

---

# STS-116/12A.1 Year End Roll-over (YERO) Options



**SR3578**

---

November 2, 2006

STS-116/12A.1

DA8/Tony Ceccacci 281-483-0699  
DA8/Norman Knight 281-483-4899  
DA8/Steve Stich 281-483-8038



# Agenda



- **Overview**
- **YERO Feasibility/Support Background**
- **Flight Software Certification Status**
- **Operational Impacts**
  - **Procedures**
    - Ground (MCC/Network) Procedures
    - Onboard Procedures
  - **Flight Rules/LCC**
    - Orbiter Hardware and YERO
    - Flight Rules/LCC
  - **Mission Timeline**
- **YERO Operations Summary**
- **YERO Operations Risks/Concerns**
- **MOD Recommendations**



# Executive Summary



## STS-116 YERO Support

- Shuttle MCC Platform and Orbiter "YERO recycle" have been successful in the limited testing performed to date
- Procedures continue to mature with each test
- Concerns of "unknowns" due to limited testing (no failures introduced during MCC Platform or Orbiter YERO recycle)
- Unknowns could have a major impact to accomplishing the STS-116/12A.1 mission objectives (most challenging assembly flight to date)
- At FOICB MOD recommended YERO should not be used to extend Launch window past 12/17/06
- If program accepts additional risks, recommendation is to use launch dates that have YERO occurring docked (12/23, 24, 25, 26)



# YERO Overview/History



- Integrated shuttle Data Processing System and MCC system not designed for YERO
  - On-board Master Timing Unit (MTU) resets to Day 1, GPC PASS FSW continue to count to Day 366
  - MCC/Network resets to Day 1
  - MCC must remain in synch with ISS which also resets to Day 1
- Historically, Space Shuttle Program has selected launch dates to avoid YERO for these reasons
- However, YERO seriously considered for STS-32 LDEF (Long Duration Exposure Facility) retrieval in late 1989
  - Peak solar cycle and additional on-orbit stay time resulted in high LDEF orbital decay placing retrieval in jeopardy
  - YERO provided option for early retrieval should continued high solar activity lead to early decay
  - STS-32 mission ultimately launched on January 9, 1990 so YERO was not required
- YERO now being considered for STS-116/12A.1 to enhance manifest flexibility
  - YERO recycle required to safely fly missions that span across the New Year



# STS-116/12A.1 Launch Dates and YERO



- STS-116 Launch Window 12/7 – 12/26
  - 12/26 Cutoff based on  $\beta > 60$  at undocking
- 12/18 – 12/26 Launch dates require YERO recovery at some point in the mission
  - 12+2 Mission duration evaluated



# Launch Date and YERO

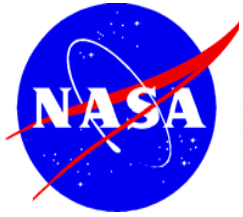


11 days (7 docked)	FD 1 launch	FD 2	FD 3 rndz	FD 4 EVA 1	FD 5 foc insp?	FD 6 EVA 2	FD 7 FD 7	FD 8 EVA 3	FD 9 EVA 4?	FD 10 undock	FD 11 undock	FD 12 deorbit	EOM+1	EOM+2	
12 days (8 docked)	FD 1 launch	FD 2	FD 3 rndz	FD 4 EVA 1	FD 5 foc insp?	FD 6 EVA 2	FD 7 FD 7	FD 8 EVA 3	FD 9 EVA 4?	FD 10 undock	FD 11 undock	FD 12 deorbit	FD 13	EOM+1	EOM+2
GMTLO (hh:mm)	LAUNCH		Docked Days												
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
23:50	12/14/06	12/15/06	12/16/06	12/17/06	12/18/06	12/19/06	12/20/06	12/21/06	12/22/06	12/23/06	12/24/06	12/25/06	12/26/06	12/27/06	12/28/06
23:26	12/15/06	12/16/06	12/17/06	12/18/06	12/19/06	12/20/06	12/21/06	12/22/06	12/23/06	12/24/06	12/25/06	12/26/06	12/27/06	12/28/06	12/29/06
23:02	12/16/06	12/17/06	12/18/06	12/19/06	12/20/06	12/21/06	12/22/06	12/23/06	12/24/06	12/25/06	12/26/06	12/27/06	12/28/06	12/29/06	12/30/06
22:38	12/17/06	12/18/06	12/19/06	12/20/06	12/21/06	12/22/06	12/23/06	12/24/06	12/25/06	12/26/06	12/27/06	12/28/06	12/29/06	12/30/06	12/31/06
22:14	12/18/06	12/19/06	12/20/06	12/21/06	12/22/06	12/23/06	12/24/06	12/25/06	12/26/06	12/27/06	12/28/06	12/29/06	12/30/06	12/31/06	01/01/07
21:50	12/19/06	12/20/06	12/21/06	12/22/06	12/23/06	12/24/06	12/25/06	12/26/06	12/27/06	12/28/06	12/29/06	12/30/06	12/31/06	01/01/07	01/02/07
21:26	12/20/06	12/21/06	12/22/06	12/23/06	12/24/06	12/25/06	12/26/06	12/27/06	12/28/06	12/29/06	12/30/06	12/31/06	01/01/07	01/02/07	01/03/07
21:02	12/21/06	12/22/06	12/23/06	12/24/06	12/25/06	12/26/06	12/27/06	12/28/06	12/29/06	12/30/06	12/31/06	01/01/07	01/02/07	01/03/07	01/04/07
20:38	12/22/06	12/23/06	12/24/06	12/25/06	12/26/06	12/27/06	12/28/06	12/29/06	12/30/06	12/31/06	01/01/07	01/02/07	01/03/07	01/04/07	01/05/07
20:14	12/23/06	12/24/06	12/25/06	12/26/06	12/27/06	12/28/06	12/29/06	12/30/06	12/31/06	01/01/07	01/02/07	01/03/07	01/04/07	01/05/07	01/06/07
19:50	12/24/06	12/25/06	12/26/06	12/27/06	12/28/06	12/29/06	12/30/06	12/31/06	01/01/07	01/02/07	01/03/07	01/04/07	01/05/07	01/06/07	01/07/07
19:26	12/25/06	12/26/06	12/27/06	12/28/06	12/29/06	12/30/06	12/31/06	01/01/07	01/02/07	01/03/07	01/04/07	01/05/07	01/06/07	01/07/07	01/08/07
19:02	12/26/06	12/27/06	12/28/06	12/29/06	12/30/06	12/31/06	01/01/07	01/02/07	01/03/07	01/04/07	01/05/07	01/06/07	01/07/07	01/08/07	01/09/07

Developed by DM2/Dawn Gabriel

## Notes:

- 12/17 Launch date (12+2) not impacted since landing opportunities on 12/31 prior to YERO
- 12/26 Launch Window Cutoff based on  $\beta > 60$  at undocking
- YERO occurs pre-sleep/during crew sleep on FD identified
  - Orbiter recovery actions required pre-sleep and post-sleep



# YERO Overview



- YERO procedures
  - **FCOH 2.13 - Ground Year End Rollover, **Orbit Ops** – YERO Procedure**
  - Have been a work in progress for the last 2 + years
  - Excellent support from Flight software, MCC, Operations
  - Procedures begin prior to crew sleep and are completed the next morning
    - Onboard Reconfiguration (Performed on 12/31)
      - GMT YERO procedure Part 1 - YERO MTU MET reset, force GPS to internal time, IMU configuration (~ 15 minutes)
    - Ground Reconfiguration (pre/post YERO)
      - GMT YERO procedure Part 1a - MCC Recycle ( ~1.5 hrs)
        - » Logoff/deallocate performed on 12/31(workstations, FEP, servers, etc.)
        - » Logon/reconfiguration/recovery on 1/1
    - Onboard Reconfiguration (Performed on 1/1 post crew awake)
      - GMT YERO procedure Part 2 – Onboard Reconfiguration (~ 1.5 hours)
        - » PASS GPC IPL (rebuilding PASS Set)
      - GMT YERO procedure Part 3 – BFS Updates ( ~ 15 minutes)
    - Ground Reconfiguration (pre/post Local YERO)
      - Local YERO MCC Recycle (~ 30 min)
  - **Total Crew time requirement – 2 Crew/ 2 hours each**



# YERO Overview



- Impacts of not incorporating YERO
  - Not tested per FOICB direction
- Only YERO option available for STS-116 is to force GPCs to MTU time
  - Synchronize MCC and on-board time (basic principle of spaceflight)
  - MCC YERO required due to ISS operations
  - Maintains synchronization to MCC and interface to integrated network (low speed C-band tracking, TDRS comm, high speed C-band tracking etc.)
  - Limitations to on-board display inputs identified on Universal Pointing and MNVR Display
    - MNVR time and TIG entries > 365:23:59:00 not accepted by FSW
  - Concerns during YERO (while MCC and on-board time differ)
    - Loss of Navigation monitoring (no SV updates can be performed) during Orbiter/ground time mismatch configuration
    - Nav and Guidance interaction due to GPC time error not well understood
- **Bottom Line – Committed to performing YERO procedures if launch into YERO window!**





---

# YERO Support Background

## DV2/Carolyn Jarrett

---

November 2, 2006

STS-116/12A.1

DA8/Tony Ceccacci 281-483-0699  
DA8/Norman Knight 281-483-4899  
DA8/Steve Stich 281-483-8038

9

---

# **STS-116/12A.1 YERO Support Background**

**Work Completed to Date, Initial 116 Test Results,  
Ground Procedure**

# Background

---

- **Shuttle was not designed to fly over year-end timeframe**
  - Potential in-flight YERO event if STS-116 launches after Dec. 16
- **At one second past GMT 365:23:59:59, the Master Timing Unit (MTU) accumulators on the Orbiter will reset GMT to day '001/00:00:00'. This causes PASS Flight Software (FSW) to fault down to GPC internal time (GPC Oscillator) and annunciate the "TIME MTU" message. PASS FSW continues to increment GMT and MET clocks (GMT rolls over to day '366/00:00:00'). GPC time accuracy is poor with respect to MTU.**
  - Worst Case:
    - MTU OSC – 0.001 PPM (0.086 MILLISEC/DAY)
    - GPC OSC – 87 PPM (7.517 SECONDS/DAY)
- **1989 STS-32 YERO Investigation (OI-8C)**
  - DPS procedure forced MTUs to accept GPC time (day 366)
  - MOC Environment
  - Not flown due to launch slip
- **2004-2005 YERO Team developed and tested new procedure**
  - NASA resources (MCC) must support concurrent ISS operations
  - Onboard/Ground procedure forces GPCs to accept MTU time (day 1)
  - Ground Rules: Quiescent Ops only, not launch, reentry, etc.
  - Scope: JSC only

# Background cont.

---

- **Performed 4 SAIL tests in '04/'05**

- YERO Procedure (with landing)
- YERO Procedure with BFS engage (with landing)
- Leap Year
- Leap Second

Used hardware MTU, GPS, COMSEC Box for high fidelity SMS used for pre-test and can support training

- **Final Report published 12/30/05**

([http://mod.jsc.nasa.gov/dv/dv2/MCC\\_HPAGE/MCCsubpages/YERO/YERO%20Final%20Report.doc](http://mod.jsc.nasa.gov/dv/dv2/MCC_HPAGE/MCCsubpages/YERO/YERO%20Final%20Report.doc))

- YERO procedure recommended for contingency use only
- On-board procedure ready but not included in FDF
- Ground procedures submitted to FCOH
  - 2.13 Ground Year-End-Rollover Procedures
  - 2.14 Leap Second Procedures
- Flight Rules/Ground Rules & Constraints reflect contingency-only status

- **May 2006 FOICB requested STS-116 flight-specific YERO testing to protect launch window**

- Flight-specific only; Generic certification cost prohibitive

# Oct. 25 STS-116 SAIL YERO Test

---

- **Test Config**

- STS-116 flight load and MCC PSS baseline
- Network facilities included (GSFC, MSFC, KSC, MILA)
- Full 116 FCT participation for training purposes (including 116 CDR, MS)
- PGSC hardware/applications
- No EVA suit test (can operate without ground data)
- No PDRS (not requested in SAIL config)
- Additional workstation activity/Traj Server to monitor onboard Nav during out-of-sync period (from YERO until YERO recovery complete)

- **Test Procedure**

- Pre-YERO Onboard Steps (YERO Procedure Part 1)
- Ground Recycle (FCOH Procedure 2.13)
- Monitor Onboard Systems in “Mixed Config”  
(Simulates crew sleep period since YERO will likely occur then)
- Post-YERO Onboard Steps (YERO Procedure Parts 2, 3)
- Deorbit Prep and Landing (for FSW Verification, no YERO steps)

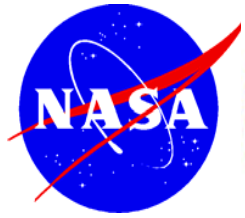
- **Initial Test Results**

- Successful Landing; Good Network Data Transfer; Some Anomalies Reported, No Show-Stoppers, Still working to resolve issues
-

# Ground Procedure

---

- **Shuttle-specific MCC resources have not been certified to run continuously past the year end. (i.e. without recycle)**
    - SGMT set to Dec. 31 for test, but workstation time unaffected
    - FEP select-over, checkpoint, allocation, deallocation, and logging expected to be problematic
    - MCC rollover test cost prohibitive unless performed during an actual YERO event (Destructive test, ISS BCC activation required)
  - **Ground recycle ensures clean MCC config**
    - Staggered recycle of all Shuttle-only ground resources  
Includes workstations, servers, FEPs, etc.  
(Logoff/deallocate performed prior to YERO)
    - ISS not affected, but must close Shuttle displays
    - Activity Reference Year updated to 2007 during recycle
    - Reconfigure Traj Server (45 min.)
    - Rebuild Command loads (cannot restore from pre-YERO checkpoint)
    - Can see “funny” timestamps during out-of-sync period  
(Timestamp source – onboard vs. ground – is application specific)  
FCT noted discrepancies during 10/25 SAIL test
    - 2<sup>nd</sup> Activity/Traj Server (not recycled) to monitor onboard Nav
    - Repeat for local YERO (this time can restore from checkpoint)
    - ~~FCOH Procedure 2.13 complete (will update for STS-116)~~
-



---

# Flight Software Certification

## USA/Carlos Valrand

---

November 2, 2006

STS-116/12A.1

DA8/Tony Ceccacci 281-483-0699  
DA8/Norman Knight 281-483-4899  
DA8/Steve Stich 281-483-8038

10

---

# YERO Validation/checking to Certify FSW for STS-116

Carlos B. Valrand  
Space Shuttle Flight Software  
November 2, 2006





# YERO FSW Validation/checking Activities <sup>1</sup>

---

- Review of YERO FSW Procedure and test plans by YERO Investigation Team and cognizant boards and panels (FOICB, FOR, JOP)
  - FSW has actively participated and contributed in review activities
- PASS Level 7 YERO SDF Tests
  - Tests demonstrate effects of YERO procedure on a realistic DPS system and modeled environment
  - Test specifications reviewed by YERO Team and approved by SASCB
    - Two Level 7 6-DOF SDF test cases (Orbit/Deorbit and Entry)
    - 3-GPC (2 GN&C/1 SM) Orbit/Deorbit simulation exercises the PASS YERO procedure (part 1 and 2) and continues to Entry Interface
    - Entry simulation continues test to landing at KSC
  - Test case Analysis is complete—no issues
  - YERO PASS Performance Test Report distribution scheduled for 11/07

# YERO FSW Validation/checking Activities <sup>2</sup>

---

- **BFS Level 7 YERO SDF Tests (Boeing)**
  - Test specifications reviewed by FSW community and approved by SASC
  - Six (3 Deorbit and 3 Entry) Level 7 6-DOF SDF test cases
    - BFS listen, BFS engaged (1 PASS GN&C/1 BFS GPC), and BFS engaged following PASS failure
  - Tests perform YERO BFS (part 3) procedure, perform deorbit, and continue to entry and landing
  - Completed 10/27/06—no issues
  - YERO BFS Performance Test Report distribution scheduled for 11/03

# YERO FSW Validation/checking Activities <sup>3</sup>

---

- FSW YERO audit
  - PASS audit to identify time parameter constraints to performing YERO procedure
    - Completed 10/31/06—no issues
  - BFS audit to assess new operational requirements and time parameter constraints
    - Completed 10/25/06—no issues

# YERO FSW Validation/checking Activities <sup>4</sup>

---

- **Fail Op/Fail Safe Evaluation (Boeing)**
  - Determine potential exceptions to Fail-Op/Fail-Safe (FO/FS) requirements due to failures during execution of YERO procedures
    - YERO takes a system configuration which previously required a set of failures and makes it an operational (no-failure) configuration, thus requiring extension of Fail Op/Fail safe analysis
  - Identify failure mode sensitivity for YERO procedures and evaluate against SSP FO/FS system requirements
  - Identify Orbiter avionics components critical to a successful YERO (for example, GPC IPL capability dependant upon good path between MMU and GPC)
  - Participation and inputs provided by Engineering, Safety, FSW and MOD
  - Completed 10/31/06 —results have been communicated to MOD and Orbiter Safety for disposition

# YERO FSW Validation/checking Activities <sup>5</sup>

---

- **YERO SAIL/MCC Test**
  - Objective of the test is to perform end to end validation (crew, Orbiter, MCC) of the YERO procedure in the most realistic environment available
  - Test was co-sponsored by MOD and Boeing IAV
  - Test plan and procedures reviewed and approved
  - Test support by MCC, SAIL, GSFC and MER
  - Test completed 10/25/06—no significant issues

# YERO Flight-Specific FSW Certification <sup>1</sup>

---

- The goal of flight software validation/checking activities is flight-specific certification of YERO tolerance for the STS-116 flight load
- Flight-specific certification will be required for future-year Shuttle missions occurring in the year-end timeframe—will leverage from STS-116 testing

# YERO Flight-Specific FSW Certification <sub>2</sub>

---

- Rationale for flight-specific YERO certification
  - Restricted operational scope
    - YERO is a planned event of restricted span and circumstances
    - The YERO procedure is ruled out for most flight software operational modes, e.g., no YERO during dynamic or propulsive flight
  - There are no software changes for YERO
  - The YERO procedure has no novel elements—steps occur in tested procedures

# YERO FSW Validation/checking Results

---

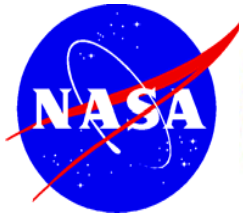
- **Summary of FSW validation/checking preliminary results analysis:**
  - **Level 7 PASS and BFS SDF performance verification tests and SAIL/MCC/Network tests exercising the YERO procedure with the OI-30 STS-116 flight software were conducted without significant problems**
  - **The Fail Op/Fail Safe (FO/FS) evaluation of YERO procedures determined potential exceptions to FO/FS requirements, identified failure mode sensitivity, and identified critical Orbiter avionics components for YERO—results have been communicated to MOD and Orbiter Safety for disposition, e.g., IFM procedures, FMEA waivers**
  - **The PASS and BFS flight software YERO audits were completed—no problems identified with software support of the YERO procedure**
- **Preliminary analysis of validation/checking activity results have increased our confidence that the flight software can successfully support YERO activities for STS-116**



# Summary

---

- **With completion of validation/checking activities for STS-116 and certification by NASA FSW TMR, FSW will be ready to support YERO activities during STS-116**



---

# Operations

## DF3/Ronnie Montgomery

---

November 2, 2006

STS-116/12A.1

DA8/Tony Ceccacci 281-483-0699  
DA8/Norman Knight 281-483-4899  
DA8/Steve Stich 281-483-8038

11

---

# **YERO Operations SR3578**

**DF32/Ronnie Montgomery**

---

# Why We Are Doing What We Are Doing

---

- **Why is YERO recovery required?**
  - **Avoids potential effects to ground capabilities**
    - **Large disconnect between ground and onboard time has potential to interfere with or disable some ground capabilities**
  - **Minimizes analysis required to verify safe operations**
    - **FOICB directed that analysis be limited to option of reloading software in GPCs**
    - **Option to bias ground to rolled-over GPC time not analyzed**
- **What happens if we don't perform YERO recovery?**
  - **Shuttle and Ground GMT will differ by 365 days**
  - **Not sure to what degree that affects ground capabilities**
    - **Confident will have voice and command**
    - **MCC's ability to build and uplink vectors is not clear**
  - **Onboard time will drift at GPC drift rate**
  - **May lose GPS during plasma**
    - **GPS may not be usable to ground**

# Onboard Procedure Overview (Pre Sleep)

---

- **Prior to crew sleep on night of YERO**
  - **Set the MET forward in time by large delta**
    - **Forces MET to roll over at same time as GMT**
  - **Align IMUs to identity matrix REFSMMAT**
    - **Maintains valid inertial reference during subsequent GPC IPLs**
  - **Force GPCs to internal time**
    - **Avoids nuisance alarm during crew sleep**
- **While crew is sleeping**
  - **Perform ground reconfiguration**

# Onboard Procedure Overview (Post Sleep PASS)

---

- Crew begins manual antenna control
- Shut down GNC and SM GPCs and begin re-IPL process
  - Reloading a fresh operating system has never been done on shuttle
  - Akin to PASS recovery from BFS engage procedure
- IPL GPC1 and establish single G2 config
  - Gets PASS back onto MTU time
- Restore IMU preflight calibration data
- Perform a series of orbiter uplinks
  - RNP matrix time parameters
  - State Vector
  - GPS SOP Time Adjustment
  - IMU Desired REFSMMAT
  - RCS Quantity Monitoring
  - Etc.

# Post Sleep PASS Procedure (continued)

---

- Reload orbiter mass
- IPL GPCs 2, 3, & 4
- Load SM into GPC4
- Re-uplink all SM TMBUs
- Take antennas back to GPC control
- Expand RS to triple G2
- Realign IMUs to launch REFSMMATs
- Contract RS and establish a G2FD and a G3FD
- Reload flight specific DAPs

# **Onboard Procedure Overview (Post Sleep BFS)**

---

- **Transition PASS GNC to OPS3**
- **Transition BFS to OPS0 and OPS 3**
  - **Needed to perform a series of uplinks to reestablish BFS operational config**
- **Reestablish nominal orbit config with PASS GNC in OPS2 and BFS in sleep**



# Critical Processors & Applications

---

- **DF audited ground applications looking for items where:**
  - the application is required to complete the YERO procedure
  - there are no currently documented and approved alternative methods or workarounds that would provide the same functionality in a timely manner
- **Concern was to ensure that we identify and understand new areas, driven by YERO, where safety is vulnerable to single point failures**
- **GNC application that builds REFSMMAT command is only one identified**
- **For a YERO flight, this app represents additional risk to successful completion of flight.**
- **DF is evaluating whether or not additional testing is needed to certify it under critical application guidelines.**

# Orbiter Hardware & YERO

---

- **Some vehicle hardware that is not normally critical for successful completion of a flight will become critical due to YERO's reliance on that hardware**
  - MMUs
  - FF1+FF3 (command)
  - NSPs
  - PCMMUs
  - IPL SOURCE Switch
  - Uplink Block Switch
  - Pending Boeing analysis may reveal more items
- **Increased criticality bestowed on hardware will affect Flight Rules, FMEAs, CILs, and potentially LCCs/MELs.**

# Flight Rules

---

- **Working on flight rules to require mission termination prior to YERO event when single fault tolerance is no longer available in a system that is critical for the completion of YERO.**
  - MMUs
  - FF1/FF3
  - NSPs
  - PCMMUs
- **Additionally, will submit flight specific rules that allow some existing generic rules to be overridden for YERO**
  - Current rule that requires maintaining onboard time to within 100 ms. Will waive rule for period between YERO and YERO recovery.
  - Current rule that requires MTU to be forced to GPC time following YERO.

# FMEA/CIL, LCC/MEL

---

- **FMEA/CIL**

- MMU

- 1 of 2 MMUs required to perform YERO
    - Currently no CIL
    - Will probably become 1R2

- IPL Source Switch and Uplink Block Switch

- If either switch fails then unable to perform YERO
    - DF Is evaluating feasibility of IFM workaround

- NSPs & PCMMUs

- Still evaluating

- This is what has been identified so far. Boeing analysis is continuing.

- **LCC/MEL**

- A DF conducted audited of the MEL and LCC revealed no items where a launch is allowed with loss in redundancy in a system that is critical for completion of YERO

---



# YERO Timeline Impact Summary (12+2) Critical Activity Impacts



## YERO recovery prior to critical mission activities (morning of):

<u>Launch Date (Critical Activity)</u>	<u>Impacts</u>
12/18 (EOM +2)	<ul style="list-style-type: none"> <li>•Recovery prior to D/O Prep</li> <li>•Requirement to land on this day due to a systems problem or bad Wx the previous 2 days (last day of Deorbit opportunities)</li> </ul>
12/19 (EOM +1)	<ul style="list-style-type: none"> <li>•Recovery prior to D/O Prep</li> <li>• EOM Waveoff due to systems problem or bad WX at KSC</li> </ul>
12/20 (EOM)	<ul style="list-style-type: none"> <li>•Recovery prior to D/O Prep</li> <li>•Loss of a KSC D/O Opportunity (best case)</li> </ul>
12/21(EOM -1)	<ul style="list-style-type: none"> <li>•Recovery prior to FCS checkout/Entry Prep</li> </ul>
12/22 (Late Inspection)	<ul style="list-style-type: none"> <li>•Recovery prior to complex robotics operations</li> </ul>
12/23 (Undock Day)	<ul style="list-style-type: none"> <li>•Recovery prior to undock (complex separation and prox ops)</li> </ul>
12/24 (FD9 if Contingency EVA)	<ul style="list-style-type: none"> <li>•Recovery prior to EVA (possible complex contingency EVA)</li> </ul>
12/25 (FD8 EVA #3 – MBSU 1/4 Reconfiguration, SMDPs)	<ul style="list-style-type: none"> <li>•Recovery prior to EVA</li> <li>•ISS may require Vern Attitude control as part of ISS Power reconfiguration operations (CMG#3 failed)</li> <li>•RMS used for SMDP task</li> </ul>



# YERO Timeline Impact Summary (12+2) Critical Activity Impacts



- FOICB agreement to investigate YERO recovery for “quiescent” operations only
  - Post sleep only “quiescent “ period / but prior to critical activity
  - Unexpected anomalies and/or FSW/MCC unknowns during YERO recovery will have impacts to critical mission objectives defined



# YERO Timeline Impact Summary (12+2) SCSC Violations



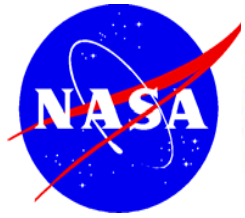
## SCSC Violations Identified/not necessarily show stoppers:

Launch Date (Day of SCSC Violation)	Post Sleep SCSC Violation/Recovery Option
12/18 (EOM +2)	<ul style="list-style-type: none"> <li>•Requires delaying D/O 1 rev (loss of 1<sup>st</sup> KSC opportunity) best case</li> <li>•EOM+2 (Systems Day) will be further complicated with YERO procedure being worked in addition to a systems failure</li> </ul>
12/19 (EOM +1)	<ul style="list-style-type: none"> <li>•Requires delaying D/O 1 rev (loss of 1<sup>st</sup> KSC opportunity) best case</li> <li>•EOM+1 (Wx Day) should maximize ability to land with all opportunities</li> </ul>
12/20 (EOM)	<ul style="list-style-type: none"> <li>•Requires delaying D/O 1 rev (loss of 1<sup>st</sup> KSC opportunity) best case</li> </ul>
12/21 (EOM -1)	<ul style="list-style-type: none"> <li>•Cannot be resolved. Increasing Post Sleep decreases Cabin Stow requirements which results in <u>SCSC violation Cabin Stow minimums</u></li> </ul>
12/23 (Undock Day)	<ul style="list-style-type: none"> <li>•Requires deleting flyaround</li> </ul>
12/24 (Transfer Day)	<ul style="list-style-type: none"> <li>•Requires deleting .5 hr transfer</li> </ul>
12/25 (FD8 EVA #3)	<ul style="list-style-type: none"> <li>•Requires delaying EVA prep by .5 hr</li> </ul>
12/26 (FD7 Off Duty/Transfer)	<ul style="list-style-type: none"> <li>•Requires deleting 2 hrs 10 min of transfer</li> </ul>

November 2, 2006

STS-116/12A.1

DA8/Tony Ceccacci 281-483-0699  
DA8/Norman Knight 281-483-4899  
DA8/Steve Stich 281-483-8038

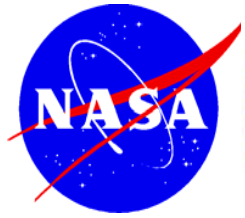


# YERO Timeline Impact Summary (12+2) YERO While Undocked



- YERO while undocked
  - 12/18 (EOM+2)
  - 12/19 (EOM+1)
  - 12/20 (EOM),
  - 12/21 (EOM-1),
  - 12/22 (Late Inspection Day)
- **Loss of ISS as “Safe Haven” for attitude control/comm for any unexpected complexities that may arise as part of YERO recovery**

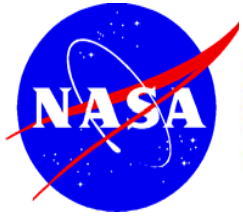




# YERO Operations Summary



- YERO Procedures (Orbiter & Ground Recycle)
  - Excellent support from Flight software, MCC, Mission Operations
  - Maturing but minimal testing/configuration
    - Have shown to be successful in limited testing
      - No failures introduced during recovery steps
- Orbiter FSW
  - Not designed to support YERO
    - IPL workaround developed/required to sync GPC with MTU and reset MET
  - STS-116 Flight Specific certification
    - FSW certification testing to validate that FSW is “YERO tolerant”
    - Certification testing limited to “restricted span and circumstance”
      - No critical systems failures tested during recovery
      - Not the standard Level B testing rigor that supports standard FSW certification
    - Successful FSW performance in limited testing
      - No failures introduced during recovery steps



# YERO Operations Summary (cont.)

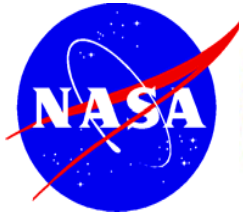


- **Shuttle MCC Platform**

- Not designed/certified to support YERO
- MCC must be recycled twice to support YERO (GMT YERO and Local YERO)
  - Opportunity to test Shuttle Platform during previous years YERO deemed to costly
    - Recycle similar to getting setup for flight support/sim
  - Experience in YERO with ISS platform
- No YERO certification planned for STS-116
- Shuttle MCC platform recycle has shown to be successful in limited testing
  - No failures introduced during recovery steps

- **Network**

- Although there has not been a complete “end-to-end” checkout of the MCC/Network no issues have been identified
  - Similar support/redundancy that is used for ISS YERO
    - Same shuttle unique Network assets (C-Band tracking, RTS Network, TDRS Tracking, NASA ground Network)
  - 10/25/06 SAIL/YERO test included KSC (ODRC), Marshall (ODRC), Goddard (FDF)



# YERO Operations Summary (cont.)



- Ground and Crew Training
  - Limited ability/availability to train YERO recovery in integrated environment
    - STS-116/12A.1 FCT and CDR/MS used 10/25/06 SAILYERO test to become familiar with and execute the recycle procedures.
      - Orbit 1 and Entry
    - No additional opportunities to train with crew
      - Crew Schedule
    - SAIL only facility the that provides actual Orbiter YERO response
      - SMS requires freeze/reset



# YERO Operations Risks/Concerns



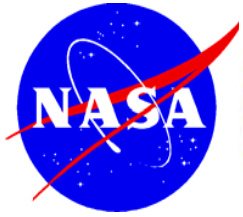
- Testing to date has not included any systems failures during YERO recovery
  - Possibility of unexpected unknowns that could have a significant impact to the YERO recovery impacting critical mission activities while troubleshooting is developed/ performed
    - Loss of attitude control, Loss of EVA day, Loss of Deorbit opportunity, Loss of +1 day
    - YERO in critical path
  - Inadvertent crew inputs
    - STS-102 GPC set expansion
      - 10 second minimum wait between GPCs to run not met
      - Caused FSW community concern about PASS integrity
    - Low probability but there is some risk
- Systems failures while in the “Hybrid” Configuration (Orbiter on GPC Internal time/MET not reset – Ground recycled to New Year)
  - Existing procedures may not support “hybrid” configuration
    - No failure/recovery testing
    - Low probability but there is that risk



# YERO Operations Risks/Concerns (cont.)



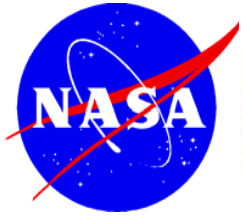
- Increased vulnerability to YERO PLS cases due to loss of single fault tolerance in systems critical to YERO recovery (MMU, PCMMU, NSP)
  - Low probability of hardware failure
  - Annex flight rule would document required LRUs
- Unexpected “conditions/results” post YERO recovery
  - During 10/25/06 SAIL test, multiple unexpected performance/results (without failures being introduced)
    - Inability to build/uplink SV in “time mismatch configuration”
    - Unexpected GPC cycle wrap on final during entry (determined to be covered by a user note)
    - Inability to uplink GPS age of aiding corrections
  - This are minor in stature but can distract the Flight Control Team
- IPL Source Select Switch
  - Smart failure required to loss capability to select either MMU1 or MMU2 as IPL source
  - Very low probability but you don’t know until you use the switch



# Recommendations



- Based on the testing to date, MOD has confidence that the YERO recovery would be successful in a “no failure” benign situation.
- The concern is the “unknowns” and the potential impacts to the mission objectives due to these unknowns
  - Limited FSW testing with no failures introduced during YERO recovery
  - Limited MSS Platform testing with no failures introduced during YERO recovery
  - YERO recovery tolerance to inadvertent crew inputs
  - All are low probability but not Zero risk
- **STS-116/12A.1 is the most complicated/challenging assembly mission to date. MOD does not recommended adding the complexity and additional risks of YERO to extend the launch past 12/17/06**
  - P5 Install (EVA #1), P6 4B retraction (once completed requires EVA #2 and EVA#3), MBSU Power reconfigurations (EVA #2, EVA#3), EATCS activation.
    - Partial power reconfiguration puts the ISS in an Hybrid Power configuration which results in constrains to ISS operations:
      - Power availability, EPS System insight (software configuration)
  - CAT1 activities, that if not successfully completed, have major impacts to assembly sequence/future missions manifest



# Recommendations (cont.)



- Utilize YERO testing/training to date for CSCS only (to configure Orbiter for unmanned undocking)
  - Ground and Orbiter procedures validated with minimum testing
  - Crew and MCC minimal familiarization with procedures

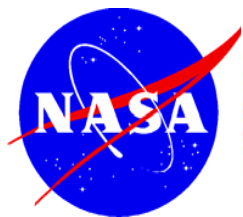


# Recommendations - Part II



- If the SSP accepts the additional risks of using YERO to provide launch opportunities past 12/17, MOD recommends that the program only consider the launch dates that have YERO occurring during the docked mission
  - 12/23 (FD10 Undock Day – YERO recovery prior to undock)
  - 12/24 (FD9 Transfer Day /Contingency EVA)
  - 12/25 (FD8 EVA #3)
  - 12/26 (FD7 Transfer/OFF Duty)
  - **Provides stable platform if “unknowns” should occur**
- Launch dates of 12/18 through 12/22 have YERO occurring “Undocked” as well as in the critical path for Deorbit (12/18-12/21)
  - 12/18 (EOM+2)
  - 12/19 (EOM+1)
  - 12/20 (EOM)
  - 12/21 (EOM-1)
  - 12/22 (Late Inspection)
  - **No “Safe Haven” to support**
  - **In critical path of Deorbit/Entry**





---

# Backup

---

November 2, 2006

**STS-116/12A.1**

DA8/Tony Ceccacci 281-483-0699  
DA8/Norman Knight 281-483-4899  
DA8/Steve Stich 281-483-8038 24



# YERO Timeline Assessment 12+2



Launch Date	MET of YERO/ (Crew Sleep Start)	Earliest MET of Orbiter YERO recovery	Next Days activity	Amount of post sleep remaining/Timeline Impacts/Other
12/18/06	FD14 13:01:46 (13:02:00)	FD15 13:10:00 (crew wake)	FD15 EOM+2 (Deorbit TIG 13/17:58)	<ul style="list-style-type: none"> <li>•CDR/PLT: 1 hr - Cannot recover (SCSC violation) without impacting D/O TIG</li> <li>•Undocked (no safety net)</li> </ul>
12/19/06	FD13 12:02:10 (12:02:00)	FD14 12:10:00 (crew wake)	FD14 EOM+1 (Deorbit TIG 12/17:35)	<ul style="list-style-type: none"> <li>•CDR/PLT: 1 hr - Cannot recover (SCSC violation) without impacting D/O TIG</li> <li>•Undocked (no safety net)</li> </ul>
12/20/06	FD12 11:02:34 (11:02:00)	FD13 11:10:00 (crew wake)	FD13 NOM EOM (Deorbit TIG 11/18:17)	<ul style="list-style-type: none"> <li>•CDR/PLT: 1 hr - Cannot recover (SCSC violation) without impacting D/O TIG</li> <li>•Undocked (no safety net)</li> </ul>

- Minimum Post sleep requirement 2 hours. Minimum Post/Pre-Sleep aggregate 5 hours.
- Orbiter crew YERO recovery steps require ~ 15 minutes prior to YERO and 1.5 hrs post YERO to complete.
- Impacts based on Basic Rev A Timeline. Impacts subject to change based on actual launch date (sleep shift requirement to support launch, rendezvous, undock, D/O)



# YERO Timeline Assessment 12+2



Launch Date	MET of YERO/ (Crew Sleep Start)	Earliest MET of Orbiter YERO recovery	Next Days activity	Amount of post sleep remaining/Timeline Impacts/Other
12/21/06	FD11 10/02:58 (10/02:30)	FD12 10/10:30 (crew wake)	FD12 EOM-1	<ul style="list-style-type: none"> <li>•CDR: 1 hr, PLT: 1.5 hrs. Trade post sleep for Cabin stow but SCSC violation on minimum Cabin stow.</li> <li>•Undocked (no safety net)</li> </ul>
12/22/06	FD10 9/03:22 (9/03:00)	FD11 9/11:00 (crew wake)	FD11 Late Inspection	<ul style="list-style-type: none"> <li>•Undocked (no safety net)</li> </ul>
12/23/06	FD9 8/03:46 (8/03:30)	FD10 8/11:30 (crew wake)	FD10 Undock	<ul style="list-style-type: none"> <li>•CDR: .75 hr, PLT: 1 hr - (SCSC violation) Nominal Undock (8/18:40) Could recover by deleting 1.5 hrs of transfer. or undock 1 Rev late (8/ 20:30) no flyaround</li> <li>•Late Undock (8/ 20:30) if +1 used docked. No violations if flyaround deleted.</li> </ul>

- Minimum Post sleep requirement 2 hours. Minimum Post/Pre-Sleep aggregate 5 hours.
- Orbiter crew YERO recovery steps require ~ 15 minutes prior to YERO and 1.5 hrs post YERO to complete.
- Impacts based on Basic Rev A Timeline. Impacts subject to change based on actual launch date (sleep shift requirement to support D/O)



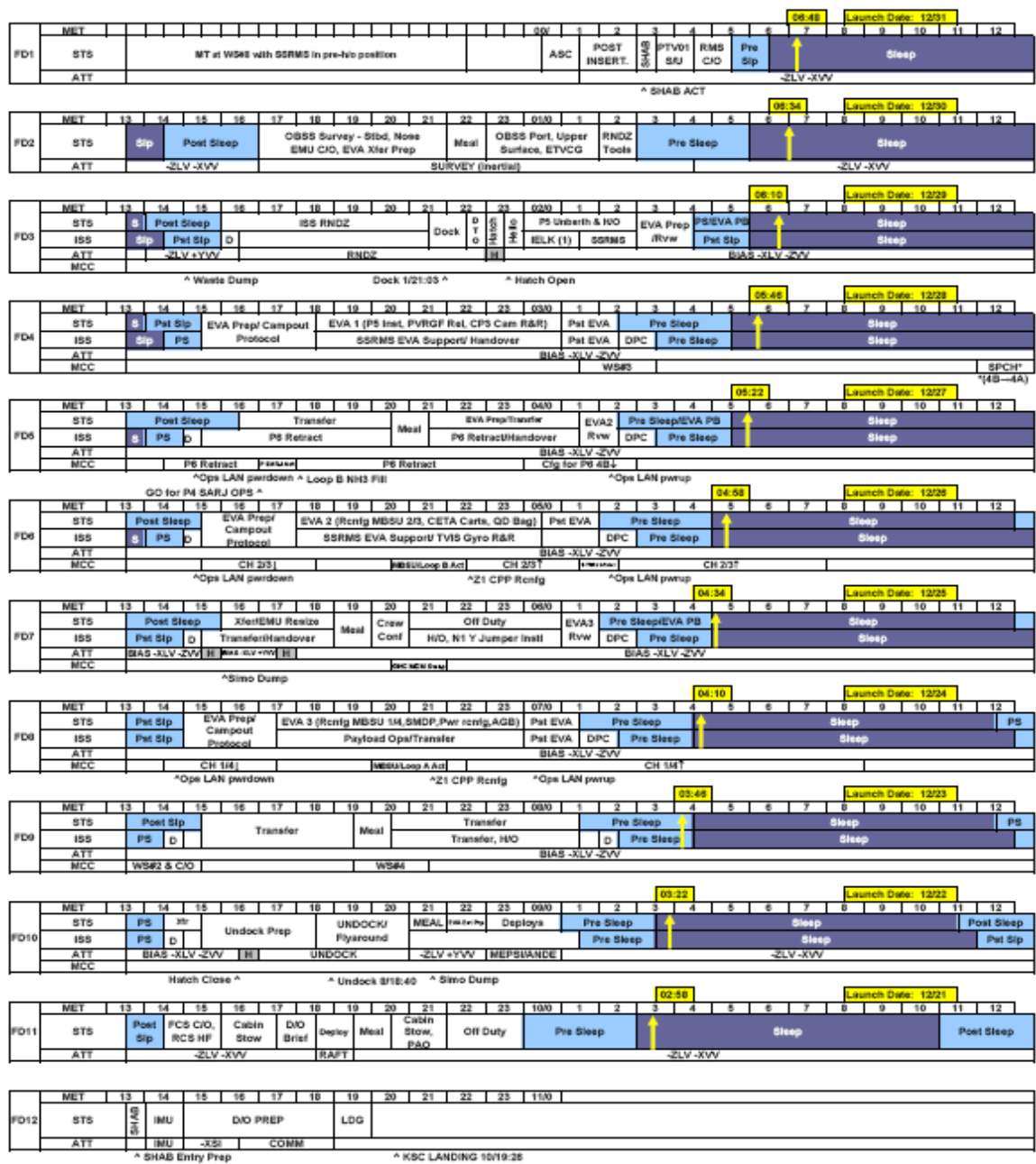
# YERO Timeline Assessment 12+2



Launch Date	MET of YERO/ (Crew Sleep Start)	Earliest MET of Orbiter YERO recovery	Days activity	Amount of post sleep remaining/Timeline Impacts/Other
12/24/06	FD8 7/04:10 (7/04:00)	FD9 7/12:00 (crew wake)	FD9 Transfer or Contingency EVA	•CDR/PLT: 1.5 hrs – (SCSC violation) Could be recovered by losing .5 hr of transfer.
12/25/06	FD7 6/04:34 (6/04:30)	FD8 6/12:30 (crew wake)	FD8 EVA #3	CDR: .5 hr. – (SCSC violation) Could recover by delaying EVA/EVA Prep .5 hr.
12/26/06	FD6 5/04:58 (5/04:30)	FD7 5/12:30 (crew wake)	FD7 Transfer /Off Duty	CDR: 1.5 hrs, PLT: 1 hr – (SCSC violation) Could recover with loss of 2:10 transfer.

- Minimum Post sleep requirement 2 hours. Minimum Post/Pre-Sleep aggregate 5 hours.
- Orbiter crew YERO recovery steps require ~ 15 minutes prior to YERO and 1.5 hrs post YERO to complete.
- Impacts based on Basic Rev A Timeline. Impacts subject to change based on actual launch date (sleep shift requirement to support D/O)

### STS-116/12A.1 Overview Timeline (11+(1)+2)



September 28th, 2006

28

# STS-116 YERO and Mated Beta Angle Range Predictions

		1/1/2007 0:00	dock	undock	+1 undock	beta angles are approximations (July 2006 reference trajectory)	
			1/21:32 MET	8/18:58 MET	9/18:58 MET	YERO during 11+2 day mission	YERO during 12+2 day mission
GMTLO (estimated)		YERO MET	beta (deg)	beta (deg)	beta (deg)		
12/14/06	23:50	17/00:10	22.8	-1.1	-5.4	Note: Based on predicted launch times and crew timeline, YERO occurs shortly after crew sleep each day.	
12/15/06	23:26	16/00:34	20.3	-5.4	-9.7		
12/16/06	23:02	15/00:58	17.4	-9.7	-14.2		
12/17/06	22:38	14/01:22	14.2	-14.2	-18.8		NEOM+2 (depends on landops)
12/18/06	22:14	13/01:46	10.7	-18.8	-23.5	NEOM+2	NEOM+1
12/19/06	21:50	12/02:10	7.0	-23.5	-28.2	NEOM+1	NEOM
12/20/06	21:26	11/02:34	3.1	-28.2	-33.0	NEOM	day before landing, STP-H2
12/21/06	21:02	10/02:58	-1.1	-33.0	-37.8	day before landing, STP-H2	undocking, STP-H2
12/22/06	20:38	09/03:22	-5.4	-37.8	-42.6	undocking, STP-H2	EVA4?
12/23/06	20:14	08/03:46	-9.7	-42.6	-47.3	transfer day	transfer day
12/24/06	19:50	07/04:10	-14.2	-47.3	-52.0	EVA3	EVA3
12/25/06	19:26	06/04:34	-18.8	-52.0	-56.6	transfer, off duty	transfer, off duty
12/26/06	19:02	05/04:58	-23.5	-56.6	-61.1	EVA2	EVA2
12/27/06	18:38	04/05:22	-28.2	-61.1	-65.2	transfer, P6 retract	transfer, P6 retract, foc insp?
12/28/06	18:14	03/05:46	-33.0	-65.2	-68.9	EVA1	EVA1
12/29/06	17:50	02/06:10	-37.8	-68.9	-71.7	RNDZ, P5 handover	RNDZ, P5 handover
12/30/06	17:26	01/06:34	-42.6	-71.7	-73.4	OBSS survey, EMU C/O	OBSS survey, EMU C/O
12/31/06	17:02	00/06:58	-47.3	-73.4	-73.5	Launch	Launch
01/01/07	16:38		-52.0	-73.5	-71.9		
01/02/07	16:14		-56.6	-71.9	-69.1		
01/03/07	15:50		-61.1	-69.1	-65.5		
01/04/07	15:26		-65.2	-65.5	-61.3		
01/05/07	15:02		-68.9	-61.3	-56.8		
01/06/07	14:38		-71.7	-56.8	-52.2		
01/07/07	14:14		-73.4	-52.2	-47.4		
01/08/07	13:50		-73.5	-47.4	-42.5		
01/09/07	13:26		-71.9	-42.5	-37.7		
01/10/07	13:02		-69.1	-37.7	-32.8		
01/11/07	12:38		-65.5	-32.8	-27.8		
01/12/07	12:14		-61.3	-27.8	-22.9		
01/13/07	11:50		-56.8	-22.9	-18.1		
01/14/07	11:26		-52.2	-18.1	-13.2		
01/15/07	11:02		-47.4	-13.2	-8.5		
01/16/07	10:38		-42.5	-8.5	-3.8		
01/17/07	10:14		-37.7	-3.8	0.5		Daylight Launch
01/18/07	09:50		-32.8	0.5	5.3		Dark Launch

September 28th, 2006