

## JSC/EC5 U.S. Spacesuit Knowledge Capture (KC) Series Synopsis

**Topic:** TPS Inspection and Repair

**Date:** February 23, 2012

**Location:** Johnson Space Center (JSC), Houston, Texas

**Presenter:** Scott Parazynski, M.D.

**Synopsis:** Dr. Parazynski provided a retrospective on the EVA tools and procedures efforts NASA went through in the aftermath of Columbia for the Shuttle Thermal Protection System (TPS) inspection and repair. He describes his role as the lead astronaut on this effort, and covered all of the Neutral Buoyancy Lab (NBL), KC-135 (reduced gravity aircraft), Precision Air-Bearing Floor (PABF), vacuum chamber and 1-G testing that was done in order to develop the tools and techniques that were flown. Scott also discusses how the EVA community worked together to resolve a huge safety issue, and how his work in the spacesuit was critical to overcoming a design limitation of the Space Shuttle.

**Biography:** Dr. Scott Parazynski is a physician and a physiologist with expertise in human adaptation to stressful environments, having been graduated from Stanford University and Stanford Medical School. He went on to train at Harvard University and in Denver in preparation for a career in emergency medicine and trauma. In 1992 he was selected to join NASA's Astronaut Corps and eventually flew five Space Shuttle missions and conducted seven spacewalks (EVAs). In October 2007, Parazynski led the EVA team on STS-120, a highly complex space station assembly flight, during which he performed four EVAs. The fourth and final EVA is regarded by many as one of the most challenging and dangerous ever performed. In his 17 years as an astronaut, he also served in numerous senior leadership roles, including EVA branch chief and the lead astronaut for Space Shuttle Thermal Protection System Inspection & Repair (in the aftermath of the Space Shuttle Columbia tragedy). He has the distinction of being the only person to both fly in space and stand on top of the planet, the summit of 29,035-foot Mount Everest. He served as chief technology officer and chief medical officer at The Methodist Hospital Research Institute in Houston, Texas.

**Video Length (Size):** 1:29:37 (0.35582 GB)

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Crew and Thermal Systems Division  
EC5 Space Suit and Crew Survival Systems Branch  
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# TPS Inspection & Repair



**Scott Parazynski, MD**

“US Spacesuit Knowledge Capture Series”

23 February 2012

[www.parazynski.com](http://www.parazynski.com)



Please  
Silence  
Your  
Cell Phone

# **“US Spacesuit Knowledge Capture Series”**

**1. “EVA Physiology & Medical Considerations Working in a Suit” --- Tuesday, January 24, 2012**

**2. “Real-time EVA Troubleshooting” ---  
Thursday, February 16, 2012**

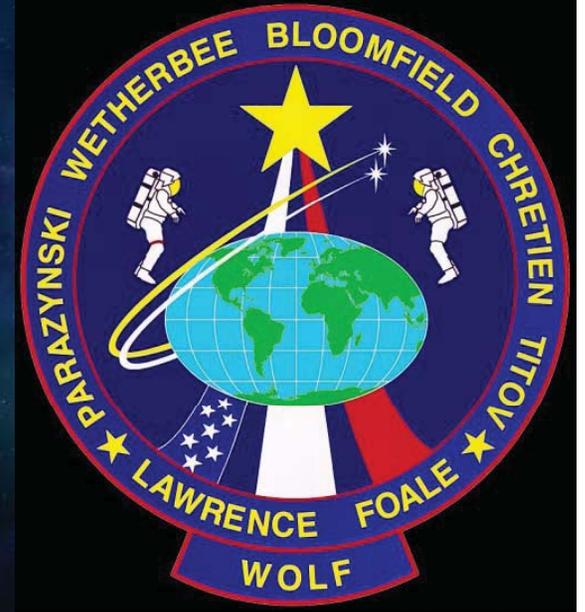
**3. “TPS Inspection & Repair” ---  
Thursday, February 23, 2012**

**4. “EVA Skills Training” ---  
Tuesday, March 6, 2012**

“Parazynski” is like “Smith” or “Doe” in Poland...



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# Fun & Games at the Launch of STS-107



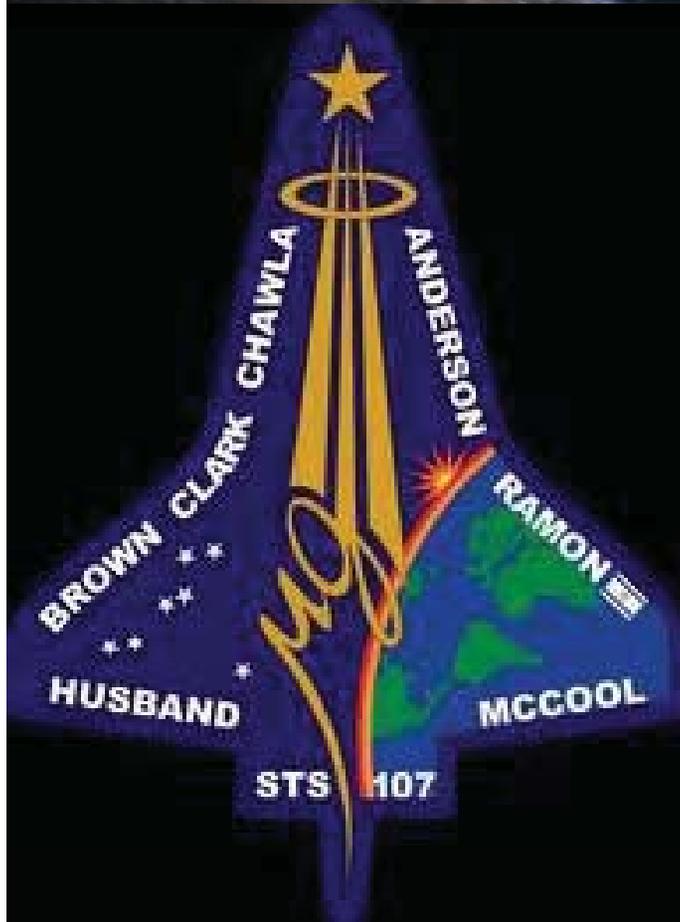
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NASA Ice/Debris Team

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# STS-107: Hail Columbia --- Kalpana, Mike, Willie, Rick, Laurel, Dave and Ilan





# Our Motivation



# Columbia Point



# Columbia Point



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# Columbia Point Dedication



# Return To Flight

- Emotion-laden
- Enormous challenges
  - Prevention
  - Inspection
  - Access & Repair where EVA crewmember was never meant to go
  - Tile and RCC repair materials
- Urgency to safely RTF before mandatory Shuttle retirement



# Commitment to Fly Again



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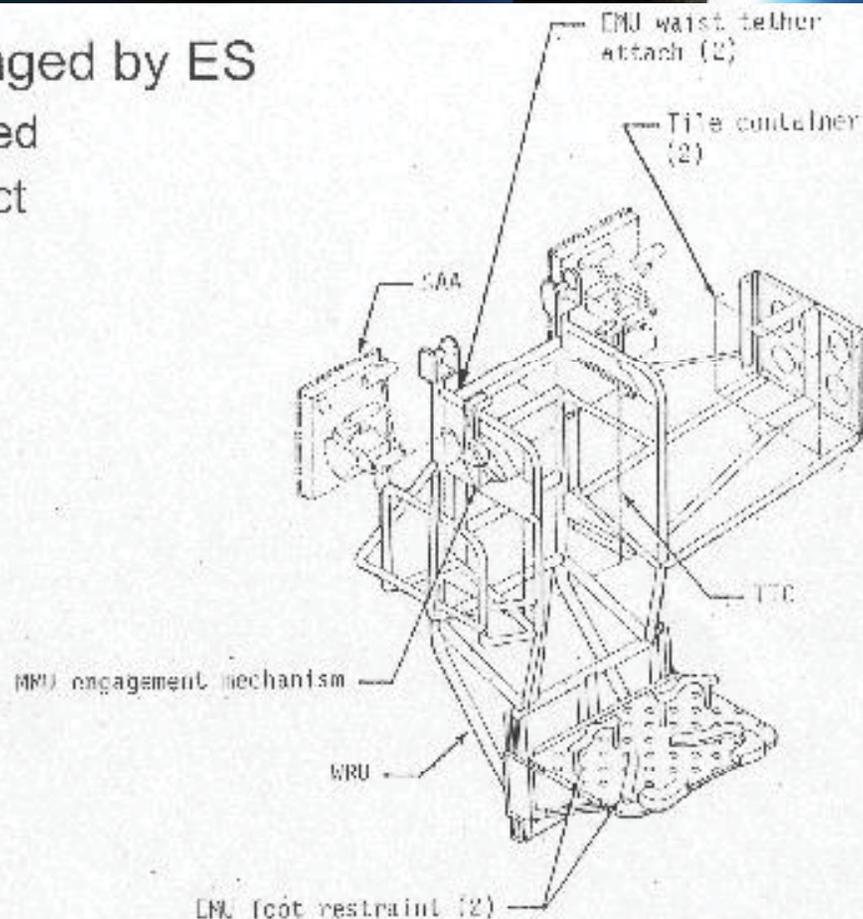
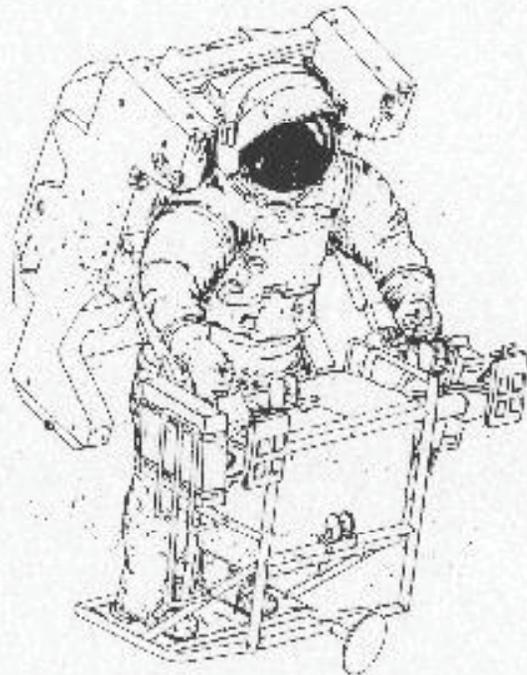
# Flat Stanley & Friends



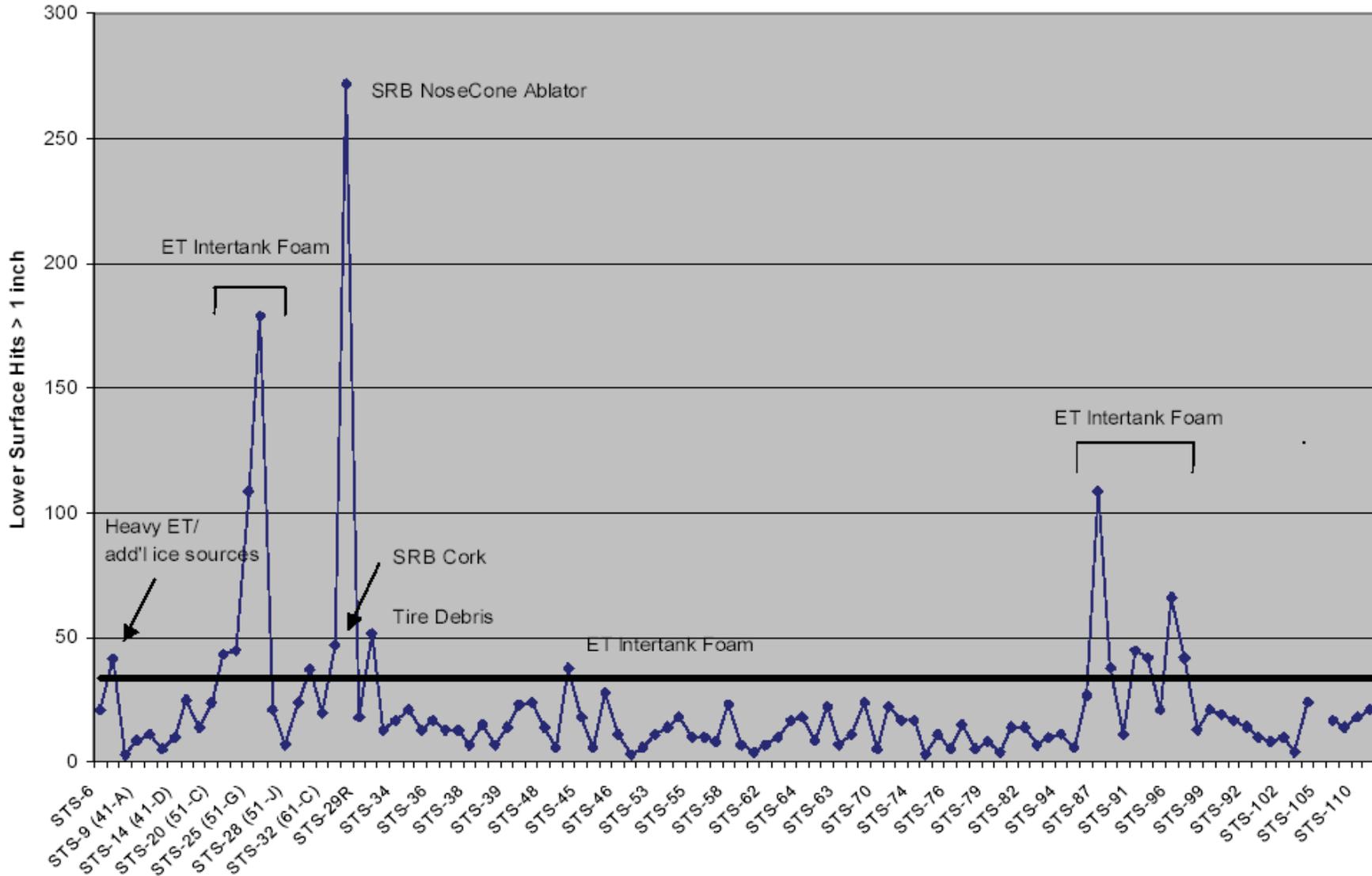
# Tile Repair Pre-STS-1

Original project was managed by ES

- EC only peripherally involved
- We did support MMU aspect



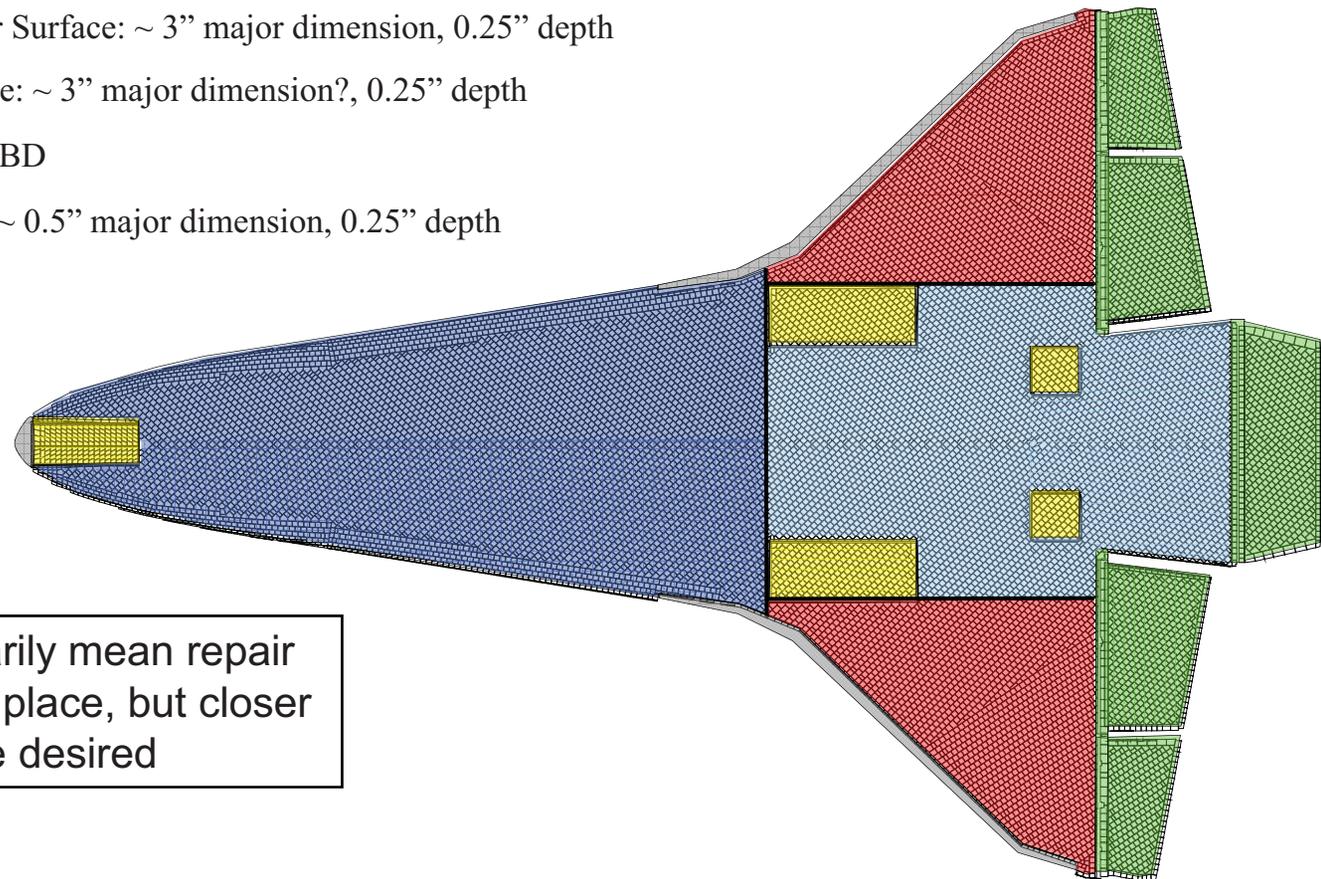
## History of Debris Hits to Lower Surface TPS Tiles STS-6 through STS-111



STS

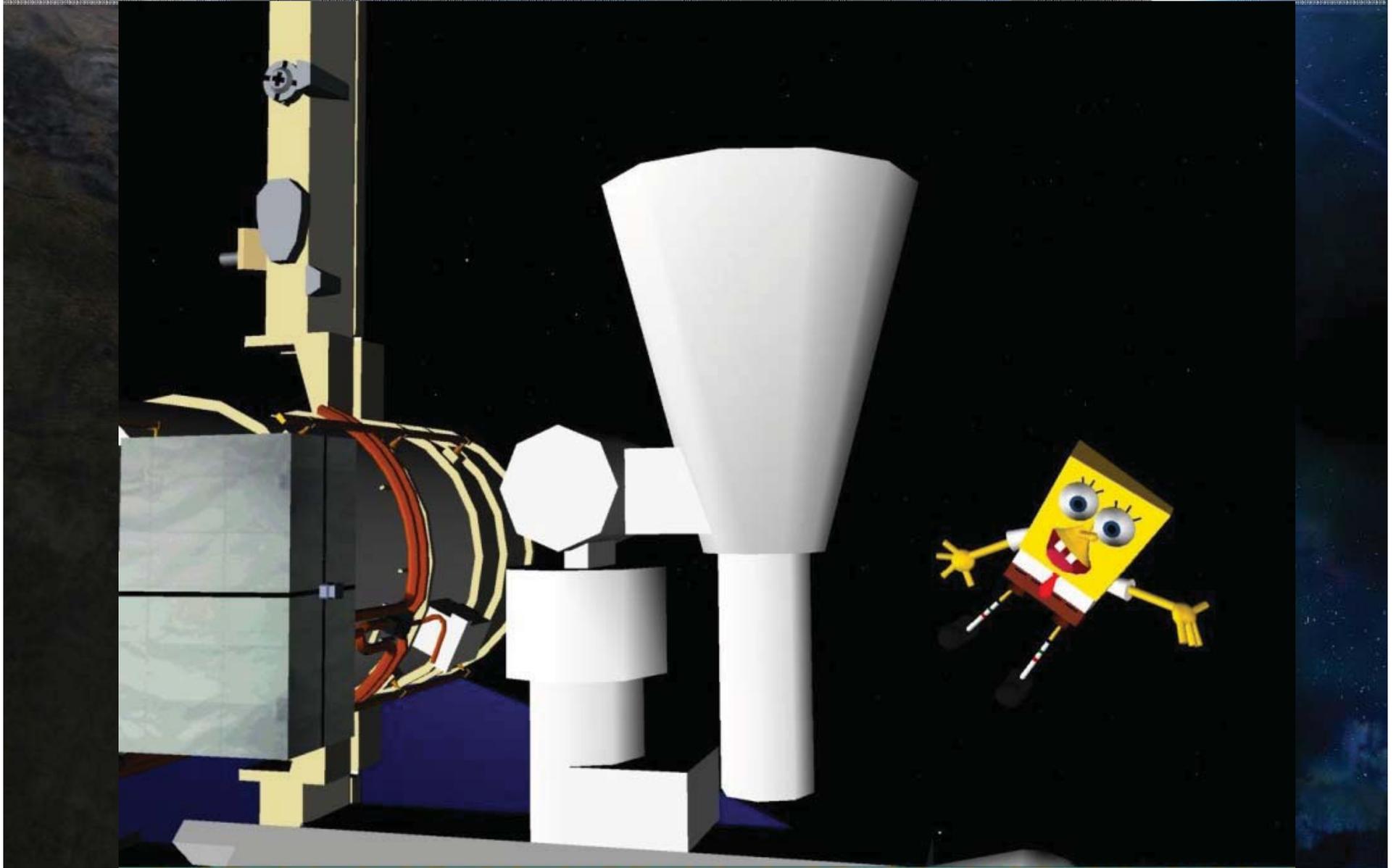
# Preliminary TPS Critical Detection Threshold\*

- Zone 1** Penetrations + Perimeter Tiles: ~ 1" major dimension, 0.25" depth
- Zone 2** Fwd. Fuselage Lower Surface: ~ 3" major dimension, 0.25" depth
- Zone 3** Aft Fuselage Lower Surface: ~ 3" major dimension, 0.25" depth
- Zone 4** Wing Lower Surface: ~ 3" major dimension?, 0.25" depth
- Zone 5** Control Surfaces: TBD
- Zone 6** RCC Components: ~ 0.5" major dimension, 0.25" depth

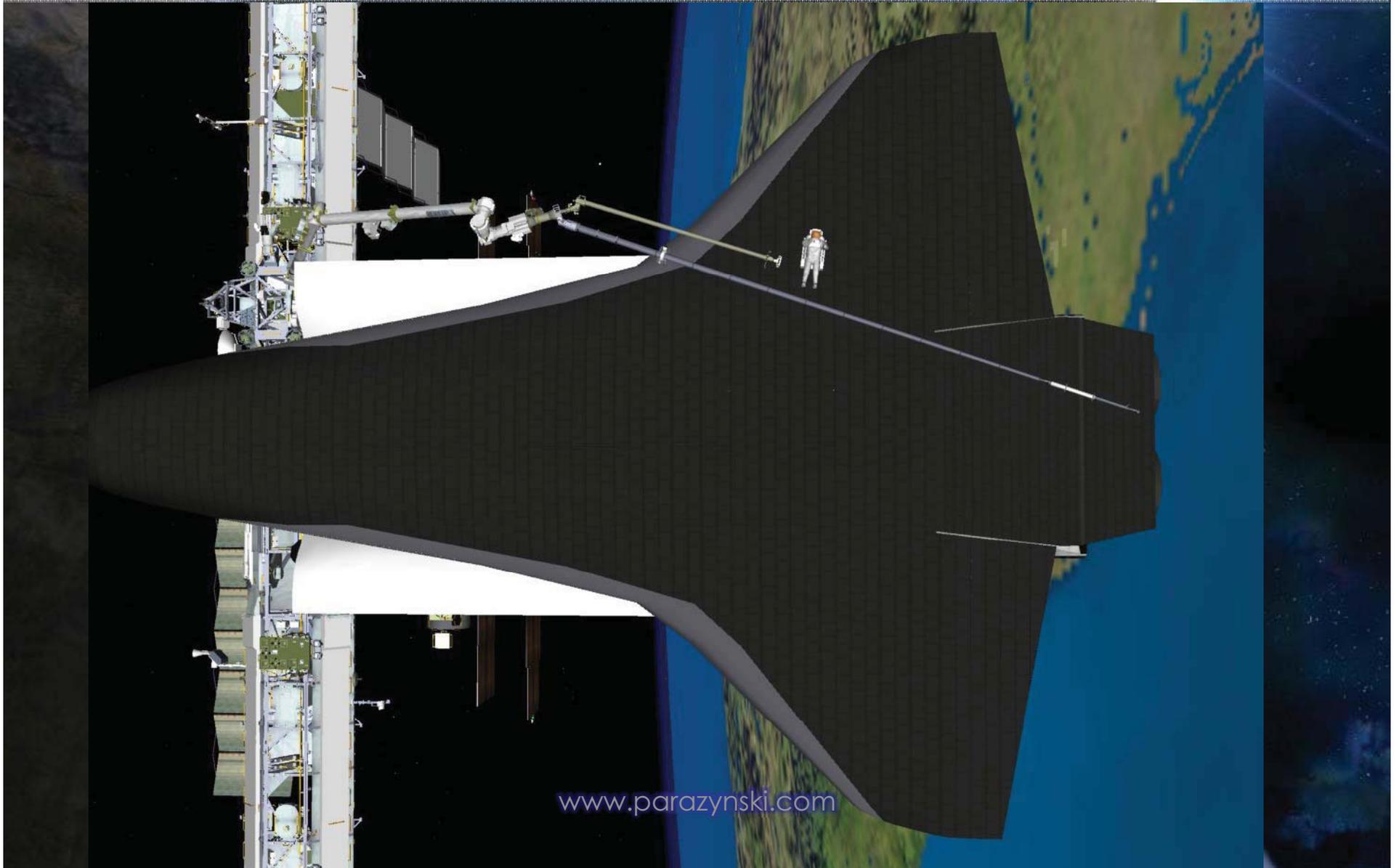


\* Does not necessarily mean repair would need to take place, but closer inspection would be desired

# VR Lab SAFER Inspection/Repair

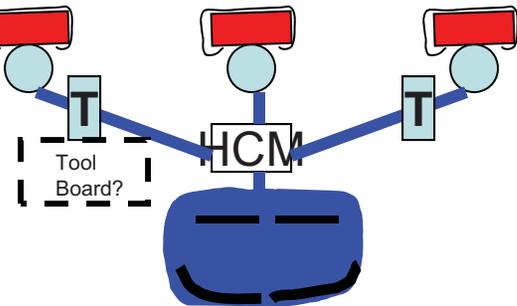
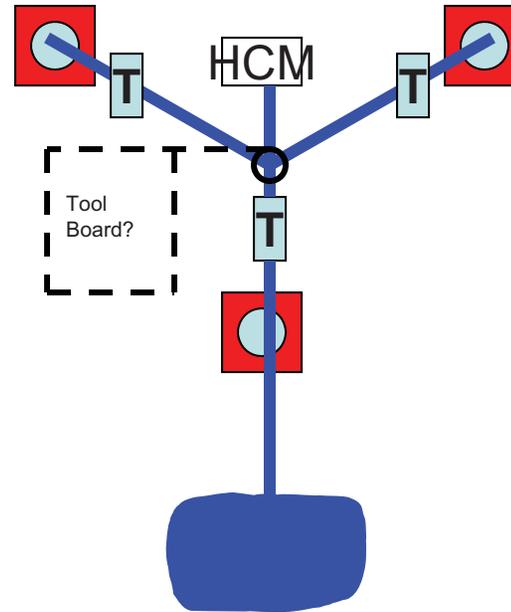
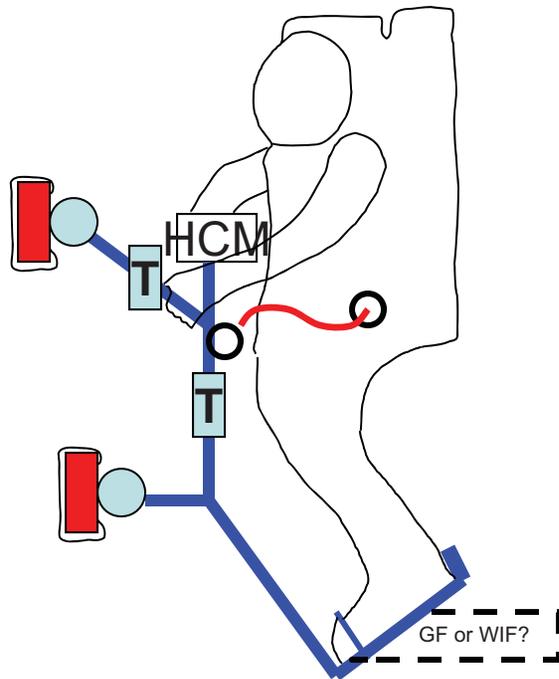


# TPS Access from OBSS and Strela



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# SAFER Underbelly Repair Fixture (SURF)



-  Retractable Safety Tether
-  Telescoping Boom
-  Universal
-  Ball Joint
-  Quick Release
-  Adhesive Pad Tether Point

CB/Scott Parazynski --- 4/23/03

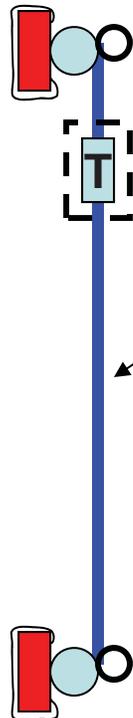
- Adjustable Tripod Legs for varying crew height and worksite topology (RCC leading edge compatible)
- Flight to/from worksite with HCM fixed on tripod; stowed out of the way during repair
- Angular misalignments (P/Y) easily corrected through foot restraint and lateral strut inputs while on short final
- Tools may be accommodated on dual Swingarms or offshoots of tripod itself
- Adhesive pads under tension on tripod feet; allows for quick release and controlled separation (adhesive sheets left on vehicle) --- lateral pads within reach of foot restrained crewmember
- Option to replace MMWS T-bar with an attachment to enable 360° yaw; alternately provide a Roll pedal on the boot plate
- Tool complement may include secondary Handrails with adhesive for work in neighboring areas, once a base is established
- Compact, lightweight for STBD TSA, sidewall carrier, or aft bulkhead Orbiter stowage (preferred)
- May want to enable adjustment of lateral strut angle, in addition to telescopic adjustment capability
- Could incorporate a GF (or WIF probe) behind the bootplate for SSRMS-based work, if tool provisioning is built into the design, or for other boom repair methods requiring greater stabilization; power to the worksite from the SSRMS or boom?
- Could mount heating lamps on dogbone portions of lateral struts, as req'd

# Transient Underbelly Repair Fixture (TURF)

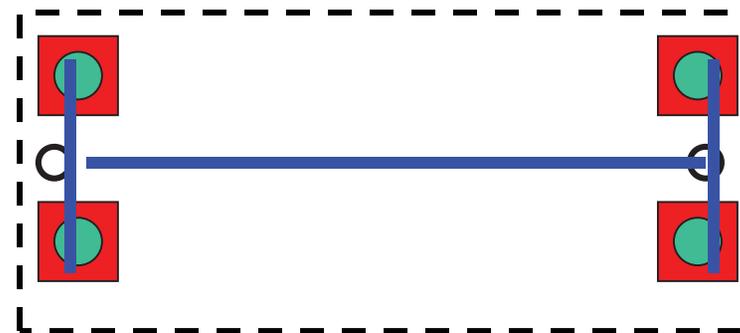


## Foot Pad Concept:

- Inflatable or felt backed block to provide a degree of cushion on contact
- Quick-release adhesive pads under tension
- Consider making the pads somewhat malleable to enable better surface contact on rounded surfaces, like the RCC leading edge (may not be necessary, depending on where the SURF is attached to structure)
- Reinstallation of new adhesive pads desirable at the worksite



Dogbone HR

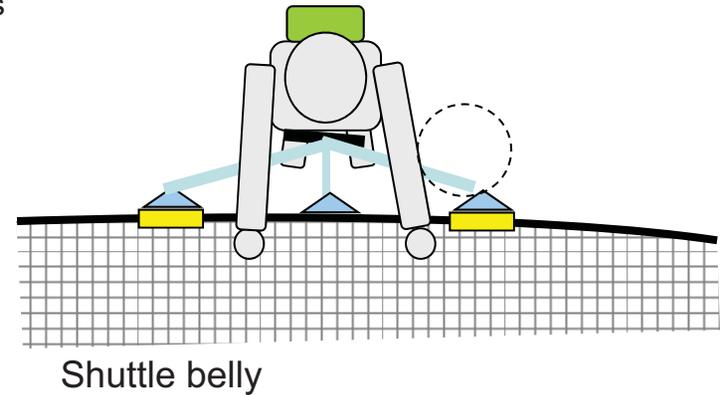
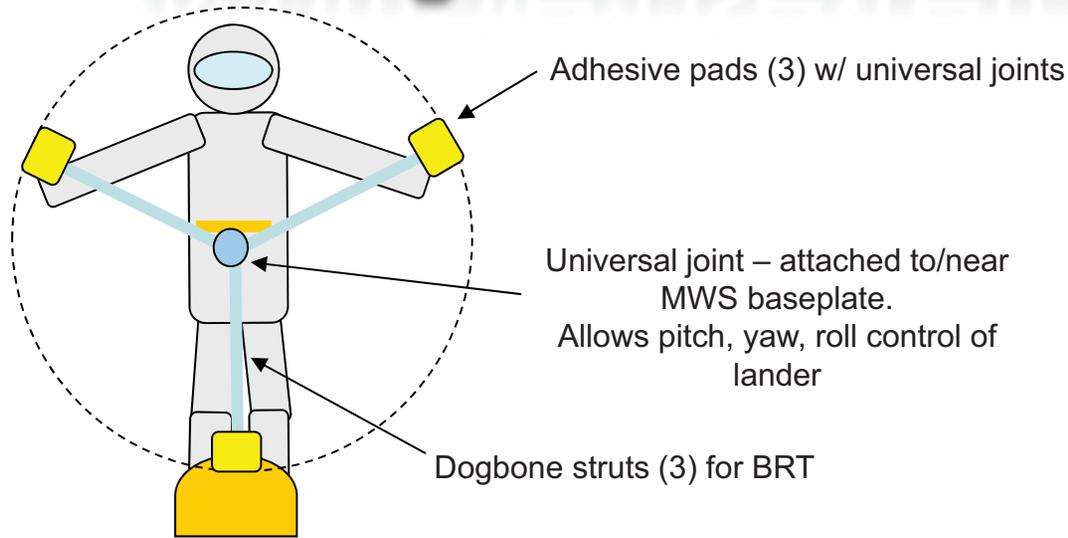


- Commonality of parts with SURF
- Consider part of standard tool kit at worksite, with perhaps 2 TURFs for work in adjacent areas
- Dogbone HR cross section allows heat lamps and/or BRT to be used; MUT/ball stack could also be used for tool stowage
- Universal ball joint for use on a variety of surface profiles
- Could build them in a variety of lengths, or make them with a telescoping feature
- Twin footpads at each end may provide more stability at some penalty in stowage

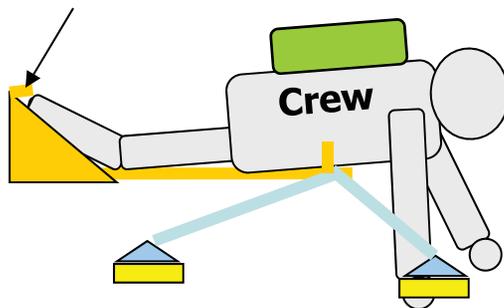
CB/Scott Parazynski --- 4/23/03

\* Variation on the theme

# Multiple Use Tether Variant

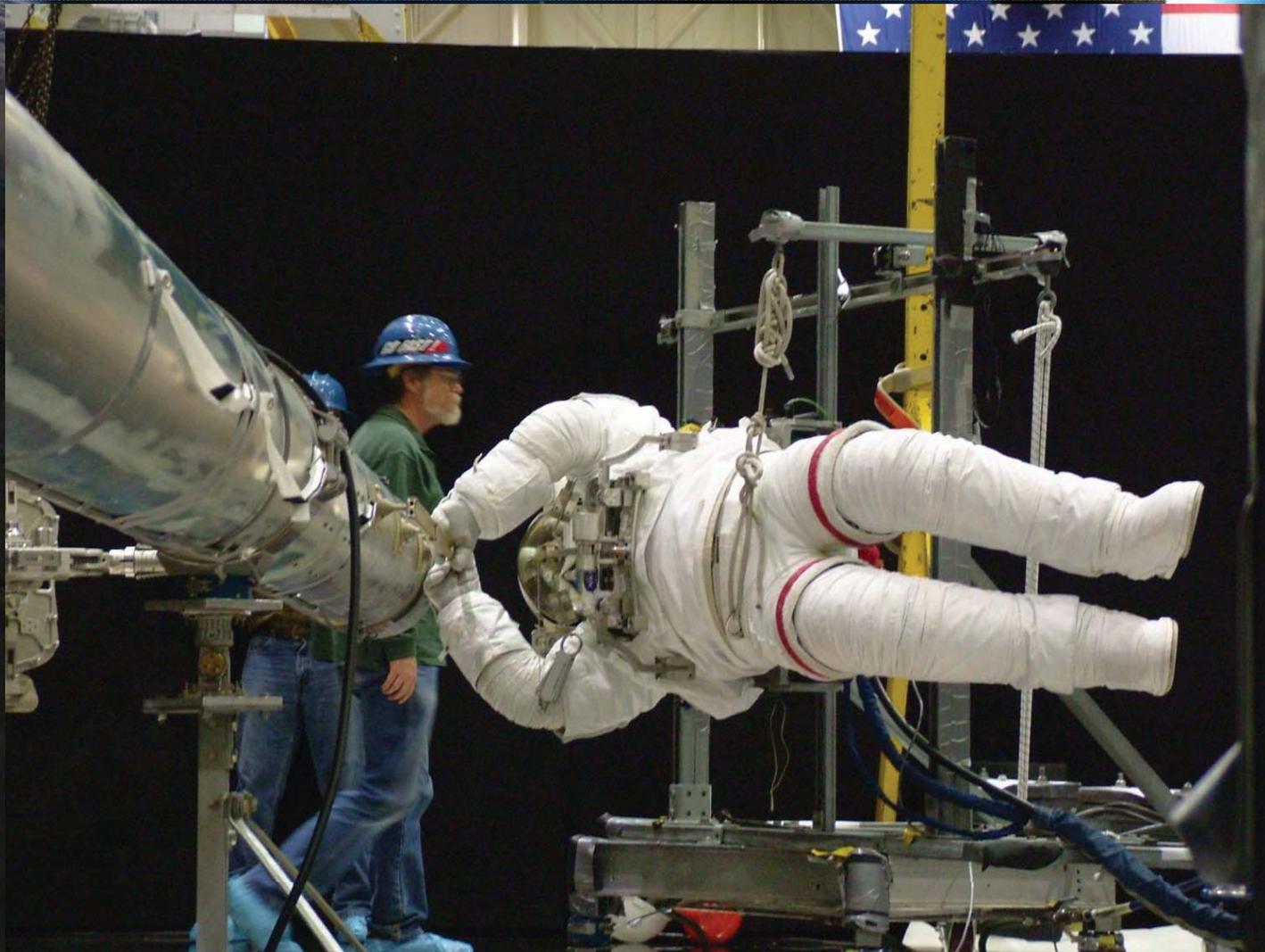


EMU boot bumper guard (not for EVA loads / stabilization)



- Can egress lander and BRT to struts
- Offset / angled landing – universal joints allow lander pads (3) to contact surface prior to load application (i.e. self aligning)
- Adhesive pads have a quick release
- Crewmember can spin around central point for greater worksite access and pad release

# Orbiter Boom Sensor System



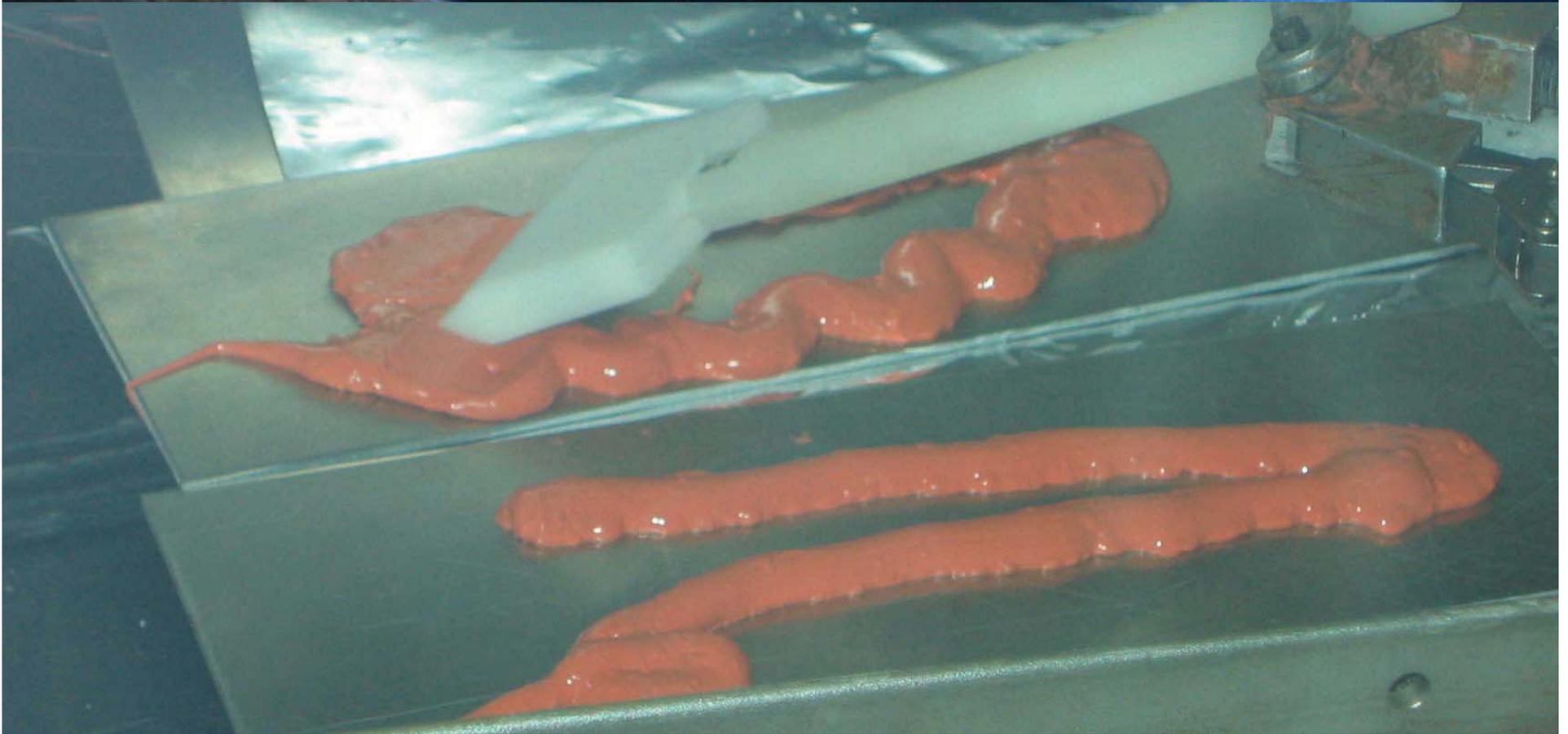
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# Tile Repair & STA-54 Uncertainties



- Perforated Membrane vs. “Open Technique”
- Swelling & Bubbling
- Uniformity of Density
- Char Layer Stability
- Operational Complexity
- Test Fidelity Concerns (1-G settling)

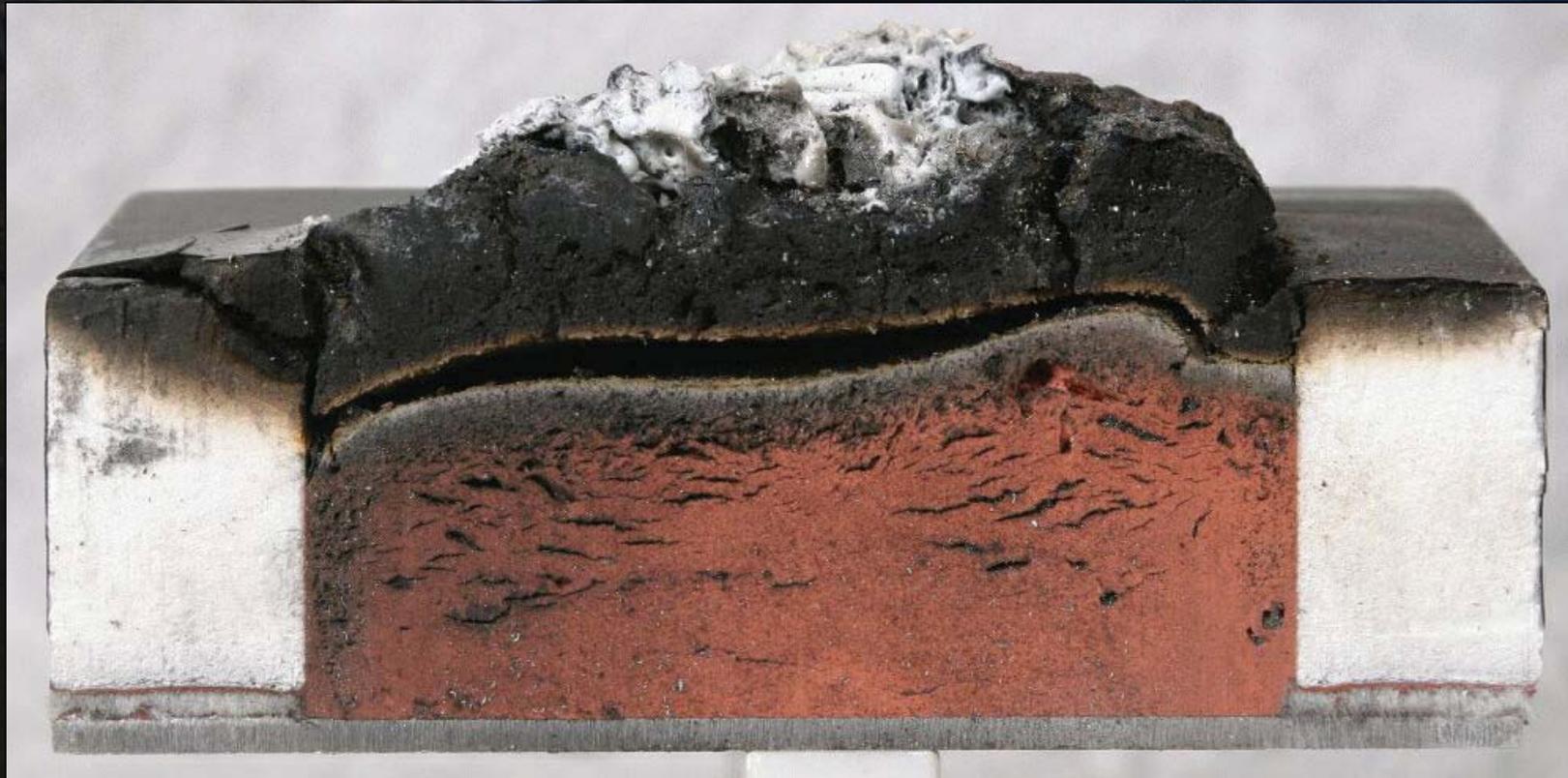
# L-M Denver Vacuum Chamber



# Arc Jet Testing



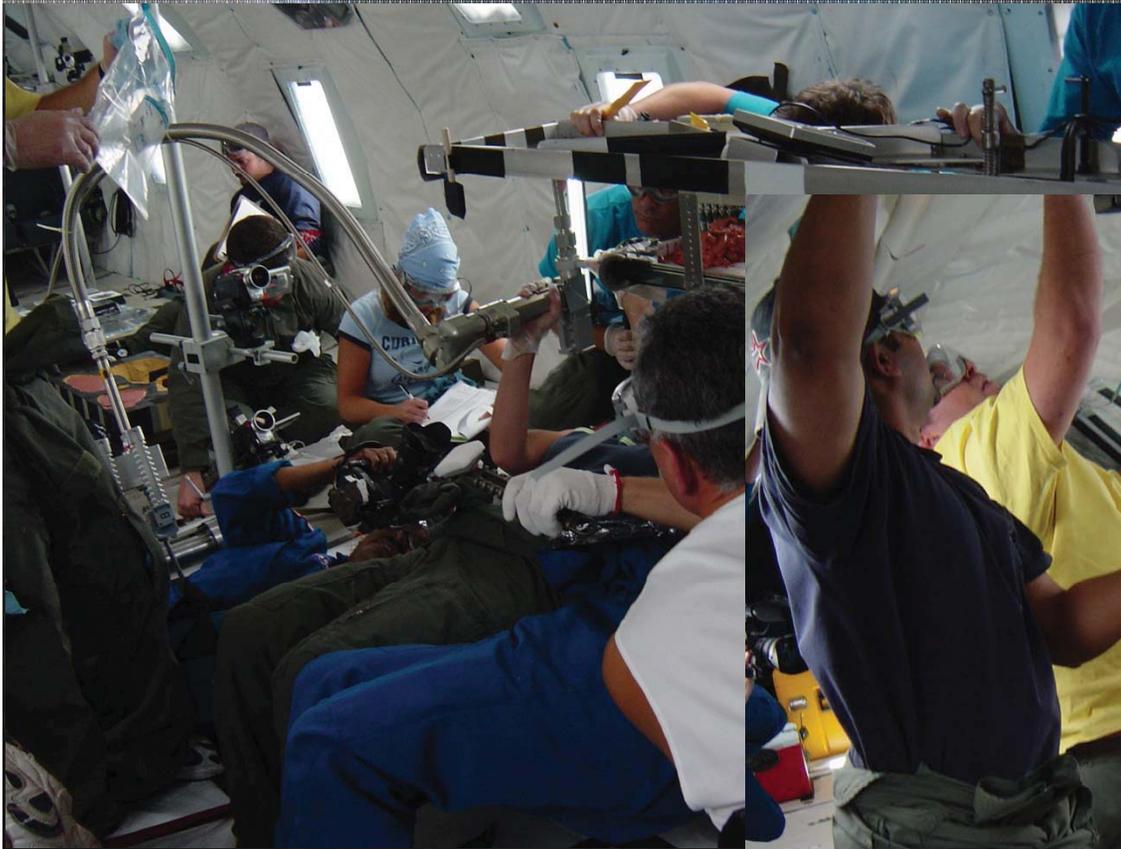
# Char Layer



# Human Thermal Vacuum Testing



# Thousands of Parabolas



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# 0-G Adherence and Technique Testing



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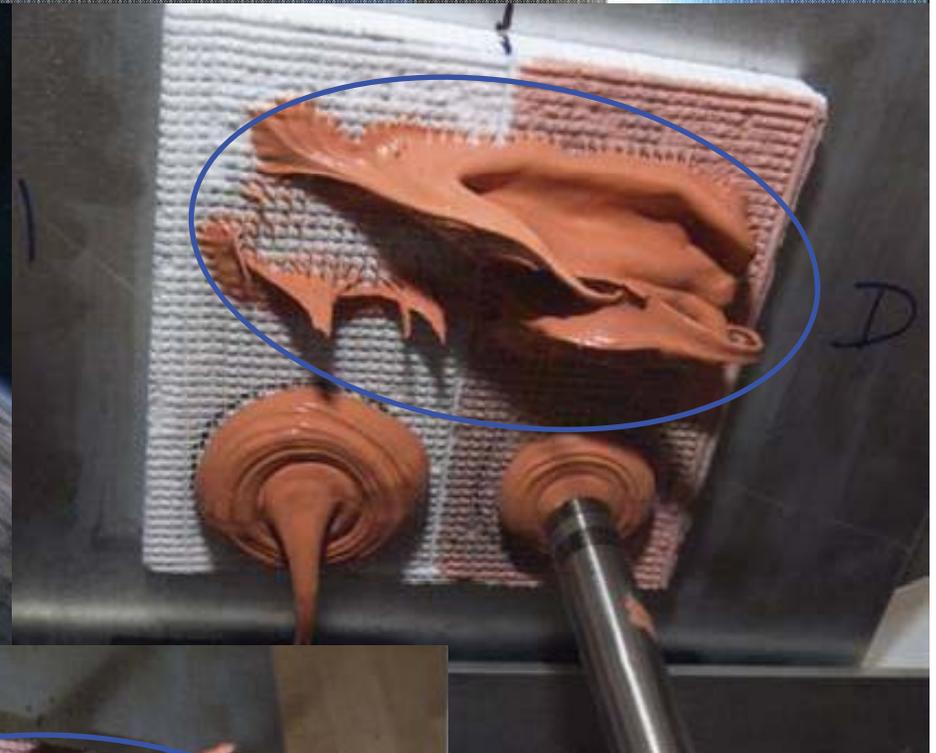


# Suited KC-135 Parabolic Tests

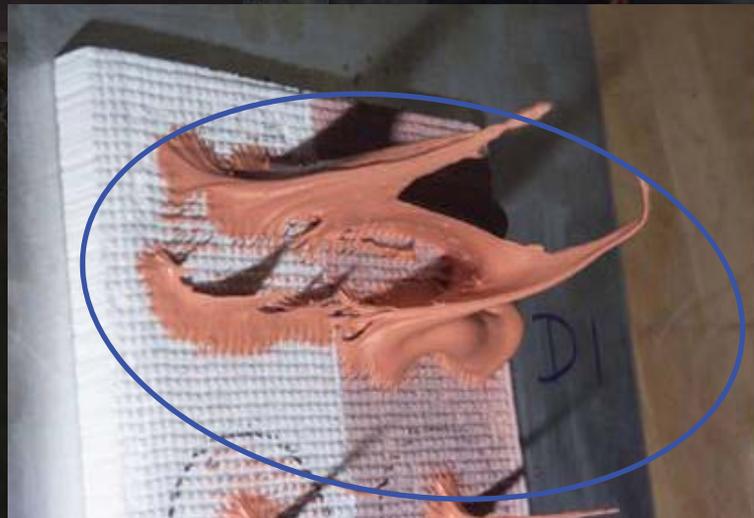


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# Tamp and Dot Techniques



Marginal Adhesion  
Flat, Raked Tile



Post Flight

# Another Day @ The Office



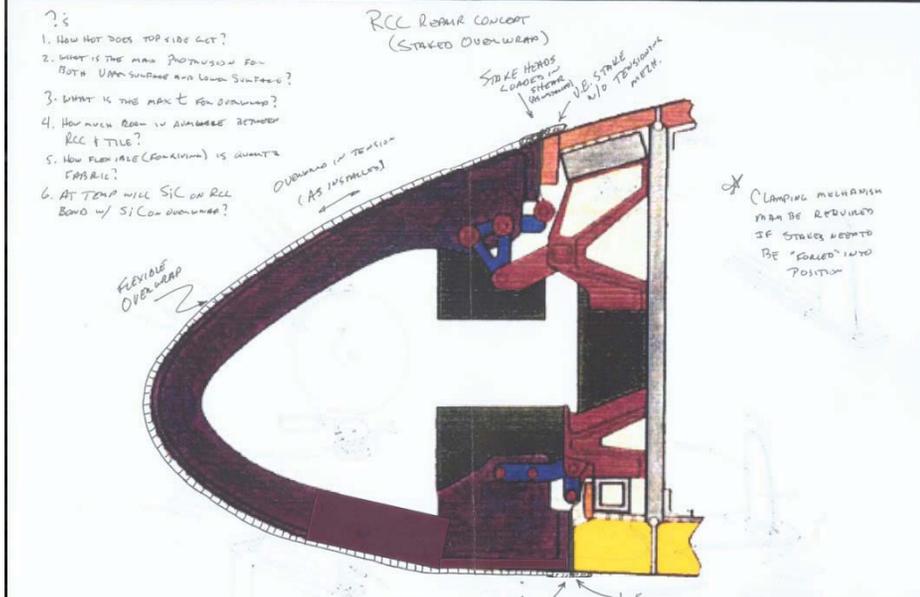
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# Dual Glovebox Thermal Vacuum

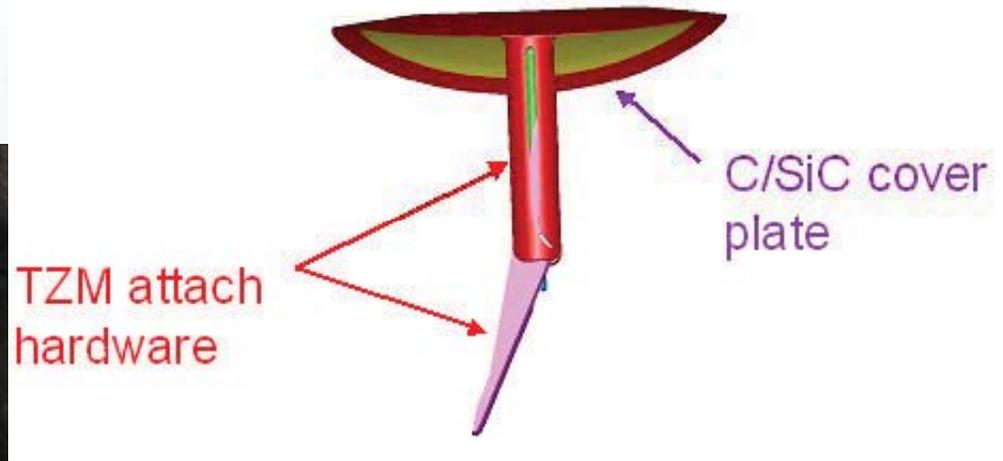


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# RCC Repair Strategies



- Fillers/Caulks
- Plugs
- Balloons
- Overwraps

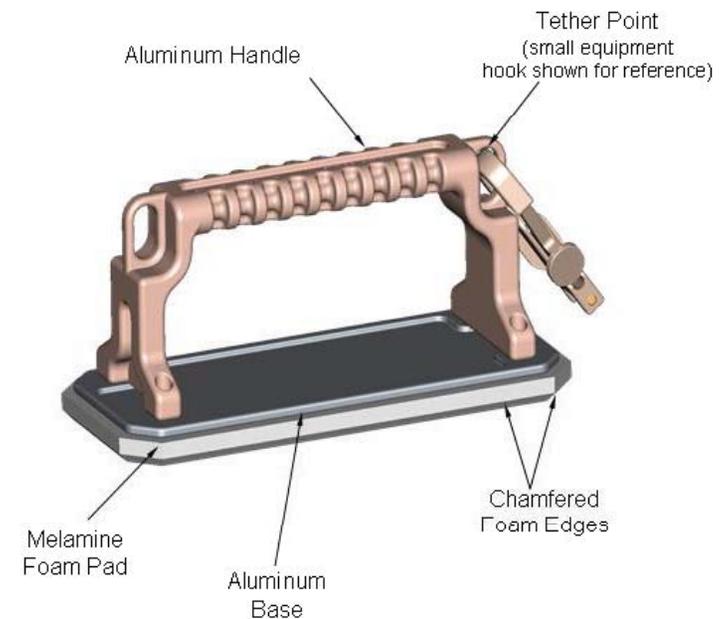


# EVA Inspection Techniques

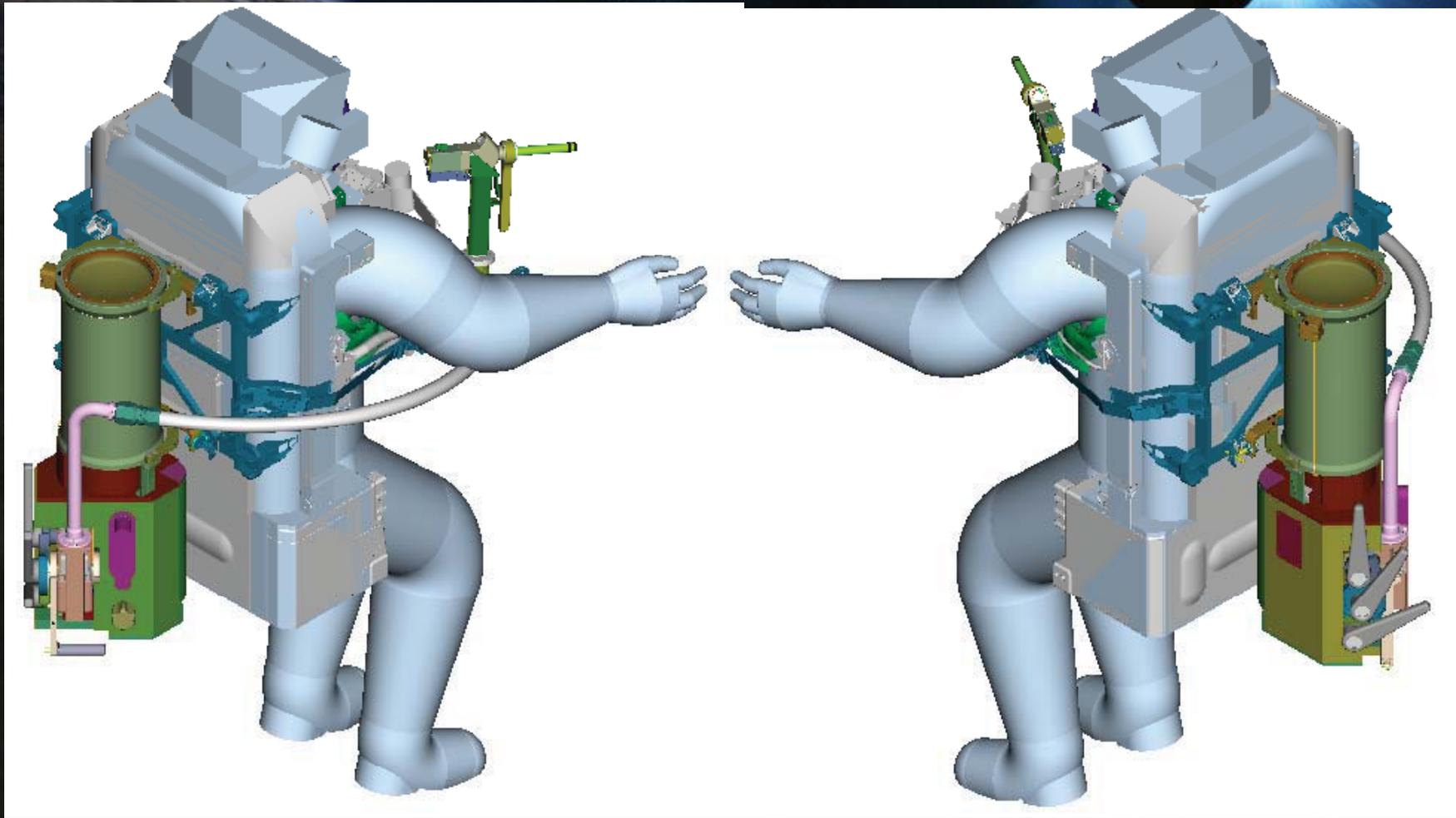


# Dozens of Tools Designed, Tested

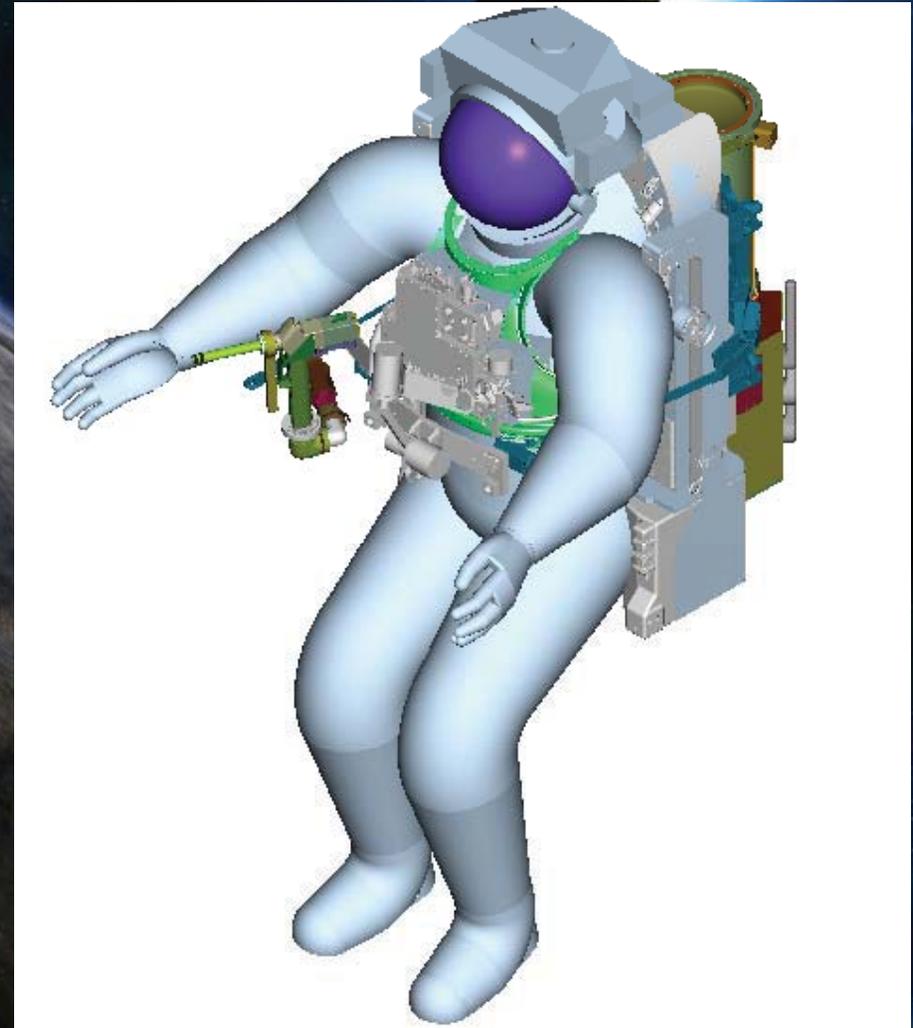
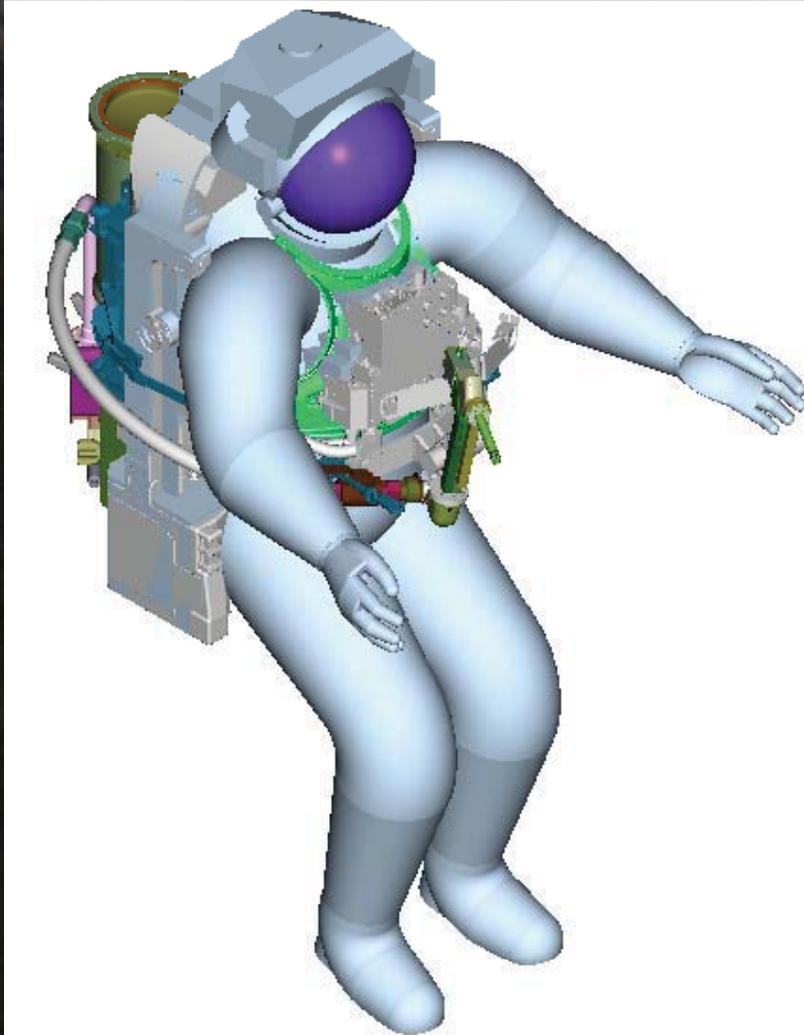
- Quick Turnaround
- Melamine Brushes from Home Depot
- Dispensers, Wipes, Caddies, Trash Containers, Primer
- Alternate Solutions: Tile Overlay, Tile Changeout



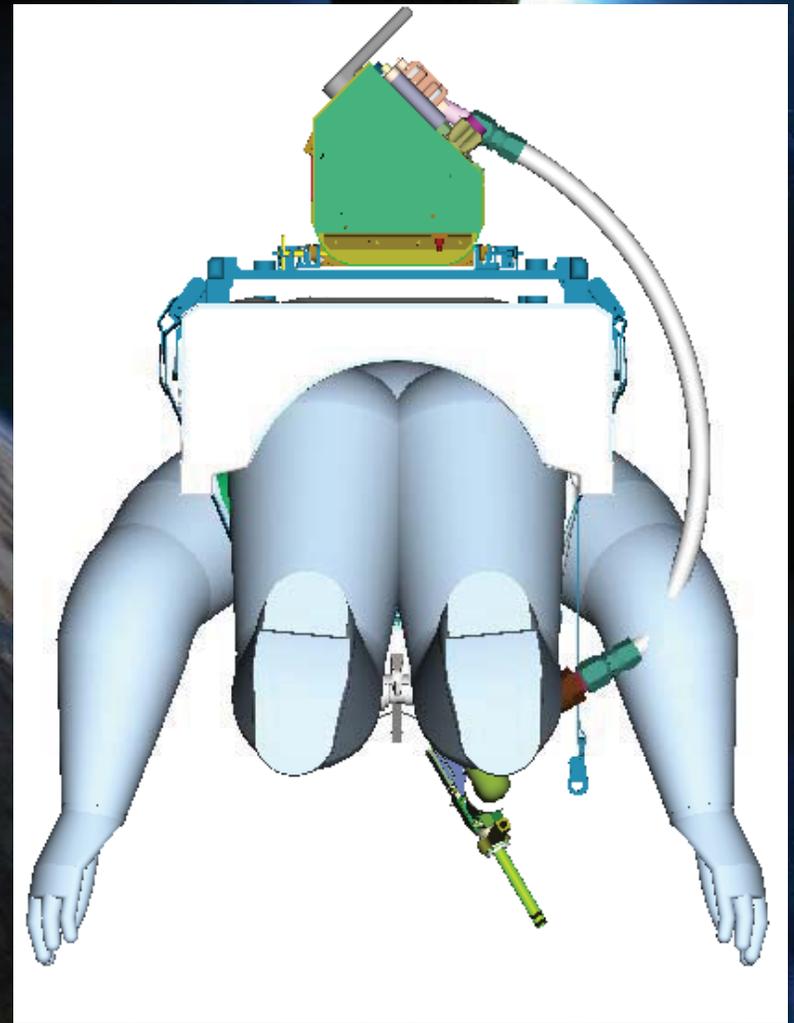
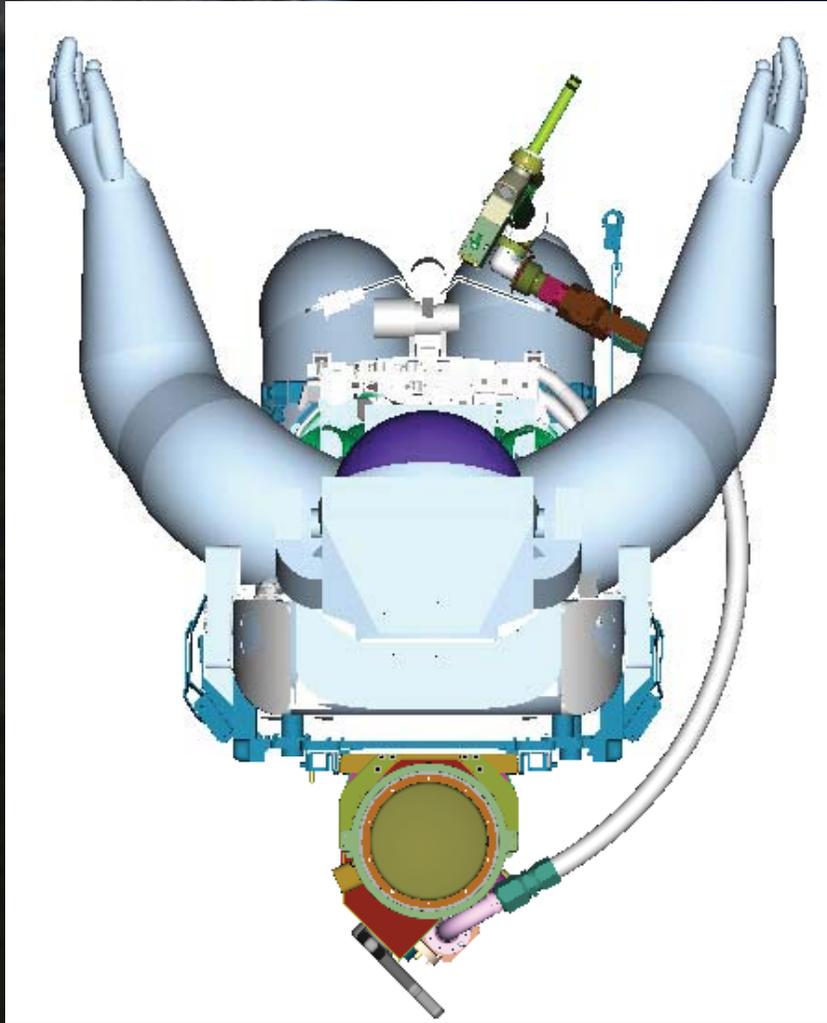
# CIPAA Backside Views



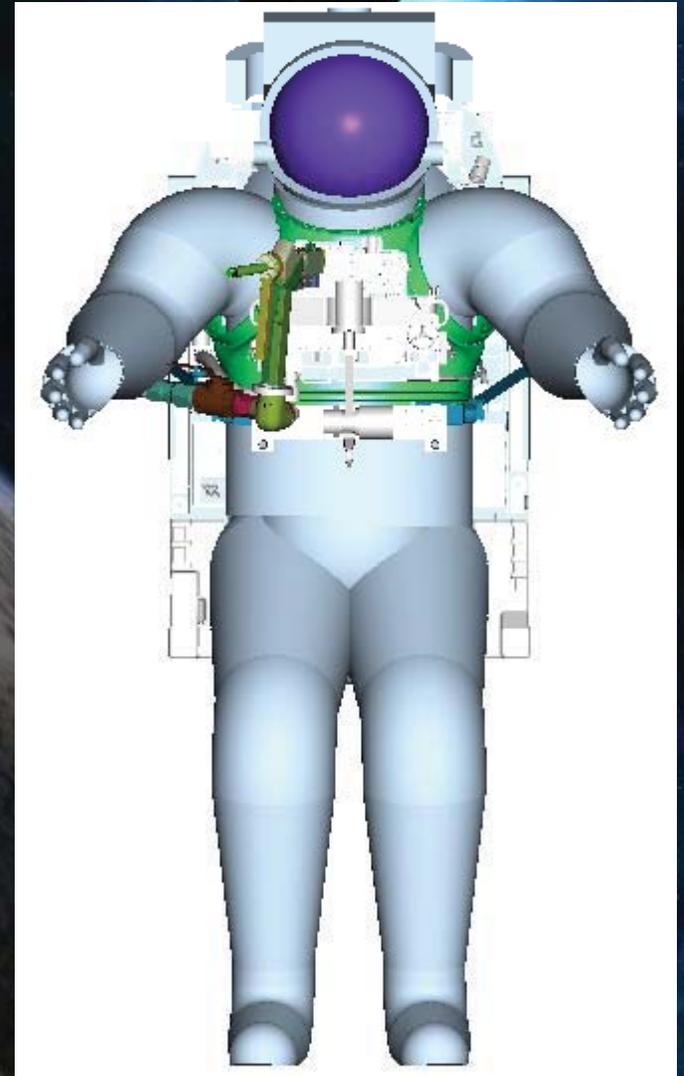
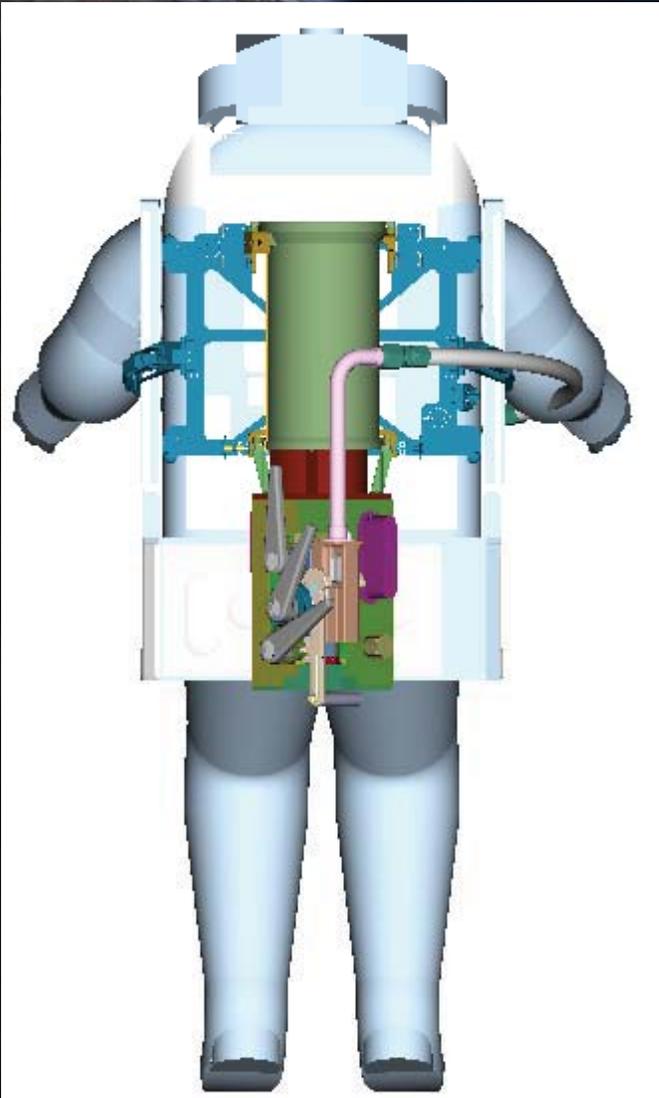
# CIPAA Frontside Views



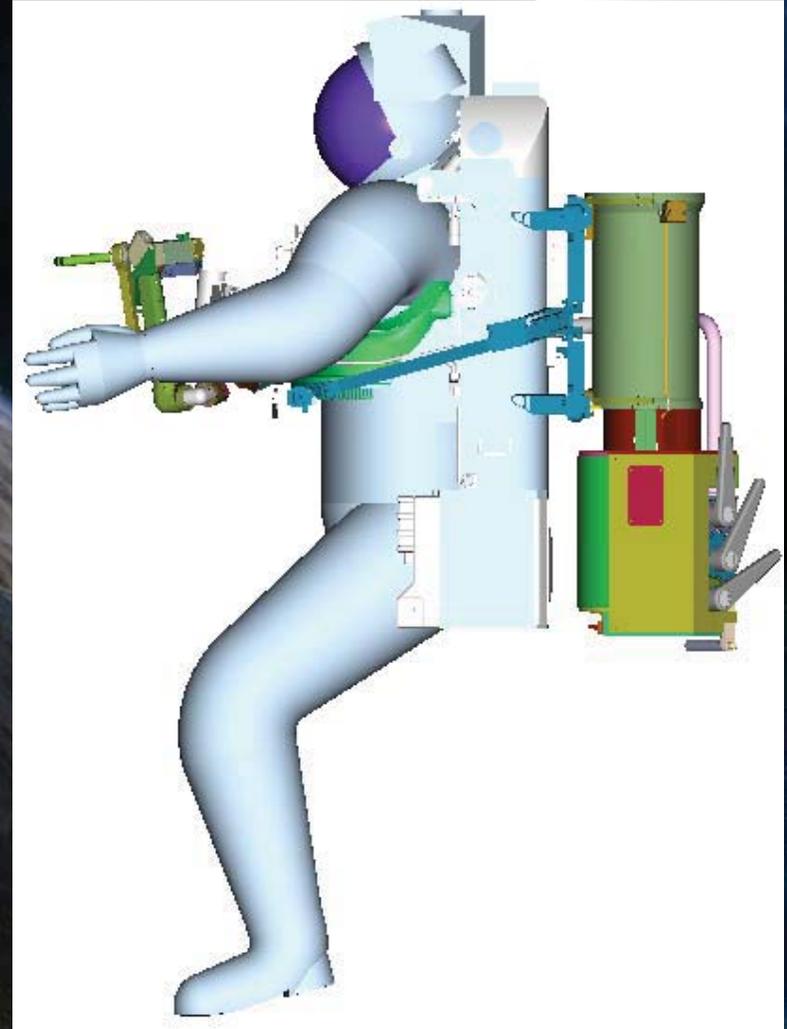
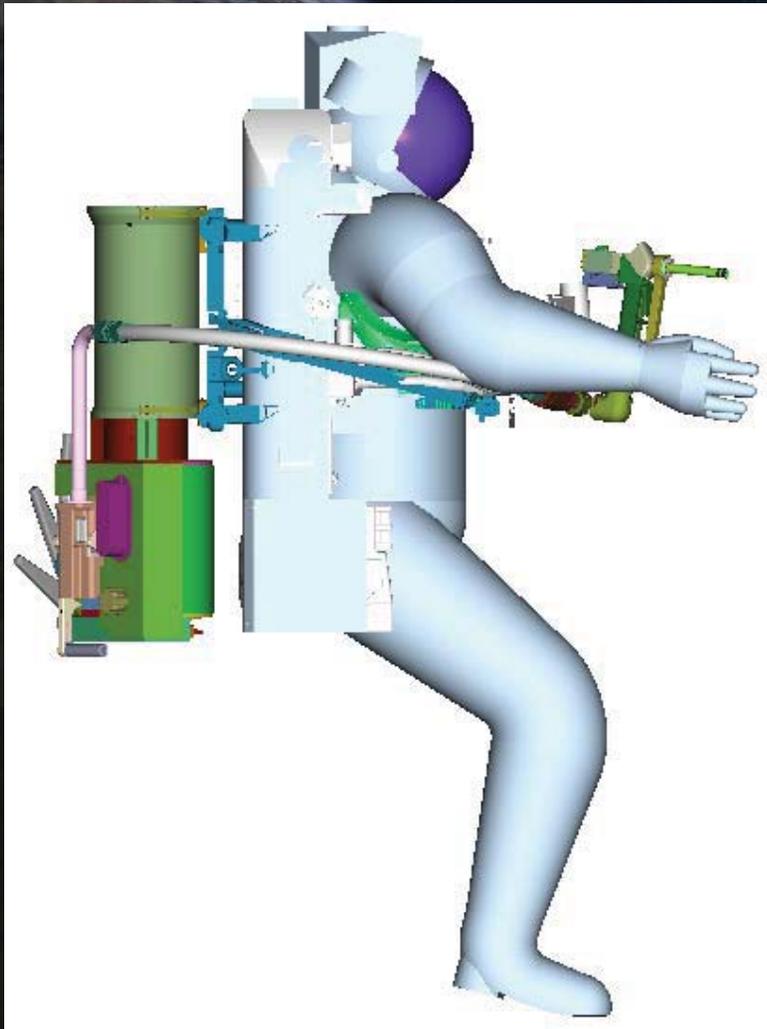
# CIPAA Top/Bottom Views



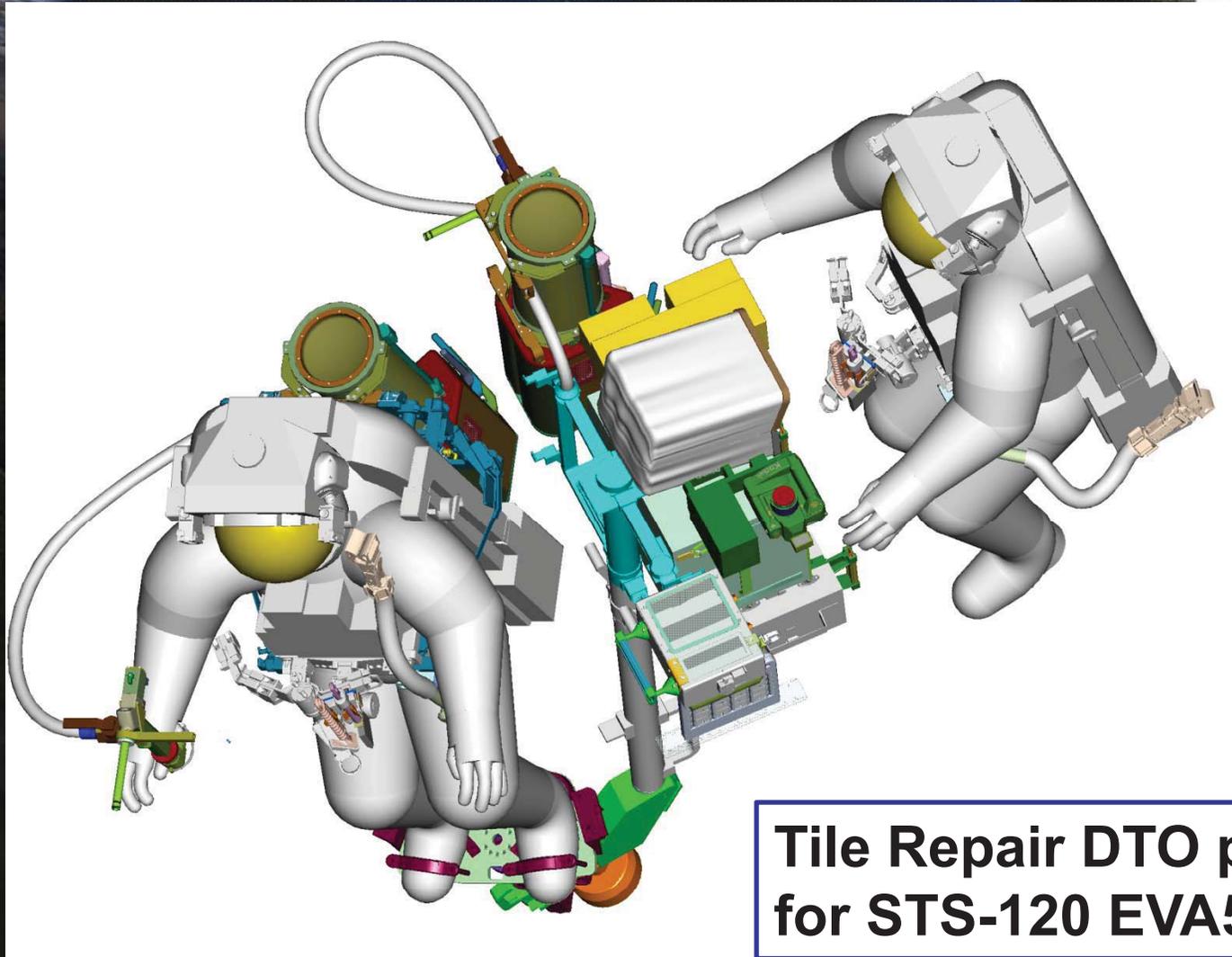
# CIPPA Front/Back Views



# CIPAA Left/Right Views

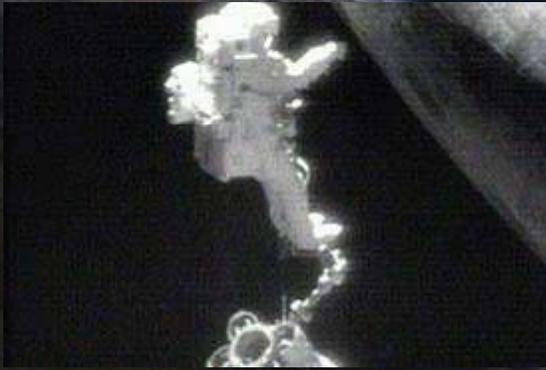


# Tile Repair: Not to be taken lightly

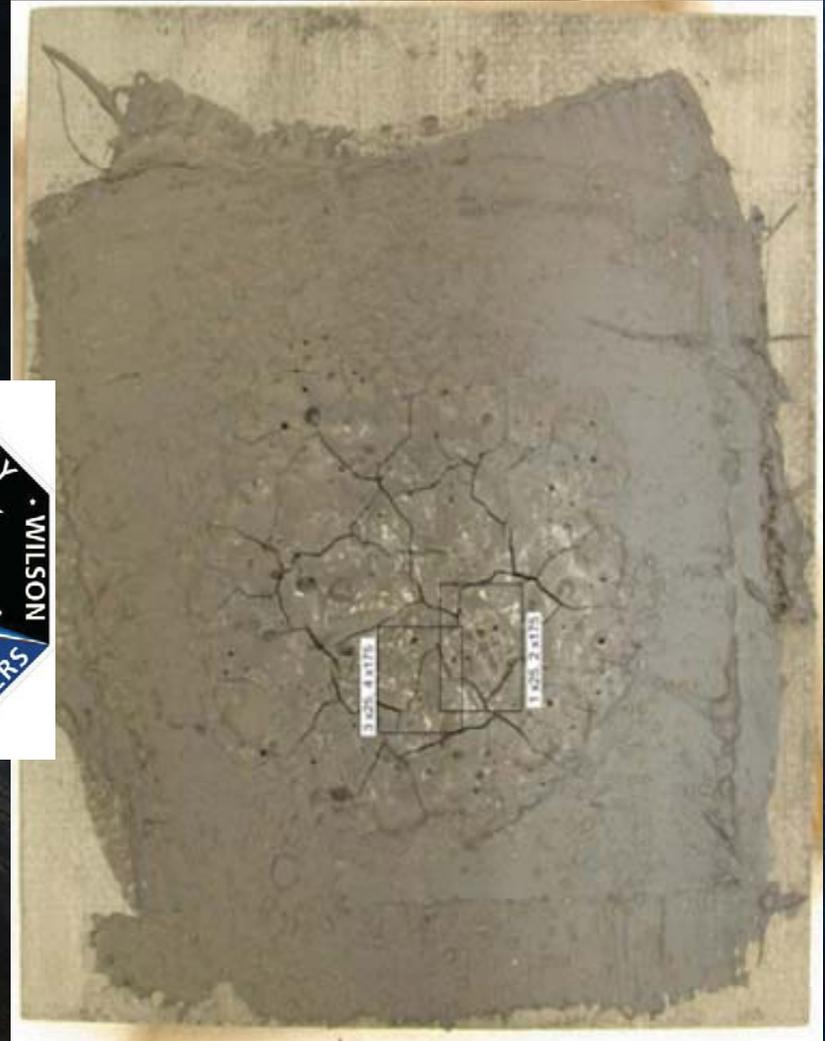


**Tile Repair DTO planned  
for STS-120 EVA5**

# STS-114 Gap Filler Experience: Stevie Ray Robinson & Soichi Noguchi



# STS-121 RCC Repair DTO (NOAX ceramic): Mike Fossum & Piers Sellers



# The STS-118 Experience

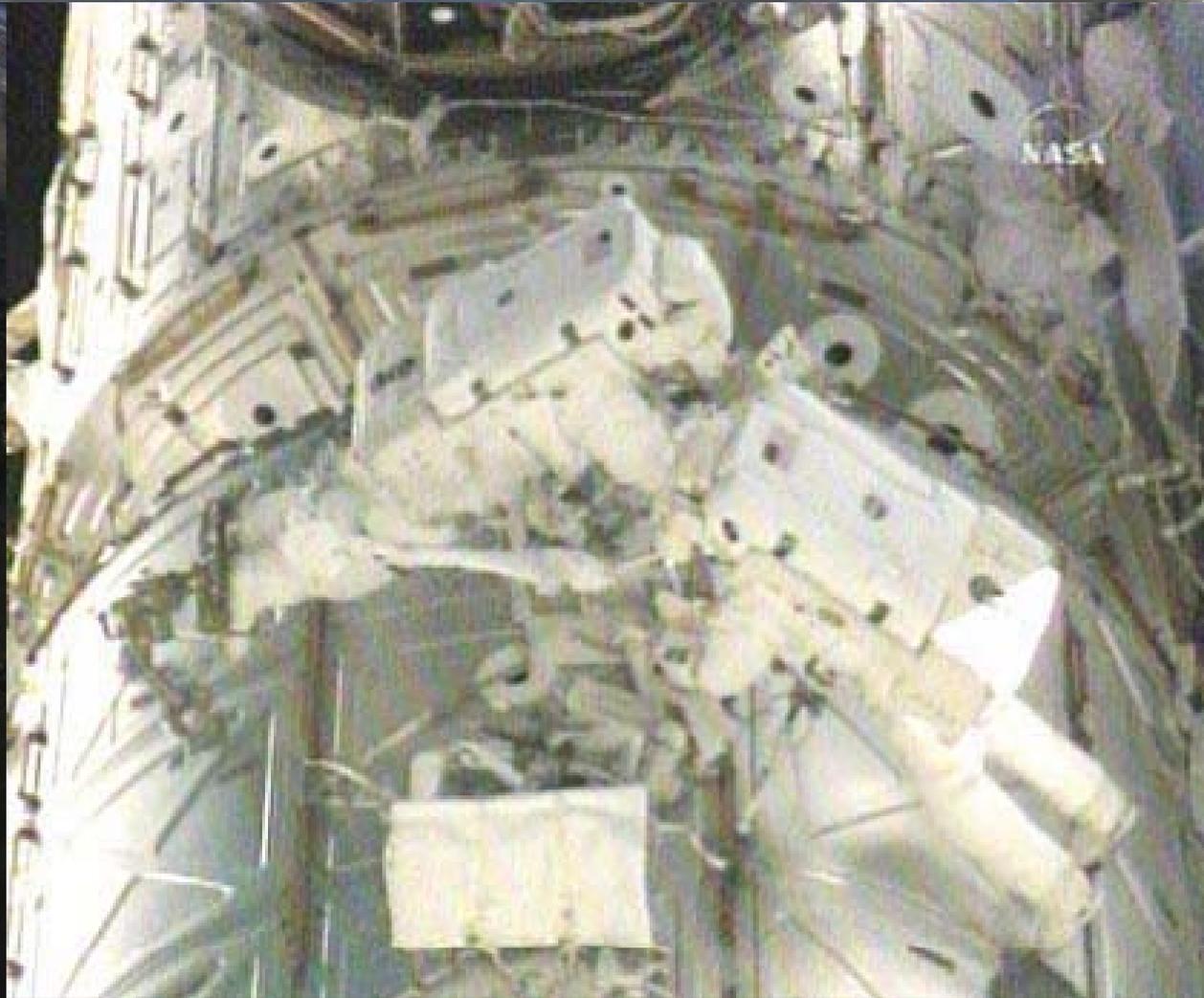
- Focused Inspection
- Analysis & Modeling
- Assessment of Repair Strategies: Dual Glovebox
- Development of Crew Briefing Materials and Procedures
- Videoconference w/crew, Q&A
- Flew home w/o repair

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# STS-123 Tile Repair Ablator Dispenser (TRAD)

DTO: Mike Foreman & Bob Behnken



# QUESTIONS/DISCUSSION



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