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# STS-131 MOD FRR

## FLIGHT DYNAMICS DIVISION



February 4, 2010

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### DM Flight Dynamics (Trajectory Operations)

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- None Special Topics
- None Issues and Concerns
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# Shuttle CoFR Status Summary

MOD Requirements Codes *	DM	USA FDD
NON-CRITICAL PROC/APPL	G	G
FD-TRAJECTORY	N/A	G
FD-CONSUMABLES (PROP)	N/A	G
FD-ANALYST CERT	N/A	G
FD-CTF	N/A	G
FDF	G	G
EMCC	G	G
CREW TRAINING	G	G
CERTIFIED FLIGHT CONTROLLERS	G	G
CERTIFIED INSTRUCTORS	G	G
FTP-NEW OPS	G	G
FLIGHT ANOMALY RES	G	G
ANOMALY-PROCEDURE	G	G
EX/AI FROM PRIOR READINESS REVIEW	None	None
NO CONSTRAINTS	None	None
LEVEL II (PROGRAM) ACTIONS	None	None
MISSION REQUIREMENTS	G	G
CMD PROC	G	G
EXCEPTION RESOLUTION	G	None
FPPP REQ MET	G	G
CONTRACTOR PROCESS INSIGHT	G	N/A

G	Ready to support flight or standard open work
Y	Non-standard open work with expected resolution
R	Open work without expected resolution
N/A	Does not apply
None	None identified

\* as defined in DA8-020 "MOD Certification of Flight Readiness Process" document  
 Note: CRIT PROC/APPL responsibility has been transitioned to FDOC

# Mission Overview Summary

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<b>Launch/Landing Times</b>	<b>Date</b>	<b>GMT</b>	<b>EDT</b>	
<b>Launch Window Open</b>	<b>March 18, 2010</b>	<b>17:30:05</b>	<b>13:30:05</b>	(hh:mm:ss)
<b>Launch Window Close</b>		<b>17:40:04</b>	<b>13:30:04</b>	(hh:mm:ss)
<b>Landing Time (KSC)</b>	<b>March 31, 2010</b>	<b>11:39</b>	<b>07:39</b>	(hh:mm)

FD3 rendezvous opportunities are anticipated for nearly every day in the March launch period (3/19 is borderline FD4)

**First Stage Design Criteria**     **DOLILU II / High Q**  
**Insertion Altitude/Inclination**     **122 nm / 51.6 deg**

**APM** (above a 5 minute window centered at in-plane, absolute)

**I-load Design**                     **1077 lbs**

**Projected APM\***                     **1352 lbs**

\* Based on 01/28/10 APM simulation and 1/26/10 Green Book

Launch hold capability inside of drainback is dependent upon actual DOL performance. Abort coverage has sufficient overlap from liftoff to MECO.

# Significant Changes Since Design Baseline

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- **Rendezvous altitude decrease from 190 nmi to 188 nmi**
  - Required to match ISS planned orbital altitude
- **Multi-stage deorbit implementation for contingency return cases**
  - Required to increase ascent performance margin
- **Removal of GN2 tank**
  - Performance gain incorporated
- **Pending CR to increase MPLM return control weight**
  - Increase from 17,700 lbm to 19,150 lbm

# Significant Mission Firsts and Unique Items

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- **Change to mission duration**
  - 13+2+2 has been approved to support dual docked operations
  - PRCB CR S072131C is being dispositioned out of board
  - Will pick up change as part of Uplink cycle

# Deviations, Exceedances and Anomalies

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## Deviations/Exceedances

- **No Dock PLS and Retrieve LMC & MPLM cases exceed the nominal EOM downweight limit**
  - No pre-flight analysis is required per AEFTP direction
  - Real-time assessment will be performed, if required
  - Exceedance has been documented in the Flight Rules Annex
- **A Contingency Abort Black Zone (CABZ) assessment is required.**
  - Mass properties meet the CABZ assessment criteria of liftoff weight greater than 259,000 lbm and Xcg aft of 1115.0 in.
  - OCF cycle liftoff weight = 266,437 lbs. and Xcg = 1119.1 in.
  - FRR cycle liftoff weight = 266,662 lbs. and Xcg = 1117.9 in.
  - Assessment revealed increased 2 and 3-engine-out black zones compared to STS-114 baseline
  - Results were reviewed with Flight Director and SSP
    - Do not plan to pursue any mitigation options

# Deviations, Exceedances and Anomalies (concluded)

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## Previous Mission Anomalies and Previous Flight of OV-103

- None



# Special Topics

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- **Upgrade to Thermal/Structural Envelope Program (TSEP) v3.8.1 at Program Direction**
  - Incorporates more refined rules for assessing Alpha-limit violations
  - Awaiting OCCB approval
    - Previous version is acceptable to use if update is not approved by 3/4/10
  - Will be tracked and completed as Non Standard Open Work

# Issues and Concerns

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- **A potential violation of FRCS tank structural limits was identified for a TAL case on flights with a minimum FRCS load**
  - STS-130 assessment showed that the standard TAL FRCS dump timer (NSTS-21075 Level B GR&C section 6.1.4.b.8) may not satisfy NSTS-08934 SODB Vol. V limits (Table 4.3.2-11)
  - Flight Design assessment resulted in negative margin; however, the derivation of the SODB requirement was not clear
  - The community met and came up with a better understanding of the SODB requirements and methodology to evaluate this requirement and determined that STS-130 does not have a violation
  - Need to determine if the new understanding/methodology results in adequate margin for STS-131 or if a new TAL FRCS dump timer should be implemented
    - Tracking as non-standard open work (ECD 02/14/10)

## Issues and Concerns (cont)

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- **US Army's Information Assurance (IA) policy affect on C-band Tracking**
  - White Sands Missile Range (WSMR) C-band tracking support is currently unavailable due to implementation of the IA policy
    - IA policy provides restrictions on the transmission of unclassified data
    - A waiver to the IA policy for WSMR C-band tracking support is currently being worked and approval is expected prior to the STS-130 launch
    - If the waiver is not approved
      - WSMR will be unavailable in the event of a Northrop landing
      - Potential violation of flight rules A3-3.B and A3-102

# Exceptions and Standard Open Work

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## Exceptions

- None

## Standard Open Work (complete listing in backup charts)

- All open work is scheduled to be completed per standard flight template
- No issues have been identified

## Non-Standard Open Work

- TAL FRCS Prop Dump Timer Assessment 2/14/10
- GNAV2 Certification 3/01/10
- NOC Certification 3/01/10
- Target Certification 3/03/10
- Winds Coordinator Certification 3/04/10
- TSEP 3.8.1 3/04/10

# Rescue Mission Status

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- **STS-132 has been designated as the LON flight for STS-131**
- **STS-132 will be ready to launch on 05/14/10, if required, with the cargo element installed**
- **All rescue mission-specific analyses will be performed after call-up**

# Flight Design and Dynamics Readiness Accountability Statement

- ☑ **Software** : FDD discipline software used to create mission products meets generic and mission-specific Program requirements and is maintained under configuration control in accordance with the appropriate Software Management Plan.
- ☑ **Flight Software** : All flight software Principal Functions (PFs) owned by FDD are ready for flight. All Discrepancy Reports and Program Notes and Waivers related to USA-owned PFs have been reviewed and appropriately dispositioned for this flight.
- ☑ **Anomaly Resolution** : All anomalies that could impact mission support have been closed, or have accepted and approved work-arounds in place.
- ☑ **Production** : All flight reconfiguration products and real-time console support products meet generic and mission-specific Program requirements.
- ☑ **Operations** : All mission support personnel and instructors are or will be trained, certified and current prior to supporting mission related activities. All flight-specific crew training will be completed prior to launch.

The FDD Flight Readiness Review Process Plan (USA009229) and the Flight Operations Flight Preparation and Readiness Plan (USA008977; Appendix D) which define the processes and products required for a successful flight have been executed and the applicable Program CoFR requirements satisfied.

The undersigned certify that the Flight Design and Dynamics Department, upon satisfactory resolution of any noted exceptions, is ready to support flight STS-131.

<b>Flight Design and Dynamics</b>	<b>S. A. Anderson Director</b>	<i>Original signed by S.A. Anderson</i>	1/28/10
<b>Ascent/Descent Flight Design</b>	<b>D. J. Brockway Manager</b>	<i>Original signed by D.J. Brockway</i>	1/28/10
<b>Orbit Flight Design</b>	<b>R. M. Hill Manager</b>	<i>Original signed by R.M. Hill</i>	1/28/10
<b>Navigation &amp; Flight Design Integration</b>	<b>G. E. Schrage Manager</b>	<i>Original signed by G.E. Schrage</i>	1/28/10

# Flight Design and Dynamics Declaration of Compliance with CoFR Endorsement Requirements for STS-131 Flight Readiness

- ☑ **Software** : FDD discipline software used to create mission products meets generic and mission-specific Program requirements and is maintained under configuration control in accordance with the appropriate Software Management Plan.
- ☑ **Flight Software** : All flight software Principal Functions (PFs) owned by FDD are ready for flight. All Discrepancy Reports and Program Notes and Waivers related to USA-owned PFs have been reviewed and appropriately dispositioned for this flight.
- ☑ **Anomaly Resolution** : All anomalies that could impact mission support have been closed, or have accepted and approved work-arounds in place.
- ☑ **Production** : All flight reconfiguration products and real-time console support products meet generic and mission-specific Program requirements.
- ☑ **Operations** : All mission support personnel and instructors are or will be trained, certified and current prior to supporting mission related activities. All flight-specific crew training will be completed prior to launch.

**Requirements Compliance:** All requirements defined by the documents below (as required by the FIDP Compliance Matrix) have been or will be satisfied prior to flight.

DOCUMENT	VERSION	DATE
Flight Implementation Data Pack (FIDP) - Generic	GEN-LT	01/19/10
Flight Implementation Data Pack (FIDP) - Flight Specific	131-BASE-S	01/25/10

## Waivers & Exceptions:

None

*The FDD Flight Readiness Review Process Plan (USA009229) and the Flight Operations Flight Preparation and Readiness Plan (USA008977; Appendix D) which define the processes and products required for a successful flight have been executed and the applicable Program CoFR requirements satisfied. Pending completion of open work and closure of noted exceptions, if applicable, Flight Design & Dynamics is ready to support STS-131.*

*Original signed by S.A. Anderson*      *01/29/10*  
 Director      Date  
 Flight Design & Dynamics

# DM Flight Design and Dynamics (Trajectory Operations)

## Significant Mission Firsts and Unique Items

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### ISS Phasing Strategy

- Two ISS Reboosts completed prior to STS-130
  - 1/22 – 3.35 ft/s (1.02 m/s) test burn with SM engines
  - 1/24 – 9.67 ft/s (2.95 m/s) sets up phasing for 36P and STS-130
- Two ISS Reboosts planned prior to STS-131 to set up phasing for STS-131, 20S landing, and 22S launch
  - 2/20 – 11.5 ft/s (3.5 m/s)
  - 2/28 – 3.3 ft/s (1.0 m/s)
  - Magnitude of both reboosts subject to change depending on perturbations (including any mated reboost acquired) from STS-130.
- Rendezvous altitude will be approximately 188 nm.
- FD3 rendezvous from 3/18 – 4/2 (3/19 is borderline FD4)
- Beta cutout 4/14 – 4/30 (for launches during this period, the mated solar beta constraint of 60 deg is violated)
- Window open on small phase angle days limited by minimum of 37 deg.



# Significant Mission Firsts and Unique Items

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## Joint Underspeed Recovery Capability

- Thrusters: 8 R&D Progress engines
- Delta-Velocity capability: ~6 mps (~19.6 fps) per burn
- Propellant available: 10088 lbs total (limited to three 2000 sec. JURE burns)
- Burn sequence: FD3 daily orbit 1&2, FD4 daily orbit 1  
With 3 burns, rendezvous is on FD5.

## Development Test Objectives

- DTO 701A TriDAR Automated Rendezvous and Docking (AR&D) Sensor
- DTO 854 Boundary Layer Transition (BLT) Flight Experiment
  - same size protuberance as STS-128 (0.035 in.)

# Significant Mission Firsts and Unique Items

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## Third Flight Taking Ku Radar to Standby Prior to RPM.

- Change initiated by INCO to avoid radiating the crew during the GPC/AUTO TRK switch.
- Performed with no issues on STS-129 and STS-130.
- Small risk of not detecting and locking onto ISS after the RPM.
  - If TCS is working, no impact.
  - If TCS is not working, HHL is the backup so radar is not required.

## Changes to the Go/No-Go for RPM

- Loss of 1 FxD jet caused the RPM to be no go because the loss the second FxD on the same side caused the rendezvous for that day to be lost
- PRCB has decided to accept the risk of losing the second FxD during the RPM
  - Window of exposure is small (~10 seconds at start of RPM)
  - Provided next day re-rendezvous capability exists
- Rules and procedures are updated

## No Planned Hardware Jettisons

## No Deployable Payloads

## Payloads of Opportunity

- MAUI, SEITE, SIMPLEX, RAMBO 2

# Exceptions and Open Work

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## Exceptions

- None

## Standard Open Work (complete listing in backup charts)

- All open work is scheduled to be completed per standard flight template
- No issues have been identified

## Non-Standard Open Work

- Entry GSO Certification Pending **Feb 4, 2010**
- Orbit TRAJ Certification Pending **Feb 26, 2010**

# STS-131 Flight Dynamics Division Readiness Statement

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The Flight Dynamics Division has performed the reviews necessary to assess the flight readiness relating to flight design requirements definition, crew and flight controller training, and trajectory operations. We have determined all applicable responsibilities acceptable for flight pending closure of the identified open work and issues.

Original Signed by S. Dunham 2/1/10

**Scott D. Dunham**  
Chief, Orbit Dynamics Branch  
Branch

Original Signed by W. Powers 2/1/10

**Barbara A. Conte**  
Chief, Ascent & Descent Dynamics

Original Signed by S. Dunham 2/1/10

**Robert D. Banfield**  
Chief, Flight Dynamics Division

As compiled by:

FDM/David Tee  
FDO/David Mayhew

# Back-Up

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**Flight Readiness Open Work**

**Propellant Summary**

**Separate Back-up File**

- **Launch Window**
- **Abort Regions Chart**
- **Nominal ET Impact Area**

## Flight Readiness Open Work

Item	Responsible	Due Date	Closed	Closure Rationale
<b>USA Flight Design Standard Open Work:</b>				
PROP37 SODB Volume II Amendment	PROP	02/05/10		
DATA43 FDD FRR Data Pack	FDM	02/09/10		
FSW Verification Test Results Review	ADFD	02/16/10		
FSW Verification Test Results Review	Orbit	02/15/10		
RNDZ/FDO Phasing Plan Meeting	Orbit	02/15/10		
DATA45 FDD FSW PF Sign-off	FDM	02/17/10		
ONOR29B RNDZ Launch Target Data	Orbit	02/17/10		
PROP06 OMRSD OMS/RCS	PROP	02/18/10		
PROP07 Abort Propellant Dump Tagup	PROP	02/18/10		
PROP02 Mass Properties	PROP	02/23/10		
L-4 week LDO Database Freeze	ADFD	02/18/10		
RNDZ08 RNDZ Phasing Limits	Orbit	02/22/10		
Prop Analyst & Flt Controller Tag-up	PROP	02/24/10		
ONOR37B Daily Planar/Phase Windows	Orbit	02/24/10		
ASCT04 Uplink APM	ADFD	02/25/10		

## Flight Readiness Open Work - Continued

Work Item	Responsible	Due Date	Closed	Closure Rationale
<b>USA Flight Design Standard Open Work - Continued:</b>				
NAVO16B GPO COTM Data Pack	Navigation	02/25/10		
NAVO18B GPO/ONAV Ops Memo	Navigation	02/25/10		
LDO: L-3 week LDO Checkout/TCDT Sim	ADFD	02/27/10		
ONOR27 Launch and Landing Data	Orbit	02/26/10		
ASCT44 DOL Uplink I-loads	ADFD	03/03/10		
ONOR29C RNDZ Launch Target Data	Orbit	03/09/10		
Dial Down Decision FIDP	FDM	03/10/10		
DSCT17 Landing Site Tables	ADFD	03/11/10		
ONOR37C Daily Planar/Phase Windows	Orbit	03/11/10		
RNDZ02 Target Drag Characteristics	Orbit	03/11/10		
PROP00A PROP/Ascent Aborts Tagup	PROP	03/11/10		
C-Band tracking Scheduling Message	Navigation	03/13/10		
PERA Pre-Flight Product	ADFD	03/11/10		
ASCT99 OMS Assist - ATO Update	ADFD	03/12/10		
RNDZ09 Rendezvous COLA Plans	Orbit	03/12/10		
PROP02A DOL Mass Properties Updates	PROP	03/13/10		

## Flight Readiness Open Work - Continued

Work Item	Responsible	Due Date	Closed	Closure Rationale
<b>USA Flight Design Standard Open Work - Continued:</b>				
Pre-Launch Mass Properties Request	PROP	03/13/10		
PROP31 ARD Data	PROP	03/13/10		
PROP33 Ferry Data Package	PROP	03/13/10		
PROP34 MCC Data	PROP	03/13/10		
SRB & ET RTLS Impact Point Update Memo	ADFD	03/15/10		
ASCT42 Collision Avoidance Data	ADFD	03/15/10		
ASCT47 Final MCC Trajectory Inputs	ADFD	03/15/10		
DSCT66 Real-Time Support Files	ADFD	03/15/10		
Range Safety Launch Window Cutout	ADFD	03/15/10		
Flight Annex	Navigation	03/11/10		
ASAB32B AME MCC Support Tables	ADFD	03/16/10		
L-2 day DOLILU System Checkout	ADFD	03/16/10		
DSCT05 Maximum Crossrange Capability	ADFD	03/16/10		
ASAB25 ARD Bias Tables	ADFD	03/17/10		



## Flight Readiness Open Work - Continued

Work Item	Responsible	Due Date	Closed	Closure Rationale
<b>USA Flight Design Non-Standard Open Work:</b>				
TAL FRCS Prop Dump Assessment	ADFD	02/14/10		
GNAV2 Certification	Navigation	03/01/10		
NOC Certification	Navigation	03/01/10		
Target certification	Orbit	03/03/10		
Winds Coordinator Flight Controller Certification (Landing)	ADFD	03/04/10		
TSEP 3.8.1 Release	ADFD	03/04/10		

## Flight Readiness Open Work - Continued

Item	Responsible	Due Date	Closed	Closure Rationale/Status
<b>Trajectory Operations Standard Open Work</b>				
Close to Launch Trajectory Data	OFDO	02/11/10		
TCDT Checkout in Ops Cert Mode	AE GPO	03/02/10		
DOD Support Readiness	LSO	03/03/10		
Flight Load Checklist Complete	Nav	03/11/10		
Flight Load Checklist Complete	DOLILU	03/11/10		
Flight Load Checklist Complete	Entry Support	03/11/10		
Flight Load Checklist Complete	Orbit-RNDZ	03/11/10		
Successful Completion of RNDZ Training	RNDZ Instructor	03/01/10		
Flight Load Checklist Complete	RGPO	03/11/10		
Flight Load Checklist Complete	AE FDO	03/11/10		
Flight Load Checklist Complete	AE GPO	03/11/10		
Flight Load Checklist Complete	LSO	03/11/10		
Flight Load Checklist Complete	OFDO	03/11/10		

## Flight Readiness Open Work - Continued

Item	Responsible	Due Date	Closed	Closure Rationale/Status
<b>Trajectory Operations Non-Standard Work:</b>				
ENTRY GSO Certification	FDO	02/04/10		
Orbit Traj Certification	FDO	02/26/10		

## Flight Readiness Open Work - Concluded

Item	Responsible	Due Date	Closed	Closure Rationale/Status
<b>DM Standard Open Work:</b>				
Orbiter Readiness Statement	DM	02/16/10		
Range Safety Readiness Statement	DM	03/02/10		

The Flight Dynamics Division has performed a final review and determined all Division and USA FDD open work and/or actions for this mission are closed or acceptable rationale is provided for proceeding with the flight.

\_\_\_\_\_  
 Flight Design Manager  
 Date\_\_\_\_\_

\_\_\_\_\_  
 STS Integration Manager  
 Date\_\_\_\_\_

\_\_\_\_\_  
 Director, Flight Design and Dynamics Department  
 Date\_\_\_\_\_

\_\_\_\_\_  
 Chief, Flight Dynamics Division  
 Date\_\_\_\_\_

# Propellant Summary

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Propellant Summary	FRCS (lbm)	ARCS (lbm)	OMS (lbm)
Loadings	1912	4970	22761
FRR Design Margins **	1	1	16

\*\* Assumptions: STS-131 ATL, FRR Cycle Trajectory Inputs, 188 nm RNDZ, 113 sec OMS Assist, 1 mated water dump