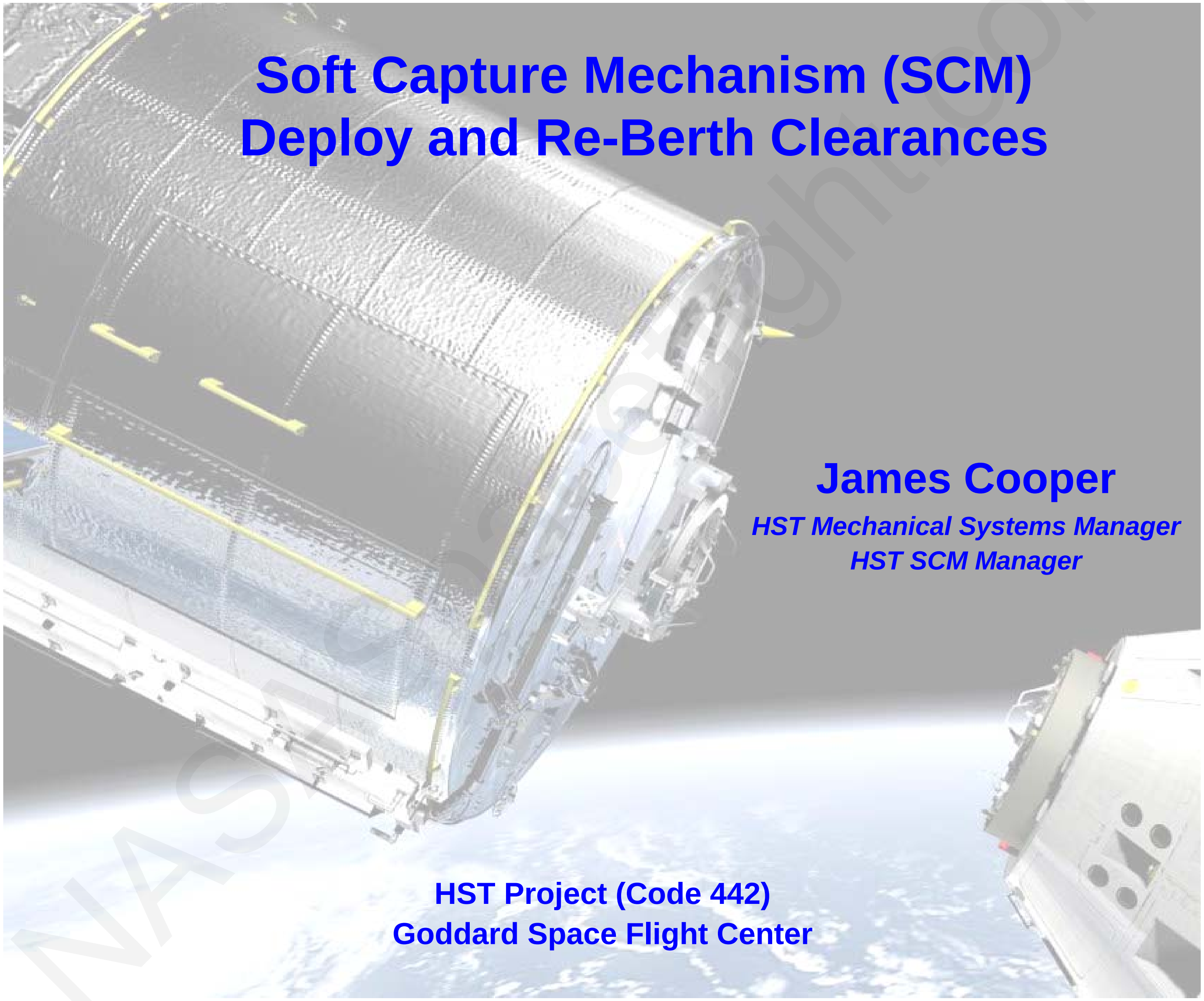
HST SM4 Payload Operations Working Group #2
March 9, 2007



# Soft Capture Mechanism (SCM) Deploy and Re-Berth Clearances

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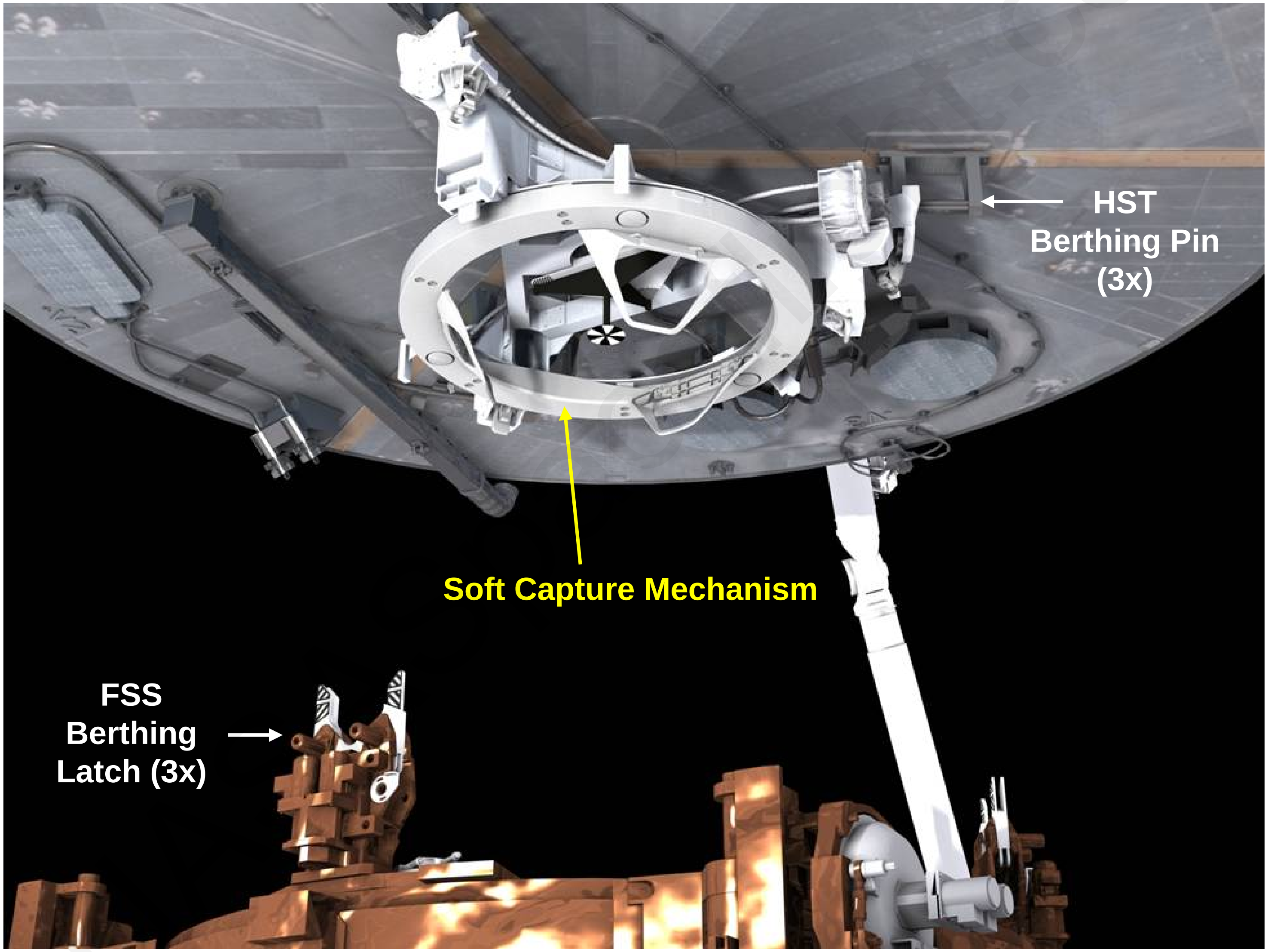
**HST Project (Code 442)**
**Goddard Space Flight Center**

# Introduction

- **Purpose**
  - Show how the HST SCM team is addressing the issue of tight structure clearances during HST/SCM deploy and re-berth.
- **Outline**
  - SCM Design Refresher
  - SCM-FSS Clearance Issue
    - Introduction to the issue
    - RMS Ops and Shuttle Backaway analysis
    - SCM Design Changes Since CDR
    - Definition of available clearance
  - SCM Scuff Plate Design
  - SCM-FSS Contact Loads Analysis
  - Summary
  - Backup Charts

# SCM Attached to HST



# Purpose of SCM

- **The HST Program has a Level I requirement to provide for safe disposal of HST at end of life**
- **The purpose of the Soft Capture Mechanism (SCM) is to provide a Low Impact Docking System (LIDS) compatible interface on HST**
  - Makes HST compatible with the "future standard" vehicle-to-vehicle docking interface
  - Substantially improves the HST capture envelope, makes HST a cooperative target, and provides a viable interface for servicing and deorbit

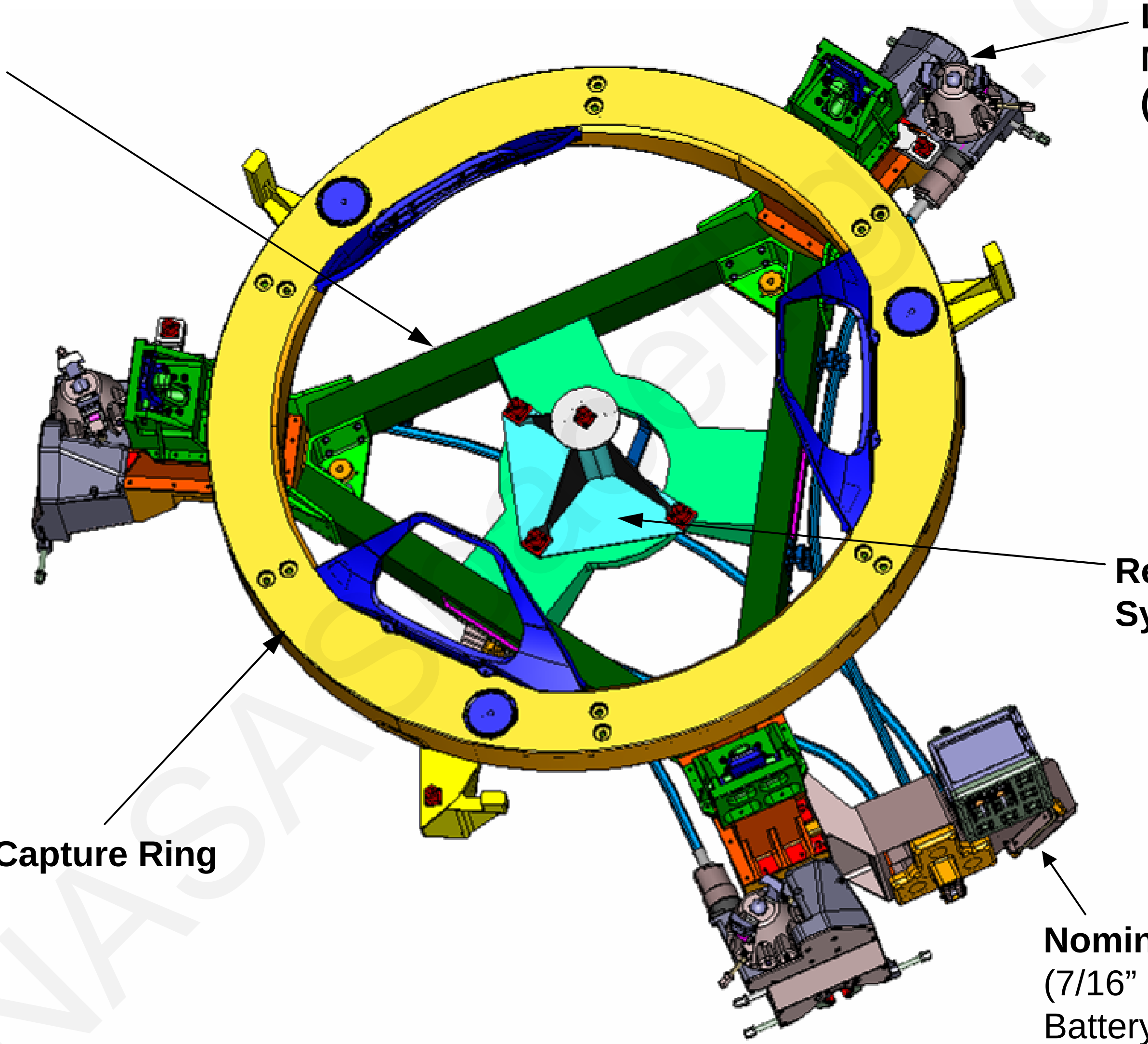
| | Direct Dock to Berthing Pins (from HRSDM program) | LIDS (prelim - ref memo in Data Pack) | Percent improvement that LIDS provides | | *Grapple Fixture (from HRSDM program)* |
|---|---|---|---|---|---|
| **Lateral** | 2.5 cm, 0.4 cm/s | 11.4 cm, 1.3 cm/s | 456 | 325 | *10 cm, 0.4 cm/s* |
| **Range** | 3.75 cm, <2 cm/s | 20.3 cm, 5.1 cm/s | 541 | 255 | *1.73m +/-10cm, 1.5 cm/s* |
| **Roll** | 1 deg, 0.1 deg/s | 4 deg, 1 deg/s | 400 | 1000 | *1 deg, 0.1 deg/s* |
| **Pitch, Yaw** | 1.5 deg, 0.1 deg/s | 4 deg, 0.25 deg/s | 267 | 250 | *1 deg, 0.1 deg/s* |

- **The HST Program and the JSC/LIDS Program have agreed on a joint effort to incorporate a passive LIDS interface onto the SCM**
  - LIDS and HST Programs will jointly document the SCM capabilities and write an ops concept for future use
- **SCM is designed to be at least as strong as the HST Berthing Pins, so servicing and deorbit load capabilities are not diminished**
  - Berthing Pins cannot be changed, and they will remain the "weak link" as they have always been.

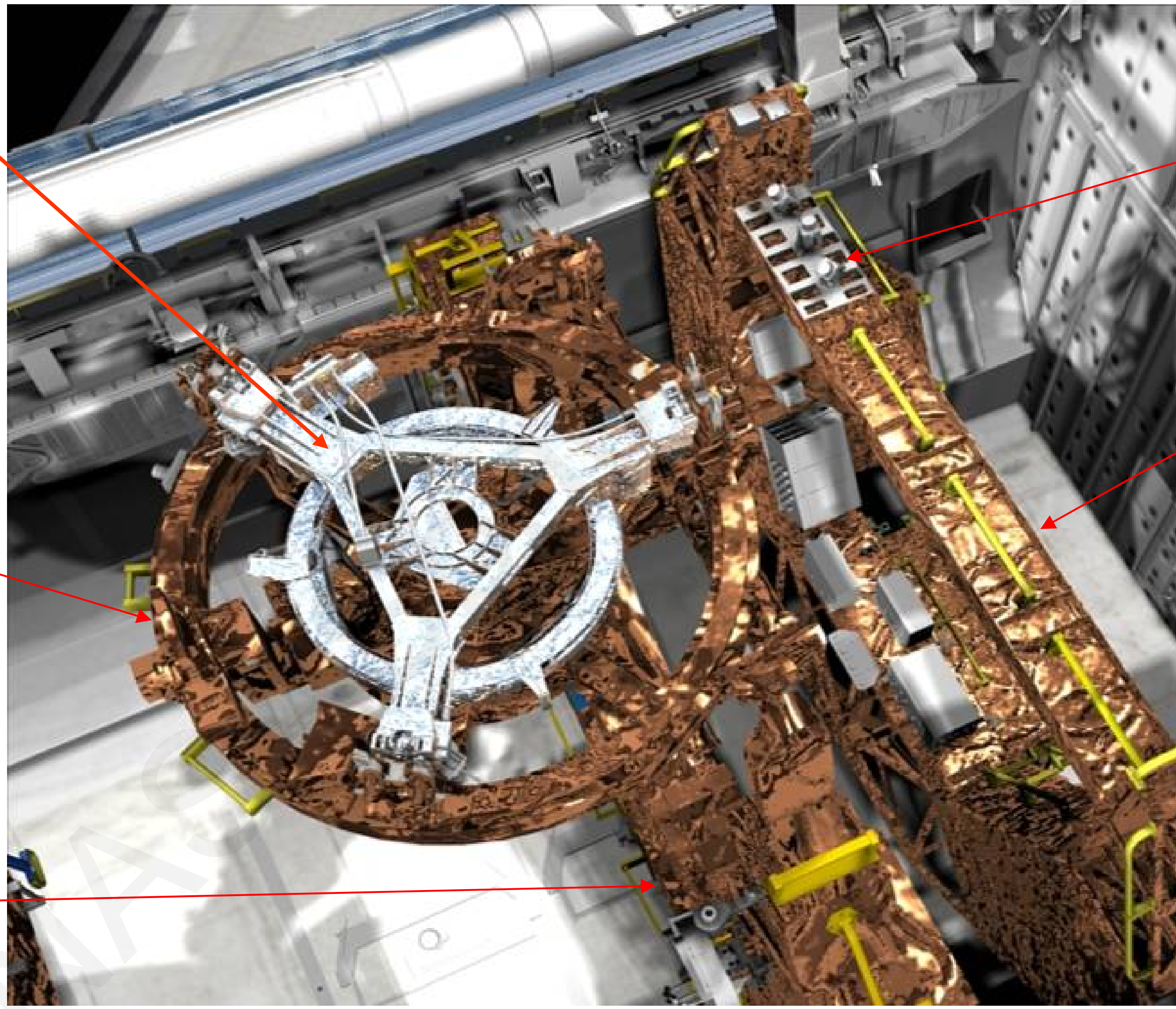
# SCM Review History

- SCM Concept Study Task Start — Oct, 2005
- First Requirements & Concept Design TIM Presentation to GSFC — Nov, 2005
- First Meeting with JSC/LIDS Team — Mid-March, 2006
- Safety Working Group Meetings: GSFC – May 4th; JSC – May 11th
- **PDR** — May 23rd, 2006
- **Clearances & Tolerances Peer Review — June 29, 2006**
  - → Thermal Design Peer Review — July 25, 2006 → Analysis & Mechanism Design Peer Review — Aug 8, 2006
  - → Clearance TIMs — July, 2006
- LIDS SRR (JSC) — Aug 22, 2006 → **Clearances TIM (JSC) *Backaway & RMS Ops* Aug 22, 2006**
- NBL (JSC) — Aug 22-25, 2006
- Safety TIM (JSC) — Oct 17, 2006
- LIDS SDR (JSC) — Oct 30, 2006
- **Ops TIM (JSC) *Backaway & RMS Ops* Oct 18, 2006**
- **CDR** — Nov 9, 2006
- Design changes and internal reviews — Nov thru Feb
- **Clearances and Scuff Loads Telecon — Feb 8, 2007**
  *JSC MOD, PDRS, and Crew*
- POWG TODAY

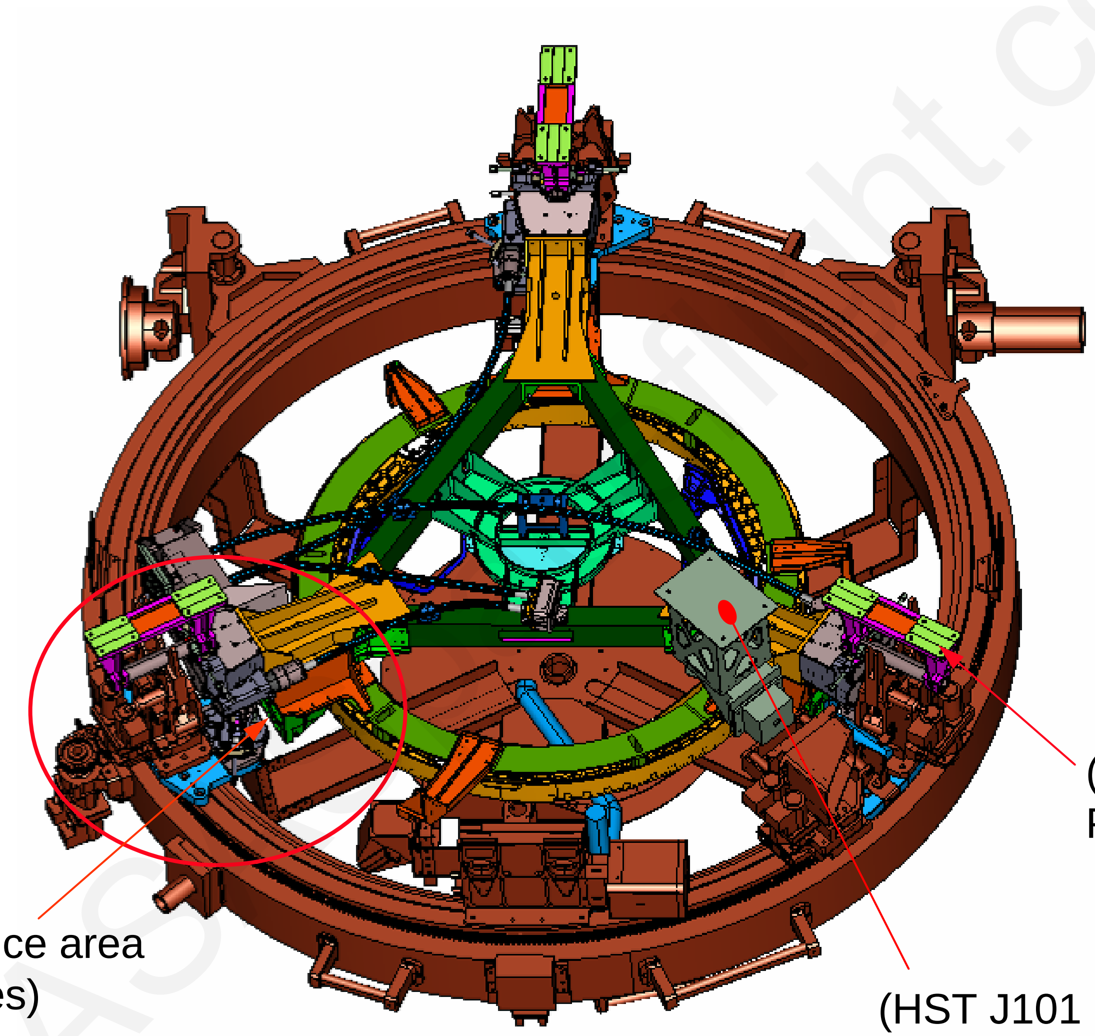
# SCM Overview – Viewed from FSS Side



# SCM Attached to FSS



# SCM Overview – Installed in FSS/BAPS



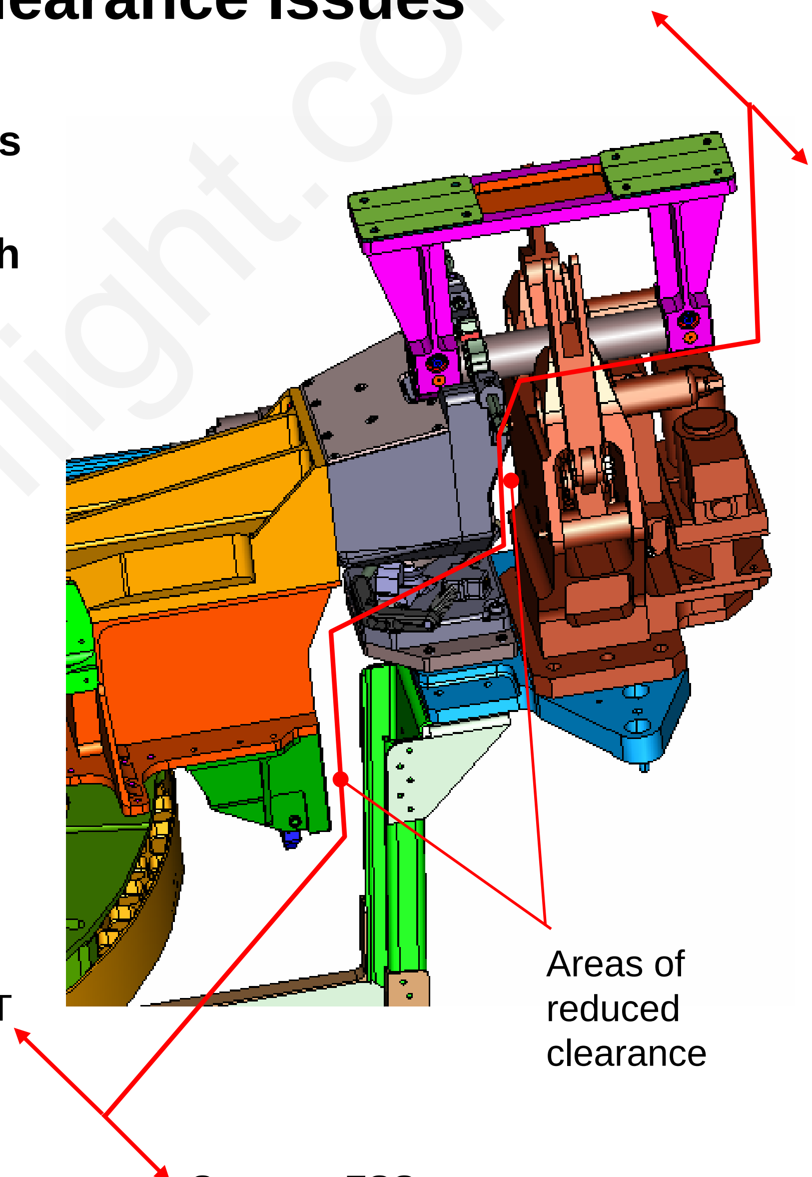

Critical clearance area
(typical 3 places)

Details of this area
shown on following slides

# SCM-FSS Clearance Issue

# Introduction to SCM Clearance Issues

- **With SCM attached to FSS, the tight clearances are not an issue (no relative motion)**
- **With SCM attached to HST, deploy and re-berth clearances are reduced relative to previous missions.**
  - Affects RMS deployment and contingency re-berth, and STS backaway deployment
- **The acceptance of reduced clearances is an open issue for the SCM design**
  - Increased likelihood of contact between SCM and FSS structure
  - SCM design has been optimized to maximize clearances
    - Fixed LIDS interface locations and SCM connection to HST Berthing Pin are the limiting factors
- **HST/SCM team has been working with JSC MOD since summer 2006.**



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# Operational Impacts from the HST Perspective

- **HST Berthing, Deployment, and contingency Re-berth are operationally NO DIFFERENT than on previous missions**
- **Initial berthing of HST is completely unchanged**
  - SCM sits out of the way, slightly below FSS Berthing Latches
- **Deployment is operationally unchanged, but clearances are reduced**
  - Previous missions had 2” nominal clearance (details on next slide)
  - For SM4 that clearance is reduced (details below), increasing likelihood of contact
  - Contacting surfaces are controlled and designed for scuff loading
    - Sensitive areas are protected by dedicated scuff plates
  - Contact (or “scuffing”) during RMS deployment is acceptable, and does not interrupt the deployment process
  - Clearances appear adequate for Shuttle backaway deployment with <u>no contact</u> (preliminary)
- **Contingency re-berth is operationally unchanged, but clearances are reduced**
  - Scuff plate initial entry envelope can accommodate 2” of RMS offset, just as with previous FSS berthing operations
  - As re-berth continues, the clearance is reduced and likelihood of contact is increased
  - Scuff plate and SCM surfaces are smooth and contoured to guide the HST/SCM into place with no impact to the re-berth process
  - Contacting surfaces are controlled and designed for scuff loading

# RMS Deploy & Re-berth

- **ICD-14009 specs on RMS control:**
  - 0.11 ft/sec velocity
  - ± 2” translation AND ± 1º rotation (at RMS end effector)
- **FSS berthing latches provide ± 2” clearance before contact occurs with the HST Berthing Pin**
  - *FSS latches have never met ICD-14009 specs*
  - 2” + 1º at RMS end effector ➔ ~4.8” offset at HST Aft Bulkhead ➔ completely miss latches
- **Contact has always been a possibility, with rate limits imposed to protect HST**
  - SM2 berthing analysis indicated that SA limits were exceeded at 0.08 ft/sec rate (SAI-TM-697, 1996)
  - Previous analysis (Fairchild 90-804-963-001, May 1990) indicated lower acceptable rates
- **On HST missions, RMS control has always been much better than spec values**
  - No evidence of any unintended contact
- **HST berthing will occur at reduced rate (likely 0.01 – 0.02 ft/sec)**
  - Per telecon on 2/8/2007 with JSC MOD, PDRS, and Crew participation:
  - JSC took action to provide SM3B actual berthing data
  - *Max* vernier rate (0.11 ft/sec) may be reduced via software change for HST berthing ops (TBD)
- **All RMS ops that involve the SCM-FSS clearances start from an exact known position**
- **All RMS ops in the critical clearance zone are aided by visual feedback (FSS CCTV looking at HST target)**
- **Animation to illustrate the FSS CCTV camera view with a 2” HST offset**

*NOTE: Recent HST master tool measurements and research on HST Target alignment indicate that a 1/8” V2 offset may be present between HST Target and FSS camera alignment*

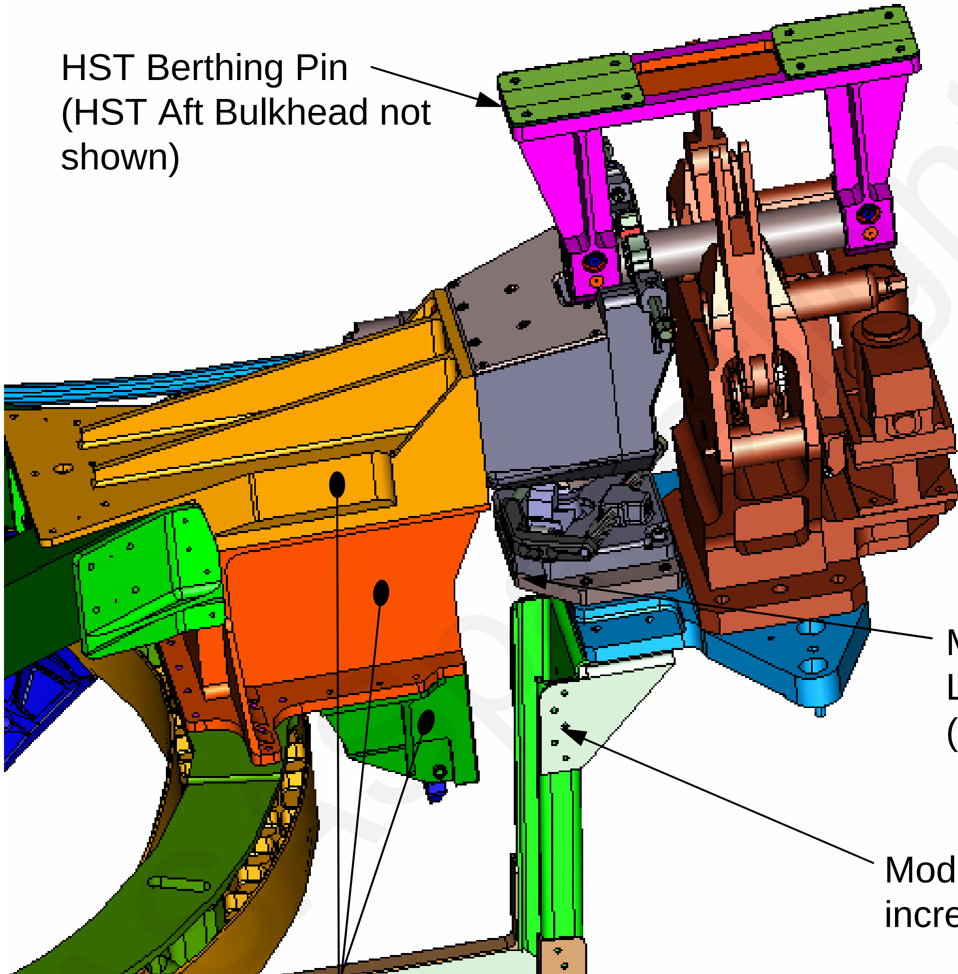
# Shuttle Backaway Deployment

- **Previous HST missions had a contingency separation sequence using Shuttle Low-Z DAP mode, to minimize contamination**
  - Clearance between the berthing latches and telescope structure (2 inches) was not judged to be a problem
- **This results in a net nose down pitch and +Z translation (see backup charts)**
  - In the past this has been deemed acceptable.
- **Due to the reduced clearances after SCM is attached to HST, Draper Lab was tasked to assess if the separation sequence could be improved**
- **Four backaway cases were run using Automatic Reboost Logic**
  - These cases are summarized in the backup charts
- **Preliminary results were presented at the Operations TIM (Oct 2006 @ JSC) and at the SCM CDR (Nov 2006 @ GSFC)**
  - GSFC performed loss-of-clearance analysis using Draper's shuttle rate results and the old SCM and FSS cable tray design (1.0" clearance at cable tray)
  - *Two of four cases looked acceptable for backaway with no contact*
  - *SCM – FSS clearances have since been increased*
  - One case using Norm-Z (aft/upfiring) jet may cause unacceptable plume on HST (see backup charts for preliminary analysis – some HST discriminators are exceeded)
  - JSC/Draper will be presenting next…

# Recent SCM and FSS Design Changes

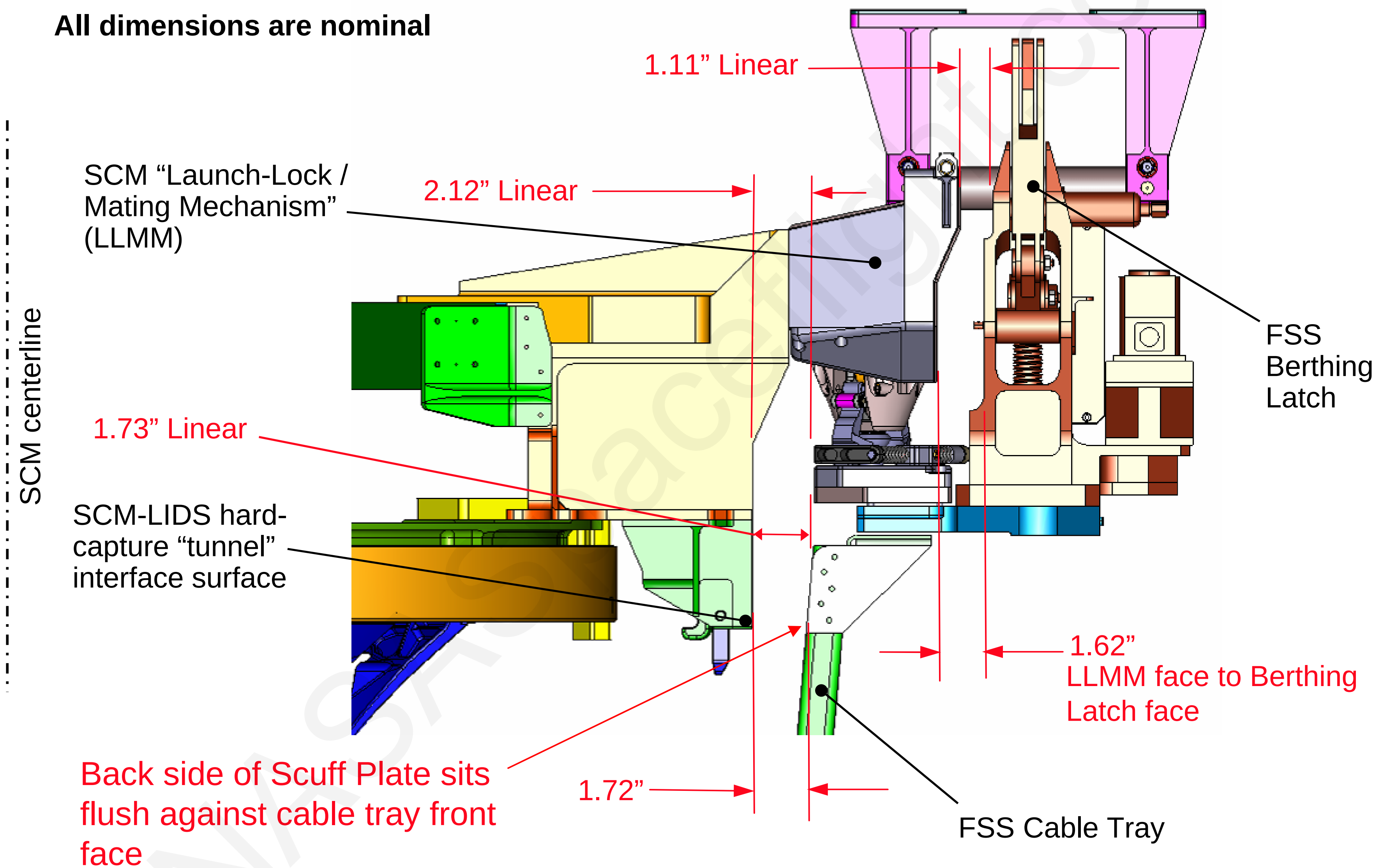
- **FSS Cable Tray redesign is complete**
  - Reduced overall depth from 1.5 to 1.38
    - Details in backup charts
  - Design now allows Scuff Plate to sit flush against face of Cable Tray
    - Previously stood off 0.12” to avoid harness contact
    - FSS harness re-work keeps the harness fully contained within Cable Tray
  - Net clearance gain = 0.12” on hardware plus 0.12” scuff plate offset = 0.25”
- **SCM Structure/LIDS Interface redesign is complete**
  - Moved outboard surface of LIDS interface pad inboard ~0.6”
  - Have concurrence of LIDS program
  - Net clearance gain = 0.6”
- **Scuff Plate detail design is in process**
  - Status below

# Summary of Design Changes – SCM & FSS



# SCM – FSS Clearances

**All dimensions are nominal**



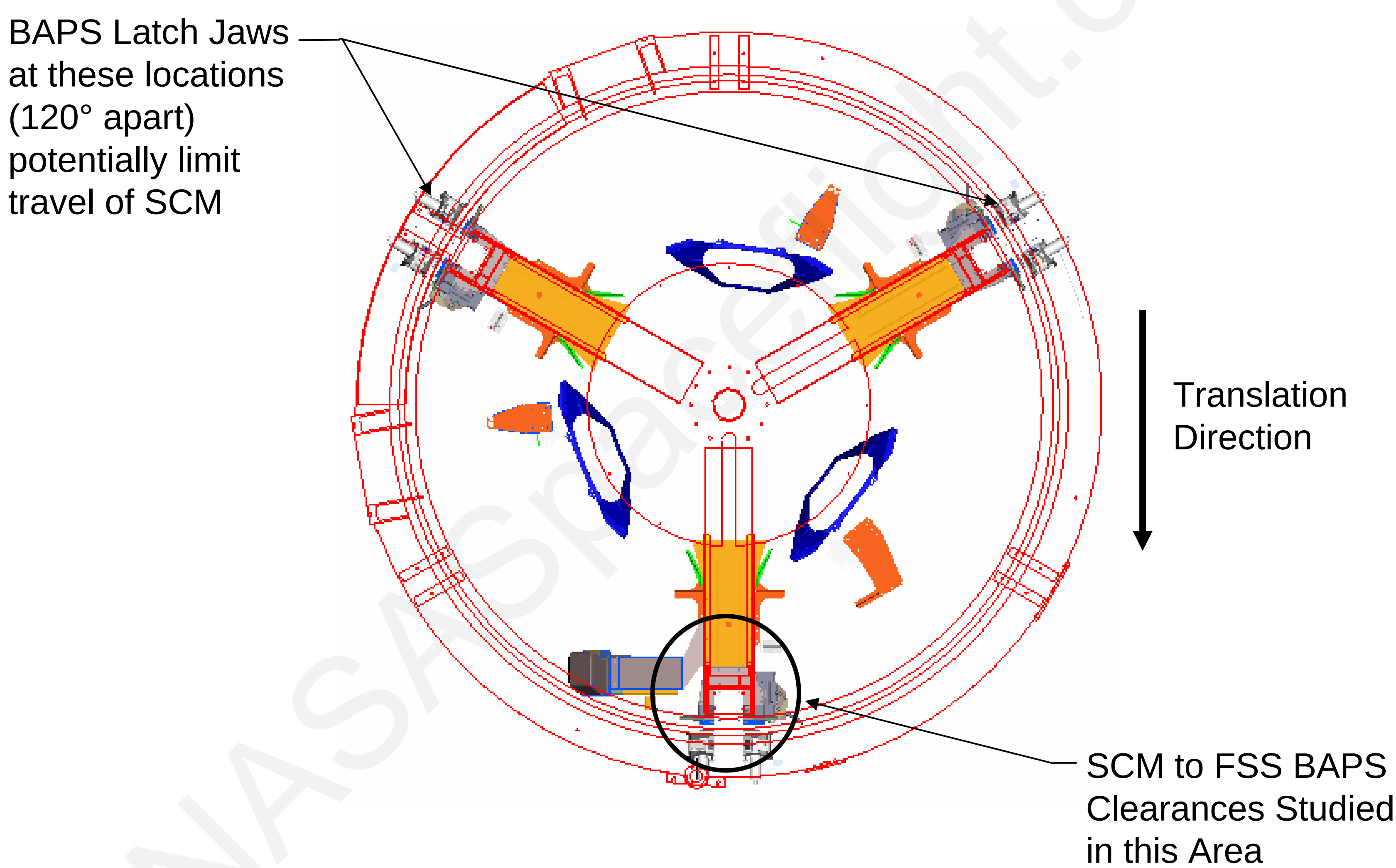
# Scuff Plate Design

# Scuff Plate Design Approach

- **Have completed an independent assembly of Aft Shroud, BAPS, and SCM models, to verify setup and static clearances**
- **ProE Clearance Study**
  - Discrete cases are currently being studied to determine SCM/FSS clearances during various stages of deploy/re-berth
  - First case run was translation along the axis of one Berthing Pin.
  - HST/SCM translated along pin axis until one of these two events occurred:
    - Two opposite Berthing Pins bottom out on their Berthing Latch jaws
    - SCM contacts FSS BAPS.
  - Resulting measured offsets at discrete points along the deployment path are aiding the design of the Scuff Plates.
- **Use of IGRIP to define 3D motion kinematics**
  - Interactive Graphical Robot Instruction Program, IGRIP, is a program developed for robotic and mechanism analysis.
    - Can perform kinematic assessment of trajectories and interactively report collisions
    - Can include near miss tolerances as well.
  - All models have been imported into IGRIP and pared down as appropriate to streamline the analysis
  - Analysis of motion trajectories is in work

# SCM Preliminary ProE Clearance Study

## SCM and FSS BAPS, Top View



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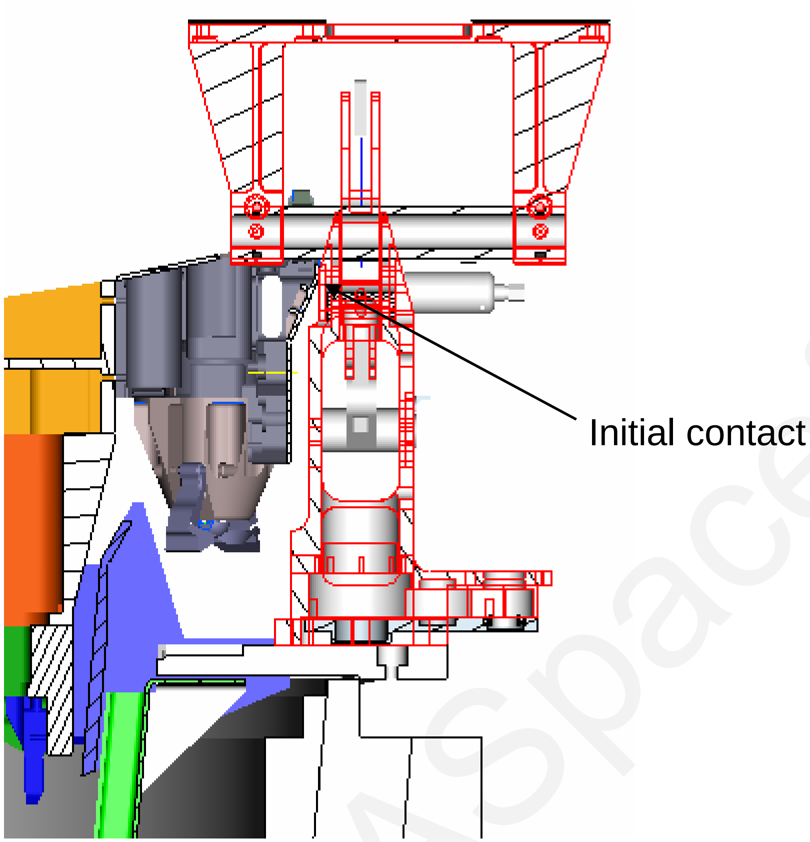
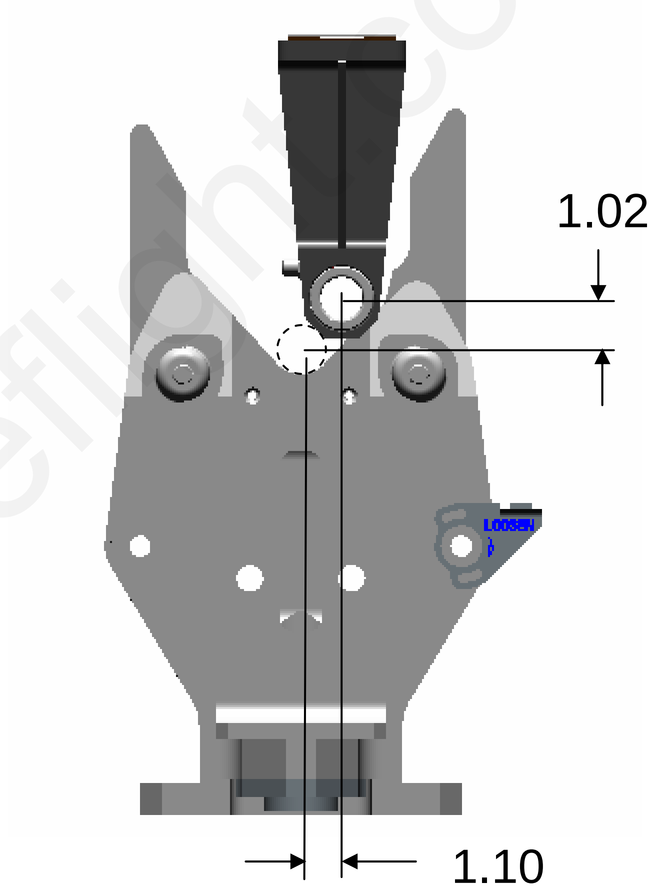
# SCM Clearance Study, Case 1




**Berthing Latch at 120° from Clearance Study Area**

**FSS Berthing Latches control the motion up to this point of first contact between SCM and FSS**

**Scuff Plate does not yet make contact with LIDS Interface**

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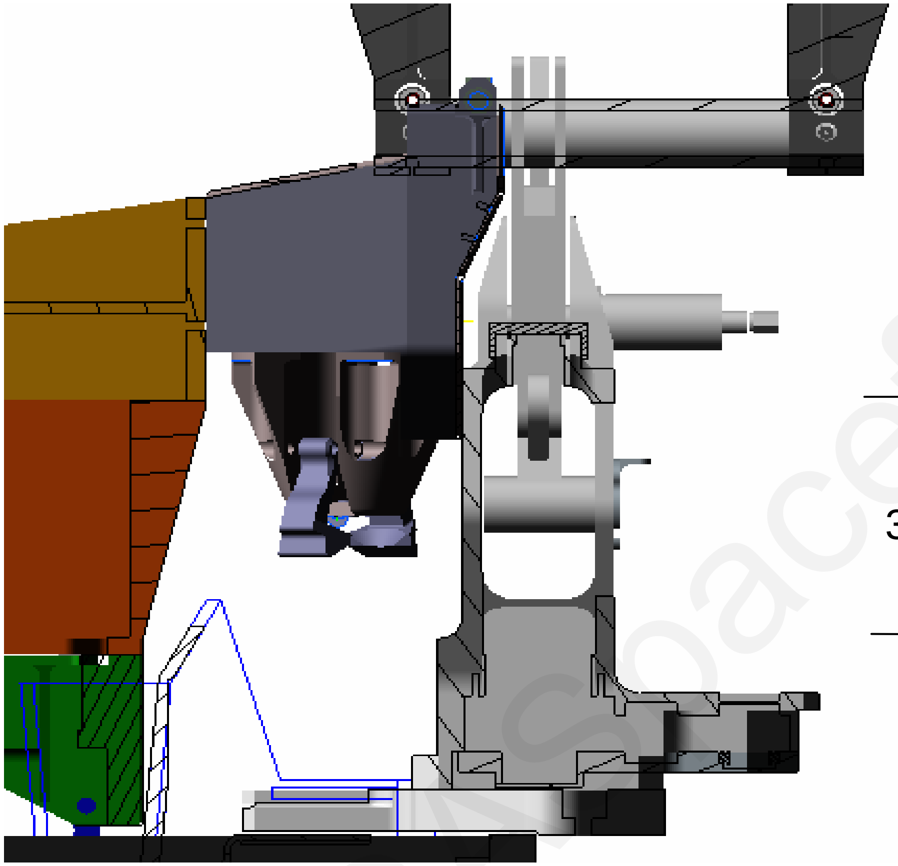
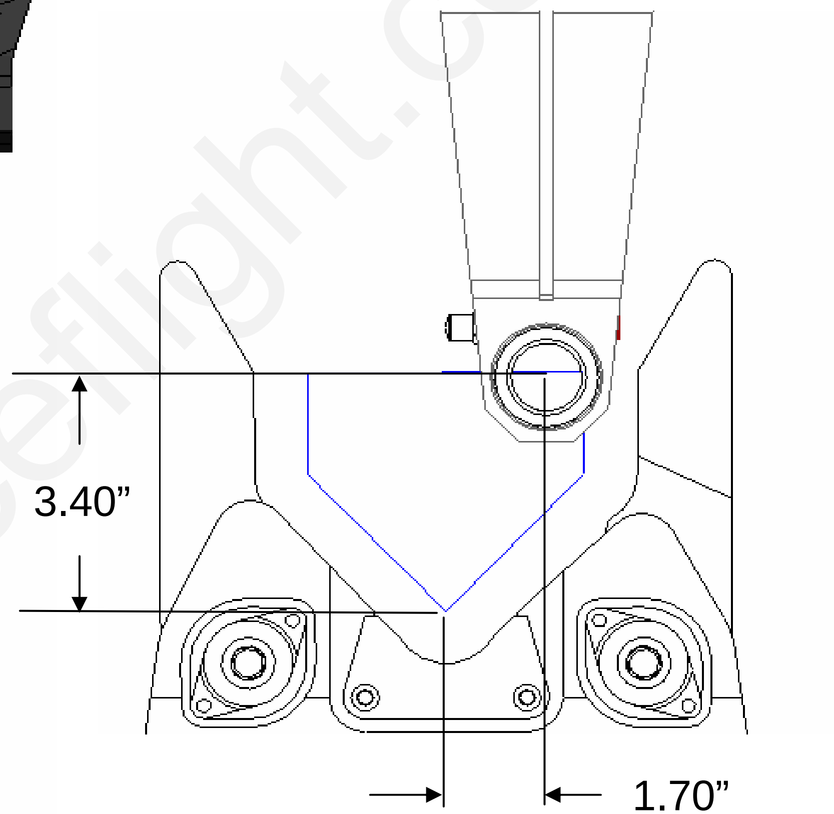
# SCM Clearance Study, Case 2



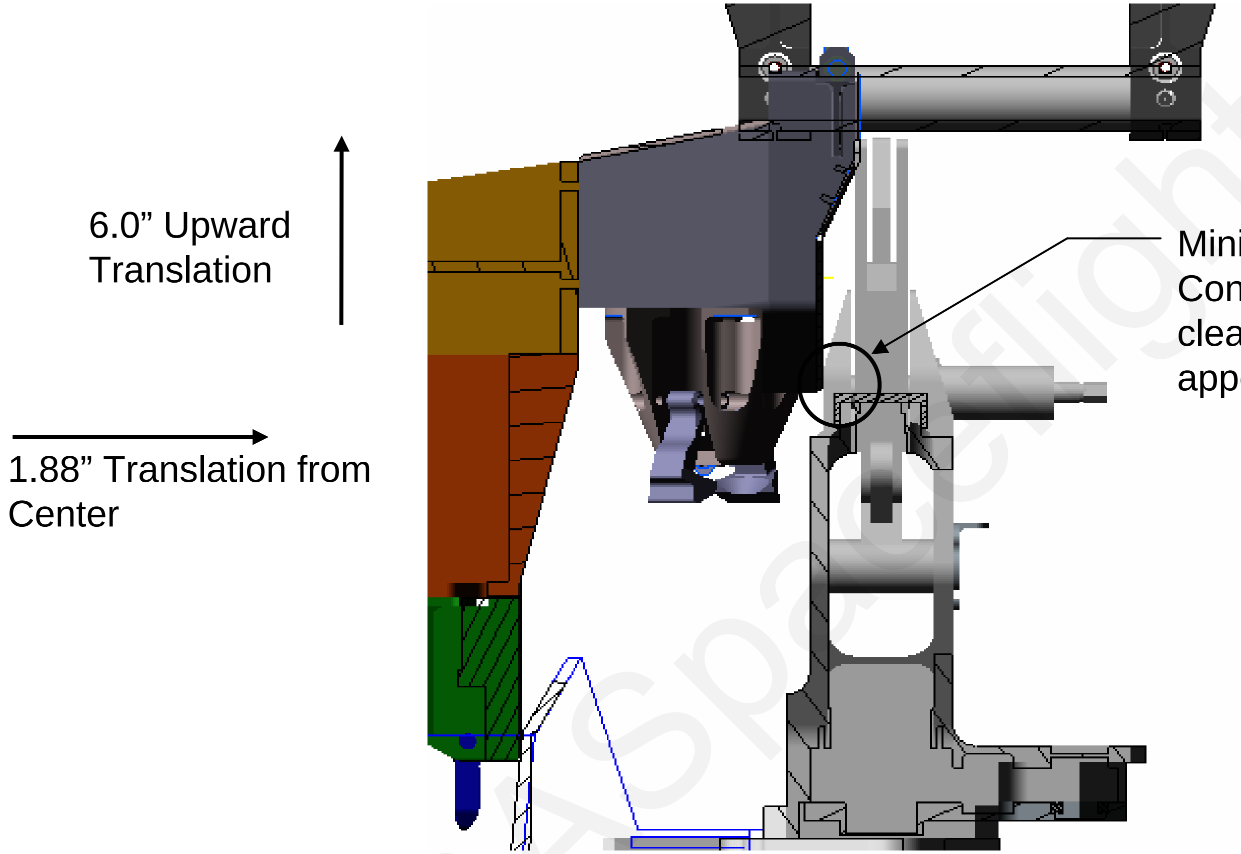



Berthing Latch at 120° from Clearance Study Area

**Scuff plate will “take over” at separation distance of ~3.0” and lateral offset of ~1.6”**

**1.7” lateral offset causes mechanism housings to make contact**

# SCM Clearance Study, Case 3




**Scuff plate continues to control the motion**

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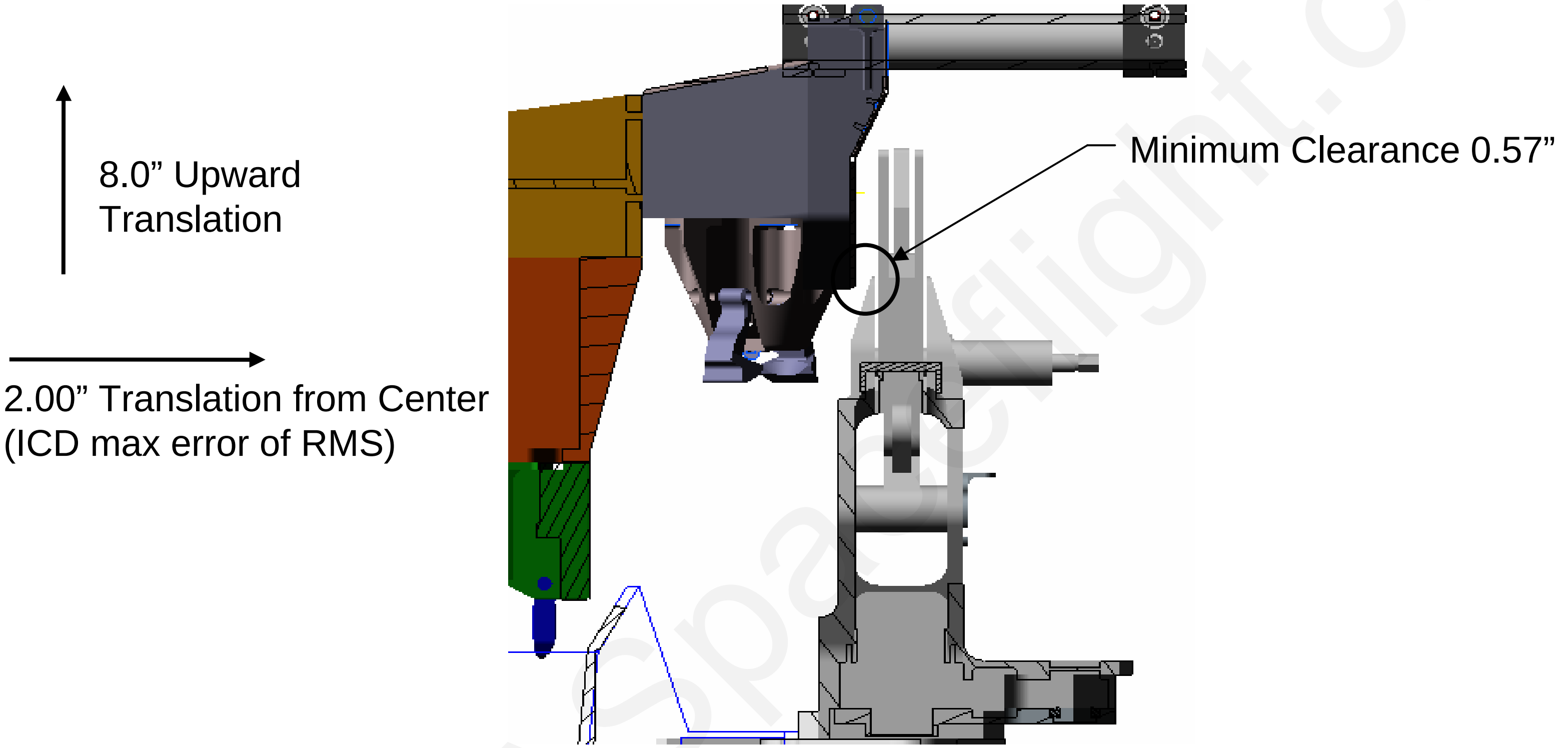
# SCM Clearance Study, Case 4




**At 8” vertical separation the max RMS offset of 2” is accommodated**

**Clearances between parts only increase for the remainder of deployment**

***Scuff plate entry envelope (top flared surface) will be modified from the picture shown, to guarantee that with a 2" offset the scuff plate is contacted first during re-berth***

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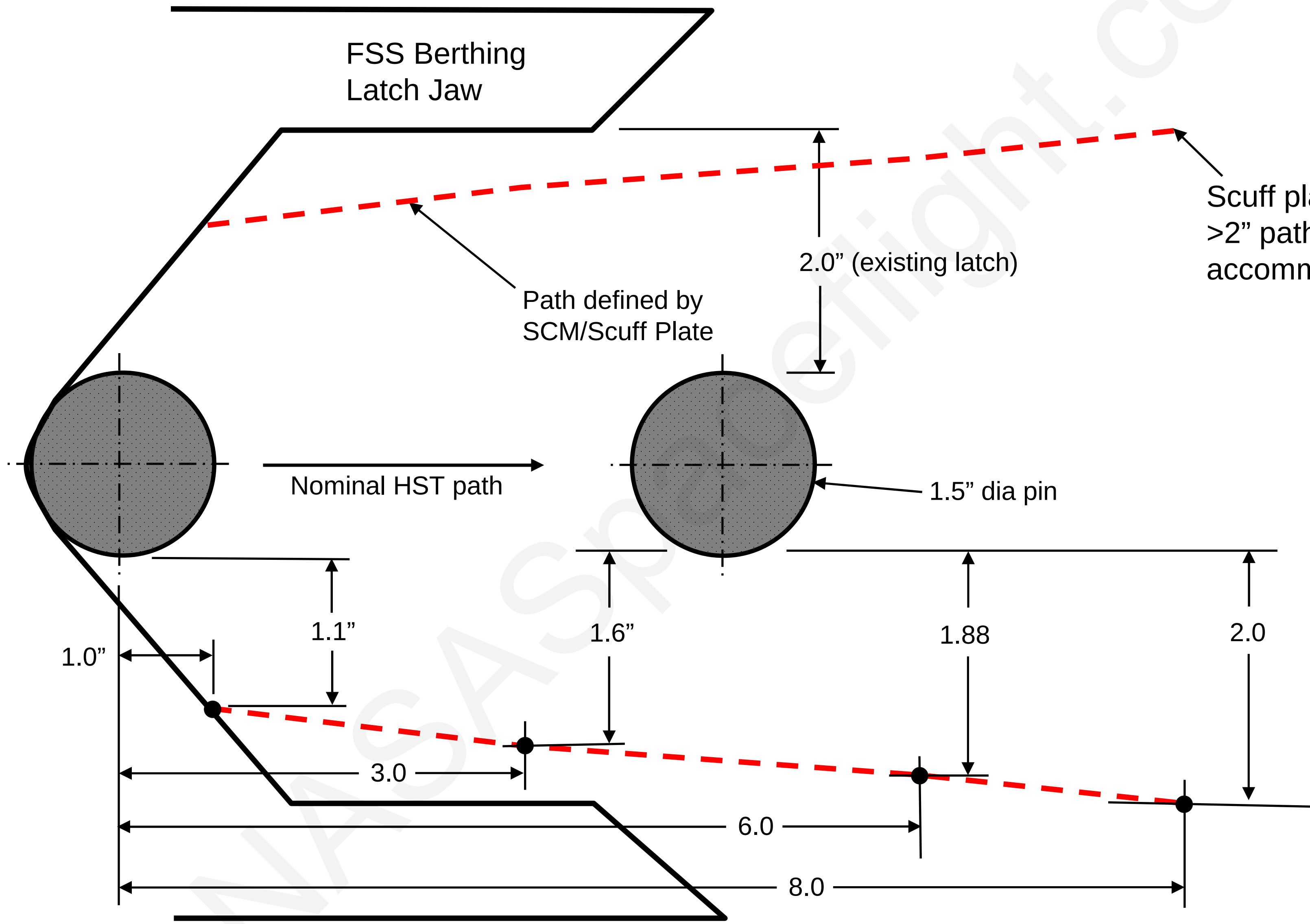
# 2-D Projection of Entry/Exit Envelope



# SCM IGRIP Analysis Details

- A motion survey program will be written to find the trajectory of HST/SCM into the FSS BAPS that has no collisions
- The final result will be the free path trajectory of the HST/SCM into the FSS BAPS, shown as a geometric path with pictures and movies
- By adding the remaining geometry (Shuttle, RMS, HST) it would also be possible to generate RMS joint angles for the trajectory
- IGRIP results will feed back into detail CAD design of scuff plates, and will give excellent visualization of SCM motions inside FSS BAPS
- Animation to show sample IGRIP trajectory

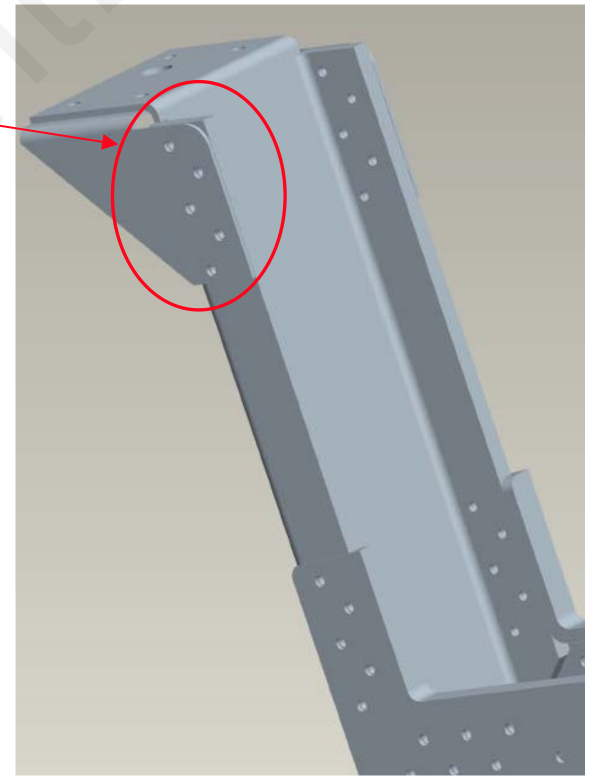
# Scuff Plate Concept Summary

- **Geometry looks promising but still needs refinement**
  - Complex surface profiles (3D tapering/contours)
  - Need to continue checking all possible relative motions/positions, within RMS control limits
    - Combination of ProE and IGRIP work
    - Check translations in other directions
    - Check "clocking" rotation errors of HST relative to FSS
- **Maintain maximum possible clearances between SCM and Scuff Plate, to protect the currently-feasible Backaway Deployment**
  - Scuff plate protects from damage and snagging
  - Scuff plate is NOT a nominal guide
- **Contact loads analysis still a work in progress, and will determine final material selections and thickness**

# Contact Loads Analysis

# SCM-FSS Contact Analysis Status

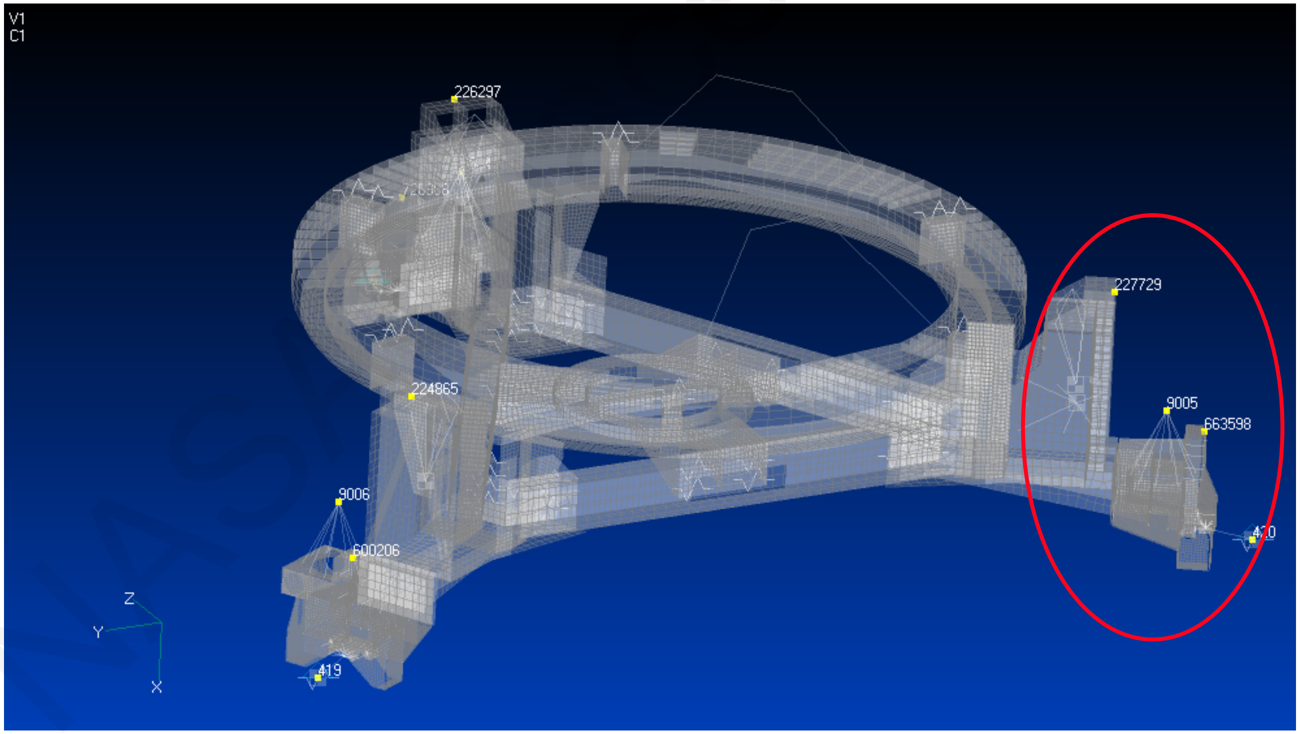
- **SCM Scuff Plate mounts to new FSS Cable Tray**
  - Use existing hole pattern that attaches vertical cable tray to Sill Plate Interface bracket



- **Cable Tray analysis:**
  - New cable tray design increases its strength while also increasing clearance to SCM
  - Launch loads analysis shows positive margins
  - SCM/Scuff Plate contact loads analysis in process
    - Anticipate that these will be enveloped by launch loads and will not drive FSS/Cable Tray design
- **Scuff Plate analysis:**
  - Have plenty of design freedom to make scuff plate work
  - Will choose construction and materials to withstand scuff loads and prevent damage to surface
  - Detailed analysis pending final design and contact loads

# SCM-FSS Contact Analysis Methodology

- **Analysis has been done using TRONS dynamics software:**
  - The scenario begins with HST positioned 2 inches from the FSS.
  - HST is rotated 1 degree about the V2 axis, so only 1 latch impacts at 1 SCM location for each case (worst-case impact)
  - The coefficient of restitution used for the contact is 0.20 (sensitivity study complete)
  - Stiffness at the impact location is 815 lb/in (sensitivity study complete)
  - The detailed SCM, HST, and FSS model flexibilities are included, but the complication of the RMS stiffness has not been included here (assumes HST in free drift hitting fixed STS)



# SCM-FSS Contact Analysis Results

- **Original case:**
  *(400 lb/in interface stiffness)*

| CLOSING VELOCITY (FT/SEC) | MAX IMPACT (LBS) AT SCM GRID ID 227729 |
|---|---|
| 0.11 | **131** |
| 0.05 | 51 |
| 0.02 | 14 |

*Note relationship of load to velocity*

- **Interface Stiffness Sensitivity Study:**
  *(0.2 coefficient of restitution, 0.11 ft/sec velocity)*

| INTERFACE STIFFNESS (LB/IN) | MAX IMPACT (LBS) AT SCM GRID ID 227729 |
|---|---|
| 815 | 172 |
| 4000 | 228 |
| 10,000 | **282** |
| 100,000 | 414 |

**Most credible case: Stiffness and coefficient of restitution most realistic based on experience**

- **Coefficient of Restitution Sensitivity Study:**
  *(815 lb/in interface stiffness, 0.11 ft/sec velocity)*

| COEFFICIENT OF RESTITUTION | MAX IMPACT (LBS) AT SCM GRID ID 227729 |
|---|---|
| 0.0 | 171 |
| 0.1 | 172 |
| 0.2 | **172** |
| 0.4 | 172 |
| 0.6 | 173 |
| 0.8 | 176 |
| 1.0 | 186 |

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# Contact Analysis Summary and Future Plans

- **Summary of results:**
  - TRONS model cannot simulate a “glancing” contact angle
    - Can only run two bodies straight together
    - This should produce conservative (high) load predictions
  - Load is sensitive to local stiffness of contacting elements
    - More detailed modeling and/or test needed to verify simulation value
  - Loads appear manageable across a range of RMS rates
    - ***SCM is designing / analyzing Scuff Plates and Cable Tray for ~300 lb contact loads***
  - **Are any HST model discriminators violated at this load???**
  - **HST Berthing normally performed at ~0.02 ft/sec (loads would be ~50 lb)**
- **Future plans:**
  - Adams modeling of the contact event
    - Simplified bodies with stiffness determined from detailed FEMs
    - Run realistic trajectories to simulate the loads from a “glancing blow” (steep contact angle between SCM and Scuff Plate)
    - Recover load vectors
  - This should produce reduced loads, and will serve to check the TRONS analysis

# Summary

# Path to Closure

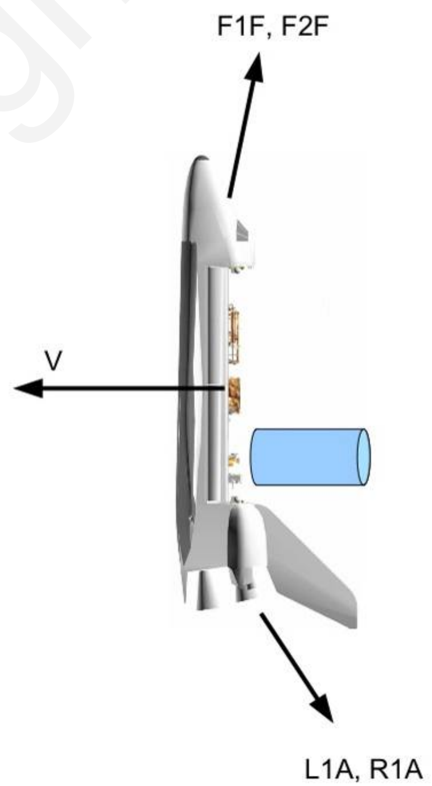
- **HST SCM team:**
  - Fully define 3D clearance envelope and finish Scuff Plate detail design
  - Complete contact loads analysis
    - Define allowable max velocity for contact (HST load limits)
  - Complete plume analysis (depends on final backaway scenario)
- **JSC team:**
  - End-to-end RMS engineering assessment
    - Velocity, control precision with visual feedback, system dynamics, etc
  - Generate final backaway scenarios
    - Tune firings for pure Z motion
    - Include flexible HST models and perform loss of clearance analysis
- **Goal is to achieve a baseline plan that allows deploy and re-berth without contact**
  - Protect for contact in contingency modes (i.e. RMS single-joint mode)

# Backup Charts

# Previous Shuttle DAP Analysis

## +Z translation with LowZ

- Uses F1F/F2F in nose with L1A/R1A in aft
- 0.48 sec firing for all four jets
- Delay between pulses is adjustable
- For this run 2 second delay was used
- Results in a +Z translation with a pitch down component



# SM4 Preliminary DAP Analysis Results

- **Draper Lab feels that improvements can be made by using the DAP automatic reboost logic.**
  - Rather than the crew manually inputting pulses, a single action triggers a train of RCS pulses
  - Pulse train can be designed to whatever requirements are desired.
- **Four options have been presented, attempting to improve the quality of the separation.**
  - Each option has advantages and disadvantages in terms purity of translation, speed of backaway, and dynamics due to jet impingements on HST.
    - Forward, down-firing jets correct pitch but slow down the separation
    - Aft, up-firing jets correct the pitch and speed up separation, but plume HST (effects TBD)

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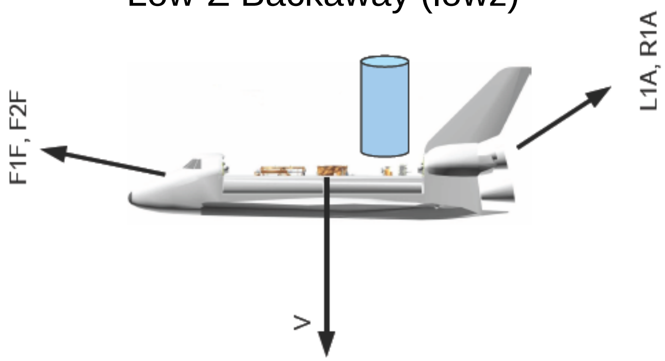
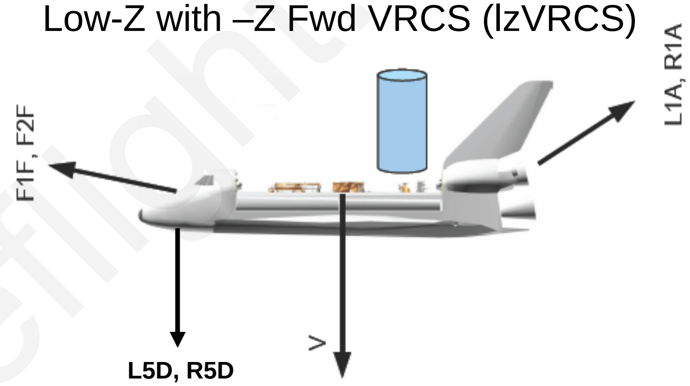
# Shuttle Backaway Scenarios Run to Date

Preliminary, first cut backaway sequences have been run as shown below

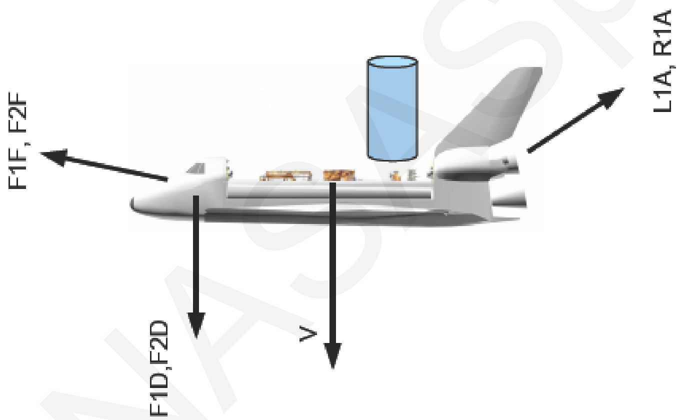
Low-Z Backaway (lowz)



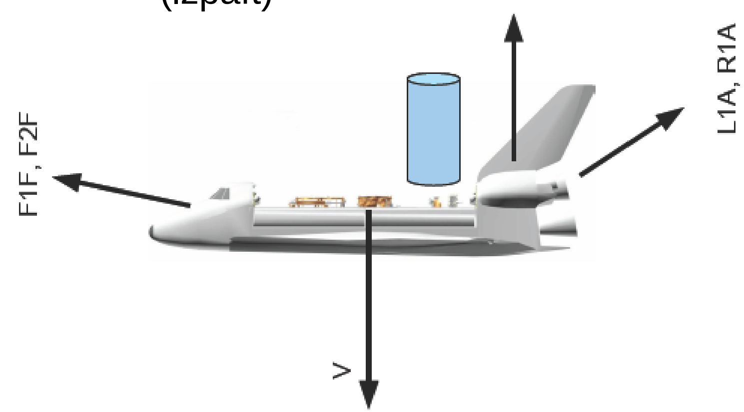

Low-Z with –Z Fwd VRCS (lzVRCS)



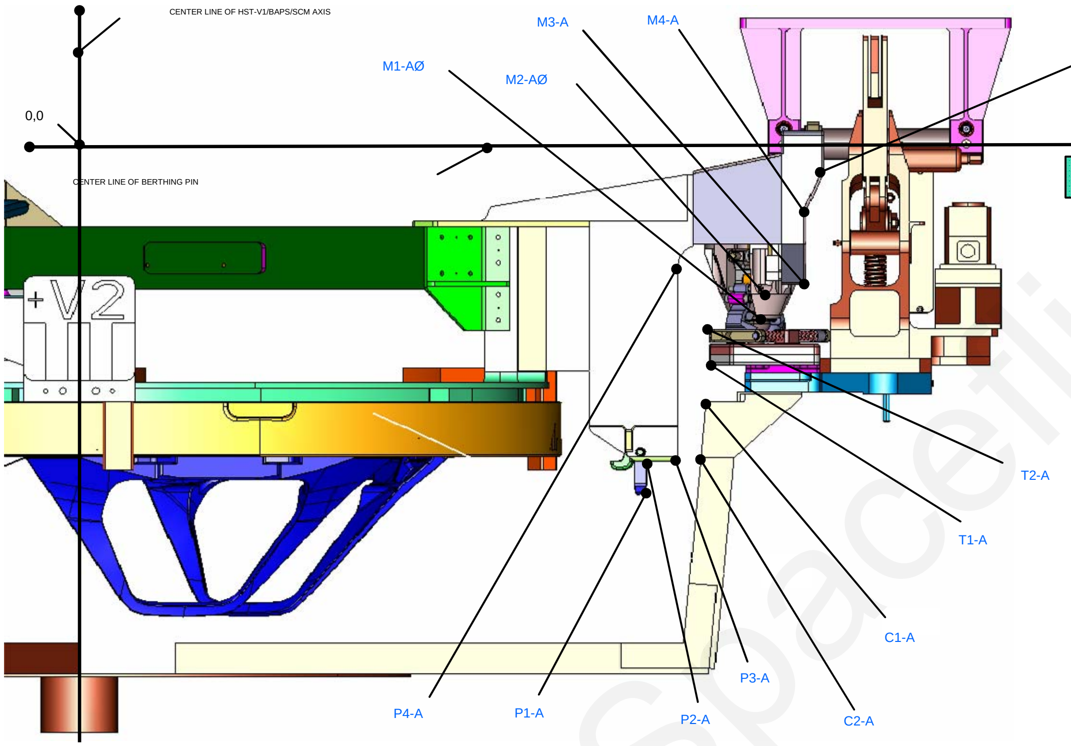

Low-Z with –Z Fwd PRCS (lzprcs)



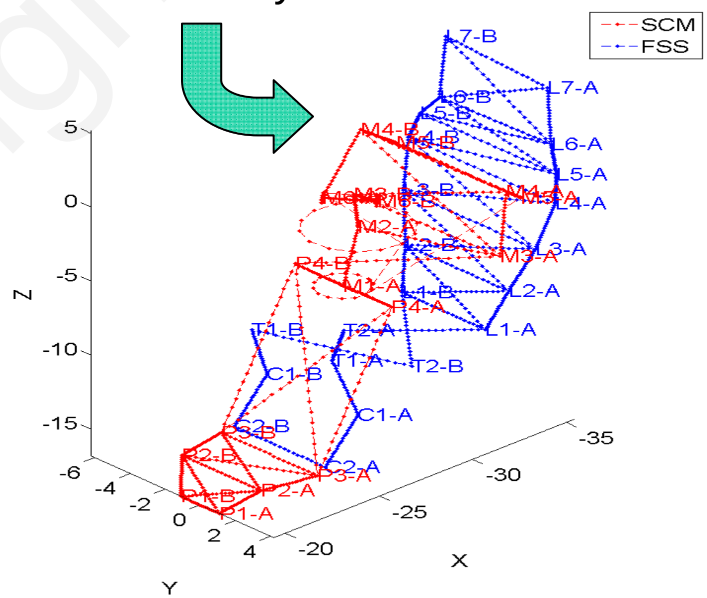

Low-Z with +Z Aft PRCS (lzpaft)



# Backaway: Loss of Clearance Analysis




Take CAD Model, create simplified array of points for analysis




- **Methodology for loss of clearance analysis**
  - Take key coordinate points from CAD model and convert to arrays of points for SCM and FSS
  - Matlab routine runs Shuttle backaway scenario, using JSC/Draper data
  - Assumes HST position is fixed
  - Tracks minimum distance between SCM point array and FSS point array

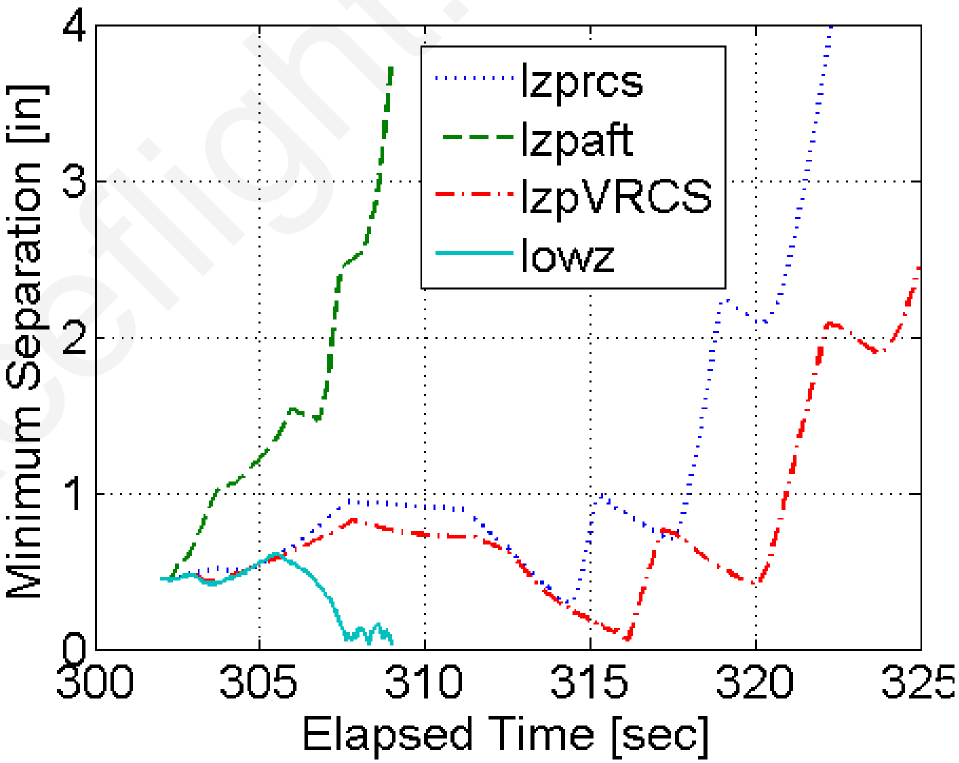
# Loss of Clearance Analysis Results

- **Min Clearance during backaway for each case (see graph):**
  - lowz 0 (re-contact)
  - lzprcs *0.28" min clearance*
  - lzVRCS 0 (re-contact)
  - lzpaft *0.44" min clearance*

- *Min initial clearance of 0.44" is due to point approximations in simulation (P3A-to-C2A). Actual clearances in this area are larger*

***** show animation here *****

- **Results to date look promising**
  - Have preliminary analyses showing two potentially workable backaway sequences.



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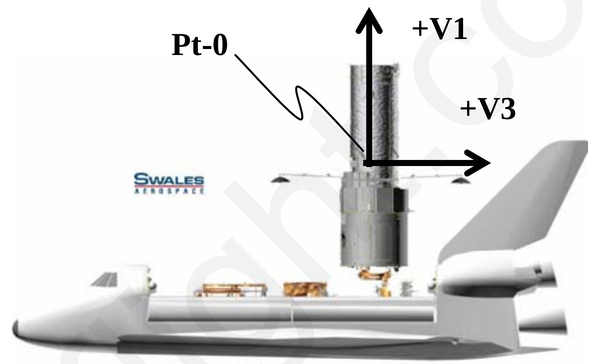
# Path to Closure: Backaway Clearances (as of 11/2006)

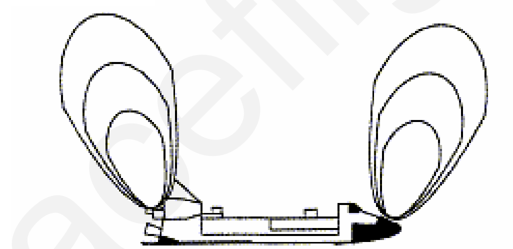
- **JSC/Draper will continue to optimize for "pure Z" motion**
  - For example, durations of the Low-Z aft jets vs. the forward jets can be altered
    - *By firing the aft jets for a longer duration at each pulse, both the nose-down pitch and the aft translation motions should be reduced*
- **MOD/Guidance, Navigation and Control, and Proximity Ops disciplines feel the piloting techniques are feasible, but would like to fly them in simulators before giving unqualified approval.**
  - Awaiting Orbiter mass property data necessary to design simulator I-loads
- **Flight Crew buy-in also required**
- **Plume impingement analysis (for aft/upfiring jet) will be completed to assess acceptability to HST**
  - Will consider damage to HST (for contingency cases) and check for re-contact with Orbiter (for emergency cases, damage to HST may be acceptable)
- **Flexible HST models will be added to analysis (combined HST and JSC/Draper)**
  - Analysis to date has assumed fixed HST
- **A more sophisticated loss of clearance analysis method will be created and verified (combined HST, GSFC flight dynamics, and JSC/Draper effort)**
- **HST and JSC will agree on primary and contingency scenarios for backaway**
  - Need to protect for VRCS failure
  - Need to consider *contingency* and *emergency* backaway scenarios

# HST SM4 Payload Operations Working Group #2
# March 9, 2007

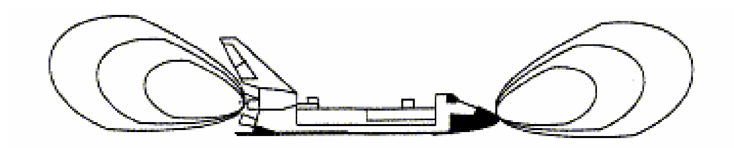
## Orbiter/HST Plume Impingement Loads Analysis




- HST Unlatched and at Zero Separation
- SA's @ 90 deg ,   HGA's Deployed
- Norm-Z  Jets ( F3U & L1U+R1U )



- Low-Z  Jets ( F1F+F2F & L3A+R3A )



- Forces and Moments Resolved in HST V1 V2 V3 Frame and Pt-0
- References:

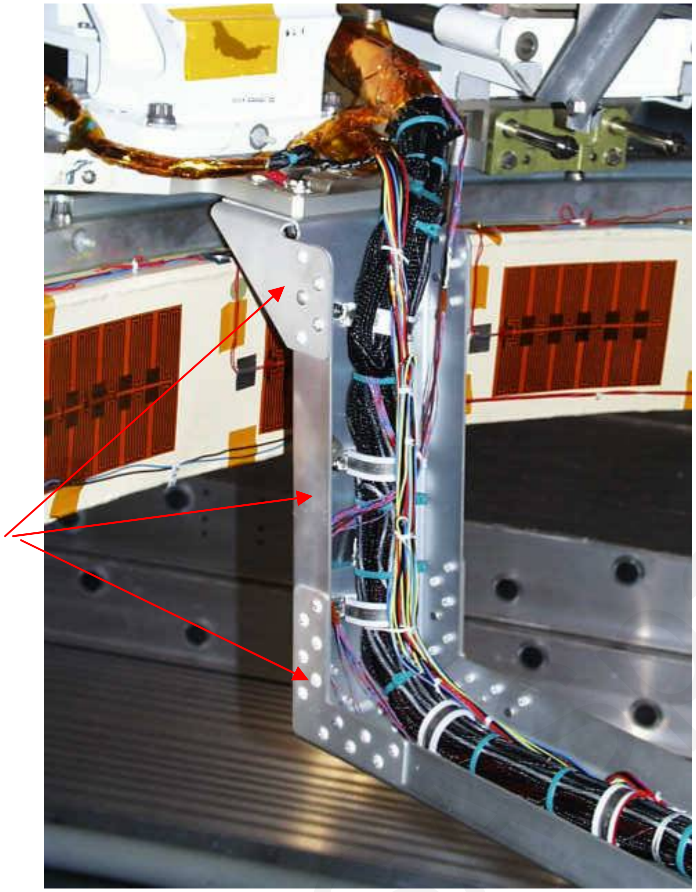

  - "Model for Predicting Orbiter PRCS Plume Impingement Loads and Heating", Fitzgerald, S.M., et.al., JSC-26507, Revision A, June 1995.
  - "Orbiter PRCS Plume Impingement Toolkit: RPM Ver. 3.0.1", Fitzgerald, S.M., et.al., JSC-26583 Revision A, Sept. 1996.
  - "Analysis of Static Loads on HST from Orbiter Norm-Z RCS Plume Impingement During HST SM-4", Mekkes, G., Swales Aerospace, January 2003.

# HST SM4 Payload Operations Working Group #2
## March 9, 2007

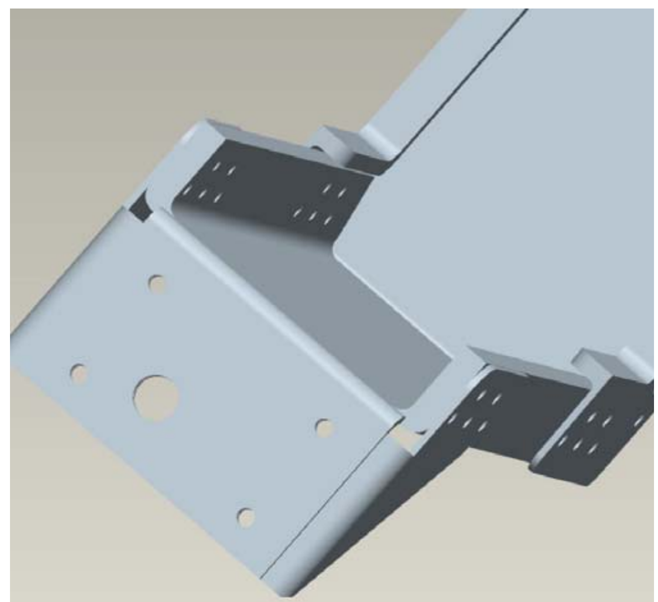
Orbiter PRCS Plume Impingement Loads on SM-4 HST

| Structure | Component | Load | Norm-Z | Low-Z |
|---|---|---|---|---|
| Solar Arrays | +V2 | Force (lbf) | 0.13, 0.08, -0.12 | 0.00, 0.00, 0.00 |
| | | Moment @ attach pt (lbf-in) | -13.85, 6.27, -11.56 | 0.00, 0.00, 0.00 |
| | -V2 | Force (lbf) | 0.13,-0.08, -0.12 | 0.00, 0.00, 0.00 |
| | | Moment @ attach pt (lbf-in) | 13.85, 6.27, 11.56 | 0.00, 0.00, 0.00 |
| HGA's | +V3 | Force (lbf) | 0.08, 0.00, -0.02 | 0.00, 0.00, 0.00 |
| | | Moment @ mast root (lbf-in) | 0.00, 11.48, 0.00 | 0.00, 0.00, 0.00 |
| | -V3 | Force (lbf) | 0.03, 0.00, 0.00 | 0.00, 0.00, 0.00 |
| | | Moment @ mast root (lbf-in) | 0.00, -3.82, 0.00 | 0.00, 0.00, 0.00 |
| Apeture Door | | Force (lbf) | 3.21, 0.00, -4.95 | 0.00, 0.00, 0.00 |
| | | Moment about hinge-line (lbf-in) | 359.26 | 0.00 |
| Central Body | | Force (lbf) | 0.84, 0.00, -7.02 | 0.00, 0.00, 0.00 |
| | | Moment @ Pt-0 (lbf-in) | 0.50, 1139.85, 0.22 | 0.00, 0.02, 0.00 |
| Total | | Force (lbf) | 1.10, 0.00, -7.27 | 0.00, 0.00, 0.00 |
| | | Moment @ Pt-0 (lbf-in) | 0.00, 1152.39, 0.00 | 0.00, 0.02, 0.00 |

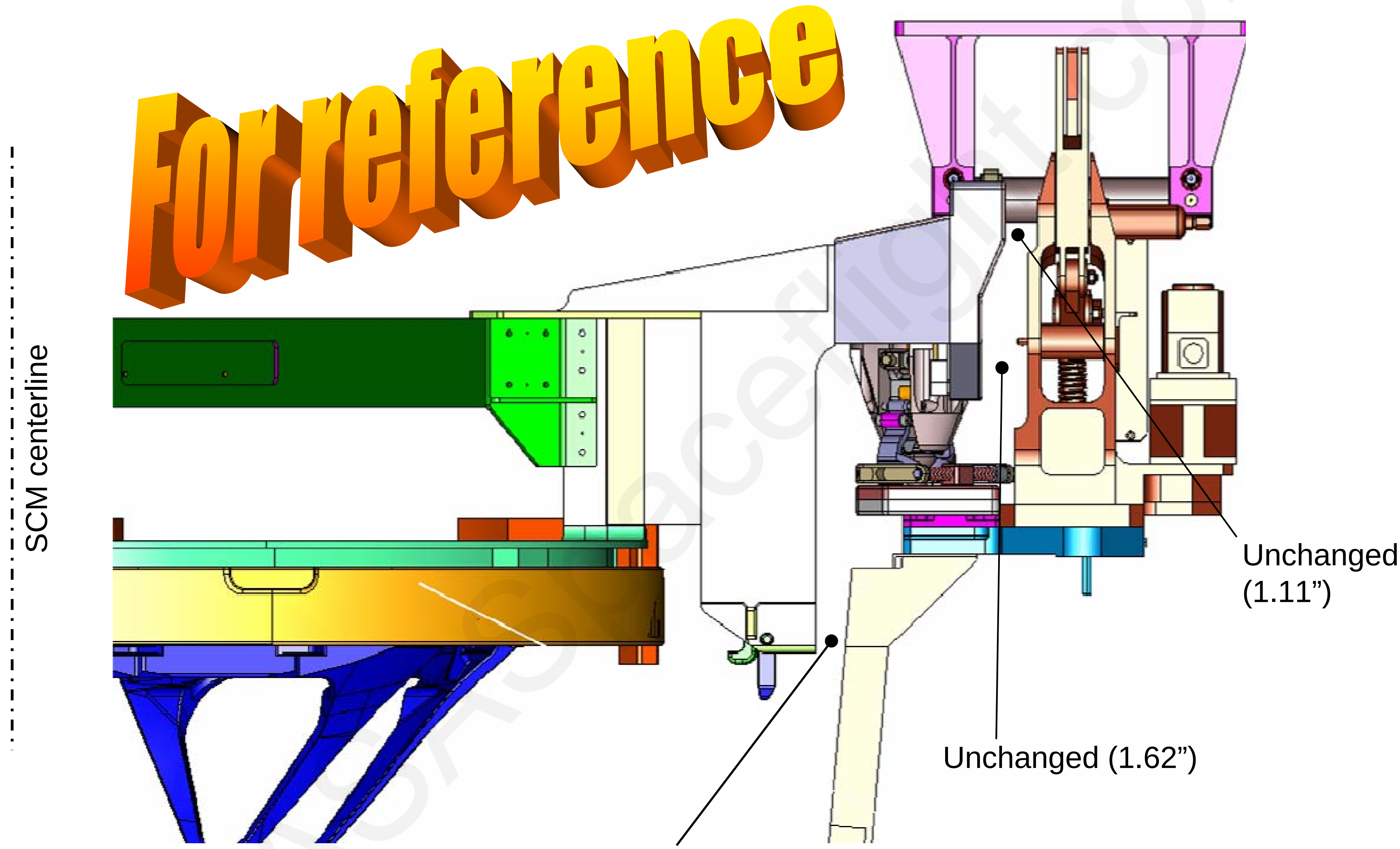
# FSS Cable Tray Redesign




- Decreased height of C-channel side walls from 1.50 in. to 1.38 in. to provide extra clearance to SCM
- Increased C-channel *wall* thickness from 0.090 in. to 0.38 in. to accommodate locking helicoil inserts
- Increased C-channel *base* thickness from 0.090 to 0.125 in. to provide increased stiffness
- Modified side support brackets to provide additional stiffness
- Changed all rivets to #10-32 fasteners for ease of removal/installation and to accommodate attachment of scuff plate to upper bracket.



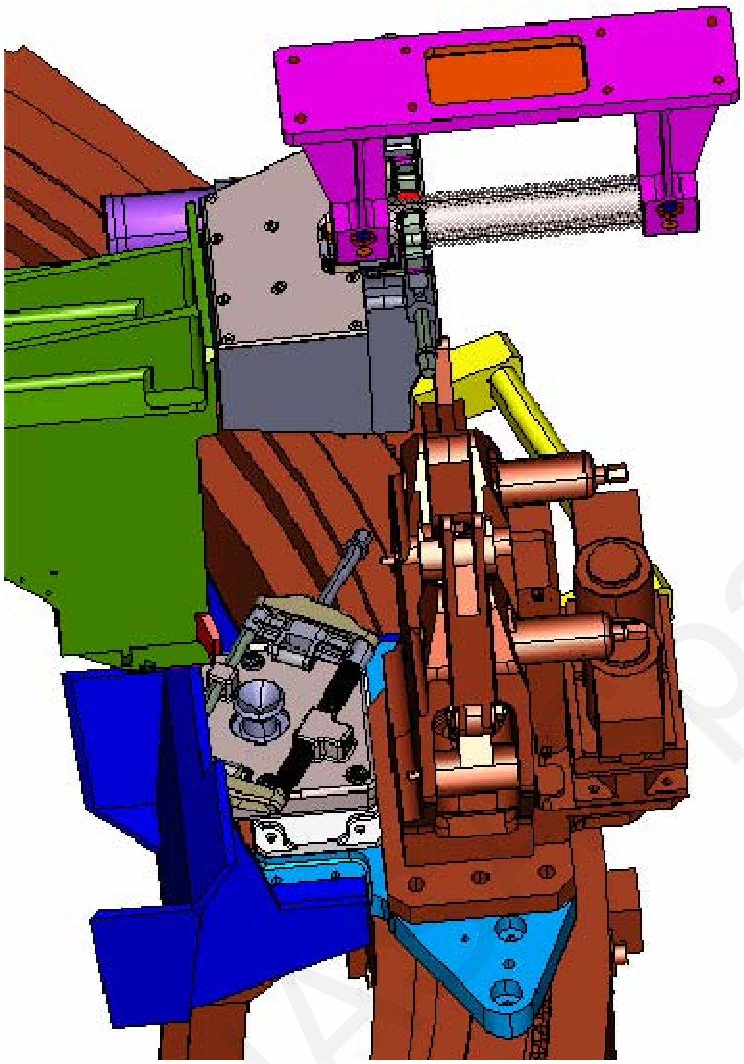
# Previous SCM – FSS Clearance

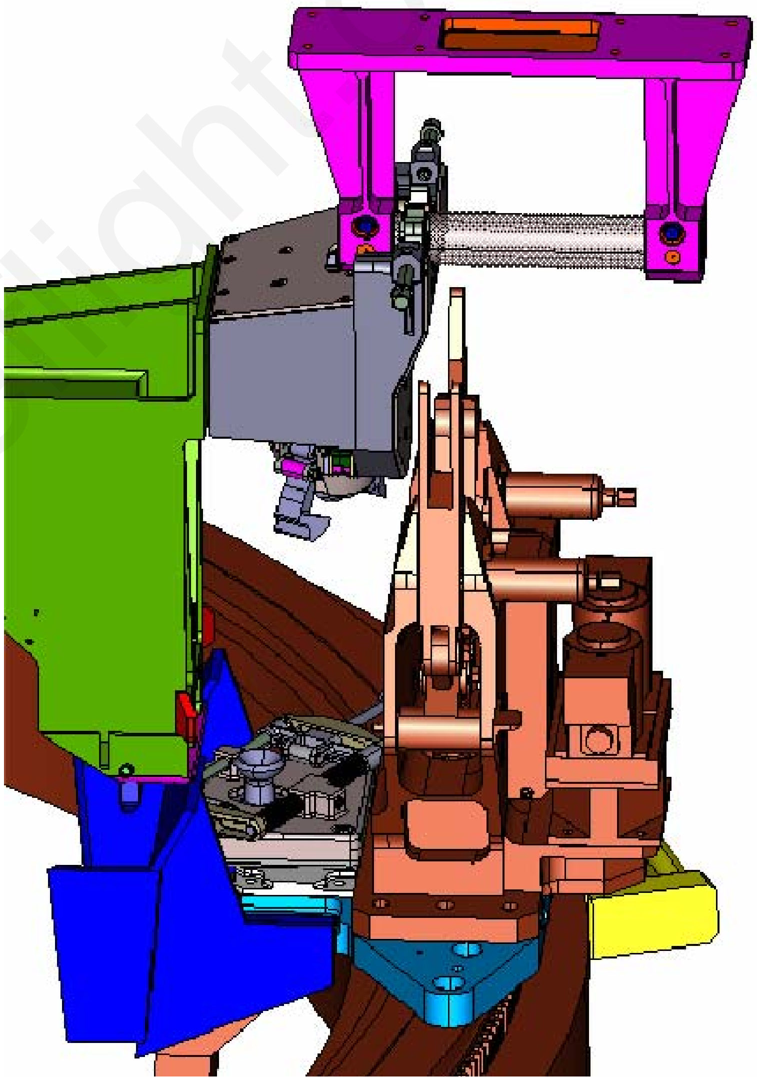



SCM End Fitting to FSS
Cable Tray = 1.04"

Goddard Space Flight Center

# Scuff Plate Concept (first iteration, for reference)





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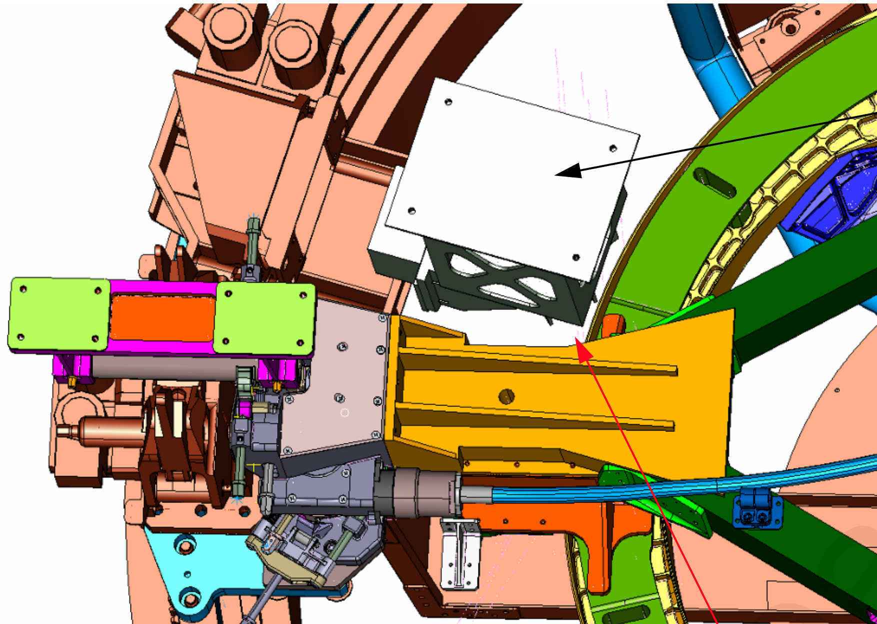
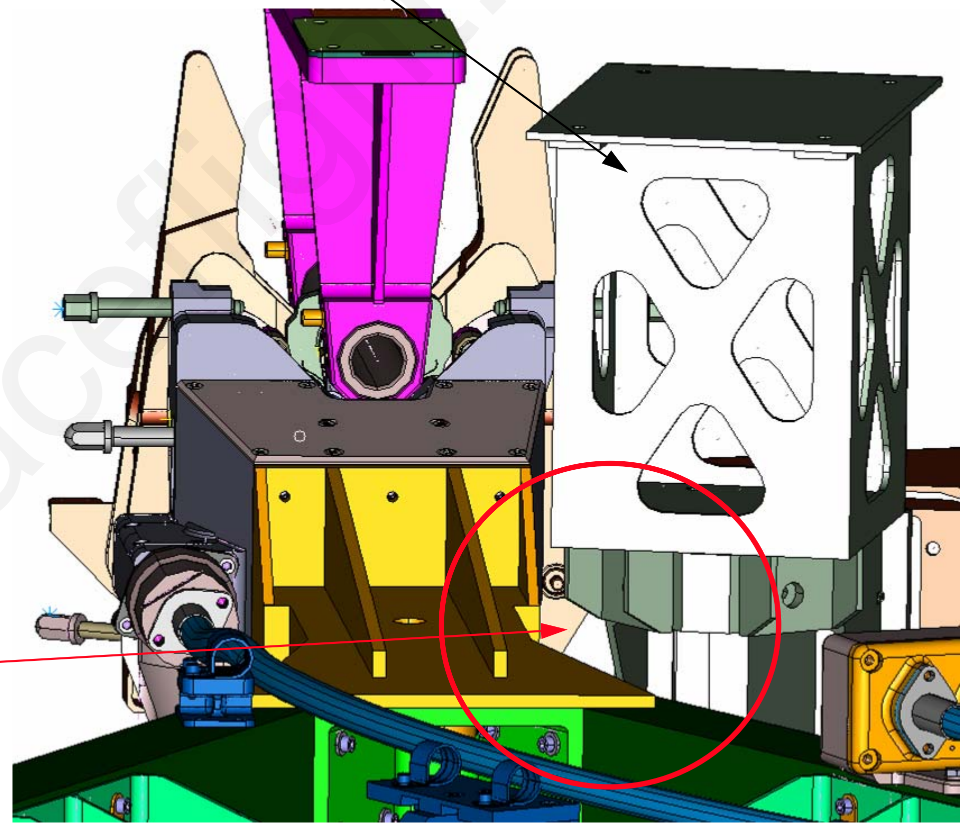
# SCM Clearance to HST J101 (Initial Berthing Only)

HST J101 Umbilical



(Looking from HST)

Min 0.9" clearance to SCM structure



(Looking outboard from center of SCM)

HST J101 is always "above" (+V1) the SCM structure during berthing, so contact cannot occur