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# STS-116/12A.1 YERO Support



**SR3578**

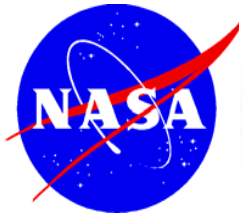
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October 23, 2006

STS-116/12A.1

DA8/Tony Ceccacci (281) 483-0699

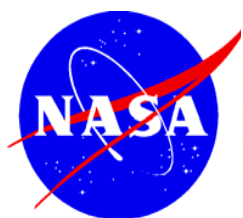
DA8/Norman Knight (281) 483-4899 1



# 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
- Program Risks
  - Generic Concerns
  - YERO while Docked/Undocked
  - YERO on De-Orbit day
- MOD Recommendations



# Launch Date and YERO



11 days (7 docked)	FD 1 launch	FD 2	FD 3 rndz	FD 4 EVA 1	FD 5 FD 5 foc insp?	FD 6 EVA 2	FD 7 FD 7	FD 8 EVA 3	FD 9 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 8 EVA 3	FD 9 EVA 4?	FD 10	FD 11 undock	FD 12	FD 13 deorbit	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:

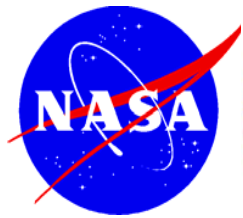
- 12/17 Launch date (12+2) not impacted since landing opportunities on 12/31 prior to YERO
- 12/26 Launch Window Cutoff based on  $\beta > 60$  at undocking
- YERO occurs pre-sleep/during crew sleep on FD identified



# YERO Procedure Timeline Overview



- YERO affects the following STS-116/12A.1 Launch dates in support of a 11(+1)+2
  - 12/18 -12/26
- YERO procedures executed on 12/31
  - FCOH 2.13 - Ground Year End Rollover, Orbit Ops – YERO Procedure
  - Procedure begins prior to crew sleep and is completed the next morning
    - Onboard Reconfiguration (Performed prior to crew sleep)
      - GMT YERO procedure Part 1 - YERO MTU MET reset & IMU configuration (~ 15 minutes)
    - Ground Reconfiguration (pre/post YERO)
      - GMT YERO procedure Part 1a - MCC Recycle ( ~1.5 hrs)
        - » Logoff/deallocate performed prior to YERO (workstations, FEP, servers, etc.)
        - » Logon/reconfiguration/recovery Post YERO
    - Onboard Reconfiguration (At crew awake)
      - GMT YERO procedure Part 2 – Onboard Reconfiguration (~ 1.5 hours)
        - » PASS GPC IPL
      - 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**
- Impacts of not incorporating YERO recovery
  - Not tested per FOICB direction
  - Testing focused on YERO recovery steps (forcing GPC to accept MTU time/MET reset)



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# YERO Support Background

## DV2/Carolyn Jarrett

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October 23, 2006

STS-116/12A.1

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# Flight Software Certification

## USA/Carlos Valrand

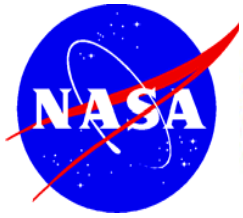
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# Operations

## DF3/Ronnie Montgomery

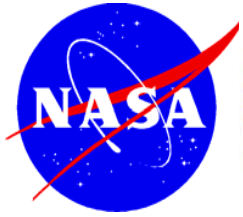
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# YERO Timeline Impact Summary (launch dates reflected)



- **SCSC Violations**

- 12/18 (EOM +2), 12/19 (EOM +1), 12/20 (EOM) - Post sleep
  - Requires delaying D/O 1 rev (loss of 1<sup>st</sup> KSC opportunity) best case.
  - EOM+1 (Wx Day) should maximize ability to land with all opportunities.
  - EOM+2 (Systems Day) will be further complicated with YERO procedure being worked in addition to a systems failure.
- 12/21 (EOM -1: FCS C/O, Hot fire) – Post Sleep
  - Cannot be resolved. Increasing Post Sleep decreases Cabin Stow requirements which results in SCSC violation Cabin Stow minimums
- 12/23 (FD10 Undock Day) – Post Sleep
  - Requires deleting flyaround
- 12/24 (FD9 Transfer) – Post Sleep
  - Requires deleting .5 hr transfer.
- 12/25 (FD8 EVA #3) – Post Sleep
  - Requires delaying EVA prep by .5 hr.
- 12/26 (FD7 Transfer /Off Duty) – Post Sleep
  - Requires deleting 2 hrs 10 min of transfer.

- **YERO while undocked**

- 12/18 (EOM+2), 12/19 (EOM+1), 12/20 (EOM), 12/21 (EOM-1), 12/22 (Late Inspection Day)

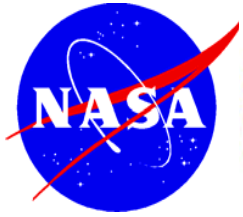




## YERO Timeline Impact Summary (launch dates reflected)



- **YERO Recovery prior to critical mission activities (morning of)**
  - 12/18 (EOM +2)
    - YERO recovery prior to D/O Prep (last Deorbit opportunities)
    - Requirement to land on this day due to a systems problem or bad Wx the previous 2 days
  - 12/19 (EOM +1)
    - YERO recovery prior to D/O Prep
    - EOM Waveoff due to systems problem or bad WX at KSC
  - 12/20 (EOM)
    - YERO recovery prior to D/O Prep
    - Loss of a KSC D/O Opportunity (best case)
  - 12/21 (EOM -1)
    - YERO recovery prior to FCS checkout
  - 12/23 (Undock Day)
    - YERO recovery prior to undock
  - 12/24 (FD9 if Contingency EVA)
    - YERO recovery prior to EVA
  - 12/25 (FD8 EVA#3 – MBSU ¼ Reconfiguration, SMDPs)
    - YERO recovery prior to EVA
    - ISS may require Vern Attitude control as part of ISS Power reconfiguration operations
    - RMS used for SMDP task
- **FOICB agreement to investigate YERO recovery for Quiescent operations only**
  - Post sleep only “quiescent “ period / but prior to critical activity
  - Unexpected anomalies during YERO recovery will have impacts to critical mission objectives defined above



# Program Risks



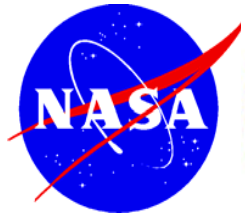
- Generic Concerns
  - Rebuilding PASS Set on Orbit (similar to PASS recovery after BFS engage, Reloading OS of personal PC)
    - IPL performed on All PASS GPC's.
    - Loss of G3 Archive
  - Procedures are mature but minimum shelf life.
    - Minimal Testing/Certification
  - Flight Control Team/Crew has limited ability to train this in an integrated environment.
    - Single SAIL verification to be run with CDR/MS and STS-116 FC Team.
    - No additional time in STS-116 Crew schedule.
    - May be able to utilize SMS for FC Team training.
  - Increased vulnerability to PLS cases due to loss of single fault tolerance in systems critical to YERO recovery.
  - IPS Source Select Switch is Zero Fault tolerant.
    - Can not IPL GPC's without this switch.
      - Switch does have MMU1 and a MMU2 position (smart failure required).
    - Hip pocket IFM being assessed for this switch.



# Program Risks



- Generic Concerns
  - Exposure to systems failure during “hybrid” configuration from YERO until YERO recovery (pre-sleep until complete)
    - Orbit Pocket may not be able to support “hybrid” configurations
    - Test to date focused on procedure development with no failures
    - Additional exposure to no attitude control periods (undocked)
      - Risks to additional Loss of Comm periods (commanding needed to support YERO recovery)
  - No End to End MCC/Network Checkout
    - Understand that in theory this would be similar to ISS YERO recovery
  - Two MCC recycles required to support YERO
    - Additional exposure risks
  - Ground/Orbiter time mismatch (from YERO to YERO recovery)
    - No testing done to determine specific impacts
    - Known Impacts:
      - Loss of Navigation monitoring (no SV updates can be performed)
      - Unknown Nav and Guidance interaction due to GPC time error



# Program Risks



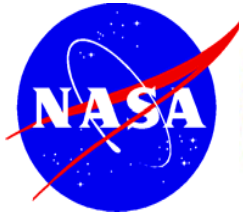
- YERO While Undocked -Launch Dates 12/21-12/22
  - SCSC violations.
  - Consequence of unexpected problems (procedural or hardware) are greater when undocked
    - May result in loss of attitude control for an extended period if GPC does not IPL correctly
      - Communication loss may also occur depending on the GG attitude and TDRS line of site which will further limit the ability to regain a stable configuration
        - » Commanding required to support YERO recovery
    - Procedure shelf life, limited certification testing, and inability to train this in the SMS all factor into this
    - Next worse failures not reviewed



# Program Risks



- YERO While Docked - Launch Dates 12/23-12/26
  - SCSC violations.
  - YERO on Undocking day does not provide checkout time for the GPC's before you count on them for undock.
  - Being Docked provides best platform for troubleshooting unexpected problems.
    - ISS attitude control and communications if required.
    - Will have time to work the problem in a stable environment.

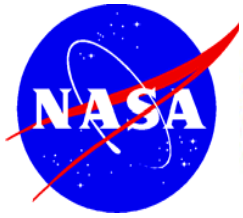


# Program Risks



- **YERO on Deorbit Days - Launch 12/18 – 12/20**

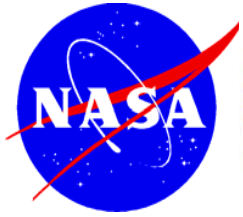
- SCSC Violations
  - EOM timeline can accommodate procedure at the expense of a KSC De-Orbit Opportunity (best case)
- EOM+1 day is the Wx Waveoff day and the goal is to maximize opportunities to KSC/EDW for landing on this day
  - YERO procedure would cost a KSC deorbit opportunity
- EOM+2 day is if a systems problem occurs and provides time for the team to workaround/understand the anomaly
  - YERO procedure would complicate this
- YERO includes both Onboard and MCC/Network configuration changes.
  - Magnitude of configuration changes increases risk of unexpected problems with minimal time to troubleshoot and resolve
- Crew/MCC should be focused on De-orbit Prep and landing.
- YERO on EOM days would provide minimal runtime on the GPC's before you really count on them
- Consequence of unexpected problems (procedural or hardware) are greater when undocked
  - May result in loss of attitude control for an extended period if GPC does not IPL correctly.
    - Communication loss may also occur depending on the which will further limits the ability to regain a stable configuration
  - Procedure shelf life, limited certification testing, and inability to train this in the SMS all factor into this



# Program Risks



- Other:
  - Loss of Missions Objectives
  - Loss of Late Inspection Day
    - Utilization of +1 to recover from YERO anomalies



## Comments



- Launches from 12/18 – 12/26 have increased risk (above the standard risks) with the dependence of YERO recovery procedures to safely configure the Orbiter for operations
- Post Sleep SCSC violations on every day 12/18 -12/26.
  - Requires delaying D/O TIG to resolve
  - Requires deleting Transfer operations to resolve
  - Cannot be resolved for a 12/21 launch (Cabin Stow)
- YERO while Undocked
  - No safety net
- Dependent on launch date, YERO recovery is required on critical mission days
  - EVA, Undocking, EOM -1 Day, Deorbit Prep
- Limited testing
- Limited testing to date hasn't combined recovery with failures

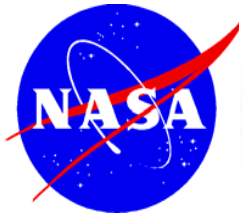




## Recommendations



- MOD recommends that YERO not be utilized to extend the STS-116/12A.1 Launch window past 12/17.
  - STS-116/12A.1 is the most complicated/challenging assembly mission to date and MOD does not recommended adding the complexity of YERO to the mission.
    - P5 Install, P6 4B retraction, MBSU Power reconfigurations, EATCS activation.
    - CAT1 activities, that if not successfully completed, have major impacts to assembly sequence/future missions manifest
  - YERO recovery is required prior to critical activities (EVA#3, Late Inspection, EOM-1 activities, Deorbit Prep)
    - Post sleep/prior to activity
    - Significant distraction to crew and MCC
    - YERO in critical path
    - Unexpected anomalies and associated impacts to critical activities
  - Increased vulnerability to PLS cases due to loss of single fault tolerance in systems critical to YERO recovery
  - Multiple SCSC violations which resolution reduces operational capability/options
  - Additional launch attempts with added YERO risks versus next launch attempt (window open 1/15/07)
- Utilize YERO testing/training to date for CSCS only
  - Ground and Orbiter procedures validated with minimum testing and shelf life
  - Crew and MCC minimal familiarization with procedures



# Backup

October 23, 2006

STS-116/12A.1

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# 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)



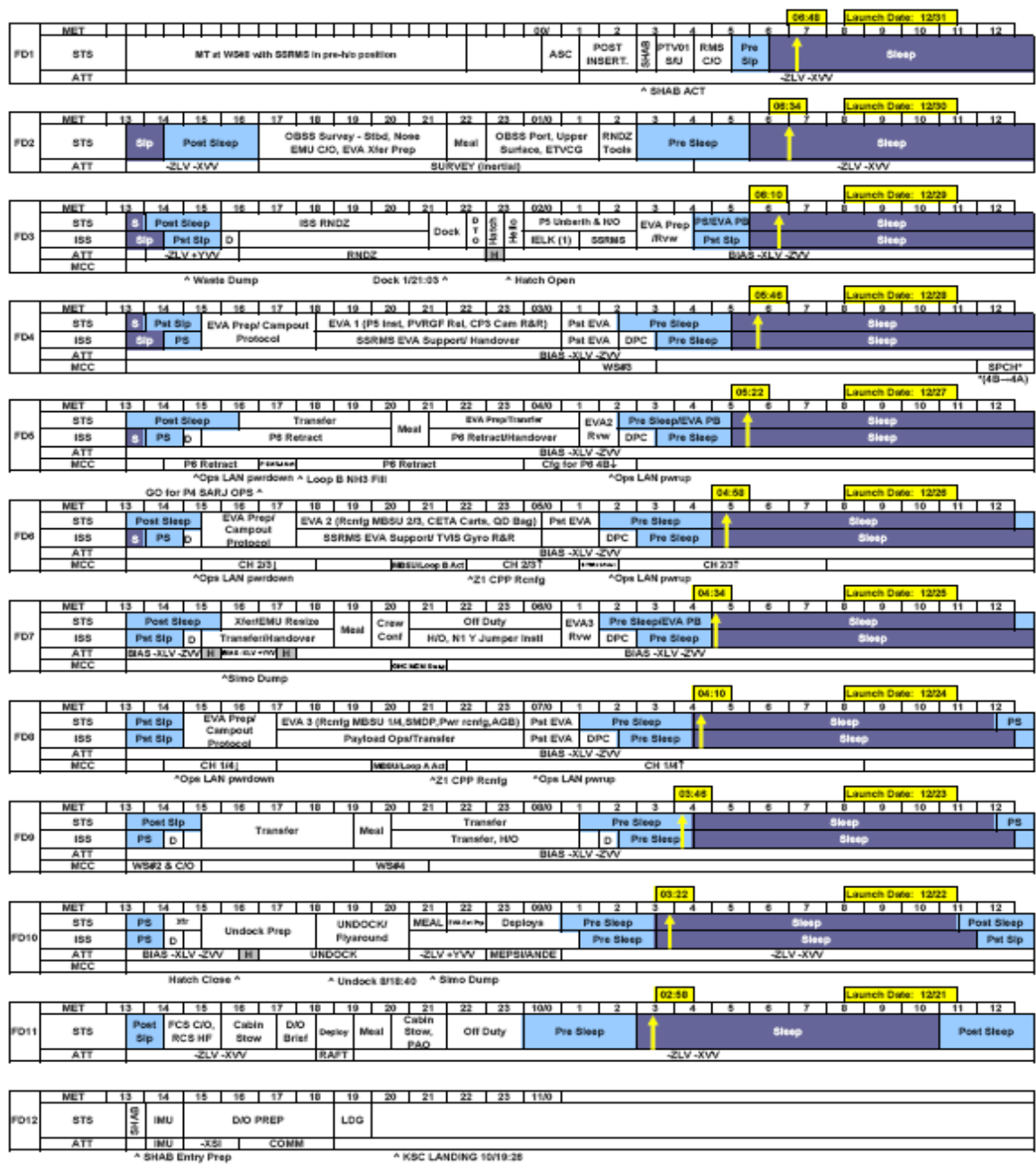
# YERO Timeline Assessment 12+2



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

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# 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			
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

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

**Work Completed to Date, Future Testing, Ground Procedure**



# Background

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- **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.

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- **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

# Future Testing

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## ● Oct. 25 SAIL- MCC- Network Test

- STS-116 flight load and PSS baseline
- Landing (after YERO recovery)
- Additional workstation activity/Traj Server to monitor onboard Nav during out-of-sync period (from YERO until YERO recovery complete)
- Network facilities included (GSFC, MSFC, KSC, MILA)
- Full 116 FCT participation for training purposes (including 116 Cmdr.)
- PGSC hardware/applications
- No EVA suit test (can operate without ground data)
- May be only training opportunity (could use SMS for training)
- Post-Test Briefing on Oct. 31

# Ground Procedure

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- **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)
  - May see “funny” timestamps during out-of-sync period  
(Timestamp source – onboard vs. ground – is application specific)  
Will note 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 (116 flight-specific version TBD)

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

Carlos B. Valrand  
Space Shuttle Flight Software  
October 23, 2006



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

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- 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
  - Demonstrates 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 GNC/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 Preliminary Analysis is complete
  - YERO Performance Test Report distribution scheduled for 11/07



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

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- **BFS Level 7 YERO SDF Tests (Boeing)**
  - **Six (3 Deorbit and 3 Entry) Level 7 6-DOF SDF test cases**
    - **BFS listen, BFS engaged (1 PASS GNC/1 BFS GPC), and BFS engaged following PASS failure**
  - **Tests perform YERO BFS (part 3) procedure, perform deorbit, and continue to entry and landing**
  - **Target completion 10/27/06**
- **FSW YERO audit**
  - **PASS audit to identify time parameter constraints to year end boundary**
  - **Target completion 10/31/06**



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

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- **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-fail) 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
  - Currently on target for analysis complete by 10/31/06



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

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- **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 is co-sponsored by MOD and Boeing IAV
  - Test plan and procedures have been developed and approved
  - MCC, SAIL, GSFC and MER support has been negotiated and scheduled
  - Test is planned for 10/25 and is currently on schedule



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

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- 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



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

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- 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



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# Summary

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



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# **YERO Operations**

**DF32/Ronnie Montgomery**

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# Why We Are Doing What We Are Doing

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- **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)

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- **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)

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- 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)

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- 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)

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- 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

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- **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

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- **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

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- **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

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- **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