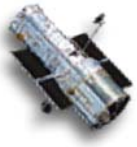
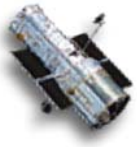


Hubble Robotics Servicing and De-Orbit Mission

Joyce A.K. Pepe/581

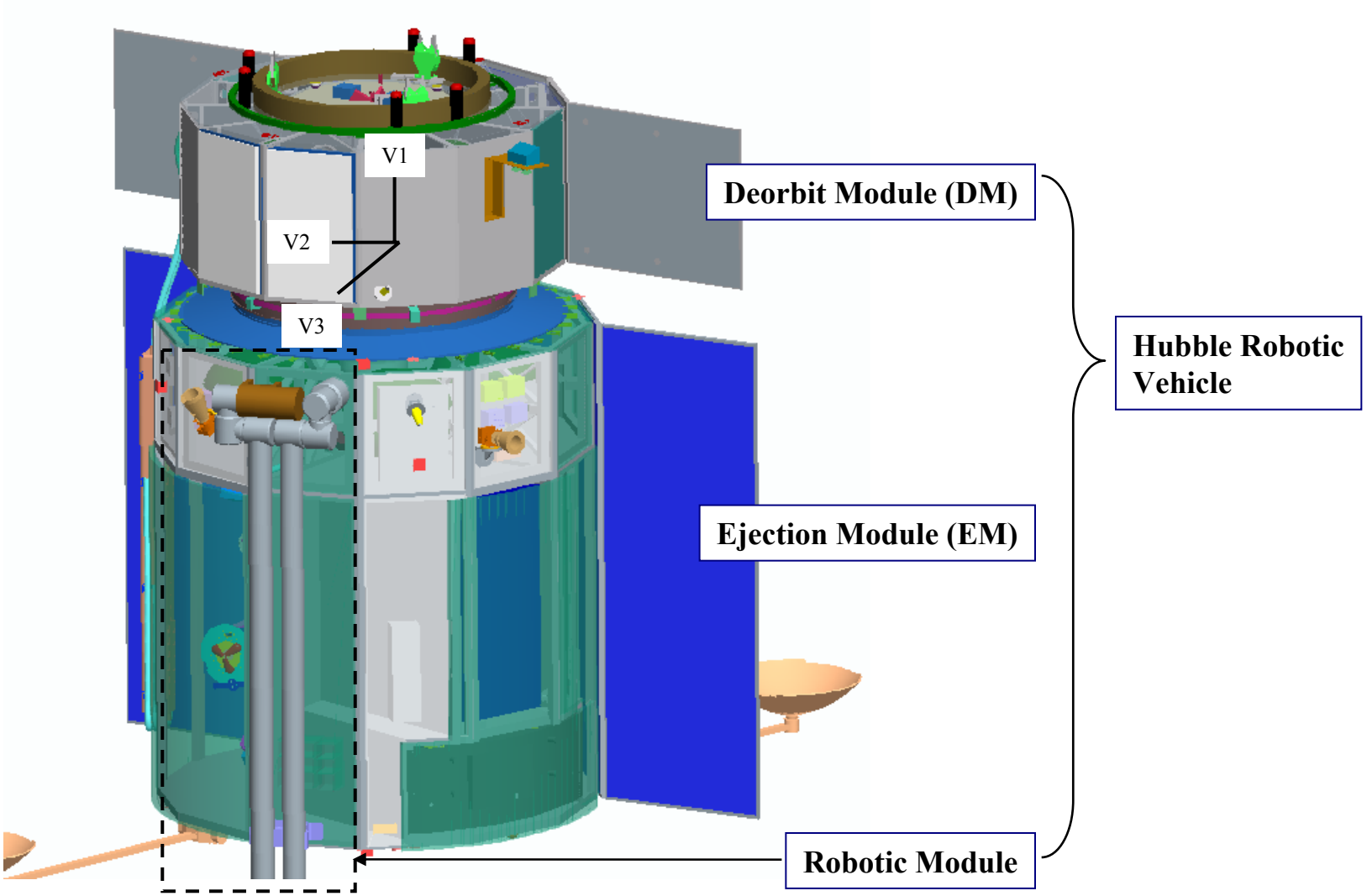
May 26, 2004



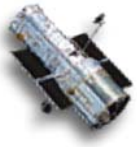
HST Observatory Status

- HST Aging Batteries
  - Battery charge capacity downward trend
  - Manage charge current
  - Lab testing alternatives for re-conditioning
- Gyro Life
  - Require 3 to operate (Gyro 1,2,4) gyro 6 reserve
  - Two Gyro Science mode in development – April 2005

Concept Vehicle Configuration



Concept System Elements



HRV

DM:

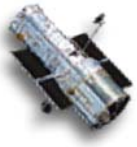
- GN&C for most mission phases
- Primary C&DH
- Direct Docking Mechanism
- Navigation Sensors
- Battery & Gyro Augmentation
- HST Reentry capability

EM:

- Robotic Element accommodations
- GN&C actuation for most mission phases
- SI accommodations
- Controlled reentry capability

Robotic:

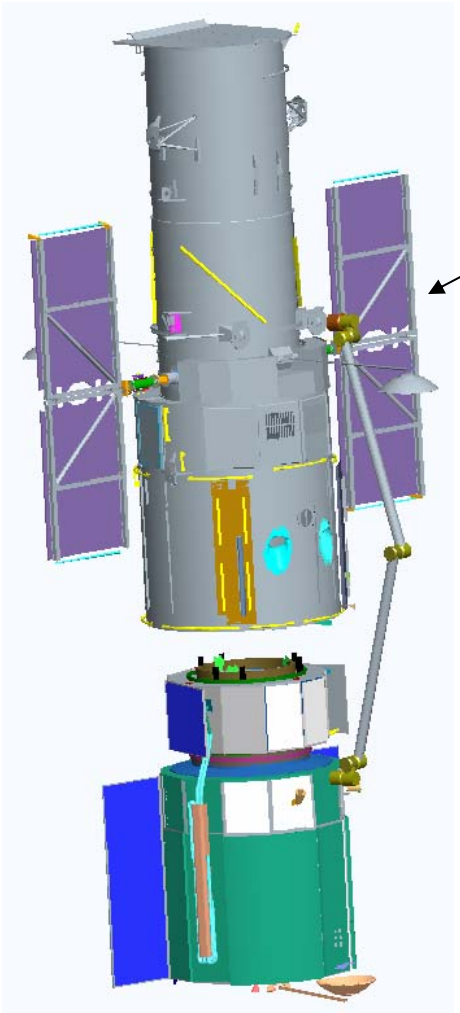
- Grapple Arm w/latching end effector
- Special Purpose Dexterous Manipulator (SPDM)
- Control Processors
- Tools



Hierarchy of HRSMD Requirements

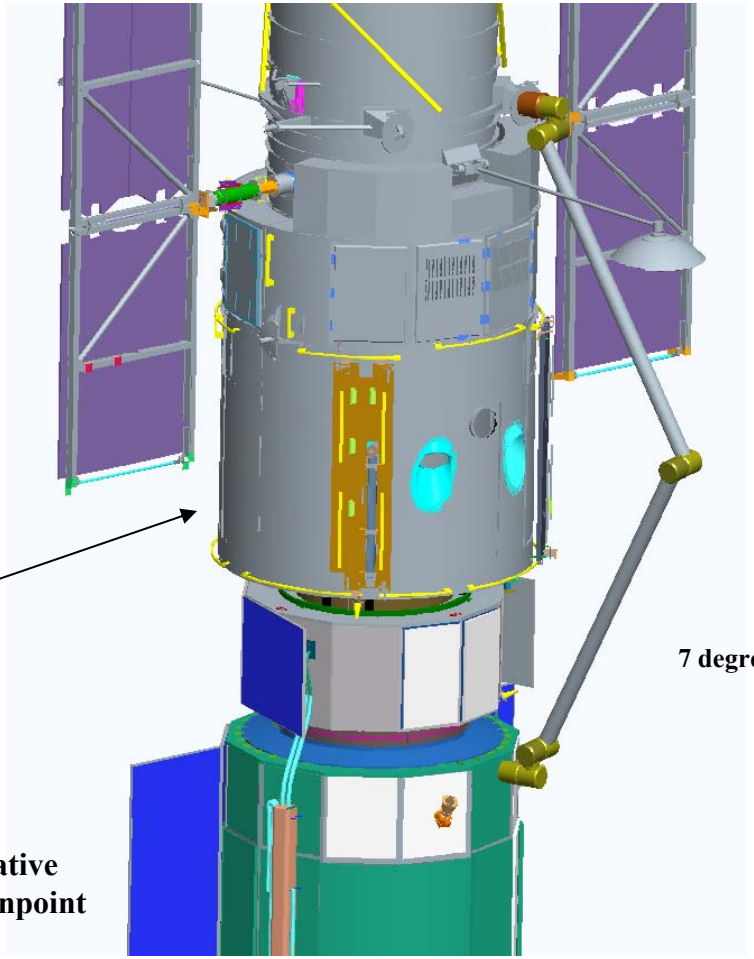
- Provide Propulsion capability to safely de-orbit HST in the future
- Do no harm to HST
- Extend the current scientific program of HST
- Enhance scientific capability with new instruments

HRV Complete
- Approach to Grapple Fixture



Approaching HST Grapple Fixture

-



Grappled and docked to Berthing Pins

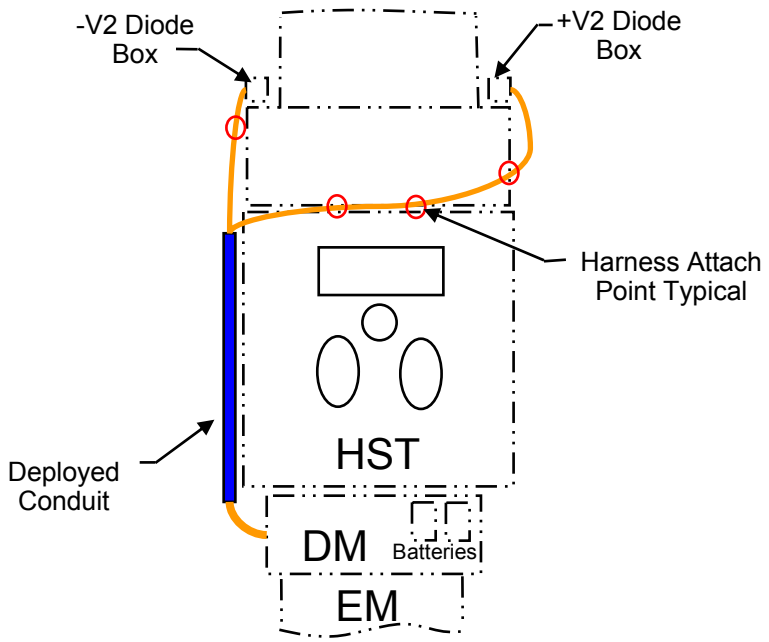
7 degrees freedom

0.22deg/sec uncooperative
SM3A – hardware Sunpoint
0.001deg/sec

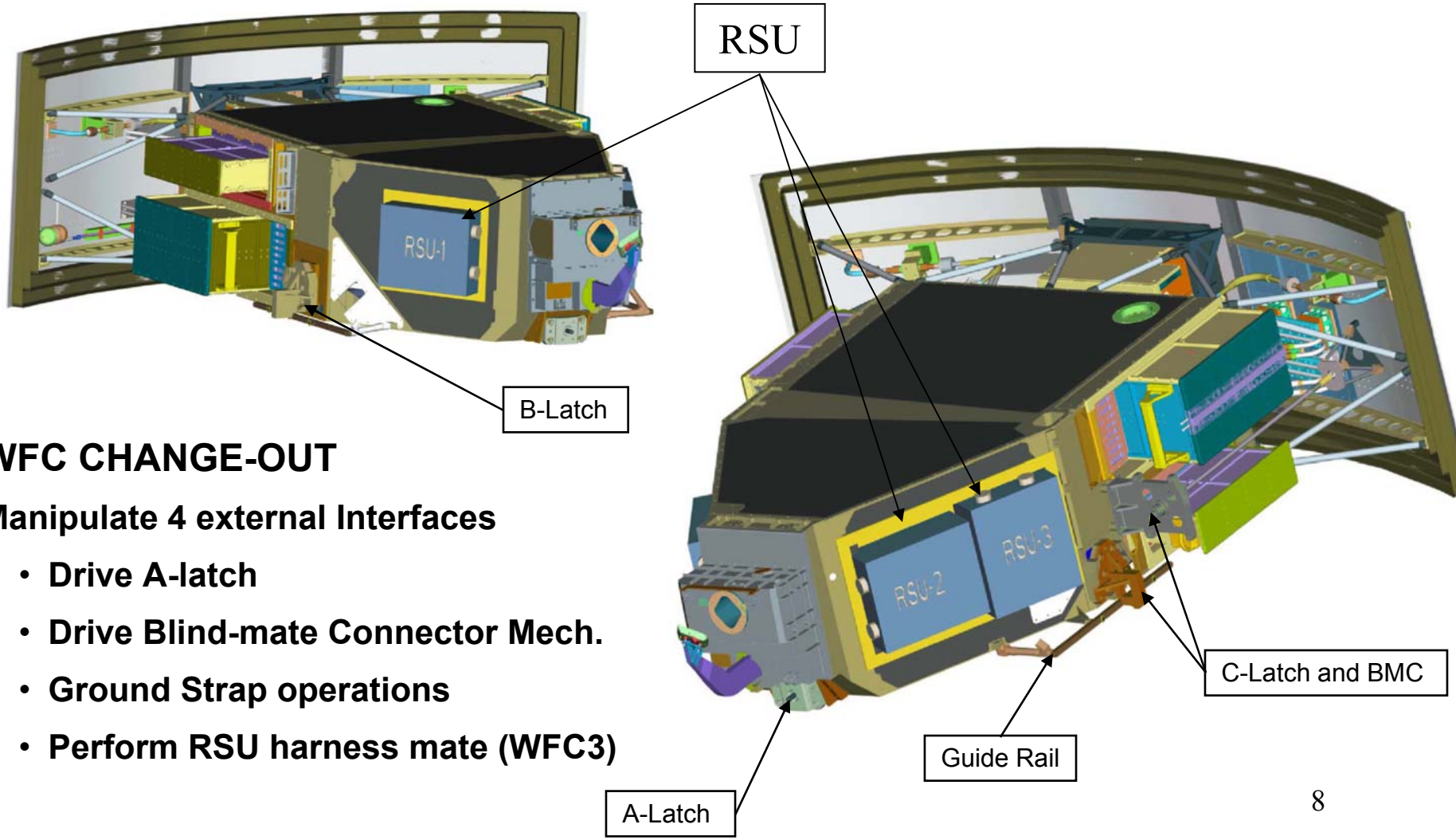
HST SA3 Battery Augmentation

Task Summary

- **Connector Interface plate attachment**
  - **Attach connector interface plate to both the –V2 and +V2 Diode Box Assemblies**
- **Attach harnesses to HST handrails**
  - **Approximately 12 locations identified for harness management**
- **Diode box power connection**
  - **Connect batteries to HST Diode Box Assemblies II (DBA II)**
- **Power cycle through the J101 connection**



WFC3 Overview



WFC CHANGE-OUT

- **Manipulate 4 external Interfaces**
  - **Drive A-latch**
  - **Drive Blind-mate Connector Mech.**
  - **Ground Strap operations**
  - **Perform RSU harness mate (WFC3)**

WFC3 Change-out Tasks

Remove and Stow WF/PC II

- Requires linear retraction from Telescope of 7.5 feet
- Temp Stow on EM

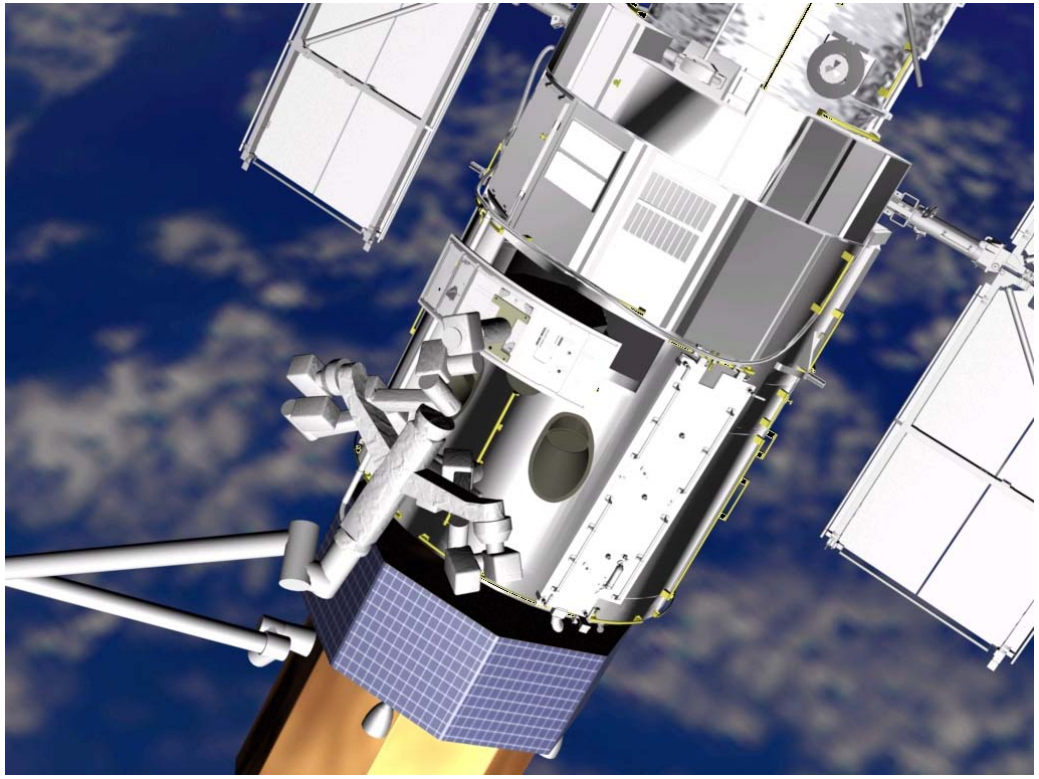
Retrieve WFC3 and begin Translation to HST

- Remove or retract thermal/contamination cover (TBR)
- Release Ground Strap on EM
- Release A-Latch
- WFC3 will have robotics interfaces built in for handling

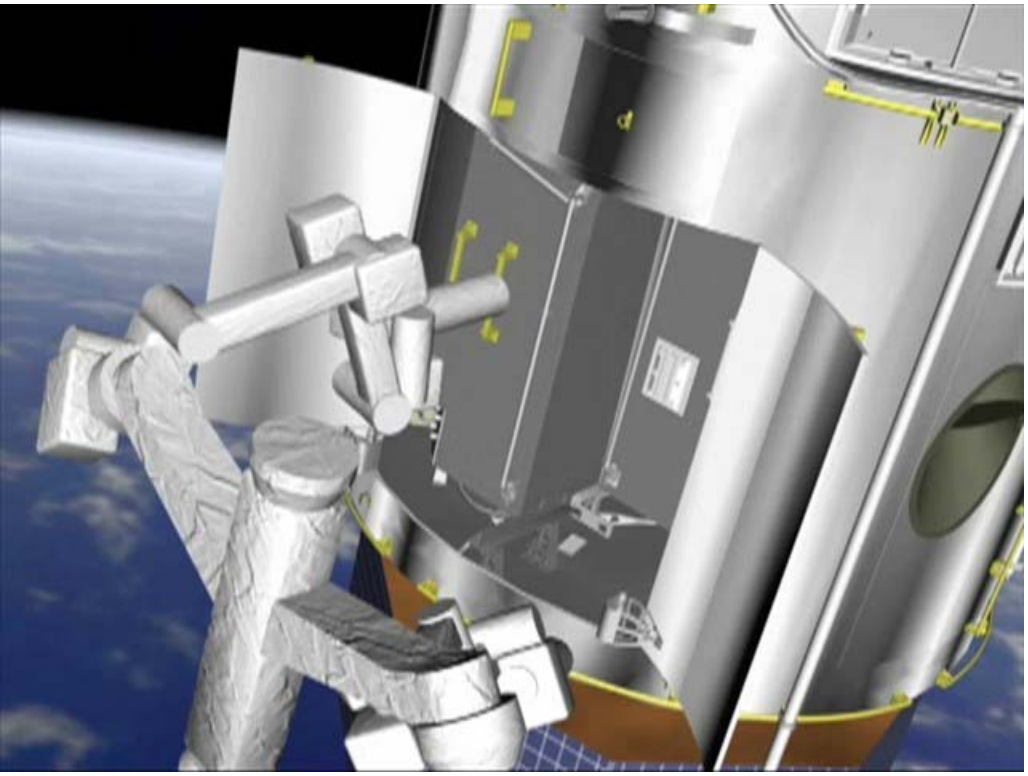
Install WFC3 into Telescope

- May require stabilization via second arm as WFC3 enters HST structure.

  -If stabilization required, camera(s) may be mounted on WFC enclosure for view of guide rails

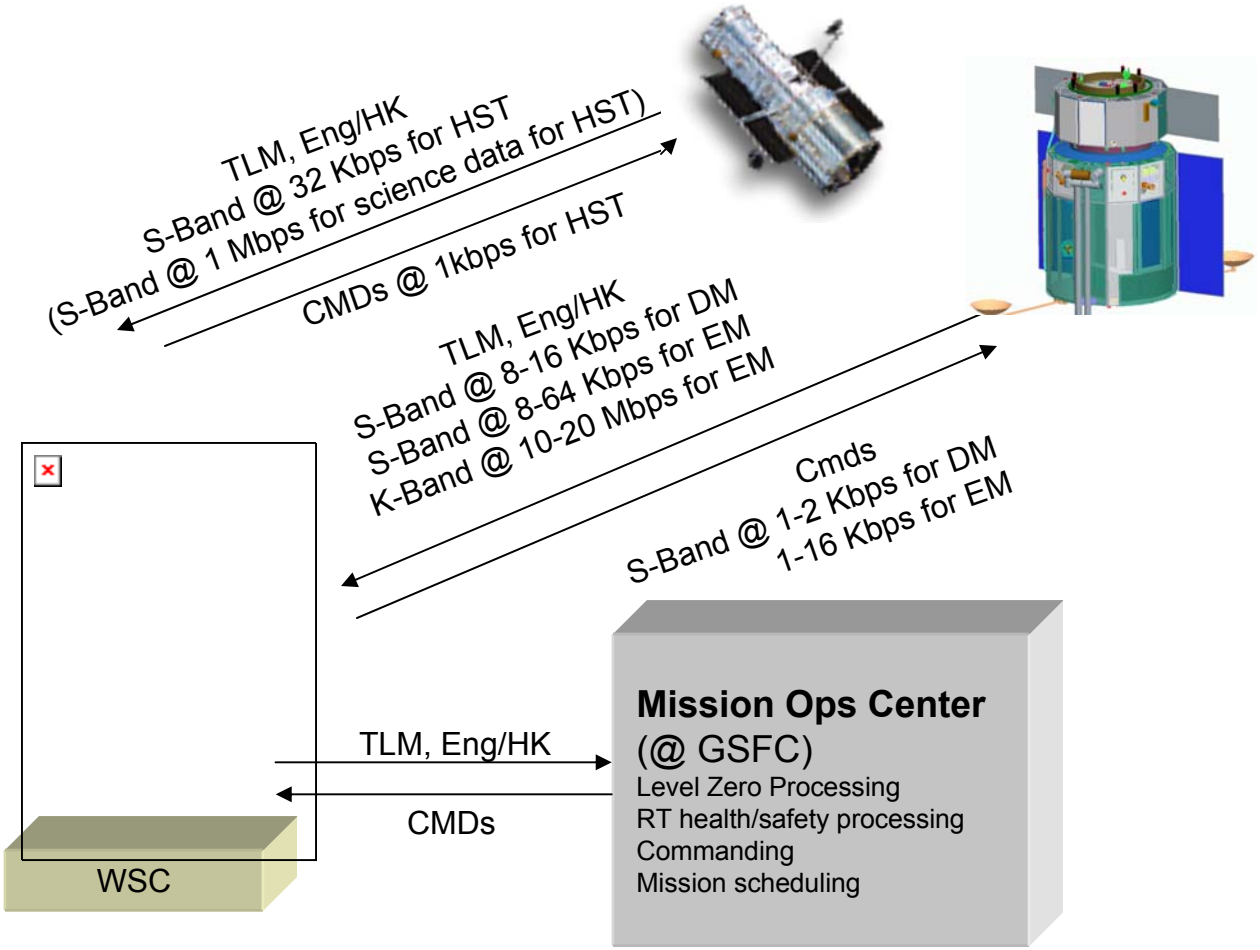


COS change-out Task – Remove COSTAR from Aft Shroud and Insert COS

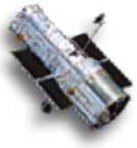


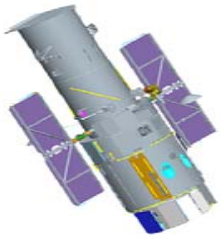
- Open HST –V2 Aft Shroud Doors
- Relocate Costar Y-Harness
- Transfer four harness connectors
- Ground strap operations
- Complete A-latch and B-latch operations
- Removal and Insertion of instruments
- Close HST –V2 Aft Shroud Doors

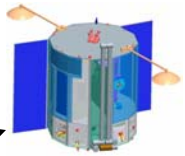
Commanding Overview (Prior EM Separation)



Commanding Overview (Post EM Separation)







TLM, Eng/HK
S-Band @ 32 Kbps for HST
(S-Band @ 1 Mbps for science data for HST)
S-Band @ 8-16 Kbps for DM

CMDs @ 1Kbps for HST
1-2 Kbps for DM

TLM, Eng/HK
S-Band @8-64 Kbps for EM
K-Band @ 10-20 for EM

CMDs @ 1-6 Kbps for EM

WSC

TLM, Eng/HK

CMDs

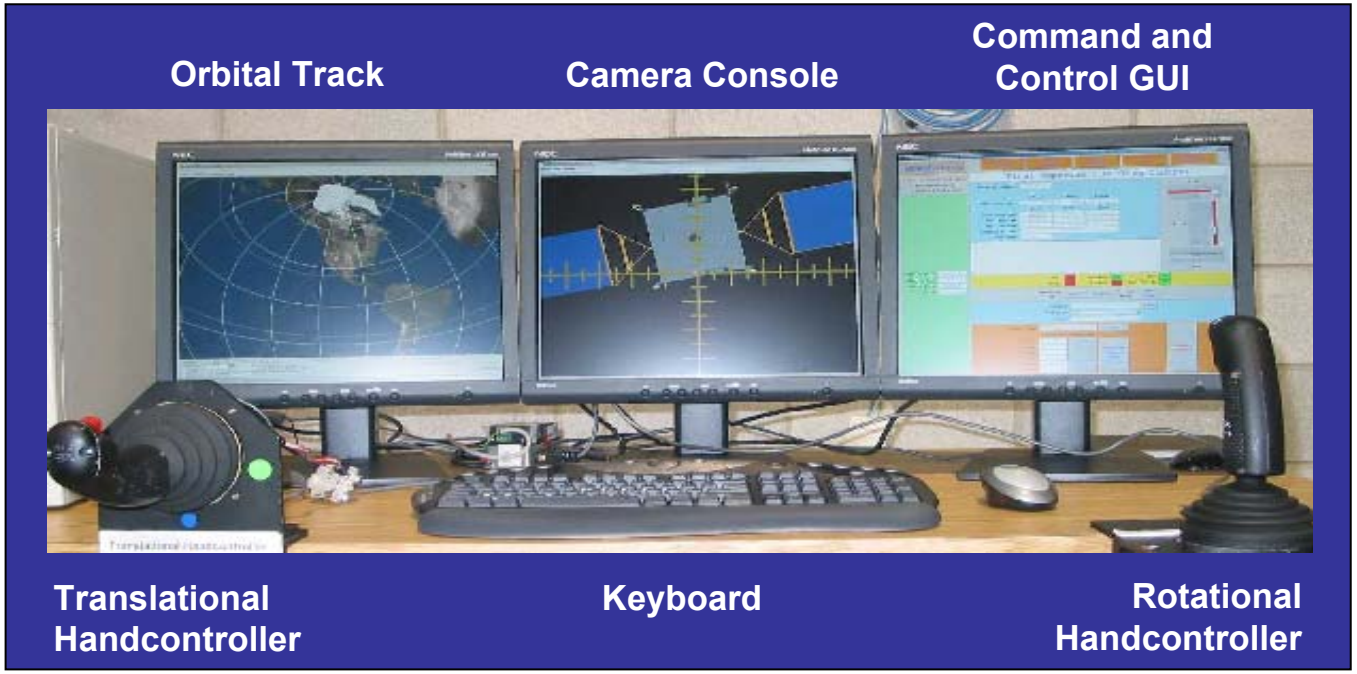
Mission Ops Center
(@ GSFC)
Level Zero Processing
RT health/safety processing
Commanding
Mission scheduling

Ground System

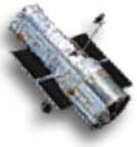
- HST personnel use the CCS ground system for all standard spacecraft activities
  - Telemetry, command, archiving, trending, etc.
  - System has supported successfully supported SM3A and SM3B and has been used operationally since 1999.
- HRV ground system will not be restricted to using CCS
  - Telemetry must be easily fed from the DM system into CCS and commands must be easily sent from a CCS system through the DM system.
- System must be adaptable to Application Program Interfaces (API)
  - API will allow existing CCS to interface
- Final Requirements for the HRV ground system are being developed
- HRV ground system will have unique requirements that differ from CCS
  - E.g., process video telemetry, encryption of command
- Similarly, workstations for the robotic modules will be integrated into the HRV ground system

SPDM Ground Segment

- Displays on-orbit video and telemetry
- Command generation for automatic tasks
- Hand controller inputs for teleoperations
- Vision processing functions for servicing tasks

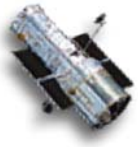


Timeline



Phase	Duration*	Phase Begins	Phase Ends	Highlights
Launch	2 hours	Launch	HRV Separation from Stage II	Launch, Stage 1 Ignition/sep, Stage II ignition/sep, HRV sep
Pursuit	2-12 days	HRV Separation from Stage II	Relative Navigation solutions achieved (~ 5 km from HST)	HRV orbit determination, HRV checkout, Orbit adjust burns
Proximity Operations	1-2 days	(~ 5 km from HST)	HRV "stops" 7 m (TBD) from HST and maintains relative translational and rotational states	Enter safety ellipse (< 1 km from HST), Survey HST, HST and HRV preparations for capture
Capture	2 hours	HRV "stops" 7 m (TBD) from HST and maintains relative translational and rotational states	HRV Captures and Docks to HST	Deploy robot arm, grapple HST, Position HST in berthing latches, Umbilical mate between HST and HRV
Servicing	30 days	HRV Captures and Docks to HST	EM jettison	Battery Augmentation, Install WFC3/RSU, Install COS
EM Jettison & Disposal	4 days	EM jettison	Perform 3 orbit adjusts to reenter EM	Release from DM, Perform evasive Maneuvers, Perform 3 deorbit burns, Impact
Science Operations	5 years +	EM Jettison	Configure and verify HST/DM ready for deorbit	Nominal HST Operations
Deorbit	4 days	Configure and verify HST/DM ready for deorbit	Perform 3 orbit adjusts to reenter HST/DM	Perform 3 deorbit burns, Impact

*** All times are TBD**



Back up Charts

GODDARD SPACE FLIGHT CENTER

APPVL RESP: _____

ACCOMP RESP: _____

HUBBLE SPACE TELESCOPE DEVELOPMENT PROJECT

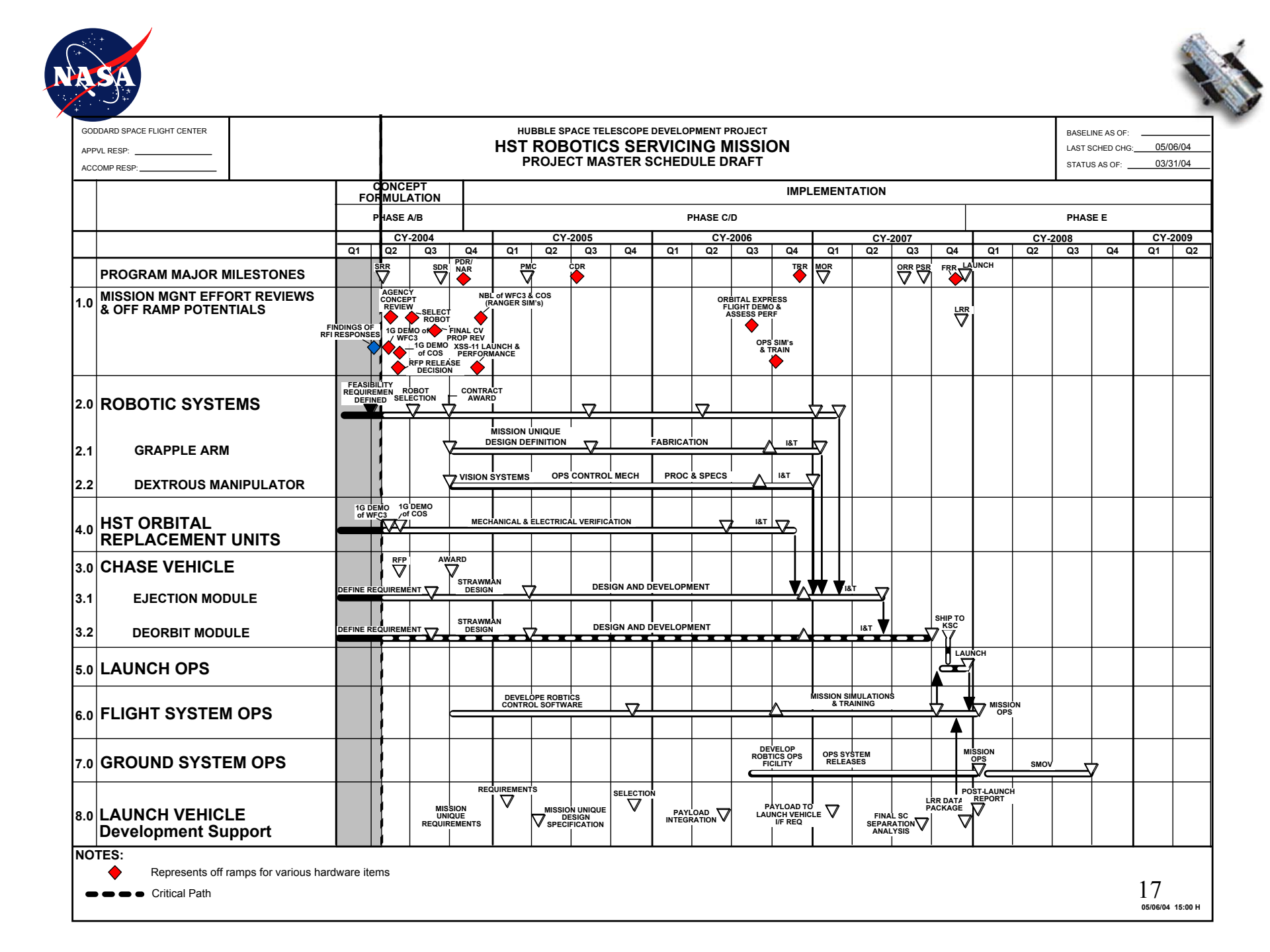
HST ROBOTICS SERVICING MISSION

PROJECT MASTER SCHEDULE DRAFT

BASELINE AS OF: _____

LAST SCHED CHG: 05/06/04

STATUS AS OF: 03/31/04

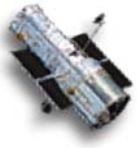


NOTES:

◆ Represents off ramps for various hardware items

Critical Path

Docking Interfaces - Attachment to HST



- Aft Shroud Bulkhead provides three berthing pins for attachment of the robotic vehicle to HST and access to HST's electrical power umbilical J101
- Direct approach by robotic vehicle for docking with Aft Shroud Bulkhead requires highly precise co-planar and rotational alignment to successfully grasp existing interfaces
- Trade studies indicate that the Aft Shroud Bulkhead is the most suitable location for attaching the robotic de-orbit/servicing vehicle

HST's Aft Bulkhead Showing the Three "Towel Bars" and the Electrical Umbilical (Pre-SM3B)

Aft Shroud Bulkhead - Post SM3B

Similar SM connection for power to J101