

Year End Rollover (YERO) STS-116 Plans & Status



JSC Mission Operations Directorate
12A.1 JOP #16 Agenda Item 4

DV2/Carolyn Jarrett
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Agenda

- **Background**
- **Test Plans**
- **Overview of YERO Procedure**
- **STS-116 YERO Impacts**

Background

- **Shuttle was not designed to fly over year-end timeframe**
 - Potential in-flight YERO event with current STS-116 launch window
- **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)

- 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

Test Plans

- **PASS Level 7 YERO Testing (USA)**
 - In progress; Performance Test Report 11/14
- **PASS Formal YERO Audit (USA)**
 - In progress; Complete 10/13
- **BFS Level 7 YERO Testing (BOE)**
 - Begin 9/25; Performance Test Report 11/16
- **YERO Fail Op / Fail Safe Evaluation (BOE)**
 - In progress
- **YERO SAIL Test Oct. 25**
 - STS-116 flight load and PSS baseline
 - Full 116 FCT participation for training purposes (Shuttle only)
 - May be only training opportunity

Upon successful completion, the STS-116 flight load will be YERO Certified.

Overview of YERO Procedure

- **Part 1 (prior to YERO event)**
 - Data checkpoints (historical purposes only)
 - Adjust MET to rollover with GMT (avoids “negative” time)
 - Realign IMUs to Identity Matrix REFSMMAT
(Retains valid inertial attitude reference during/after IPL)
- **Part 2 (post YERO event)**
 - Ground Steps:**
 - Staggered recycle of all Shuttle-only ground resources
Includes workstations, servers, FEPs, etc.
(Logoff/deallocate performed prior to YERO)
 - Required because MCC rollover test not performed
(FEP select-over, checkpoint, allocation, deallocation,
and logging expected to be problematic)
 - ISS not affected, but must close Shuttle displays
(Flight activity defined without reference year)
 - Reconfigure Trajectory Server; Manually input new year
 - Reconfigure Command Server; Rebuild command loads
(Cannot restore from pre-YERO checkpoint)

Overview of YERO Procedure

- **Part 2 (Continued)**

- On-Board Steps:**

- DAP: FREE VERN
- Comm Reconfig (Manual Antenna Selection)
- Mode all GPCs to STBY
- IPL GPC1 (G2) (accepts MTU time)
- Uplink: RNP Matrix, SV, GPS Time Adjust, IMU REFSMMAT, RCS Quantity Monitoring (and others as needed)
- Uplink/load dummy burn target (correct Orbiter mass)
- Configure remaining PASS GPCs; Comm reconfig; Uplink variable parameters and TMBU; Realign IMUs; DAP config

- **Part 3 (prior to deorbit)**

- Uplink RNP Matrix to BFS while it's in Ops 000
- Uplink GPS Delta Time and TDRS SV to BFS while in Ops 3

STS-116 Impacts

- **YERO procedure restores vehicle to nominal config, except:**
 - Onboard MET reset to zero at rollover
 - ODRC MET is **not** reset; Use GMT for data requests post-rollover
 - Data recorded during ground recycle will be available from ODRC (Timestamp will initially have old year; Recorders will be stopped/started at next LOS; ODRC will manually re-index files for interim)
 - Traj Server launch time reset
- **Docked and undocked configs supported (Docked preferred)**
 - Timeline impacts during docked operations
 - ISS resources (Comm, Attitude Control) not available after undock
- **Leap second not required**
- **ISS not affected**

Can YERO procedure be delayed?

- **Part 1 must be performed prior to rollover**
 - May be performed any time prior to rollover, but MET and IMUs affected
 - Allow 15 min. crew time
 - Don't have to wait until IMU align complete
- **Part 2 Ground recycle must be performed on schedule**
 - Applications not certified for rollover (can't test everything)
 - Recent load testing indicates that 50 users can logon/logoff concurrently
 - More important to phase logoff than logon
 - Allow 1 hour post-YERO for recycle (Traj Server takes ~45 min. to configure)
- **Part 2 Onboard steps can be delayed somewhat**
 - Immediate execution preferred but 8-10 hours anticipated
 - Allow 1 to 1-1/2 hours crew time
- **Part 3 can be delayed until Deorbit**
 - No timeline impact if performed during Deorbit Prep
 - BFS not available until Part 3 complete

Impacts if Delay 8-10 Hours

- **ComSec equipment must be set to clear mode prior to crew sleep if YERO procedure not complete**

- INCO can handle antenna selection etc. as long as they have command capability
- Can also send time-tagged commands to disable/enable command during planned LOS

Note: Any planned periods of command-in-the-clear must be kept confidential. Announcing them would invite malicious intrusion.

- **The "TIME MTU" message will wake the crew, assuming current ISS sleep schedule**

- This can only be inhibited/restored via GMEM (Not like TMBU)

- **No Shuttle attitude maneuvers and no undock until Part 2 complete**

- Can hold inertial attitude if DAP reloaded

Note: In case of emergency, if the crew does not have time to complete onboard Part 2 steps prior to undock, may chose to stay even if this results in a disabled Shuttle. ISS is Safe Haven. (Not safe to land in mismatch config.)

Impacts if Delay 8-10 Hours (cont.)

- **GPS will only be available for Nav updates for a short time (few hours)**
 - Unaided when GPC clock error exceeds 245ms (fast) or 2s (slow)
 - May require GPS age-of-aiding updates
 - May lose GPS during plasma effect (TACANs available on OV103)
- **Some impact to telemetry**
 - Displays/applications may have funny timestamps
 - FEP will disseminate all downlinked data and assign a local timestamp in addition to the onboard timestamp(s). Which one gets used is application specific.
 - Opportunity to note discrepancies during Oct. 25 SAIL test
- **Planning system impact unknown**
 - May have to recycle Shuttle-unique resources

Impacts if Delay 3 to 4 Days

- **Impact: Same as for 8 hours only magnified**
 - State Vector accuracy may degrade up to 31 miles/day
 - Greatly increased opportunity for human error during interim
 - There is no way to test effect of long duration mismatch.
We cannot predict which ground applications may have problems, and failures may not be easily detected (may give erroneous data rather than no data).
- **Flight rule violations:**
 - Anytime deorbit requirement
 - 100ms time accuracy
 - Command in the clear for long period
- **YERO team does not recommend delaying this long.**
 - No delay at all is preferable

YERO Contact List

DPS:

Jud Frieling
Jim Hill
Ron Montgomery

FD:

Tony Ceccacci
Norm Knight
Mike Moses

FDO:

Dick Theis

GC:

Mike Marsh

GNC:

Jason Helms
Mike Interbartolo

GPO:

Tom Schmidt

INCO:

Joe Fanelli

Nav:

John Hutchins
Carolyn Propst
Charles Yu

Network:

Rebecca Marsh
Cheryl Smith (GSFC)

MSOC/MCC Facility:

Scott Bossert
Ray Grossman
Bill Trueblood
Susan Weingarten

Boeing/BFS:

Robert Winkler

Boeing/DPS Int:

Kevin Moormann
Lynna Wood

Boeing/FSW:

Doug Huntsman

IV&V:

Mel Rother

SAIL:

Jim Caldwell

USA/FSW:

Paul Relyea
Carlos Valrand