

PROGRAM INTEGRATION



SPACE SHUTTLE PROGRAM
Space Shuttle Program Integration
NASA Johnson Space Center, Houston, Texas



STS-103 Flight Readiness Review

November 19, 1999



Agenda

Presenter

Date 11/19/99

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- • **Program Integration - Flight Manager**
 - **Payload Topics**
 - **Hubble Space Telescope Status**
 - **Orbital Debris Status**
 - **Payload In-Flight Anomalies ***
 - **STS-82 External Airlock Venting Resolution**
 - **Payload & System Safety ***
 - **Launch Commit Criteria ***
 - **Mission Director Summary**
- **USA Program Integration**
 - **Systems and Cargo Integration Flight Preparation**
- **BNA-RSS Integration**
 - **Program Anomalies**
 - **Waivers to Vol X**
- **System Integration TMR**
- **Flight Readiness Statement**

Denny Holt

John Campbell

Bob White

- **No Issues**

- **No Issues**

Rod Wallace

* **Backup Material Included**



Payload Topics

Presenter **J. D. Holt**

Date **11/19/99**

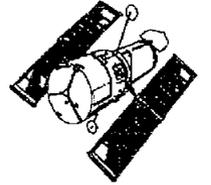
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- **With RSU 1 Failure There Is Open Work To Ensure Successful Capture and Berthing**

- **HST Project Report**
 - **Health of Space Telescope**
 - **Controllability at capture**
 - **Hardware Sun Point**
 - **Zero Gyro Sun Point**
 - **Actions being taken**
 - **Additional evaluation and testing**
 - **Additional training**
 - **Results of RSU 1 Failure Review Board**



HUBBLE SPACE TELESCOPE PROJECT



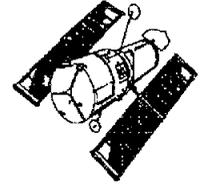
HST PROJECT SPECIAL TOPICS

John H. Campbell

Goddard Space Flight Center



HUBBLE SPACE TELESCOPE PROJECT



SPECIAL TOPICS

Effect of most-recent gyro failure on:

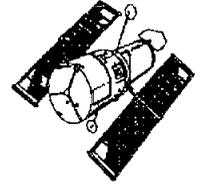
1. Rendezvous and Grapple

2. EVA Timeline



HUBBLE SPACE TELESCOPE PROJECT

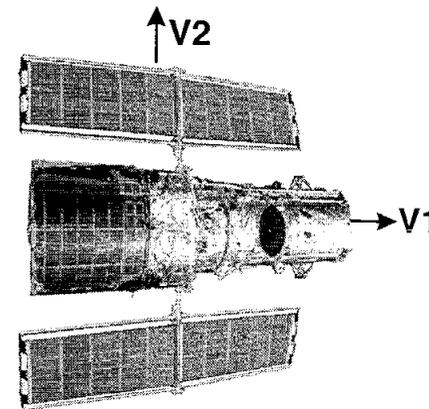
RENDEZVOUS AND GRAPPLE



Two control modes available (solar arrays are fixed and aligned along the length of the telescope):

1. Primary mode: Hardware Sun Point Safemode (aka PSEA) using dedicated mechanical gyros (aka RMGA)

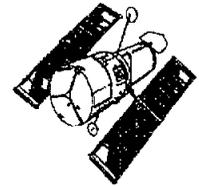
- Controlled by safemode computer
- Orbit Day: Controlled by reaction wheels. Coarse sun sensors used to keep the arrays pointed to the sun, mechanical gyros used to damp rotation rates about all 3 axes
- Less than 6 degrees off-axis angles after sun capture
 - Rates of 7 degrees/hour about all 3 axes
- Orbit Night: Controlled by reaction wheels. Mechanical gyros used to damp rotation rates about all 3 axes
 - Rates of 7 degrees/hour about all 3 axes





HUBBLE SPACE TELESCOPE PROJECT

TWO CONTROL MODES AVAILABLE (CONT.)



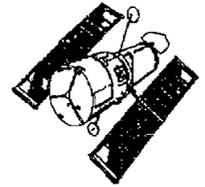
2. Back-up mode: Zero-Gyro Sun Point Safemode

- Controlled by on-board central computer
- Orbit Day:
 - Controlled by reaction wheels. Coarse sun sensors used to keep the arrays pointed to the sun, magnetometers sense earth's magnetic field to damp rotation about sun-line (V3)
 - Less than 6 degrees off-axis angles (V1 and V2) after sun capture
 - 2 revolutions per orbit or less about V3 axis.
- Orbit Night:
 - No control
 - Nominal drift from sun point less than 30 degrees on entry to orbit day
 - Rate while capturing sun at beginning of orbit day: up to 9 degrees per minute



HUBBLE SPACE TELESCOPE PROJECT

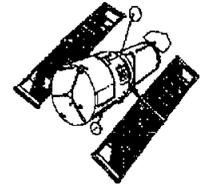
STATUS AND EXPERIENCE



- **Hubble currently in Zero-Gyro Sun Point Safemode, preferred over Hardware Sun Point Safemode**
 1. **A failure in Zero-Gyro will cause an autonomous transition to Hardware Sun Point but not vice versa**
 2. **The Hardware Sun Point mechanical gyros have a limited life: specification life of 1 year, 1/3 of which has been used**
- **On-orbit Experience:**
 1. **Many days using Zero-Gyro Sun Point Safemode**
 - excursions of 60 to 80 degrees (instead of 30 degrees) approximately once per day
 - Not yet predictable and avoidable
 2. **Hardware Sun Point Safemode using dedicated mechanical gyros**
 - Many days of hardware sunpoint using standard gyros, but not with the mechanical gyros



HUBBLE SPACE TELESCOPE PROJECT

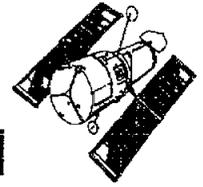


OPEN WORK

- **On-orbit test of Hardware Sun Point Safemode planned for week of November 22**
- **Rendezvous and Grapple simulation planned for week of November 29**
- **Development of contingencies for a failed mechanical gyro leading up to grapple. To be completed week of November 29.**



HUBBLE SPACE TELESCOPE PROJECT



EFFECT OF MOST-RECENT GYRO FAILURE ON EVA TIMELINE

Has the gyro in the Rate Sensor Unit (planned to be changed) failed?

-or-

Has a different black box called the Electronics Control Unit (not planned to be changed) failed?

- Failure Review Board in process: “Determine whether the failure is most likely in the RSU, ECU or some other source”

Results

- FRB has not yet exonerated the ECU with 100% certainty

Open work: Carry a 2nd ECU in the mid-deck

Open work: Complete FRB by November 24

- Potential Action: Replace ECU before powering gyro #1 (OK to power 2nd gyro in RSU)
 - OK to install ECU after 2nd EVA day according to crew preference



STS-82 External Airlock Venting Resolution

Presenter **J. D. Holt**

Date **11/19/99**

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- **HST Solar Array Slew Occurred During External Airlock Depress During STS-82**
 - Two sources of airlock gas can impinge on the arrays
 - Airlock venting during depress
 - Hatch opening gas surge
- **Venting Requirements**
 - Analysis determined maximum allowable vent rate of 100 lbs/hr based on HST defined requirements for:
 - Maximum average pressure over each solar array panel
 - Maximum allowable torque about the mast
- **SSP Corrective Actions Taken**
 - Airlock modifications to control depress rate
 - Airlock vent cap modified to reduce flow rate
 - Airlock vent duct "T" fitting was removed
 - Airlock depress procedures modified to prevent hatch opening gas surge
- **No Issues Expected For STS-103**



STS-103 Orbital Debris Status

Presenter **J. D. Holt**

Date **11/19/99**

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- **Orbital Debris / Micrometeoroid Risk Is Acceptable**

<u>Criteria</u>	<u>Risk</u>	<u>Guideline</u>
Critical Penetration	1 in 761	1 in 200
Radiator Tube Penetration	1 in 60	1 in 60
Window Replacements	0.674	N/A



Payload and System Safety

Presenter **J. D. Holt**

Date **11/19/99**

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- **Integrated Hazards Assessment Is Complete**
- **Payload Environmental Impact Assessment Complete**
- **Toxicology Process**
 - **Verification 1: Complete**
 - **Verification 2: Standard Open Work For Late Load Items**
- **Payload Safety Review Process Is Complete**



Payload and System Safety

Presenter **J. D. Holt**

Date **11/19/99**

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- **Two Non-Compliance Reports (NCR's) Are Approved**
 - **HST inadvertent RF radiation during unplanned contingencies may exceed allowable ICD limits**
 - **HST High Gain Antennas (HGA's) are not two fault tolerant to creating a hazard**
 - **HGA's would have to be pointing at the Orbiter**
 - **HGA's would have to fail on - single failure**
 - **Rationale for PRCB approval**
 - **HST HGA's are turned off during Servicing missions**
 - **Exception - SSA checkout requires power briefly**
 - **HGA's are managed to avoid pointing at the Orbiter during nominal operations**
 - **Flight Rules will not allow the HGA's to point at the Orbiter during contingency operations**
 - **EMI analysis of the HST-SM3A RF shows the radiation levels are acceptable**



Payload and System Safety

Presenter	J. D. Holt	
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- **Two Non-Compliance Reports (NCR's) Are Approved (cont'd)**
 - **EVA connectors are not two fault tolerant for hat mate / demate**
 - **During scheduled EVA's, some cable connectors are not two fault tolerant to creating a hazard while mating or demating**
 - **Voltage Interface Kit (VIK) installation - new for STS-103**
 - **Solid State Recorder (SSP) replacement - performed on STS-82**
 - **Rationale for acceptance**
 - **Downstream loads minimized**
 - **Connector design prevents pin damage (scoop proof connectors)**
 - **PRCB approved NCR for two scheduled tasks and four contingency tasks**



Launch Commit Criteria for STS-103

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- **Update to Aft Compartment Hydrogen Limits**
 - To be presented by Shuttle Processing
- **Updates for the Advanced ADTA**
 - Documents the new Air Data Transducer Assembly (ADTA) hardware flying initially on STS-103
- **Firex Loop & Tank T-3 Pressure Anomaly Update**
 - Updates the Ground Support Equipment LCC to reflect current configuration of the Firex System for Launch Pad A and B



Launch Commit Criteria for STS-103

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- **Single String Engine Ready Changes**
 - To be presented by SSME
- **Single String Purge and Ancillary Changes**
 - To be presented by SSME
- **Cold SSME GN2 Purge LCC Impact**
 - To be presented by SSME
- **Reference Junction Temperature Deletion**
 - To be presented by RSRM



STS-103 Mission Director Summary

Presenter **J. D. Holt**

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- **HST SM-3A Objectives**
 - Replace failed gyroscopes
 - Restore original capability, make life-extending changes, and improve productivity
- **Rapid Response Based Upon**
 - Maximum reuse of STS-82 Orbiter (OV-103) and, engineering and operations products
 - Experienced crew
 - EVA crew already assigned - EVA tasks well-defined
 - Meeting schedule commitments
- **Thorough Preparations and Well-Supported Reviews**
 - HST SM-3A engineering changes made schedule
 - HST hardware deliveries made schedule
 - Flight operations planned and trained for
 - Additional failures, e.g. - the zero gyro option
 - A range of EVA scenarios



STS-103 Mission Director Summary

Presenter **J. D. Holt**

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- **Re-evaluation of the Effects of the RGA1 Failure**
 - Responded to actual HST performance in zero gyro
 - Failure scenarios worked
 - New capability added - aft flight deck command
 - Testing and training added
 - Primary option for gyro failure held up under scrutiny
 - Additional failures better understood

- **Well Established Lessons Learned Process Followed**
 - Reviewed recommendations through STS-103 IPT
 - Closure documented in Letter on September 23, 1999

- **External Independent Readiness Review Team Oversight**

- **GSFC / JSC / KSC / HQ Team**
 - Excellent corporate memory - good anticipation
 - Excellent motivation - good follow through
 - Excellent communications



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- Denny Holt**
- John Campbell**
- Bob White**
- **No Issues**
 - **No Issues**
- Rod Wallace**

* Backup Material Included

<h1>STS-103 ASCENT VERIFICATION CRITERIA</h1>	Presenter: Bob White
	Organization/Date: Program Integ/11-19-99

STS-103 Operations Are Within Certified Limits

CRITERIA	CERTIFICATION BOUNDARIES	STS-103 CRITERIA	ACCEPTABILITY
INCLINATION	28.45 - 57 DEG	28.45 DEG	YES
SRB BURN RATE AT 70° (L-R) DELTA	.3655 TO .3755 ips +/- .0026 ips	L/R .3699 / .3697 ips +/- .0002 ips	YES YES
PMBT	DEC: 54° TO 77°	69°	YES
LIFTOFF WEIGHT SLWT	SLWT: MIN - 4,485,322 LB MAX - 4,540,322 LB	4,506,880 LB	YES
THROTTLE BUCKET	104% / 67% / 104% 104% / 72% / 104% 104.5% / 67% / 104.5% * 104.5% / 72% / 104.5% * 106% / 72% / 106% **	104.5% / 67% / 104.5%	YES
DYNAMIC PRESSURE	SUMMER / WINTER LOW Q SUMMER / WINTER HIGH Q	WINTER / LOW Q	YES
Hdot TARGET	2100 OR 2200 FPS	2100 FPS	YES
ELEVON SCHEDULE	DOLILU II / PE	DOLILU II / PE	YES
LAUNCH WINDOW FOR RENDEZVOUS	-5 TO +5 MIN FOR 51.6 DEG INCL OR EQUIV. BETA FOR OTHER INCL	WITHIN CERTIFIED BETA ENVELOPE	YES
DADS INPUTS	NSTS 08209 VOL IV APPENDIX B	NSTS 08209 VOL IV APPENDIX B	YES

* For Block IIA Engines with 104% Commanded Throttle, SSME Controller Bias Produces 104.5% Equivalent Thrust

** 106% Thrust Available For Block II SSME's Only

SYSTEMS AND CARGO INTEGRATION ANALYSES	Presenter: Bob White
	Organization/Date: Program Integ/11-19-99

- Generically Certified Systems Requirements Have Been Evaluated for STS-103 Applicability - No Issues
- Mission Specific Systems and Cargo Integration Analyses Have Been Completed Except for Standard Planned Work - No Issues
- Supported the Testing and Verification of Block Update 99.01 for DOSS - No Issues
 - All ISVT and L-3 Week Testing Were Satisfactorily Performed From Huntington Beach
 - Standard Planned Work - L-2 Day Verification Testing

SYSTEMS AND CARGO INTEGRATION ANALYSES (CONT'D)	Presenter: Bob White
	Organization/Date: Program Integ/11-19-99

- Payload Integration Hardware Reconfiguration and Interface Verification Tests (IVT's) Have Been Completed Except for Standard Planned Work - No Issues
- STS-103 Flight Elements and Cargo Configuration Requirements Have Been Documented and Released in Engineering Drawings - No Issues



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- Flight Readiness Statement

Denny Holt

John Campbell

Bob White

- No Issues

- No Issues

Rod Wallace

* Backup Material Included



**STS-103 NASA System Integration TMR
Flight Readiness**

Presenter	R. Wallace	
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- **Insight, Audit and Surveillance Requirements Complete**
- **No Out-of-Family Problems Have Been Identified for Impact to Safety of Flight, or Planned Flight Operations**
- **Approved Program Requirements Changes Have Been Implemented and Verified**
 - ICD, OMRS, LCC
 - Vehicle Configuration
 - DOSS Configuration
 - NSTS 07700, Volume X
- **System Integration Is Ready for Flight Pending the Completion of Remaining Open Work**



STS-103 Flight Readiness Statement

Presenter

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**THIS CERTIFIES THAT ALL MISSION REQUIREMENTS HAVE BEEN MET AND
 SPACE SHUTTLE INTEGRATION IS READY FOR FLIGHT, PENDING COMPLETION
 OF THE DEFINED OPEN WORK**

Don Hal

**L. D. AUSTIN, JR., MANAGER
 SPACE SHUTTLE SYSTEMS INTEGRATION**

William J. Moon

**R. M. SWALIN, MANAGER
 SPACE SHUTTLE CUSTOMER AND
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 SPACE SHUTTLE KSC INTEGRATION**

John D. Holt

**J. D. HOLT, FLIGHT MANAGER
 SPACE SHUTTLE PROGRAM INTEGRATION**



SPACE SHUTTLE PROGRAM
Space Shuttle Program Integration
NASA Johnson Space Center, Houston, Texas



STS-103 Flight Readiness Review

Backup Charts



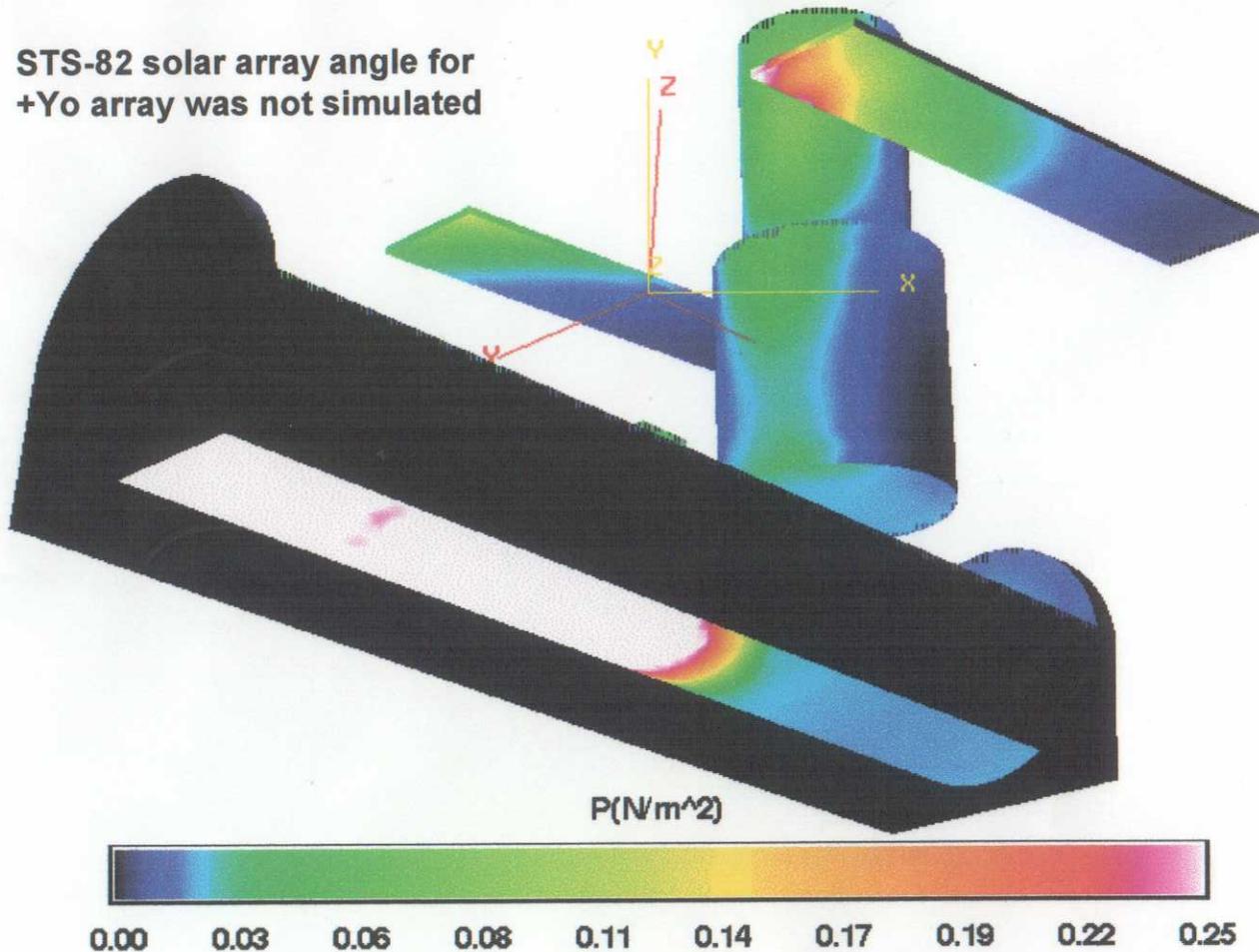
STS-82 1st EVA ODS Venting P Environment (-Yo Array)

Presenter J. D. Holt

Date 11/19/99

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STS-82 solar array angle for +Yo array was not simulated



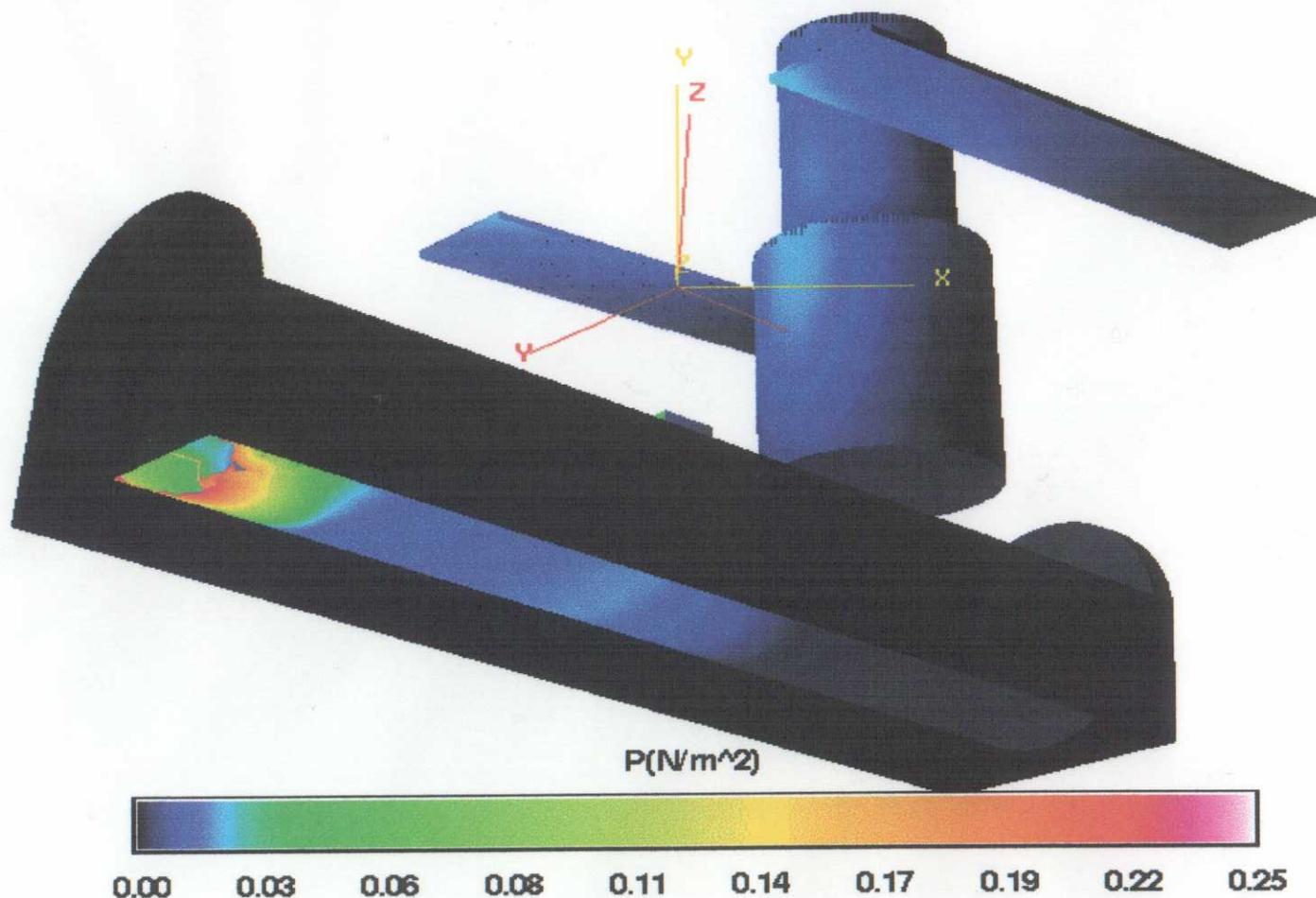


Predicted ODS Venting Pressure Environment For STS-103

Presenter J. D. Holt

Date 11/19/99

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Closed Payload In-Flight Anomalies Affecting STS-103

Presenter **J. D. Holt**

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- **Hubble Space Telescope (HST) +V2 Solar Array Rapid Slew During Airlock Depress (STS-82-P-01)**
 - The HST solar arrays underwent a rapid and unexpected slew while airlock was being depressed
 - Crew reported the array had slewed from 0 deg position to nearly -90 deg position in approx 5 seconds
 - Slew resulted in Solar Array (SA) rebounding from the rotation hard stop, precipitating a second slew in the plus direction at about the same speed
 - Start of airlock depress and start of slew coincided within 1 second
 - Preliminary cause of slew was that contents of airlock were evacuated in such a way as to impinge on the +V2 SA with sufficient force to displace it
 - The second slew occurred when SA recoiled off a hard stop in the SA mechanism
 - A second airlock depress was initiated at a much slower initial rate (less than 80 lb/hr vs 475 lb/hr)
 - At the slower rate, no anomalous SA dynamics were observed



Closed Payload In-Flight Anomalies Affecting STS-103

Presenter **J. D. Holt**

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- **Hubble Space Telescope (HST) +V2 Solar Array Rapid Slew During Airlock Depress (STS-82-P-01) (cont'd)**
 - The unexpected slew caused the start of the EVA to be delayed approx 1 orbit
 - Airlock depress from 5 psi to 0 psi was accomplished by using the aft hatch manual pressure equalization valves (MPEV) instead of the airlock depress valve
 - Analysis indicated HST bistreams were deflected 22 in maximum during initial event
 - Subsequent EVA's will be performed by a revised procedure using the aft hatch MPEV's for depress for duration of HST Servicing Mission
 - Revised procedure limits depress flow to 80 lbm/hr or less
 - Lower airlock depress rates will be used on all future HST missions to preclude the Solar Array rapid slewing



Closed Payload In-Flight Anomalies Affecting STS-103

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- **Translation Aid (TA) Clearance for Payload Bay Door Envelope (STS-82-P-02)**
 - During EVA 5, HST customer expressed a clearance uncertainty regarding the retracted translation aids and the payload bay doors when closed
 - EVA Checklist states on both the Daily Closeout and the Final Closeout that TA's are to be retracted to a partially stowed configuration
 - This configuration was based upon preflight agreement and analysis by GSFC
 - GSFC personnel expressed concern in real-time during the Final Closeout activity that the TA's may exceed the payload bay door envelope unless retracted and fully stowed
 - Crew positioned TA's within the PLBD envelope and position was verified via review of downlink TV
 - TA configuration in the Orbiter will be reviewed to determine if the partially stowed configuration is sufficient and update procedures in accordance



Closed Payload In-Flight Anomalies Affecting STS-103

Presenter **J. D. Holt**

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- **Bent Pin on Solar Array Drive Electronics (SADE)-2R Harness (STS-82-P-03)**
 - When attempting to mate SADE-2R P2 harness to HST J2, the crew noticed a bent pin in the corner on the short side
 - Were unable to mate P2 connector
 - All connectors are required for SADE
 - Obtained spare P2 harness and installed successfully



Closed Payload In-Flight Anomalies Affecting STS-103

Presenter **J. D. Holt**

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- **+V2 Aft Shroud Door Latch (STS-82-P-04)**
 - During opening of +V2 aft shroud doors on EVA 1, the bottom latch bolt only backed out 3 1/2 turns (expected 6-8 turns) when door was initially opened
 - Latch was also missing the soft stop feature
 - During door closure the 2nd latch up from bottom would not drive closed with nominal tool setting
 - Neither in position nor out of channel
 - When lowest latch was attempted, it also did not drive
 - Torque setting for Pistol Grip Tool (PGT) was increased to 38 ft-lb to start both fasteners and then reduced to 23 ft-lb
 - Each latch turned without the Multi-Torque Limiter (MTL) slipping
 - Lowest latch only drove 3 1/2 turns
 - The 2nd bolt from the bottom drove nominally



Closed Payload In-Flight Anomalies Affecting STS-103

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- **HST Handrail Paint Loss of Adhesion (STS-82-P-05)**
 - Crew observation and photo and TV surveys showed the Bay A and J HST handrail s have experienced significant loss of paint adhesion
 - As much as 50 percent of the handrail surface exposed
 - Crew also reported periodically the yellow particulates, apparently paint form handrails, transferred to their gloves
 - Paint may become a problem during the third servicing mission
 - No actions were taken to contain loose paint surfaces
 - HST Project will analyze photo documentation of handrails taken during Second Servicing Mission and develop possible work arounds for the Third Servicing Mission



NCR Compliance Summary

Presenter	J. D. Holt	
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Scheduled Tasks	Verifiable Upstream Inhibit	Additional Design Feature	Powered Side Terminated in Sockets	Scoop Proof Connector	First Flight Performed or Scheduled
* VIK	Hot	Yes	No	Yes	STS-103
ESTR / SSR	Hot	Yes	Yes	Yes	STS-82
Unscheduled Tasks					
Essential Bus Harness	Hot	Yes	No	Yes	
* CT Bus Plug	Hot	Yes	Yes	Yes	
Fuse Plug	Hot	Yes	No	Yes	STS-61
ECU	Hot	Yes	Yes	Yes	STS-61

* New Hardware



Launch Commit Criteria for STS-103

Presenter **J. D. Holt**

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- **Maximum Allowable Ground Winds**
- **Minimum Equipment List (MEL) Mission Dependent**
- **Pad Elevator Not at Pad Level**
 - Clarification change to explicitly state pad elevator location requirements
- **DPS Updates for MEDS Flights**
 - Update of multifunction electronic display subsystem LCC's to reflect the Integrated Display Processor (IDP) 4 will be powered up for launch
 - IDP4 requirements are mission specific

SYSTEMS & CARGO INTEGRATION STANDARD PLANNED WORK	Presenter: Bob White
	Organization/Date: Program Integ/11-19-99

- HST-SM3A IVT ECD: 11/19/99
- HST-SM3A End-to-End Test ECD: 11/22/99
- Final Payload Bay walkdown ECD: 11/24/99
- Verification of as-designed vs as-installed TOP's ECD: 12/04/99
- Verify Mods, NSW and Mission Equipment in WAD's for as-built vs as-installed ECD: 12/04/99
- DOSS L-2 day verification test ECD: 12/04/99
- GN&C ATO dump uplink I-load verification ECD: 11/28/99
- GN&C prelaunch configuration and testing to support L-2 day verification testing and launch ECD: 11/29/99
- Closure of Cargo Integrated Risk Assessment Report (CIRAR) tracking log ECD: 11/19/99
- Approval of Annex 1 Deliverable for Payload Weight Log ECD: 11/19/99