Over Contract Life
- Emphasize Performance-Based Objective Contracting Through Service Level Agreements (SLAs)

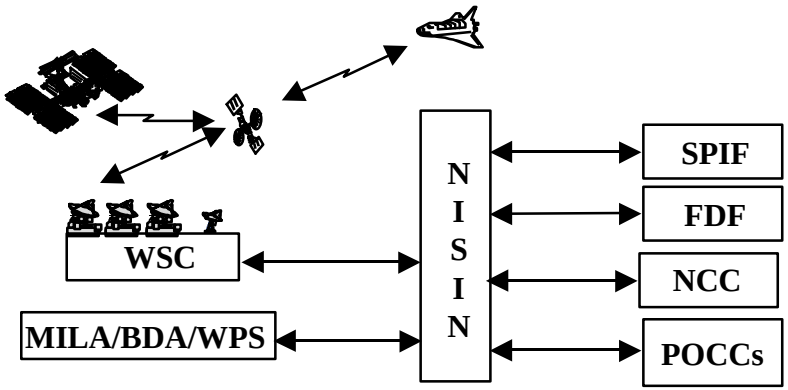
REDEFINED NASA/CONTRACTOR ROLES WITHIN THE SLAs

NASA Roles:

- Perform Research and Development
- Perform Hands-on End-to-End Ground System Development for Selected Missions
- In-House Development and Application of New Technology
- Identify and Pursue New Business Opportunities
- Provide System Acquisition
- Define Advanced Missions
- Provide Consolidated NMOS Oversight
  - Establish Requirements and Metrics
  - Act As SLA Owner
  - Perform Evaluation of End Results
  - Manage Consolidated NMOS Budget
  - Serve As Primary NASA Customer Interface
  - Continue to Hold Ultimate Responsibility to End User

Contractor Roles:

- Operations and Maintenance
- Engineering
- Development and Sustaining Engineering
- Project and Mission Management
- Consolidated NMOS Program Management
- R&D Support If Required (Advanced Engineering, Research, SETA)
- Progress Reporting



GSFC HUMAN SPACEFLIGHT SERVICE LEVEL AGREEMENT (SLA-12)

- Created Service Level Agreement #12 to Provide GSFC Support to Human Spaceflight Missions
- Human Spaceflight SLA is Multi-Mission and Multi-Project (STS, ISS, RLV)
- SLA-12 Combines the Support Services, Activities, and Products of the Human Spaceflight Mission Management Department and the Human Spaceflight Network Director
- Cohesive Team of Multiple Contractors and NASA Personnel
- NASA Specifies “What” - Contractor Determines “How”
- NASA Specifies Metrics - Contractor Delivers the Products and Services
- SLA-12 Customers Include:

  - JSC/KSC/MSFC
  - STS Program Office
  - ISS Program Office
  - RLV Project Office
  - ISS Free Flyer Projects
  - SOMO
  - DOD
  - RLV Contractors

GSFC HUMAN SPACEFLIGHT MISSION SUPPORT OVERVIEW

GSFC HUMAN SPACEFLIGHT

ORGANIZATION & INTERFACES

NASA HQ Operations Council
Space Operations Management Office

Center Mission Service Manager

Mission Management Services (SLA-14)

- MOU/MOAs
- Requirements Mgmt.
- Mission Information Services

Human Spaceflight SLA-12

Network Director

Tracking & Data Acquisition (SLA-2)

- Communications (NISN)
- Tracking
- RF Services
- TDRS Operations Mgmt.

Advanced Mission Planning/ Requirements

- GSFC Resident Office @ JSC
- GSCB
- GAIT
- Systems Engineering
- Operations Integration

Mission Support Facilities

- ESTL
- ASPC
- SPIF
- FDF

Networks Integration

- NSG
- NOIG
- Near-term Planning
- Mission Integration, Test, and Verification
- Networks Engineering

Network Operations

- Mission Readiness & Cert.
- Operations Procedures
- Support Configuration Planning
- Configuration Management

GSFC HUMAN SPACEFLIGHT MISSION SUPPORT OVERVIEW

GSFC HUMAN SPACEFLIGHT

MISSION SUPPORT ROLES AND RESPONSIBILITIES

MISSION PLANNING & REQUIREMENTS DEVELOPMENT

Advanced Mission Planning

- Advanced Requirements Identification
- Advanced Mission Support Capability Analysis
- Future Operational Guidelines
- Cost Estimating of Standard/Non-Standard Services

Mission Support Planning

- Mission Support Configuration Planning
- Test and Verification Planning
- Systems Engineering and Analysis
- Support establishment of GSFC Element Support Commitments
- Network Integration Planning

System Engineering and Analysis

- Mission Management Plans
- System Concepts
- Risk Analyses
- System/User Interface Analyses
- System Assessments
- Integrated Schedules
- Operations Scenarios

Mission Documentation Development

- Interagency Agreements Development
- Intercenter Agreements Development
- Implementation & Integration Reports
- SOMO Sponsored Support Plans
- Support Working Groups/Panels
- Operational Planning
- Interface Document Development

Requirements Management

- Requirements Analysis
- Requirements Allocation
- Requirements Traceability
- Requirements Integration

CUSTOMER INTERFACE ACTIVITIES

Near Term Integration Planning

- Mission Readiness Certification Activities
- Develop Operational Procedures
- Real-time Nominal & Contingency
- Support Configuration Planning
- System IT&V Planning
- Establish Future Ops Guidelines

Engineering Services

- Network Integration
- Development and Use of Mission Support Configurations
- NW Configuration Management
- Engineering Support Analyses

Documentation Maintenance

- Operations Plans
- Operations Directives

Reporting

- Real-Time Support (Element Reports)
- Test Reporting
- Operational Mission Reporting

Mission Engineering

- Operational & Technical Support (Real-time Failure Assessment)
- Post-anomaly Reconstruction

Mission Integration Test & Verification

- NW Compatibility Test Planning & Conduct
- NW Engineering Data Flow Planning & Conduct
- Interface Test Planning & Conduct
- Verification & Validation Test Planning & Conduct
- Simulations / Training
- Launch Support (PAD) Tests & On-Orbit Checkout

MISSION INTEGRATION & OPERATIONS

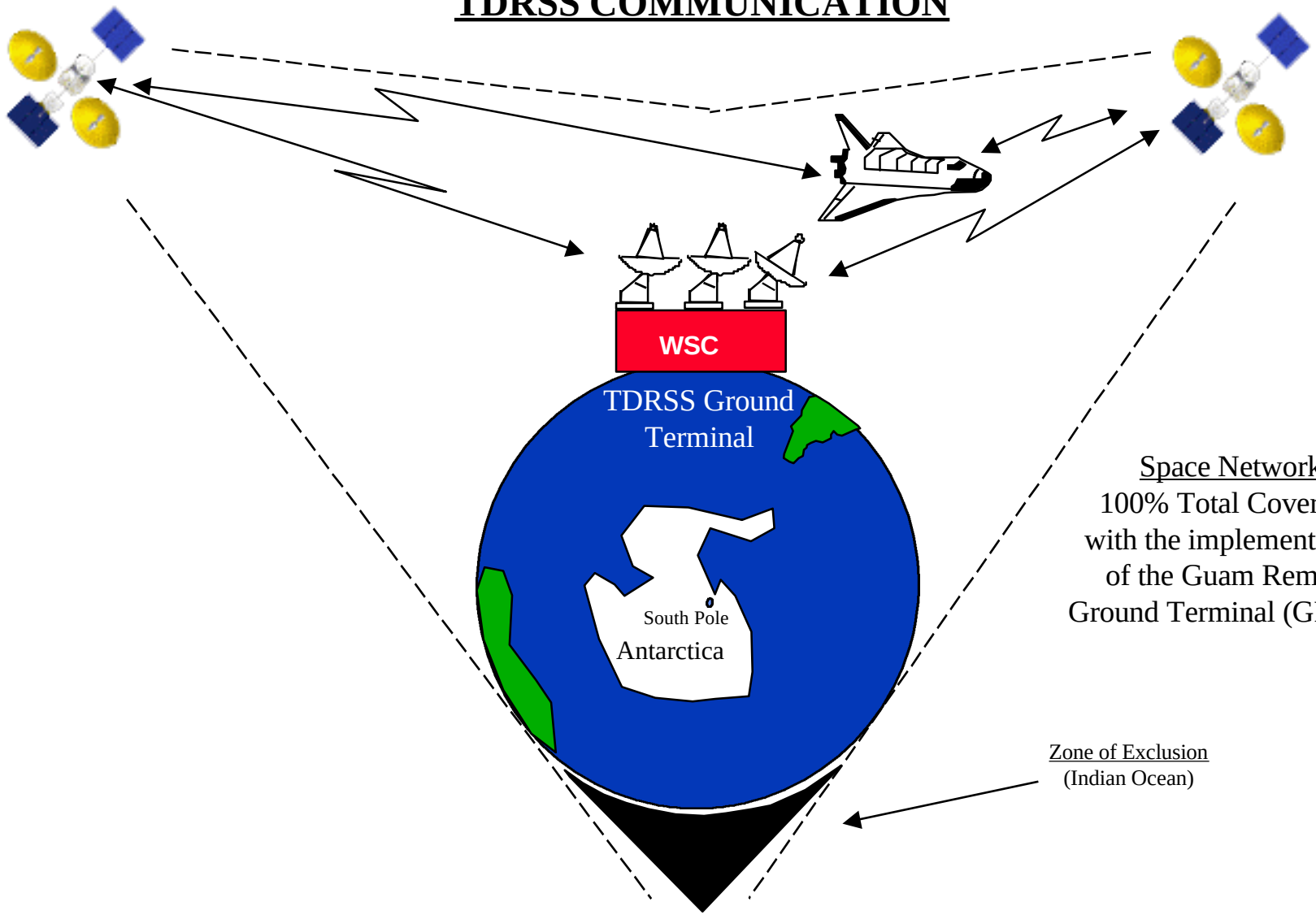
Planning ----- Implementation **Integration** **ORR ISI** **FRR LRR** **Launch ------ Operations**

Human Spaceflight Network Support

GSFC HUMAN SPACEFLIGHT MISSION SUPPORT OVERVIEW

GSFC HUMAN SPACEFLIGHT

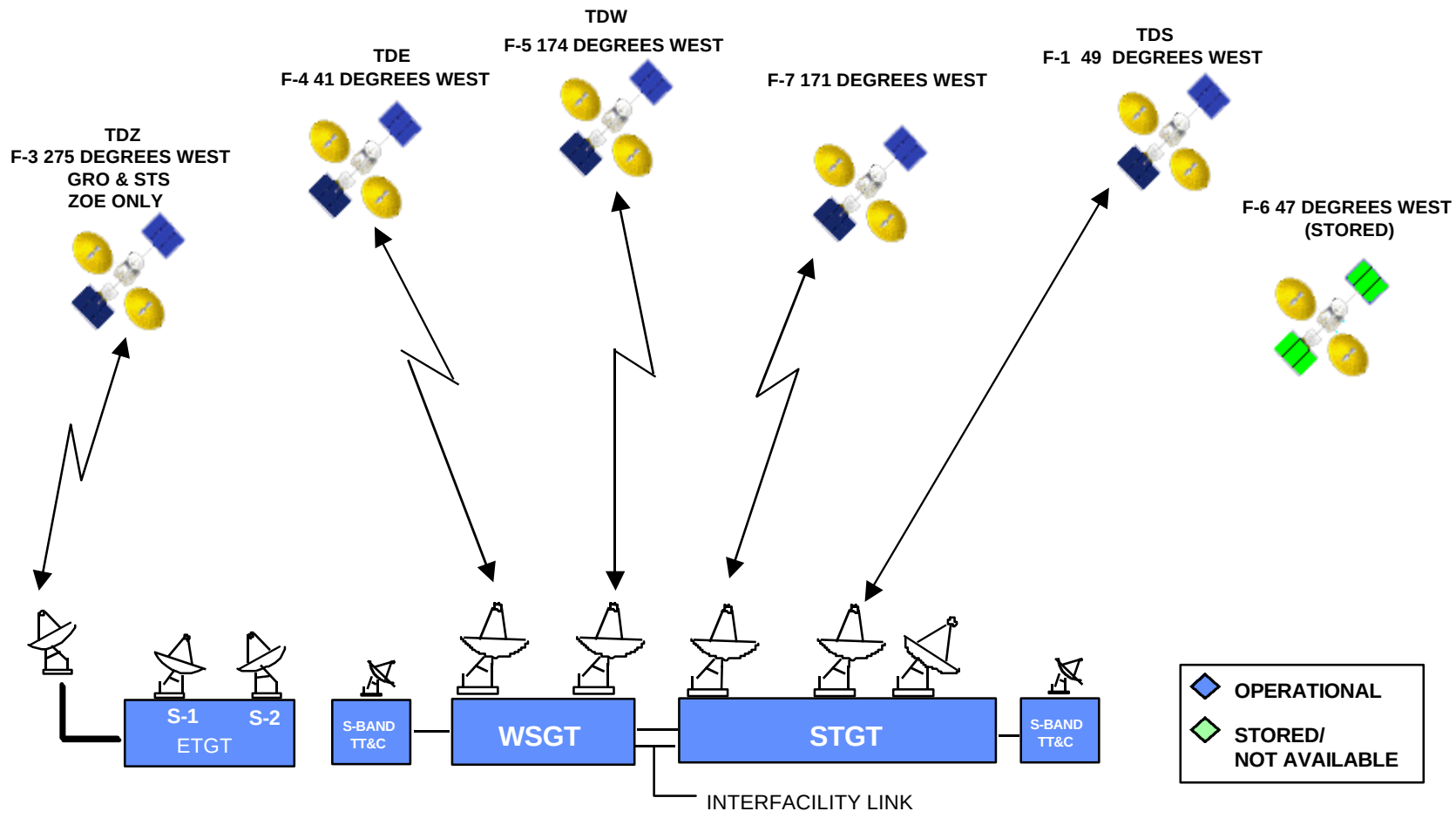
TDRSS COMMUNICATION



GSFC HUMAN SPACEFLIGHT MISSION SUPPORT OVERVIEW

GSFC HUMAN SPACEFLIGHT

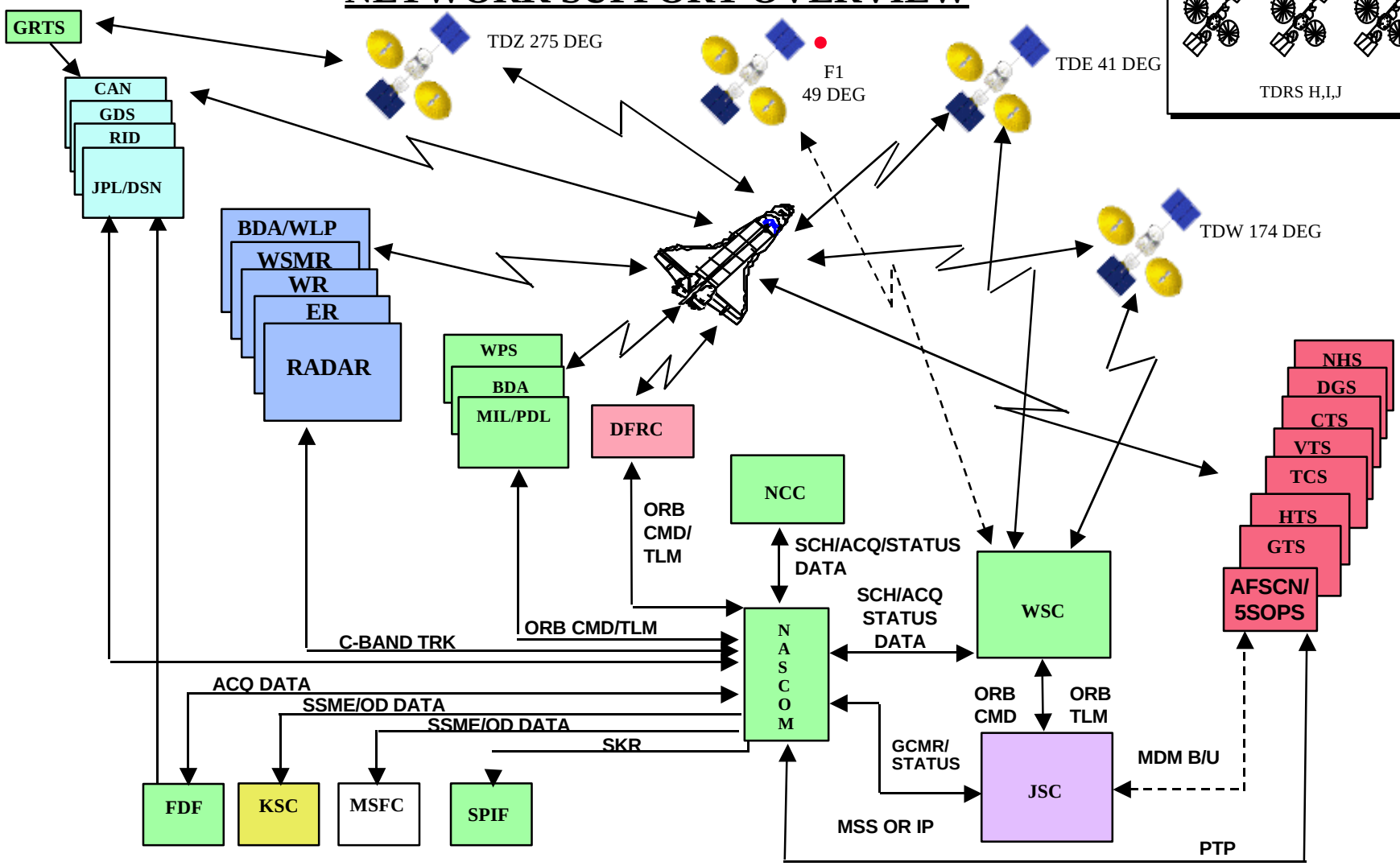
TDRS CONSTELLATION



GSFC HUMAN SPACEFLIGHT MISSION SUPPORT OVERVIEW

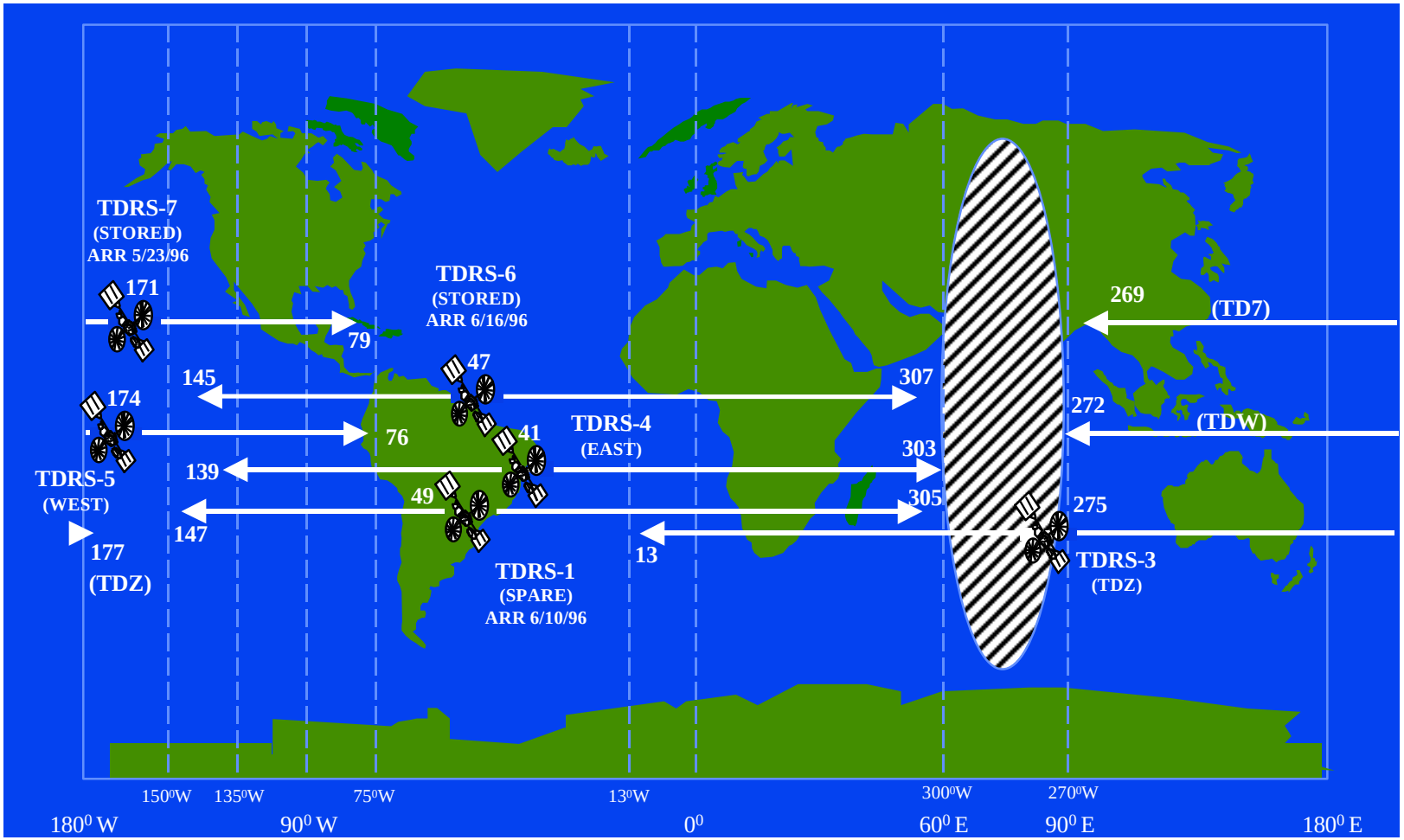
GSFC HUMAN SPACEFLIGHT

NETWORK SUPPORT OVERVIEW



● BACKUP LAUNCH SUPPORT

TDRS LOCATION



INTEGRATED NETWORK EVOLUTION

- Pre 1972
  - Satellite Tracking and Data Acquisition Network (STADAN)
    - » Santiago, Chile
    - » Quito, Equador
    - » Rosman, North Carolina
    - » Tannanarive, Madagascar
    - » Winkfield, England
    - » Fairbanks, Alaska
  - Supported Scientific Satellite Programs - OAO, IMP, Nimbus
  - Manned Space Flight Network (MSFN)
    - » Merritt Island, Florida
    - » Kuaii, Hawaii
    - » Madrid, Spain
    - » Honeysuckle Creek, Australia
    - » Corpus Christie, Texas
    - » Bermuda, U.K.
    - » Goldstone, California
    - » Ascension Island
  - Supported Mercury, Gemini, Apollo, and ALSEP/P+FS

INTEGRATED NETWORK EVOLUTION (cont'd)

- Post 1972
  - STADAN and MSFN merged into Space Flight Tracking Data Network (STDN)
    - » Supported Manned Flight and Scientific Satellite Programs
      - ° Atmospheric Explorer (AE)
      - ° LANDSAT - Earth Resource
      - ° Apollo Soyuz Test Program
      - ° Skylab
  - Space Network Era
    - » Tracking and Data Relay Satellite System (TDRSS) began in April 1983 with Launch of TDRS-1 on-board STS-6
      - ° STS-9 was First Operational Flight to be Supported by the Space Network
    - » Ground Network Station Closures
    - » Second TDRS Ground Terminal Operational in 1994

NETWORK MISSION ACCOMPLISHMENTS

- MIR VHF - WLP/DFRC
  - February 28, 1995 proof of concept testing with JSC
  - May 1995 Engineering test passes (MIR-18)
  - June 1995 STS-71 first operational passes (MIR-18)
  - Duplex Operations Mid 1996
  - Routine support averages 90 passes/month

NETWORK MISSION ACCOMPLISHMENTS (cont'd)

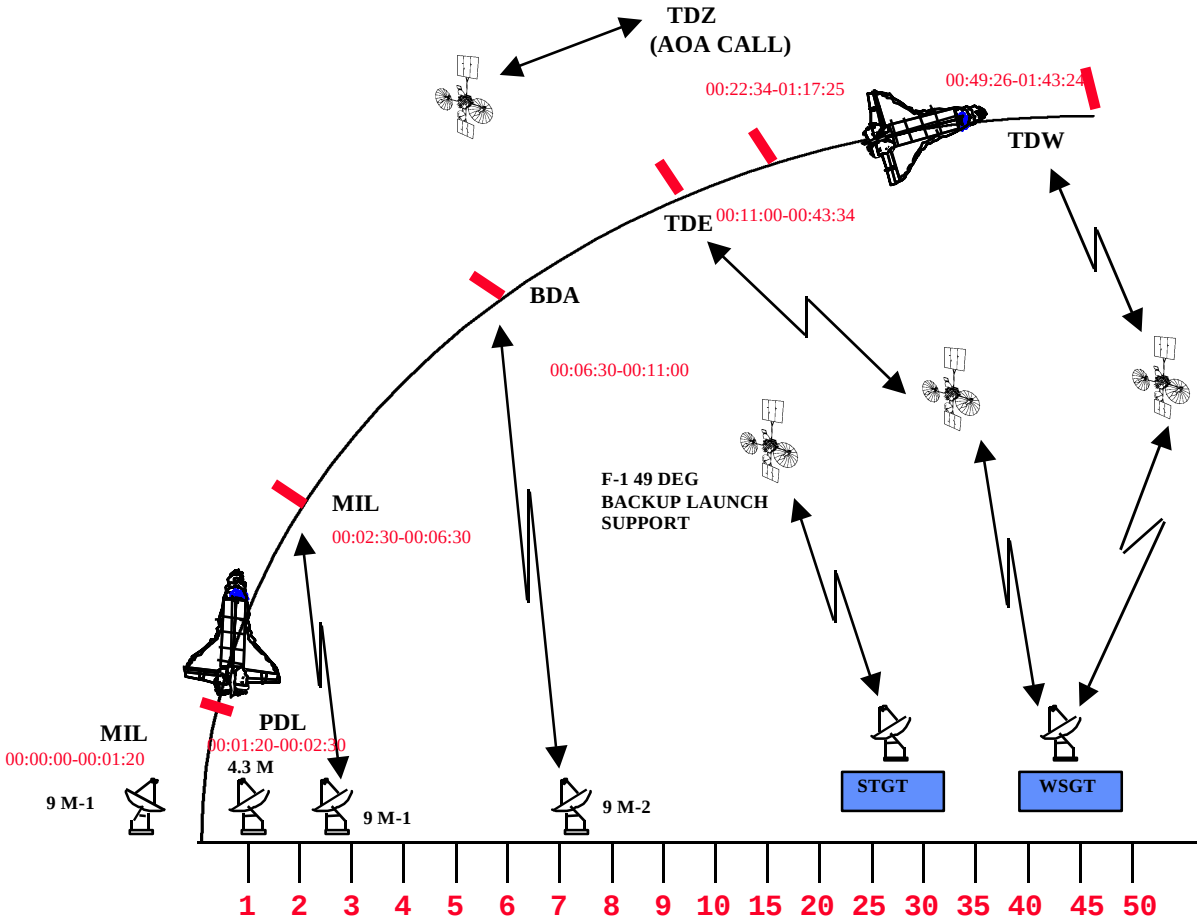
- TETHERED SATELLITE SYSTEM (TSS) CONTINGENCY RECOVERY OPS
  - STS-75 (February 1996)
    - » During TSS Deployment the Tether Cable Snapped and Spacecraft became an Unintentional "Free Flyer".
  - The Integrated Networks provided Contingency CMD/TLM support until Battery Depletion for Experiment Data Recovery
  - Utilization of the NASA/DOD Ground Networks Contributed to the Knowledge-Base Necessary to Understand the Failure Mode and Future Applications

NETWORK MISSION ACCOMPLISHMENTS (cont'd)

- GRO REMOTE TERMINAL SYSTEM (GRTS)
  - Zone of Exclusion (ZOE) closure required for:
    - » Abort Once Around (AOA) calls
    - » De-orbit burns
    - » Rendezvous/Deployments
  - S/Band Return capability implemented-April 13, 1995
  - S/Band Forward service implemented- March 23, 1996
  - Recent support coverage during STS-80 - 50 passes
- RATE 1/3 CHANNEL 1 WSC DECODING OF SHUTTLE DOWNLINK APRIL 1996
  - Provides JSC best source select between S-Band and K-Band telemetry
- DOPPLER COMPENSATION ENABLED FOR ALL USER TRACKING SERVICES
  - March 1996-Increases tracking data opportunities
- LAUNCH CONTINGENCY SUPPORT AUGMENTATION
  - TDZ-Enhances Launch and Ascent Support
  - TDS-TDE/Ground Terminal failure coverage

NETWORK MISSION ACCOMPLISHMENTS (cont'd)

SPACE SHUTTLE LAUNCH PROFILE



MISSION ELAPSE TIME (MET) IN MINUTES

FUTURE NETWORK MILESTONES

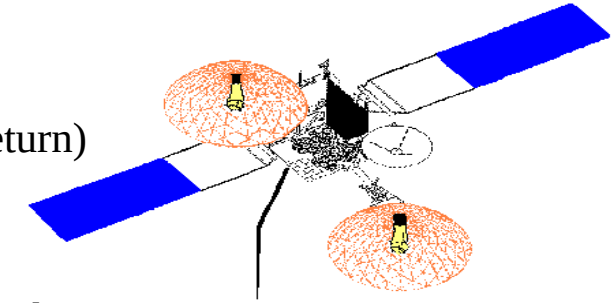
- GUAM REMOTE GROUND TERMINAL (GRGT)
  - Replacement for GRTS with added capabilities
  - Proof of concept study/presentation to NASA Code 0 May 28, 1996
  - Funding approval August 5, 1996
  - Implementation schedule
    - » Official start September 1, 1996
    - » Installation team visit to GUAM September 9-11, 1996
    - » GRGT proposed operational date June 6, 1998

FUTURE NETWORK MILESTONES (cont'd)

- GOLDSTONE (GDS) TO DRYDEN FLIGHT RESEARCH CENTER (DFRC) TRANSITION
  - JPL 26 meter subnet phasedown
    - » No new business accepted after October 1998
    - » Commercialization year ~2000
  - DFRC Improvements
    - » Increase S-Band Antenna Size
    - » On-Orbit TV Capability
    - » Upgraded Radars

FUTURE NETWORK MILESTONES (cont'd)

- TDRS H,I,J
  - Three (3) New Spacecraft - TDRS-H (7/99), TDRS-I (1/00), TDRS-J (7/00)
  - Spacecraft to Provide All Current Generation Services
    - » Ku-Band Single Access (4)
    - » S-Band Single Access (4)
    - » S-Band Multiple Access (1 Forward, 1 Return)
  - Additional Ka-Band Service (4)
    - » Ku or Ka-Band on Each SA Antenna
    - » Spacecraft Has Capability to Support 800 Mbps
  - Enhanced Multiple Access (Higher EIRP, Better G/T, Higher Data Rates)
  - Perform On-Board MA Return Service Beamforming Which Allows 5 Simultaneous Spacecraft Users
  - Ability to Be Stored on Orbit
  - 15 Year Operating Life



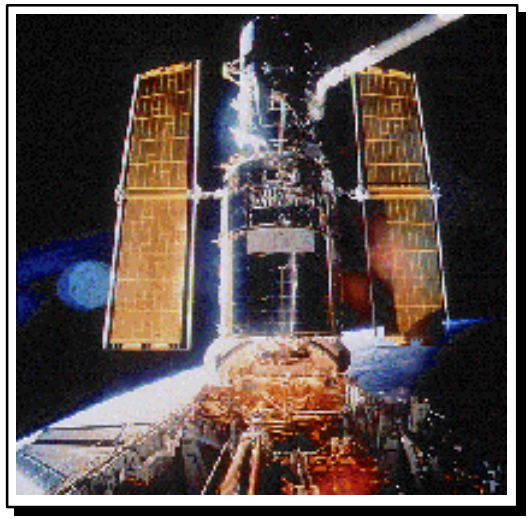
Shuttle Program

Typical Support Profile (HST Servicing Mission)

HUBBLE SPACE TELESCOPE MISSION SUPPORT PROFILE

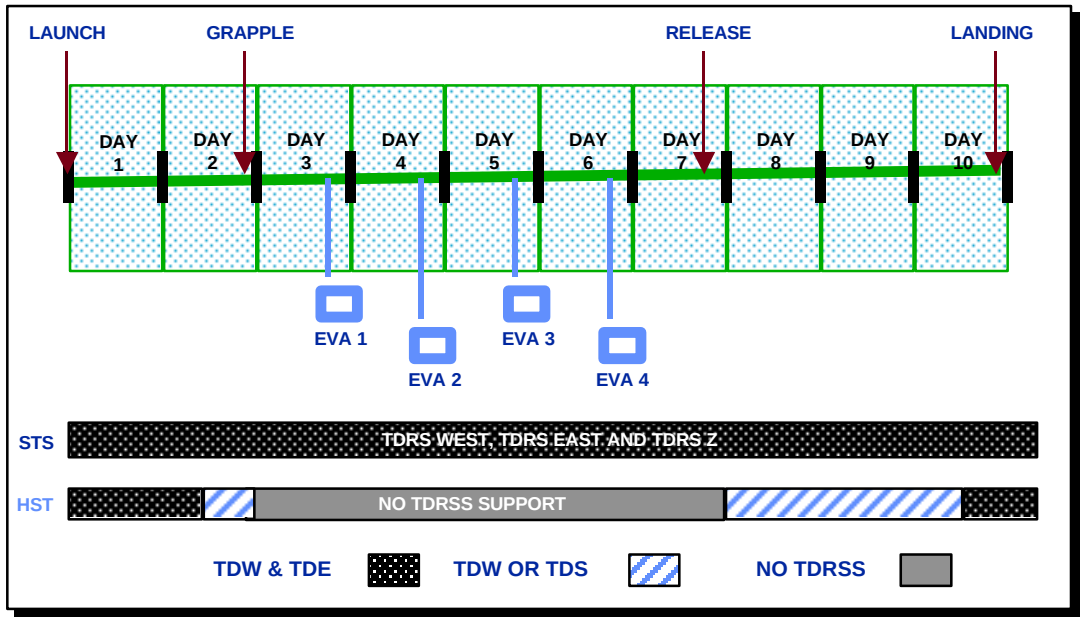
SHUTTLE FLIGHT PROFILE

EVENT	ORBIT	MET
LAUNCH		00/00:00
OMS 2		00/00:45
HST GRAPPLE	31	01/22:54
HST RELEASE	104	06/21:05
SEP-1	104	06/21:06
SEP-2	105	06/21:36
DEORBIT BURN	149	09/21:16
LANDING (KSC)	150	09/22:29



HUBBLE SPACE TELESCOPE MISSION SUPPORT PROFILE (cont'd)

- HST SUPPORT OVERVIEW



- EVA CRITICAL SUPPORT PERIODS
  - Four EVA'S are Planned During STS-82
  - EVA's Occur Between 0300Z and 1000Z
  - Each EVA Scheduled for 6 Hour Duration
    1. 2 Days 19 Hours 25 Minutes MET
    2. 3 Days 19 Hours 25 Minutes MET
    3. 4 Days 19 Hours 25 Minutes MET
    4. 5 Days 19 Hours 25 Minutes MET

SHUTTLE PROGRAM CHANGES (COMMUNICATION RELATED)

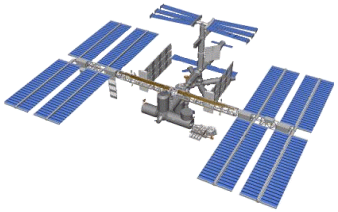
- LIGHT WEIGHT TANK
  - Heads-Up Roll
  - Non-Spread Forward Acquisition
- GLOBAL POSITIONING SATELLITE (GPS)
- PILOT'S POINT OF VIEW CAMERA
  - First Flight STS-78 (June 1996)
    - » Camera mounted behind pilot to provide landing runway video
  - Limited to Orbiter "Columbia"
  - Supported by DFRC/MIL/GDS via the 2250 Mhz Downlink

International Space Station (ISS)

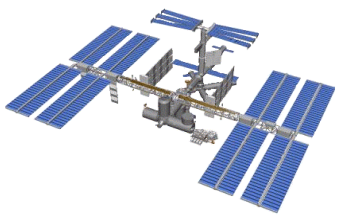
ISS MISSION OVERVIEW

GOALS & OBJECTIVES

- A research institute for cutting edge science
- A catalyst for international peace and cooperation
- A test bed for developing 21st century technologies
- A springboard for global systems management
- A space laboratory to provide new insight into life sciences
  - Microgravity
  - Environmental Health
  - Biomedical Science
  - Fundamental Technology



ISS MISSION OVERVIEW



NASA CENTER RESPONSIBILITIES

GSFC - SN, NISN, FDF, and GN (VHF) services

JSC - Overall command and control of ISS and overall program management

MSFC - Processing and distribution of ISS payload data, as well as command and control of ISS payloads

LeRC - Design and delivery of ISS power supply system

KSC - Payload processing and Shuttle launch and landing operations

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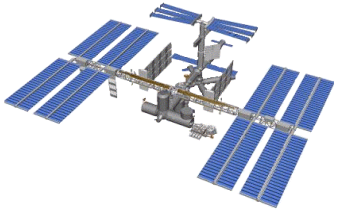


International Space Station
NASA

Prime Contractor
Boeing Houston

Product Group 1
McDonnell Douglas

- Integrated Truss
- External Thermal Control Systems
- Command and Data Handling
- Navigation/Propulsion
- Communications/Tracking
- Node/Cupola Integration
- Pressurized Mating Adapter

Product Group 2
Rocketdyne

- Primary Power
  - Solar Arrays
  - Batteries
  - Switching Units
  - Converters

Product Group 3
Boeing Huntsville

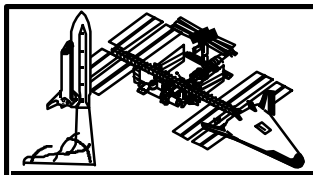
- Node/Cupola, Primary Structure
- U.S. Laboratory Module
- Life Support Systems
- Internal Thermal Control
- Internal Audio/Video
- Secondary Power Subsystem
- Habitation Module

Internationals

- **Canada (CSA)** Station Remote Manipulator System
- **Europe (ESA)** Laboratory
- **Italy (ASI)** Mini Pressurized Logistics Module
- **Japan (NASDA)** Laboratory (2)
- **Russian (RSA)**
  - FGB Tug *
  - Service Module
  - Soyuz CTV (2)
  - Station Propulsion
  - Power Modules
  - Experiment Modules (3)
  - Progress Resupply
  - Docking Modules (3)

PROGRAM STRUCTURE

* Provided by ISS Prime Contractor



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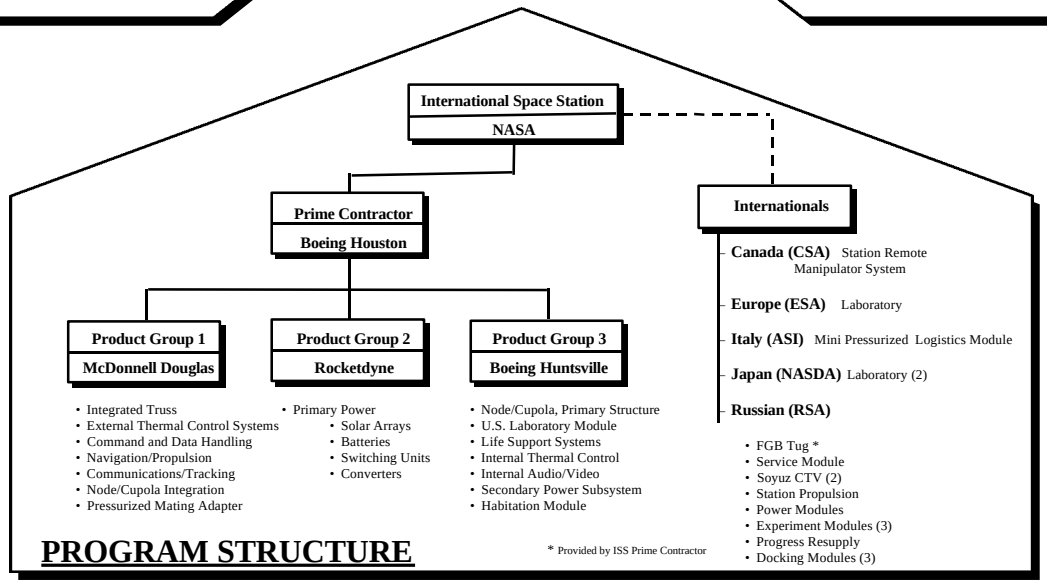
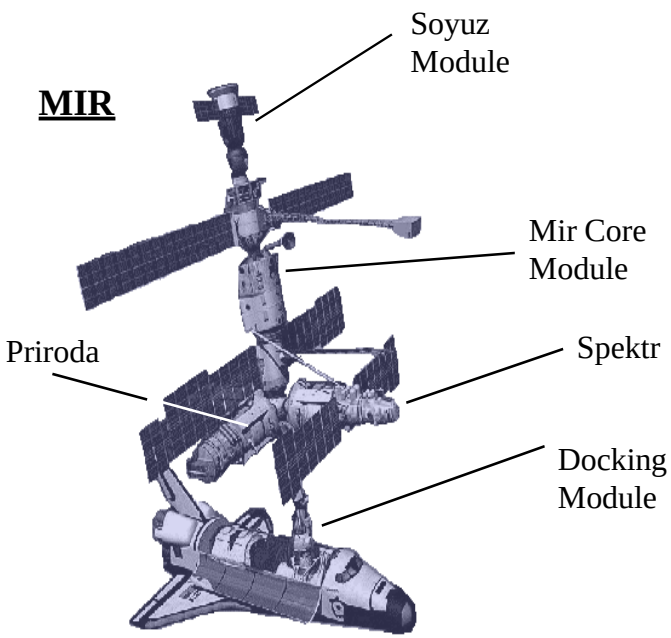


PROGRAM STRUCTURE

ISS IMPLEMENTATION PHASE SUMMARY



Phase 1
(Feb 1994 to May 1998)

- Shuttle-Mir program to exercise shuttle rendezvous and docking techniques
- Mir crew exchange and logistical resupply of the Mir
- Perform on-orbit joint US-Russian science, medical, and earth observation investigation

ISS PHASE 1 MISSION HIGHLIGHTS

- $400 million contract with RSA for use of the Mir (About 20% of this contract goes towards ISS Phase 2/3 primarily in the form of data and docking mechanisms.)
  - ISS Phase 1 Project Managed out of JSC's Russian Programs Office

- Up to eleven US Shuttle flights to Mir
  - STS-74 delivered the Russian-built docking module
  - US experiment hardware aboard the Spektr and Priroda modules added to Mir complex in 1995
  - US hardware aboard two Progress vehicles
  - Phase 1 Program Entering 6th Rendezvous and 5th Docking Mission (STS-81)

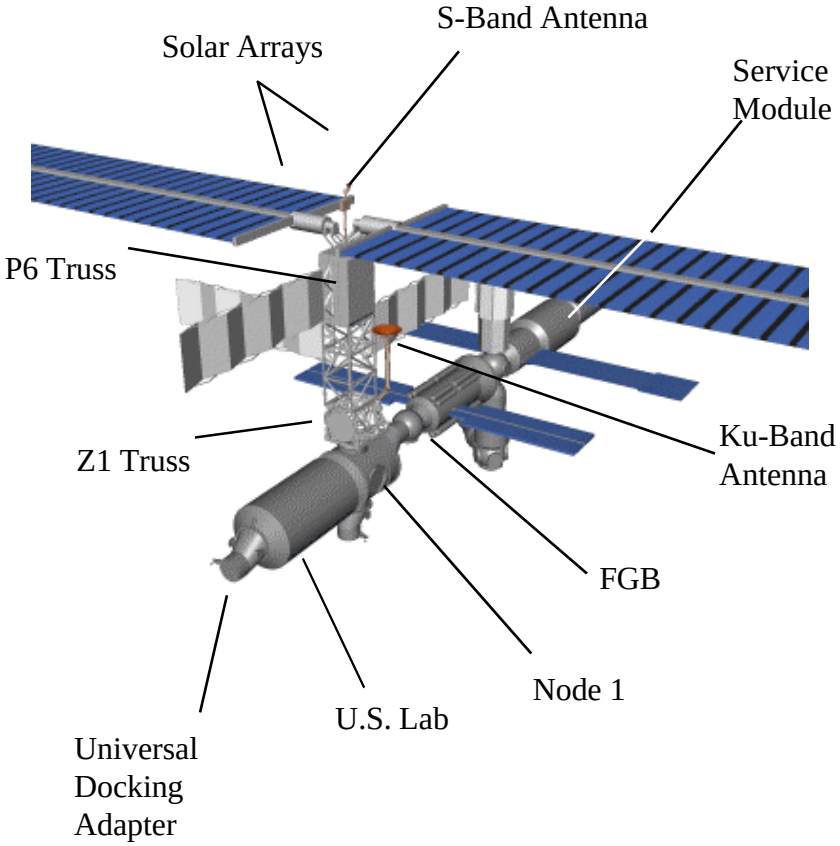
- Four additional long duration missions (totaling about 21 months) of US astronauts aboard Mir
  - Continual U.S. Astronaut presence on Mir From March 1996 to ISS Human Tended Operations

- Mir lifetime extension by the addition of the Mir Cooperative Solar Array (MCSA)
  - Phase 1 Program Extended to Late 1998

- VHF voice provided by Wallops and Dryden, used Daily

- ZOE Closed for Space Shuttle Forward/Return Link

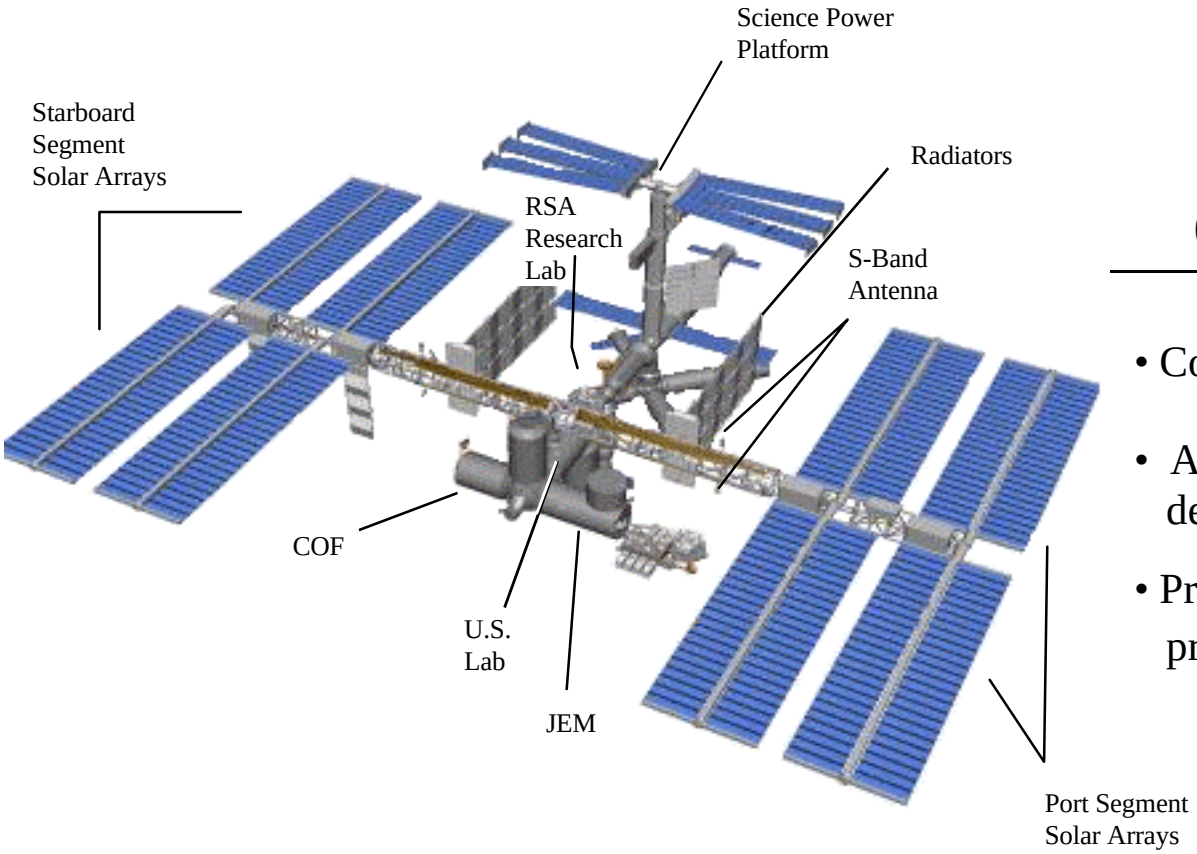
ISS IMPLEMENTATION PHASE SUMMARY



Phase 2
(Nov 1997 to April 1999)

- Use of US and Russian developed launch vehicles
- Combines US and Russian hardware to create totally new, advanced orbital research lab
- Provides three-person permanent human presence (PHC) capability (May 1998)

ISS IMPLEMENTATION PHASE SUMMARY



Phase 3
(May 1999 to June 2002)

- Completes ISS construction
- All International Partner components delivered to the Station
- Provides six-person permanent human presence capability (June 2002)

GSFC HUMAN SPACEFLIGHT MISSION SUPPORT OVERVIEW

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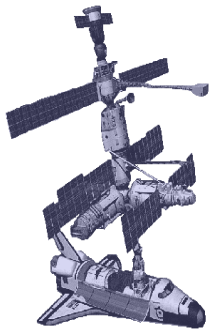
ISS IMPLEMENTATION PHASE SUMMARY



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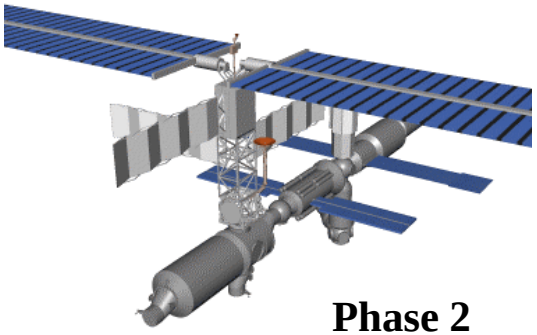

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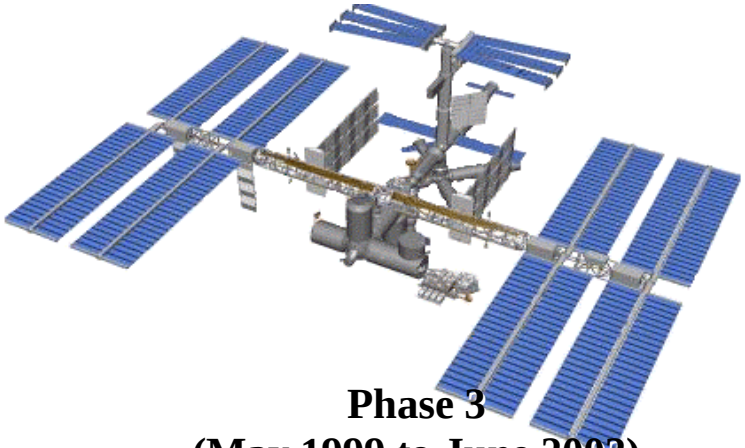

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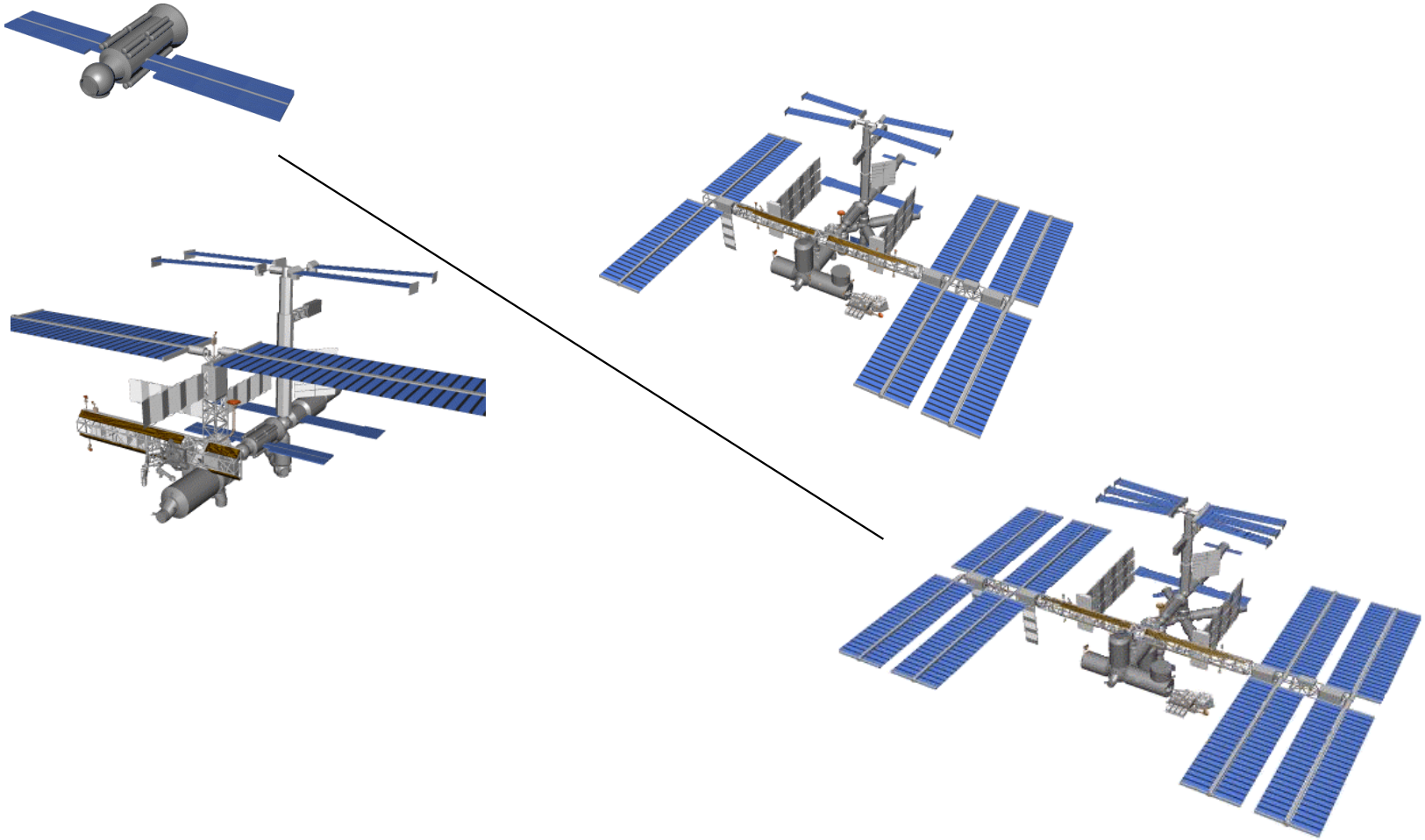
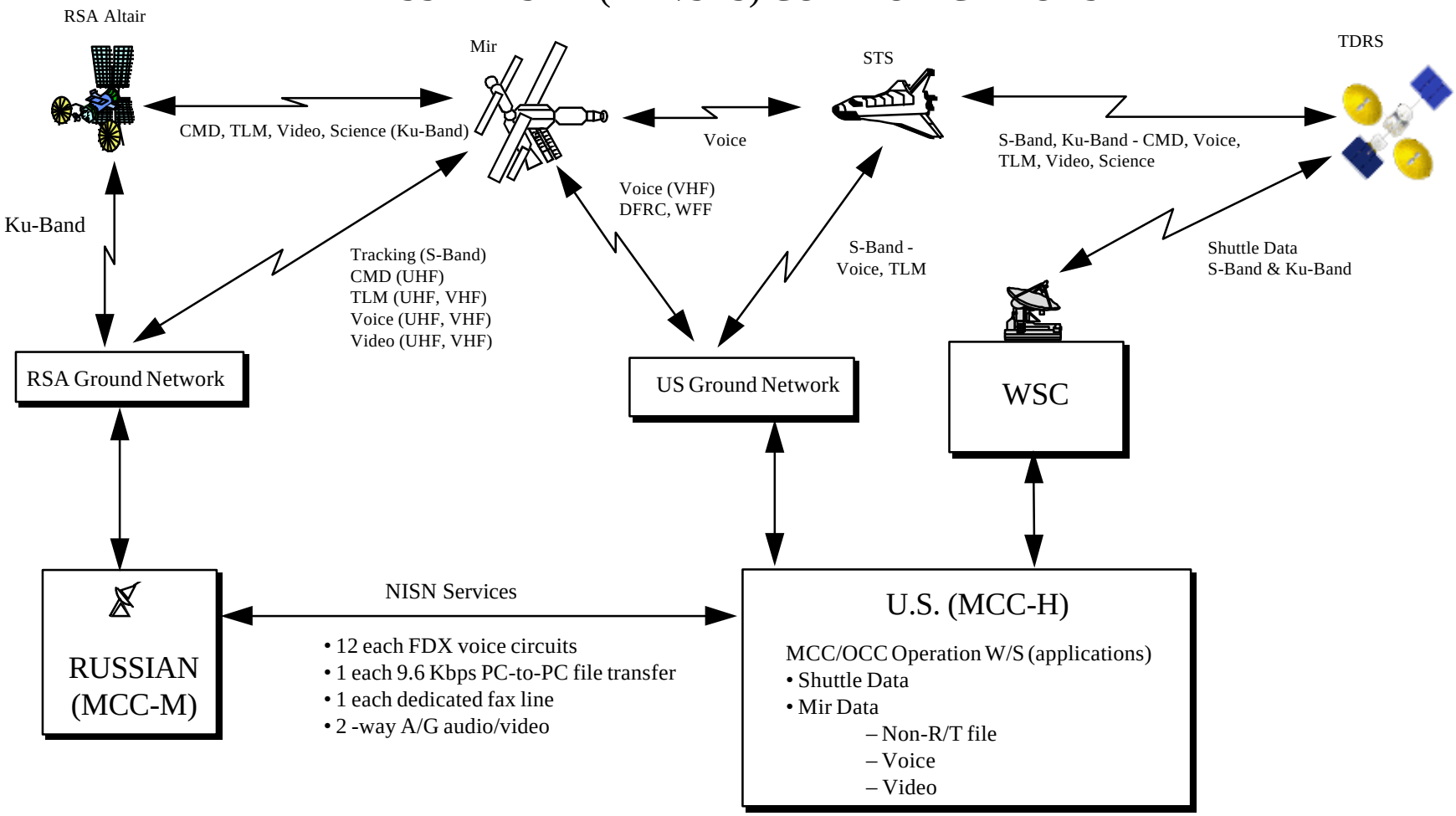
ISS PHASE 2 & 3 BUILD SEQUENCE



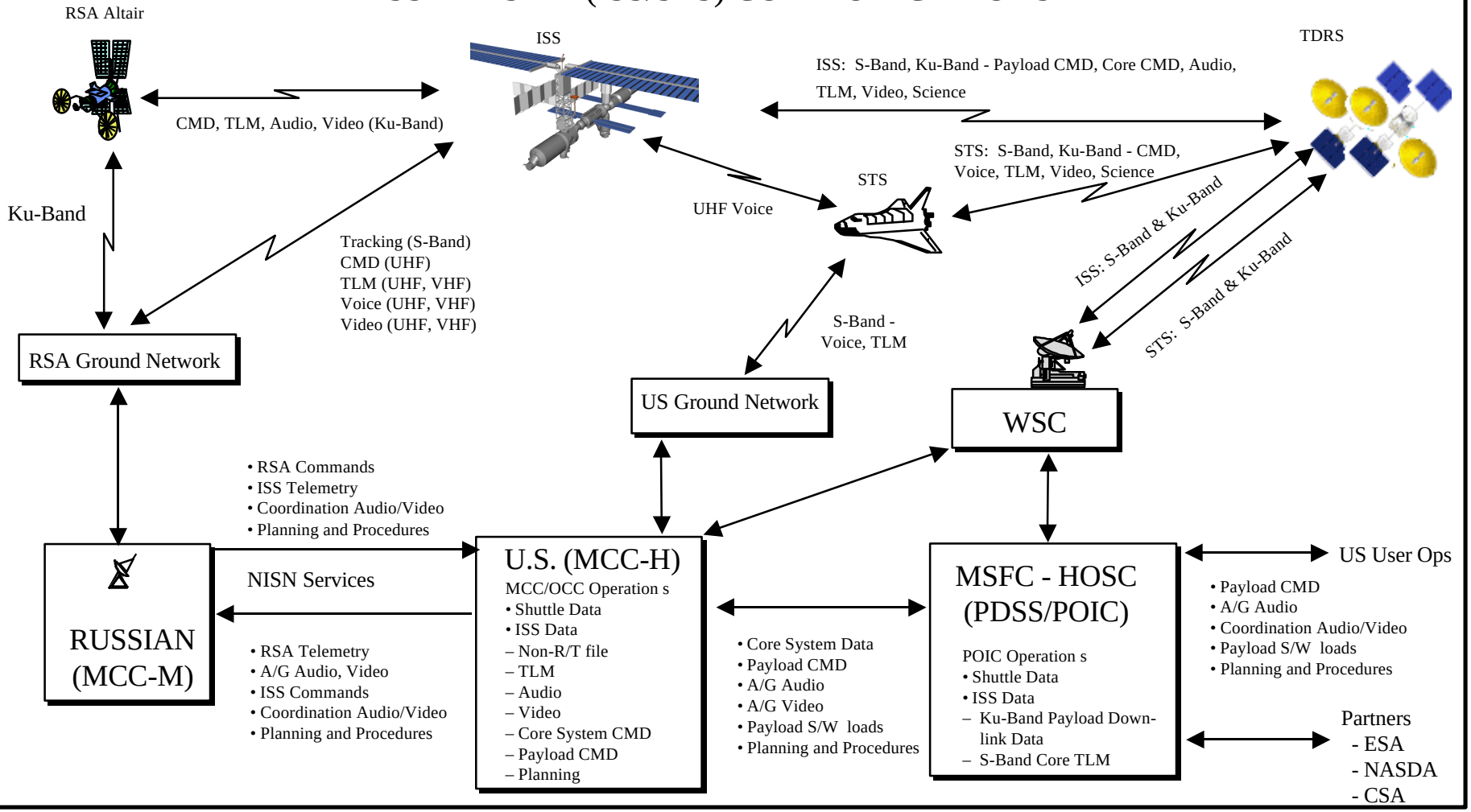
ISS COMMUNICATIONS & DATA SYSTEMS SUMMARY

ISS PHASE I (MIR/STS) COMMUNICATIONS



ISS COMMUNICATIONS & DATA SYSTEMS SUMMARY (cont'd)

ISS PHASE 2 (ISS/STS) COMMUNICATIONS

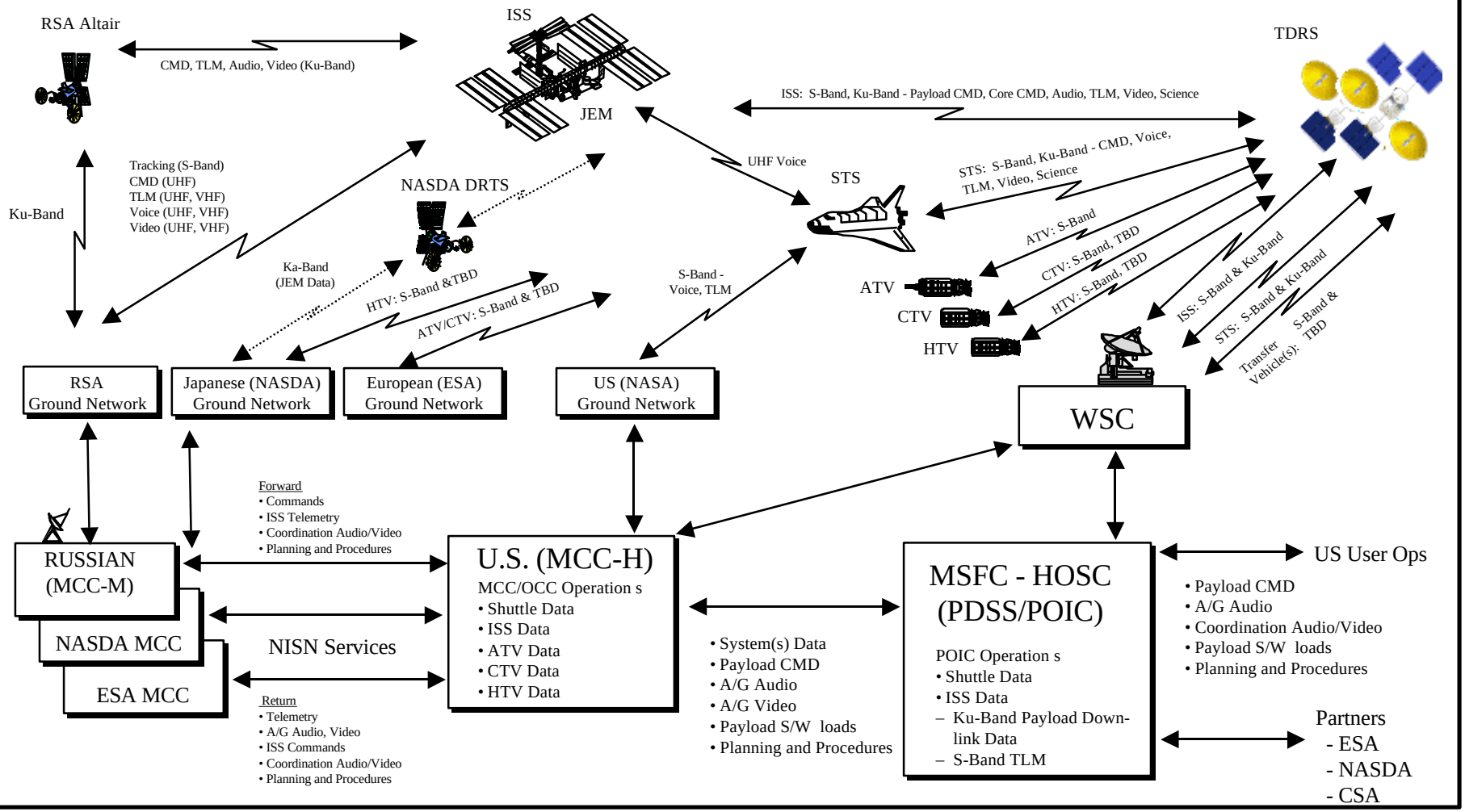


GSFC HUMAN SPACEFLIGHT MISSION SUPPORT OVERVIEW

GSFC HUMAN SPACEFLIGHT

ISS COMMUNICATIONS & DATA SYSTEMS SUMMARY (cont'd)

ISS PHASE 3 (INTERNATIONAL) COMMUNICATIONS



Reusable Launch Vehicle (X-33)

REUSABLE LAUNCH VEHICLE (RLV) PROGRAM INTRODUCTION

- Primary Objective of the RLV Program:
  - Mature Technologies for the Next-generation Space Transportation System
  - Reduce Development and Operational Cost, and Reduce Launch Turnaround Time
  - Reduce Technical Risk (Private Investment in Commercial Development and Operation)
- RLV Program: Developing and Validating Vehicle, Propulsion, and Operations Technologies
  - DC-XA: Aluminum-lithium liquid oxygen tank, composite liquid hydrogen tank, composite internal tank structure, integrated auxiliary propulsion system (liquid-to-gas conversion), modified auxiliary power unit, hydrogen leak-detection sensors.
  - X-33: Structural/thermal concept, aircraft-like operations & maintenance concepts, flight dynamics, flight loads, ascent and reentry environments, mass fraction, fabrication methods. Also, Advanced thermal protection systems, advanced avionics and flight-control systems (autonomous reentry and landing), vehicle health monitoring systems, ground operations/rapid turnaround

REUSABLE LAUNCH VEHICLE (RLV) PROGRAM INTRODUCTION (cont'd)

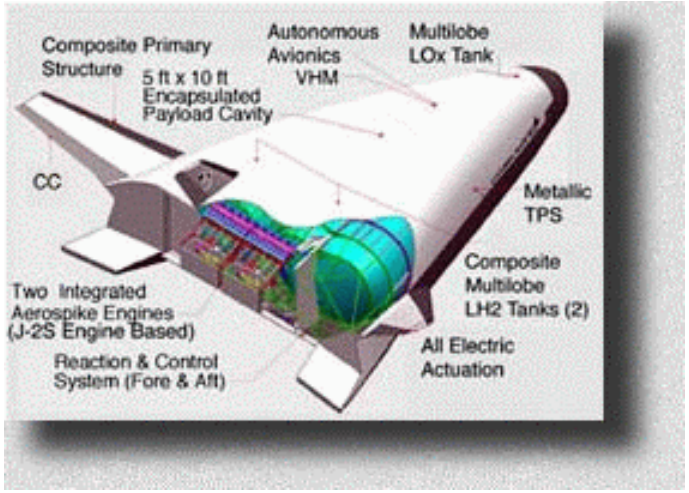
- From the Human Spaceflight point of view, focus is placed on the RLV Flagship, X-33
  - Sub-scale Advanced Technology Demonstrator (ATD) for the actual RLV
    - » Must prove the concept of the reusable next-generation system
    - » Autonomous, suborbital, experimental, single-stage rocket flight vehicle
    - » Integrated Flight Vehicle for key technology, operations, and reliability requirements
  - RLV the eventual replacement of the current Space Shuttle Program

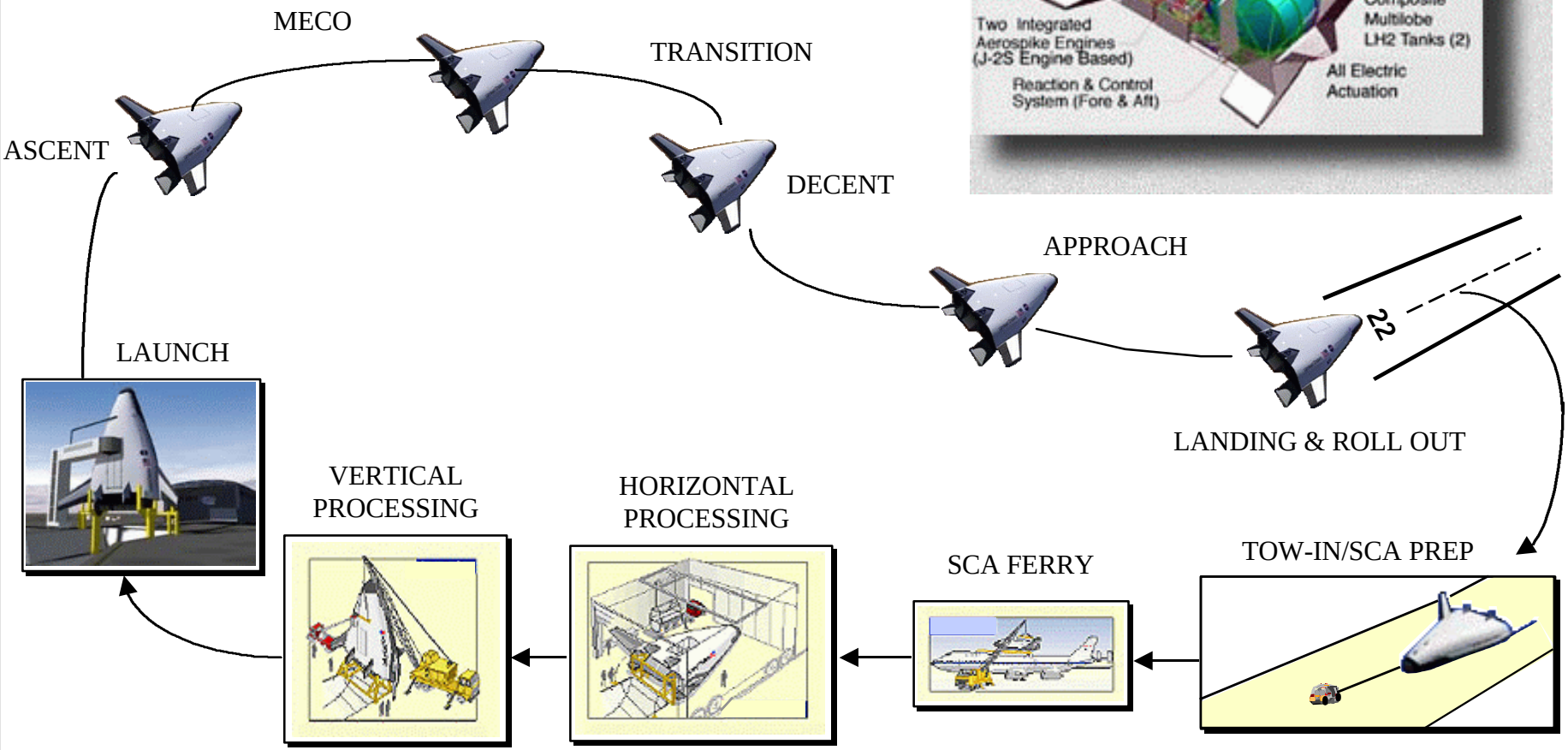
GSFC HUMAN SPACEFLIGHT MISSION SUPPORT OVERVIEW

GSFC HUMAN SPACEFLIGHT

X-33 VEHICLE SUMMARY

- 53% Scale Version of VentureStar (RLV)

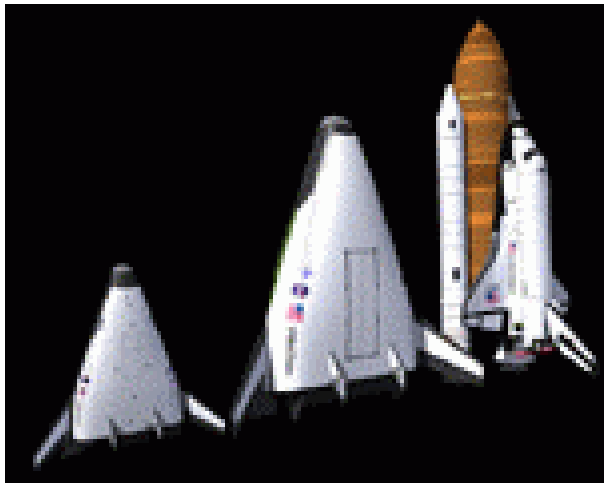




X-33 VEHICLE SUMMARY (cont'd)

- X-33/RLV/Shuttle Comparison

Vehicle / Characteristics	X-33	RLV	SHUTTLE
Length	67 ft	127 ft	122 ft
Width	68 ft	128 ft	78 ft
Bay Size	5 ft by 10 ft	15 ft by 45 ft	15 ft by 60 ft
Lift Weight	273,277 lbs	2,186,000 lbs	4,500,000 lbs
Payload	N/A	50,000 lbs	65,000 lbs
Propulsion	2 - LH_2/LO_2	8 - LH_2/LO_2	3- LH_2/LO_2 Main Engines 2- Solid Propellant SRBs
Maximum Speed	Mach 15+	Orbital	Orbital



OPERATIONS PLANNING GOALS

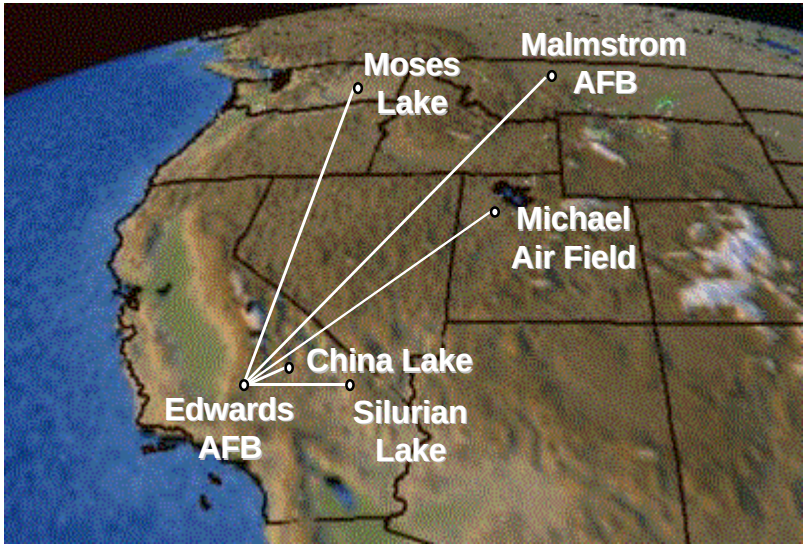
- X-33/RLV/Shuttle Comparison

Vehicle / Characteristics	X-33	RLV	SHUTTLE
$/Launch	.9M	4M	500M
Turnaround Time	2 Days	3.5-7 Days	~60 Days +
Operations Team	<50	<300	3000 +
Grnd Sys Spt Sprt Concept	Vehicle Process @ Pad Off Line Payload Process	Vehicle Process @ Pad Off Line Payload Process	High Bay Processing Facility
On-Time Launch	TBD	>95%	~50%
Safety - Reliability	.99 +	.999 +	~.97

GSFC HUMAN SPACEFLIGHT MISSION SUPPORT OVERVIEW

GSFC HUMAN SPACEFLIGHT

X-33 GROUND SYSTEM SUPPORT SUMMARY

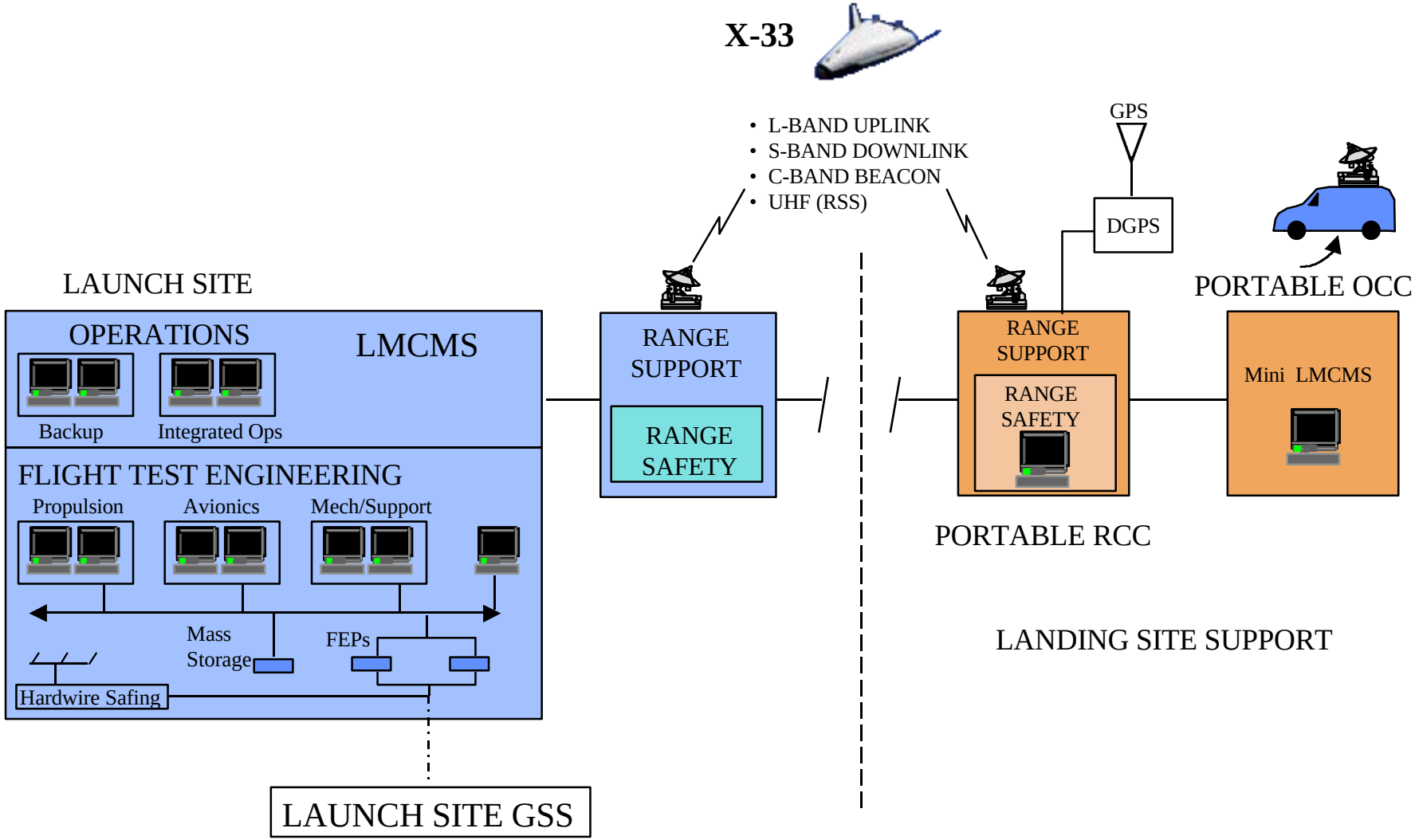


FLT	LAND SITE	DIST SM	MACH NO.	MAX ALT. (k ft.)	TIME MECO	MISSION OBJECTIVES
1	Silurian	104	3.9	138	128	Overall Vehicle and Ground System Performance
2	Silurian	104	3.9	138	128	
3	Silurian	104	3.9	138	128	
4	Michael	450	9.2	175	200	Thermal & Power Distribution Performance
5	Michael	450	9.1	162	189	Propellant Management
6	Michael	450	8.8	162	172	TPS Performance; Payload Bay Environment; Propellant Tank
7	Michael	450	9.1	164	176	1st 7 Day Turn;48 Hour Turn - Ops Demo
8	Michael	450	8.1	200	155	2nd 7 Day Turn (2nd 48 Hour Turn if Required)
9	Michael	450	8.8	162	172	3rd 7 Day Turn
10	Michael	450	10.8	175	204	Engine-Vehicle/Engine-Engine Characteristics
11	Malmstrom	950	14.4	240	194	TPS Durability; Thermal Cycling
12	Malmstrom	950	15.1	260	192	Mach 15+; Real Gas Effects; TPS Durability; Thermal Cycling
13	Malmstrom	950	15.1	260	192	Mach 15+; TPS Durability; Thermal Cycling
14	Malmstrom	950	14.9	244	194	TPS Durability; Thermal Cycling
15	Malmstrom	104	14.9	244	194	Propellant Tank Durability/Reuse; TPS Durability; Thermal Cycling

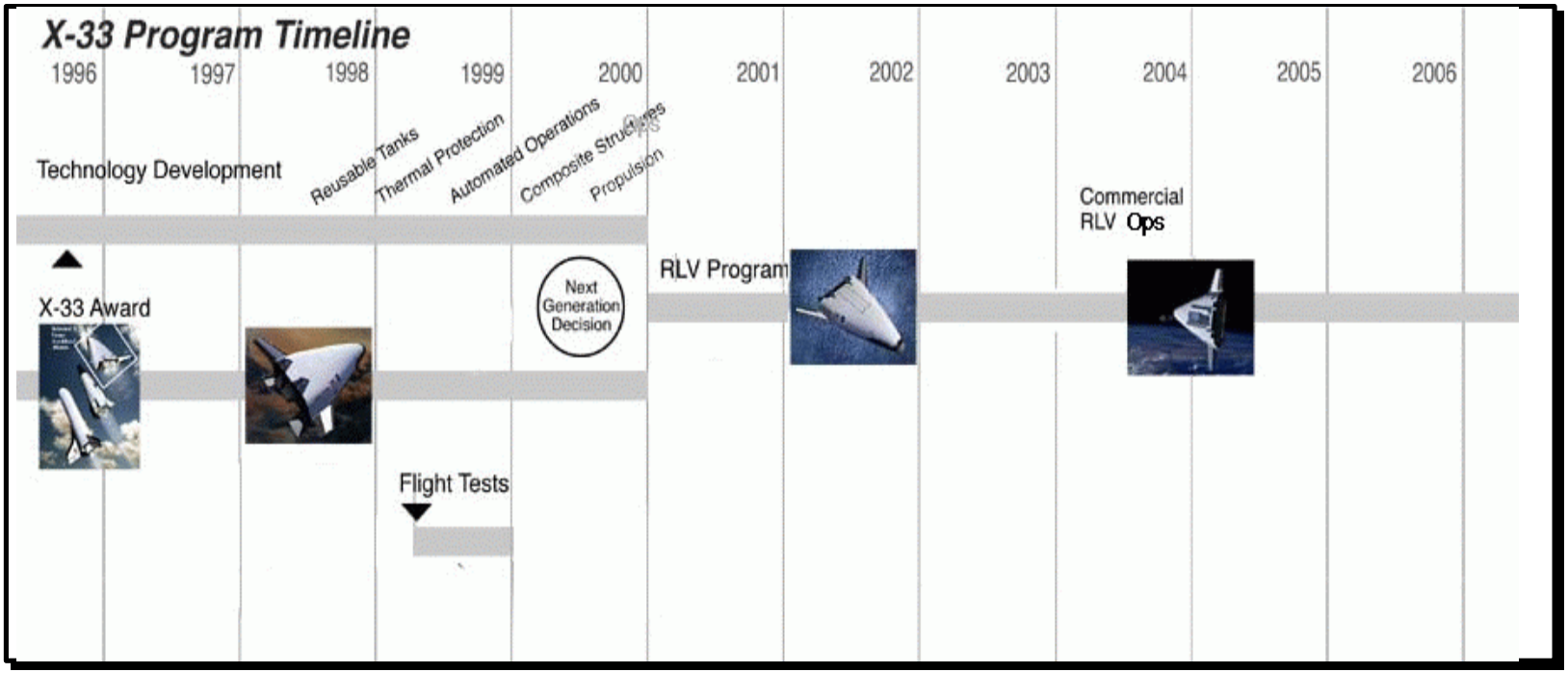
GSFC HUMAN SPACEFLIGHT MISSION SUPPORT OVERVIEW

GSFC HUMAN SPACEFLIGHT

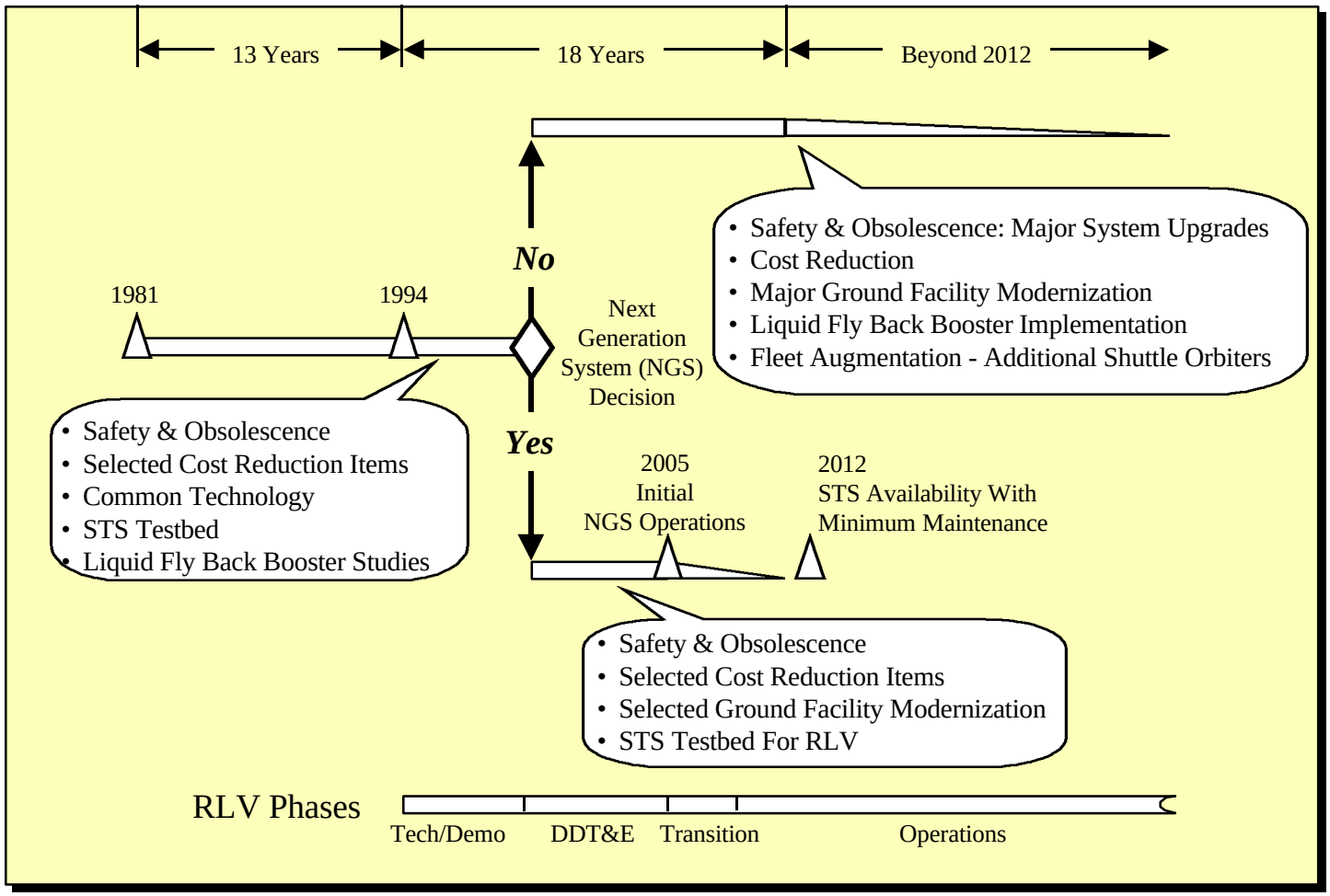
X-33 COMMUNICATIONS AND DATA SYSTEMS



RLV IMPLEMENTATION & SUPPORT SCHEDULE



RLV PHASING STRATEGY TIMELINE



Conclusion

CONCLUSION

- GSFC is Directly Involved in Support to Human Spaceflight Missions by providing Enhanced Communications Capabilities
- Diverse International Human Spaceflight Programs
  - Multi Mission / Multi Vehicle (ISS, STS, Transfer Vehicle(s))
  - International Elements & Communications Systems
  - Evolving Vehicles (STS--->RLV)
- Global Customer/Integrated Service Provider
  - Shared Resources (Space and Ground)
  - Space Network Interoperability
- Future Technology Applications
  - Ka-Band
  - Higher Data Rates (for ISS, STS, EOS)
  - Automated Ground Stations
- Flexibility to Meet Changing Needs
  - Better, Faster, Cheaper
  - Working Closely with the Customer Community
  - Service Commercialization

BACKUP MATERIAL

ISS ASSEMBLY SUMMARY SHEETS

Space Station Partners	United States, Canada, Japan, Russia, nine European Space Agency member countries: Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, United Kingdom, Norway
Start/end dates for assembly	November 1997; June 2002
First/last Space Station element	FGB/Habitation Module & outfitting
Number of Phase II flights	15: seven Russian, seven American, one combined
Phase II goals	Full operations for Laboratory Module Begin science and research Full sustainability inside and outside Space Station
Number of Phase III flights	29: 21 Shuttle, 7 Russian, one Ariane (3 Shuttle flights are for Japanese Segment)
Phase III goals	Complete United States Habitation Module Perform science and research across five Utilization Flights Complete Space Station Assembly

ISS ASSEMBLY SUMMARY SHEETS (cont'd)

Total number of assembly flights	44
Launch vehicles	United States Space Shuttle; Russian Zenit, Soyuz, Proton; European Ariane V
Space Station mass when complete	900,000 lbs.
Altitude and inclination	190-250 nautical miles (217-286 statute miles), 51.6°
Percentage of Earth visible from Station	85%
Number of truss segments/truss length	10/310 feet
Total module volume at completion	43,000
Number of United States and Russian solar arrays	8 (4 pair) each
Total Power Capability (kWatts) at assembly Complete	110 kW

ACRONYMS

ACN	-	Ascension Island
ACQ	-	Acquisition
AE	-	Atmospheric Explorer
AFB	-	Air Force Base
AFSCN	-	Air Force Satellite Control Network
ALSEP	-	Apollo Lunar Surface Experiments Package
AOA	-	Abort Once Around
APM	-	Attached Pressurized Module
ARR	-	Arrival
ASI	-	Agencia Spatiale Italiano
ASPC	-	Attached Shuttle Payload Center
ATD	-	Advanced Technology Demonstrator
ATV	-	Automated Transfer Vehicle
BDA	-	Bermuda
BSP	-	Baseband Signal Processor
C&T	-	Command and Telemetry
CCT	-	Closed Circuit Television
CDR	-	Commander
CERT	-	Certification
CETA	-	Crew and Equipment Translation Assembly
CGSE	-	Customer Ground Support Equipment
CMD	-	Command
CMG	-	Control Moment Gyro
CNMOS	-	Consolidated Network & Mission Operations Support
COF	-	Columbus Orbital Facility
COMM	-	Communications
CSA	-	Canadian Space Agency
CTV	-	Compatibility Test Van
DEG	-	Degrees
DDCU	-	DC-to-DC Converter Unit
DDT&E	-	Design, Development, Test, and Evaluation
DFRC	-	Dryden Flight Research Center
DGPS	-	Digital Global Positioning Satellite
DGS	-	Diego Garcia Station
DIST	-	Distance
DKR	-	Dakar
DOD	-	Department of Defense
DRS	-	Data Relay Satellite
DRTS	-	Data Relay Test Satellite
DSN	-	Deep Space Network
DVTM	-	Design Verification Test Model
ECOMM	-	Early Communications
ECOMS	-	Early Communications Systems
EF	-	Exposed Facility
ELV	-	Expendible Launch Vehicle
EIRP	-	Effective Isotropic Radiated Power (dBW)
EMCC	-	Emergency Mission Control Center
EOS	-	Earth Observation System
ESA	-	European Space Agency
ESTL	-	Electronics Systems Test Laboratory
ETGT	-	Extended TDRS Ground Terminal

ACRONYMS

EVA	- Extravehicular Activity	I&T	- Integration and Test
FDF	- Flight Dynamics Facility	IEA	- Payload
FDX	- Full Duplex	IMP	- Spacecraft
FEL	- First Element Launch	IP	- Internet Protocol
FLTS	- Flights	IPD	- Information Processing Division
FGB	- Functional Cargo Block	ISI	- Interim Support Instruction
FRR	- Flight Readiness Review	ISS	- International Space Station
GCMR	- Ground Control Message Request	IT&V	- Integration Test and Verification
GDS	- Goldstone	JEM	- Japanese Experiment Module
Ghz	- Gigahertz	JPL	- Jet Propulsion Laboratory
GN	- Ground Network	JSC	- Johnson Space Center
GPS	- Global Positioning System	Kbps	- kilo bits per second
GRO	- Gamma Ray Observatory	KSC	- Kennedy Space Center
GRTS	- GRO Remote Terminal System	LeRC	- Lewis Research Center
GRGT	- Guam Remote Ground Terminal	$L0_2$	- Liquid Oxygen
GSA	- General Service Agreement	lbs	- Pounds
GSCB	- Goddard System Configuration Board	LH2	- Liquid Hydrogen
GSFC	- Goddard Space Flight Center	LMCMS	- Lockheed Martin Command Mgmt System
GSS	- Ground Support System	LR	- Low Rate
GTS	- Guam Tracking Station	LRR	- Launch Readiness Review
GWM	- Guam	Mbps	- Mega bits per second
HOSC	- Huntsville Operations Support Center	MBR	- Mila/Bermuda Reengineering
HQ	- Head Quarters	MCC-M	- Mission Control Center - Moscow
HSD	- Human Spaceflight Department	MCC-H	- Mission Control Center - Houston
HST	- Hubble Space Telescope	MCSA	- Mir Cooperative Solar Array
HTS	- Hawaii Tracking Station (AFSCN)	MDM	- Multiplexer/Demultiplexer
http	- Hyper Text Transfer Protocol	MECO	- Main Engine Cut Off
HTV	- H-II Transfer Vehicle	MET	- Mission Elapse Time

ACRONYMS

MFD	- Payload
MGMT	- Management
MHZ	- Megahertz
MILA	- Merritt Island
MO&DSD	- Mission Operations and Data Systems Directorate
MOA	- Memorandum of Agreement
MOC	- Mission Operations Center
MOU	- Memorandum of Understanding
MPLM	- Mini Pressurized Logistics Module
MSFC	- Marshall Space Flight Center
MSFN	- Manned Space Flight Network
MS	- Mission Specialist
NASA	- National Aeronautics and Space Administration
NASDA	- National Space Development Agency
NCC	- Network Control Center
NGS	- Next Generation System
NHS	- New Hampshire - RTS Station
NISN	- NASA Integrated Services Network
NMOS	- Network Mgmt and Operations Support
NOIG	- Network Operations Integration Group
OAO	- Payload
OCC	- Operations Control Center
OMS	- Orbiter Maneuvering System
ORD	- Operations Requirements Document
ORR	- Operations Readiness Review
OV	- Orbital Vehicle
PC	- Payload Controller
PDL	- Ponce DeLeon
PDSS	- Payload Data Services System
PHC	- Permanent Human Capability
PLT	- Pilot
PMA	- Pressurized Mating Adapter
POCC	- Payload Operations Control Center
POIC	- Payload Operations Integration Center
PORTCOMM	- Portable Communications
PS	- Payload Specialist
PTP	- Portable Telemetry Processor
QM	- Qualification Model
RCC	- Range Control Center
RF	- Radio Frequency
RSA	- Russian Space Agency
RSS	- Range Safety System
RLV	- Reusable Launch Vehicle
RMS	- Remote Manipulator System
SA	- Single Access
SCA	- Shuttle Carrier Aircraft
SCH	- schedule
SEAS	- System Engineering and Analysis Support
SKAR	- Single Access K-Band Return
SLA	- Service Level Agreement
SM	- Service Module
SN	- Space Network

ACRONYMS

SOMO - Space Operations Management Office
SPDM - Special Purpose Dexterous Manipulator
SPIF - Shuttle/POCC Interface Facility
SPP - Science Power Platform
SRB - Solid Rocket Booster
SSCC - Space Station Control Center
SSME - Space Shuttle Main Engine
SSRMS - Space Station Remote Manipulator System
STADAN - Spacecraft Tacking and Data Acquisition Network
STDN - Spaceflight Tracking Data Network
STS - Space Transportation System
STGT - Second TDRSS Ground Terminal
TAS - Payload
TCS - RTS Station
TDE - TDRS East
TDRS - Tracking Data Relay Satellite
TDRSS - Tracking Data Relay Satellite System
TDS - TDRS Spare
TDW - TDRS West
TDZ - TDRS Zone of Exclusion (TDRS-Z)
TLM - Telemetry
TP - Telemetry Processor
TPS - Telemetry Processing System
TRK - Tracking
TSS - Tethered Satellite System
TT&C - Tracking Telemetry and Command
UDM - Universal Docking Adapter
UK - United Kingdom
ULC - Unpressurized Logistics Carrier
ULCAS - Unpressurized Logistics Carrier Attach System
US - United States
USMP - Payload (Hitchhiker)
USOC - U.S. Science Operations Center
VHF - Very High Frequency
VTS - Vandenberg Tracking Station (AFSCN)
WFF - Wallops Flight Facility
WLP - Wallops Island
WPS - Wallops Island
WR - Western Range
WSC - White Sands Complex
WSGT - White Sands Ground Terminal
WSMR - White Sands Missile Range
ZOE - Zone Of Exclusion