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: Where necessity drives out-of-the-box thinking, Parazynski discussed a retrospective on the EVA tools and procedures efforts NASA went through in the aftermath of Columbia for the Space Shuttle TPS inspection and repair. He was the lead astronaut on this effort and participated in all the NBL, KC-135, PABF activities, and in vacuum chamber and 1-G testing. He led the crew consensus reporting and helped develop the tools and techniques that were flown. Parazynski described how the EVA community worked together to resolve a huge safety issue (how to conduct EVA repairs on the Space Shuttle) and how work in the spacesuit was critical in 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): 1:26:34 (1.19 GB)

NASA Johnson Space Center
Crew and Thermal Systems Division
EC5 Space Suit and Crew Survival Systems Branch
2101 NASA Parkway
Houston, TX, 77058

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TPS Inspection & Repair

Scott Parazynski, MD

"US Spacesuit Knowledge Capture Series"

23 February 2012

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DEMAG
EXIT
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

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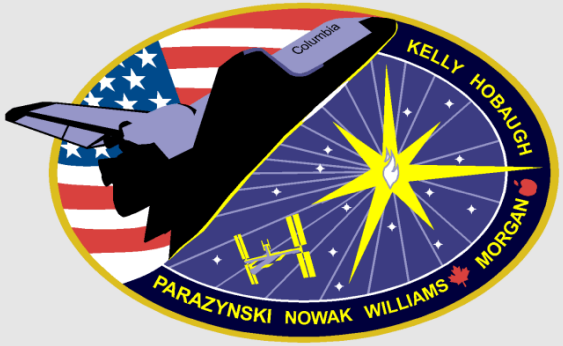

Fun & Games at the Launch of STS-107

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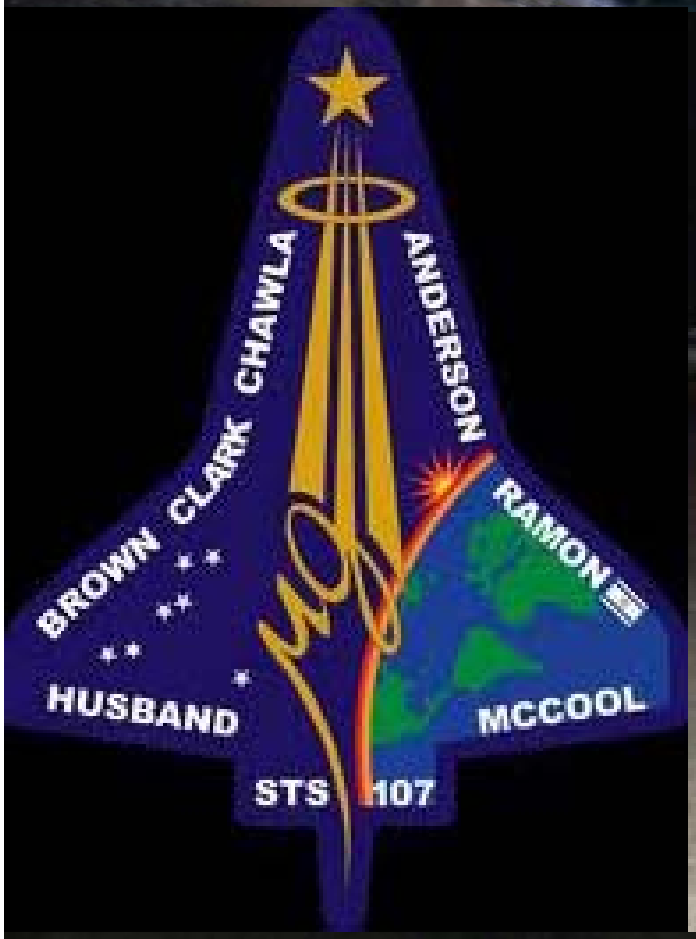
STS-107: Hail Columbia --- Kalpana, Mike, Willie, Rick, Laurel, Dave and Ilan



Our Motivation

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Columbia Point

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Columbia Point

Columbia Point Dedication

Return To Flight

- Emotion-laiden
- 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

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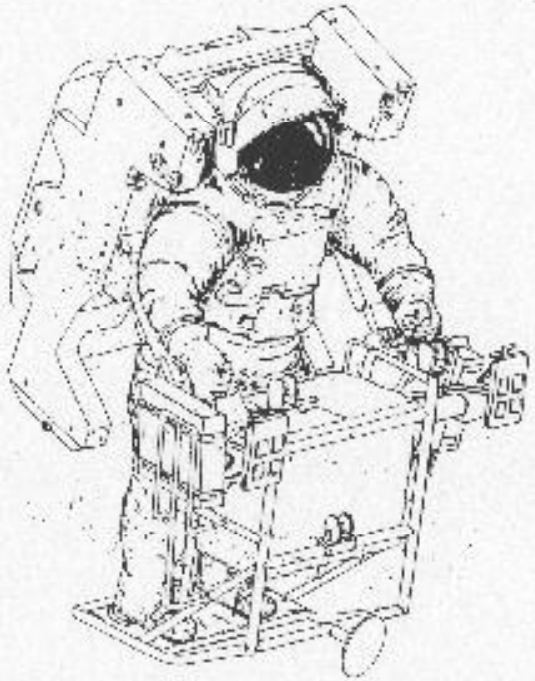
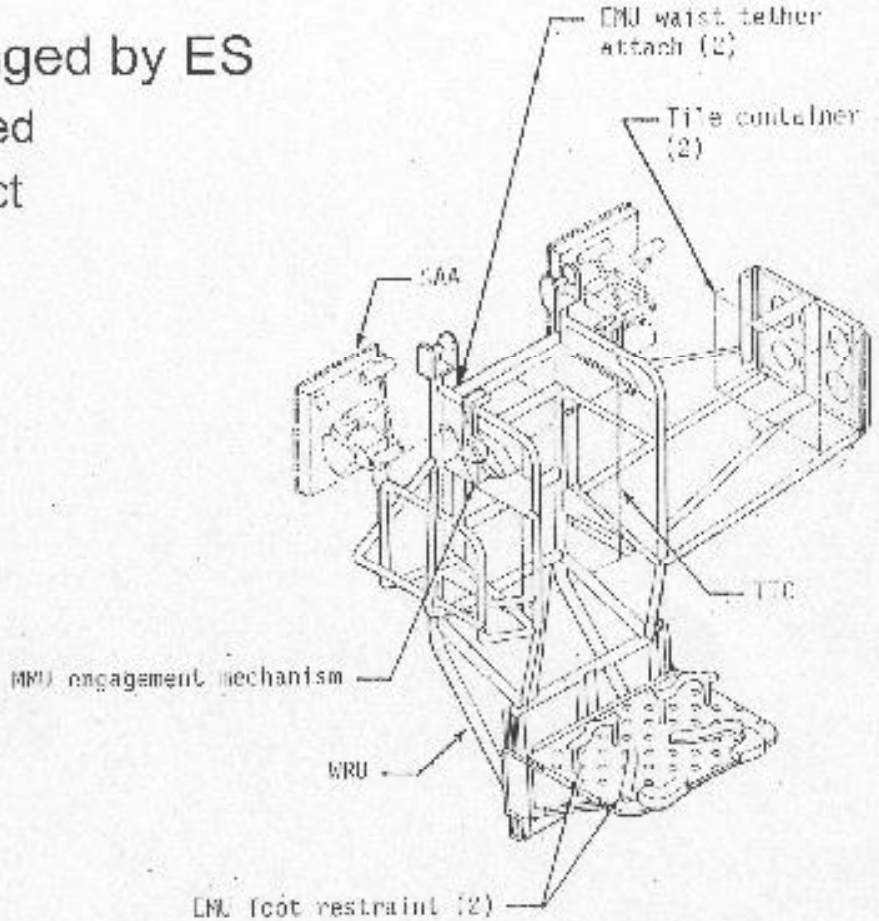
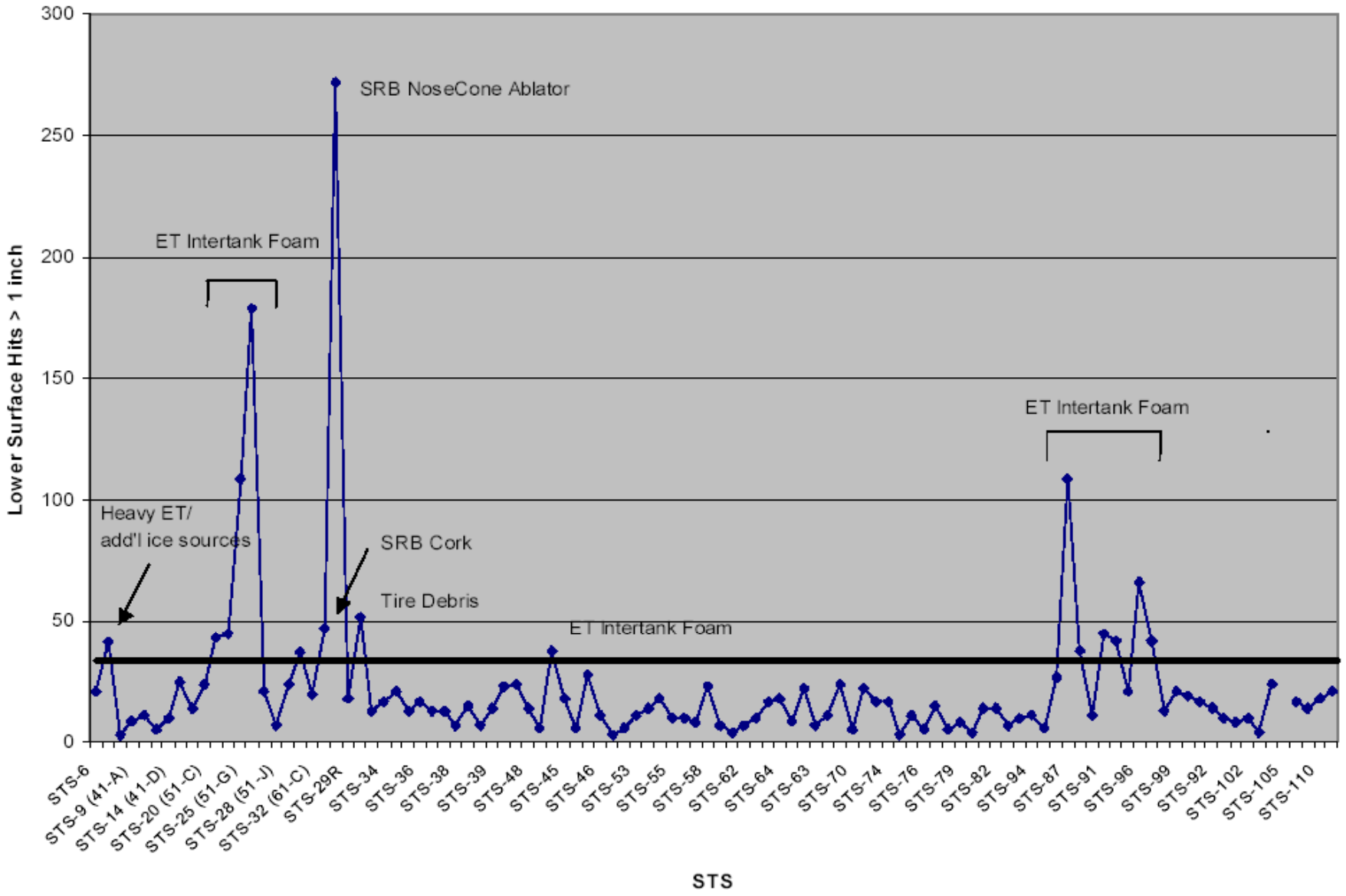
Tile Repair Pre-STS-1

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
Lower Surface Hits > 1 inch
300
250
200
150
100
50
0
SRB NoseCone Ablator
ET Intertank Foam
ET Intertank Foam
Heavy ET/
add'l ice sources
SRB Cork
Tire Debris
ET Intertank Foam
STS-6
STS-9 (41-A)
STS-14 (41-D)
STS-20 (51-C)
STS-25 (51-G)
STS-28 (51-J)
STS-32 (61-C)
STS-29R
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STS-92
STS-102
STS-105
STS-110
STS

Preliminary TPS Critical Detection Threshold*

Zone 1 Penetrations + Perimeter Tiles: ~ 1” major dimension, 0.25” depth

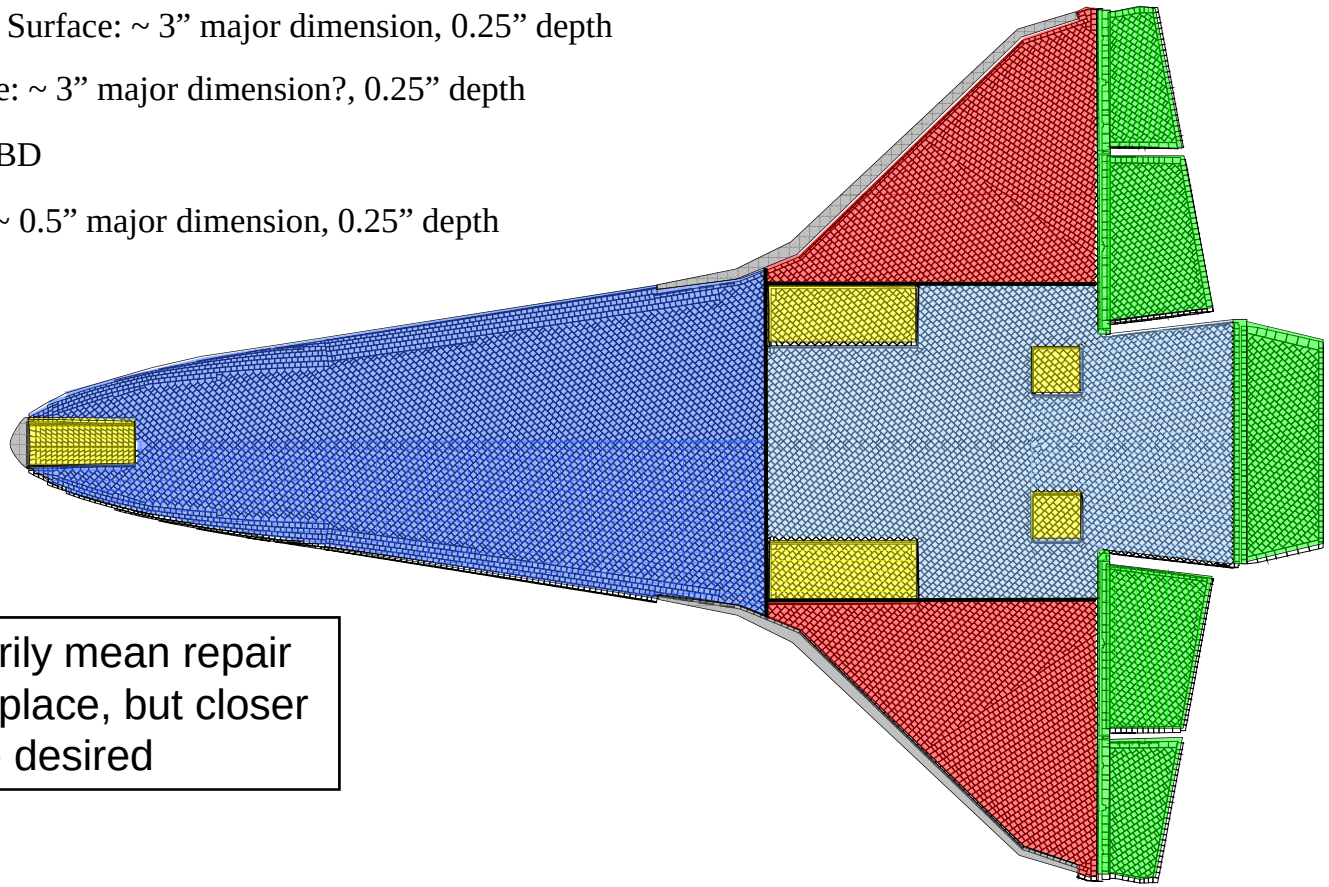
Zone 2 Fwd. Fuselage Lower Surface: ~ 3” major dimension, 0.25” depth

Zone 3 Aft Fuselage Lower Surface: ~ 3” major dimension, 0.25” depth

Zone 4 Wing Lower Surface: ~ 3” major dimension?, 0.25” depth

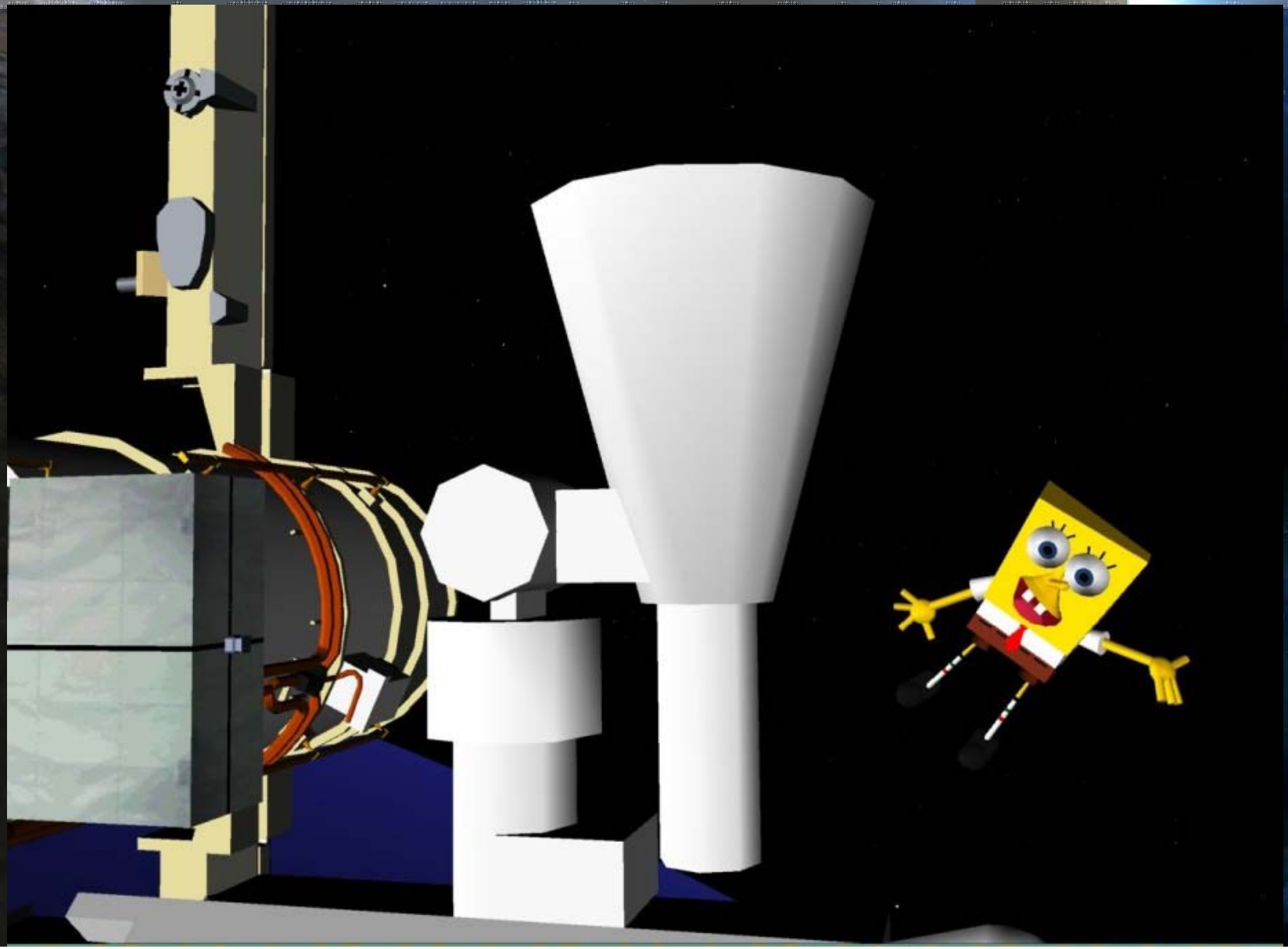
Zone 5 Control Surfaces: TBD

Zone 6 RCC Components: ~ 0.5” major dimension, 0.25” depth



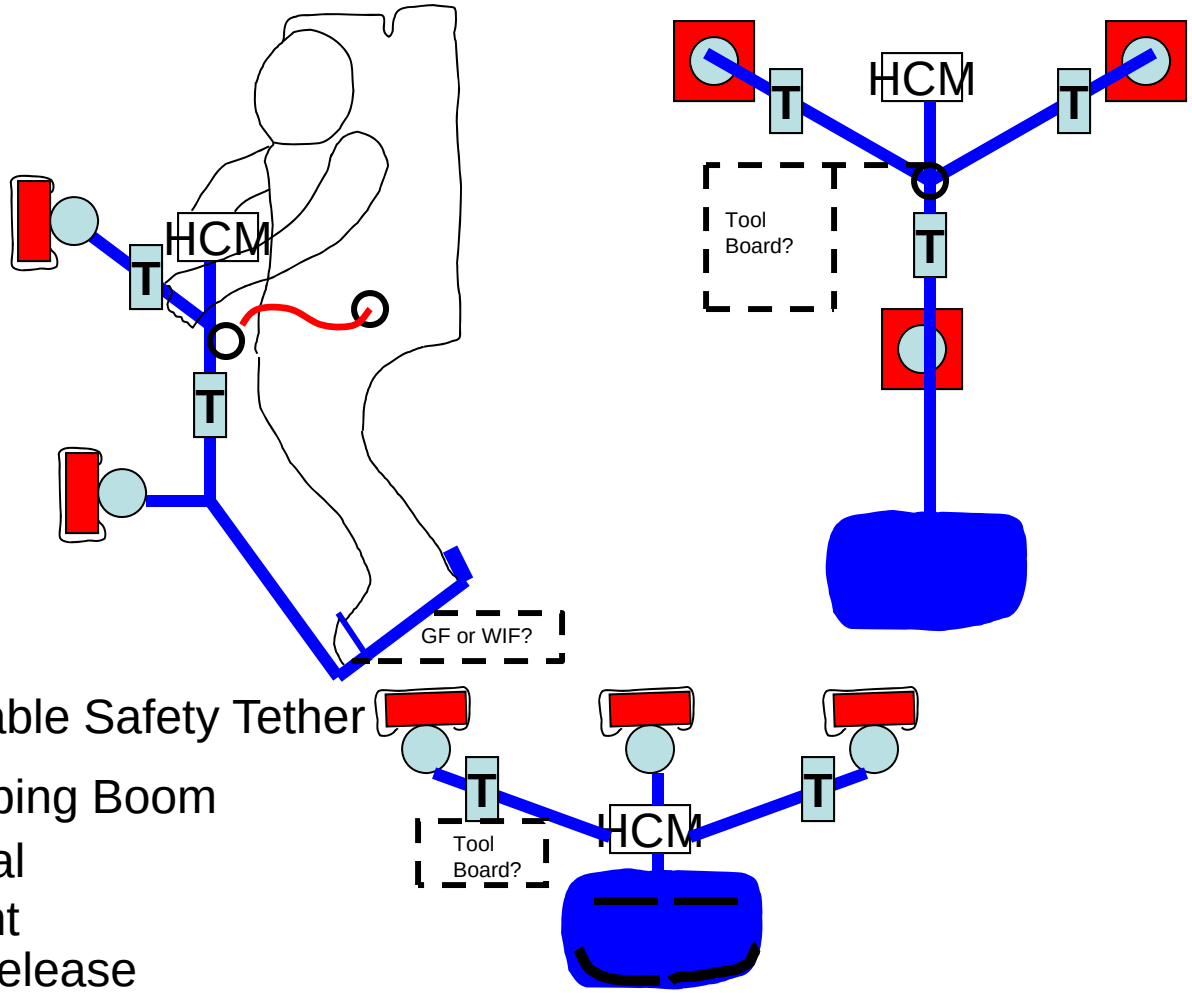
* Does not necessarily mean repair would need to take place, but closer inspection would be desired

VR Lab SAFER Inspection/Repair



TPS Access from OBSS and Strela

SAFER Underbelly Repair Fixture (SURF)



Retractable Safety Tether

T Telescoping Boom

Universal

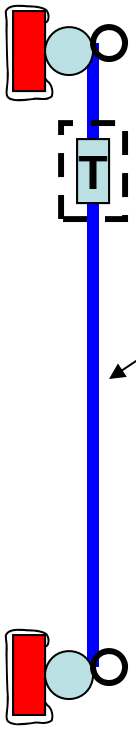
Ball Joint
Quick Release

Adhesive Pad
Tether Point

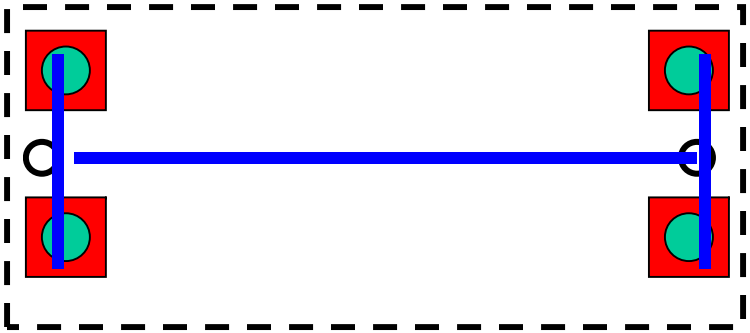
CB/Scott Parazynski --- 4/23/03

- 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 360º 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)



Dogbone HR



Foot Pad Concept:

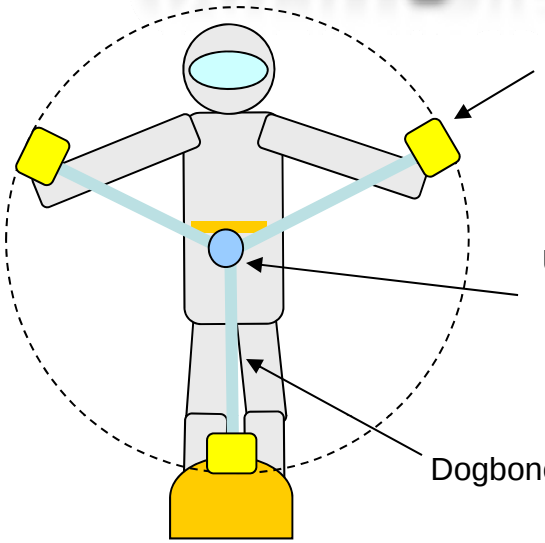
- Inflatable or felt backed block to provide a degree of cushion on contact
- Quick-release adhesive pads under tension
- Consider making the pads somewhat malleable to enable better surface contact on rounded surfaces, like the RCC leading edge (may not be necessary, depending on where the SURF is attached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

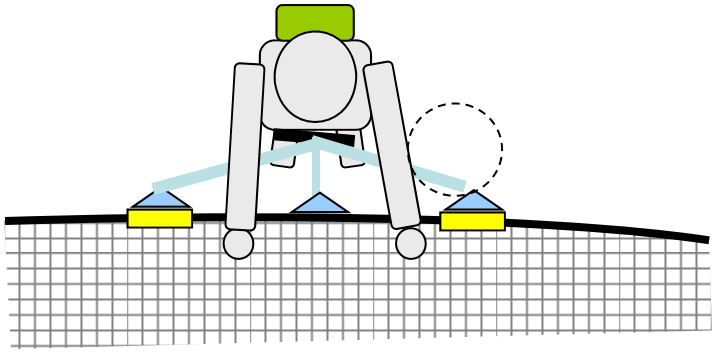
- Commonality of parts with SURF
- Consider part of standard tool kit at worksite, with perhaps 2 TURFs for work in adjacent areas
- Dogbone HR cross section allows heat lamps and/or BRT to be used; MUT/ball stack could also be used for tool stowage
- Universal ball joint for use on a variety of surface 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

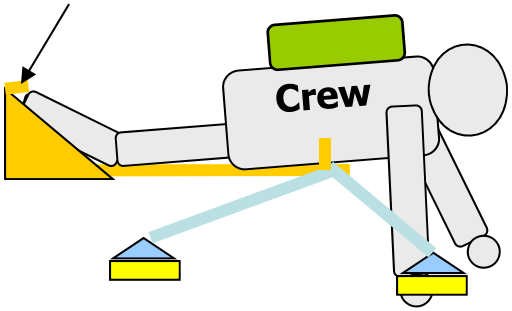
* Variation on the theme

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

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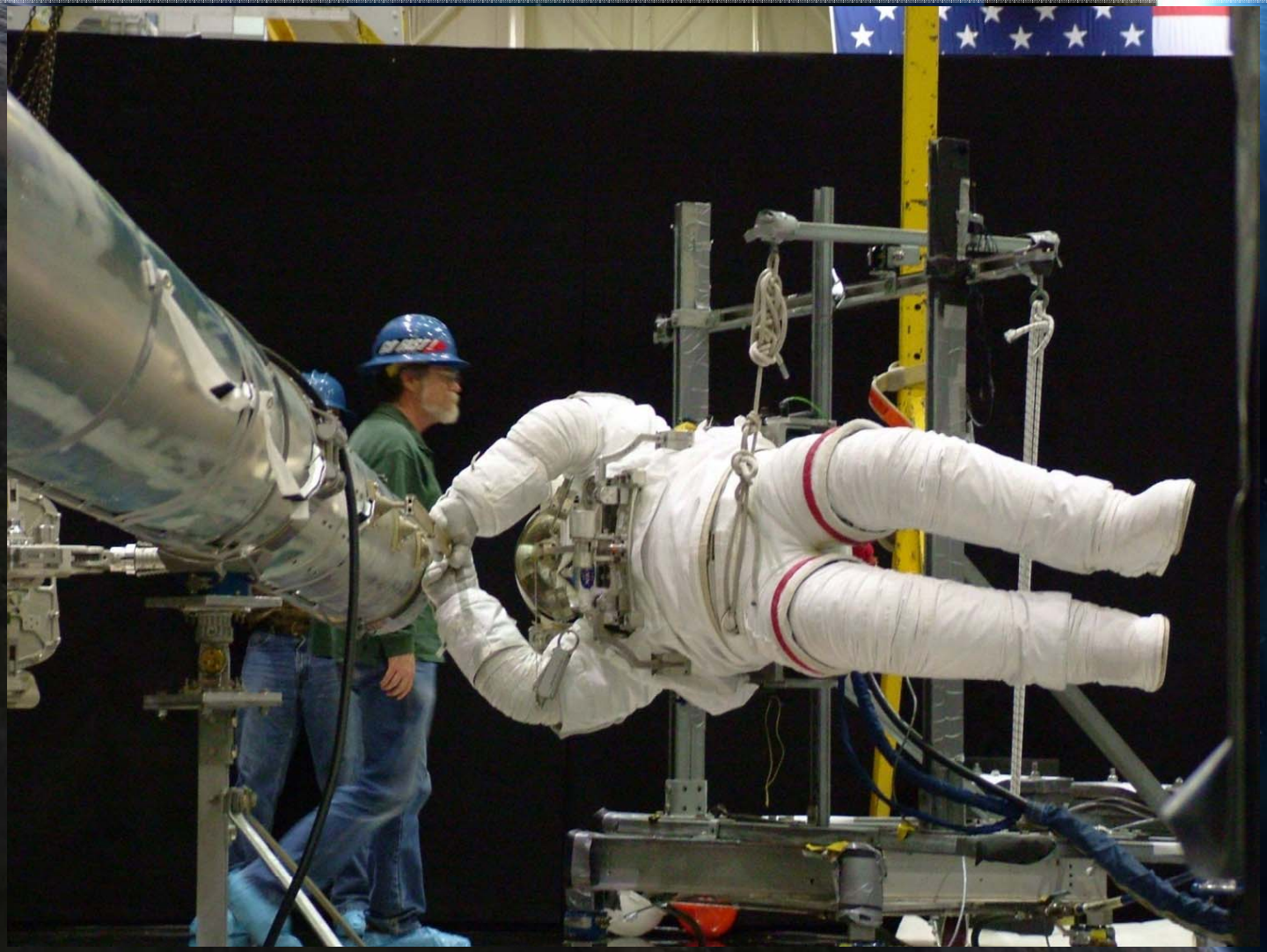
Orbiter Boom Sensor System



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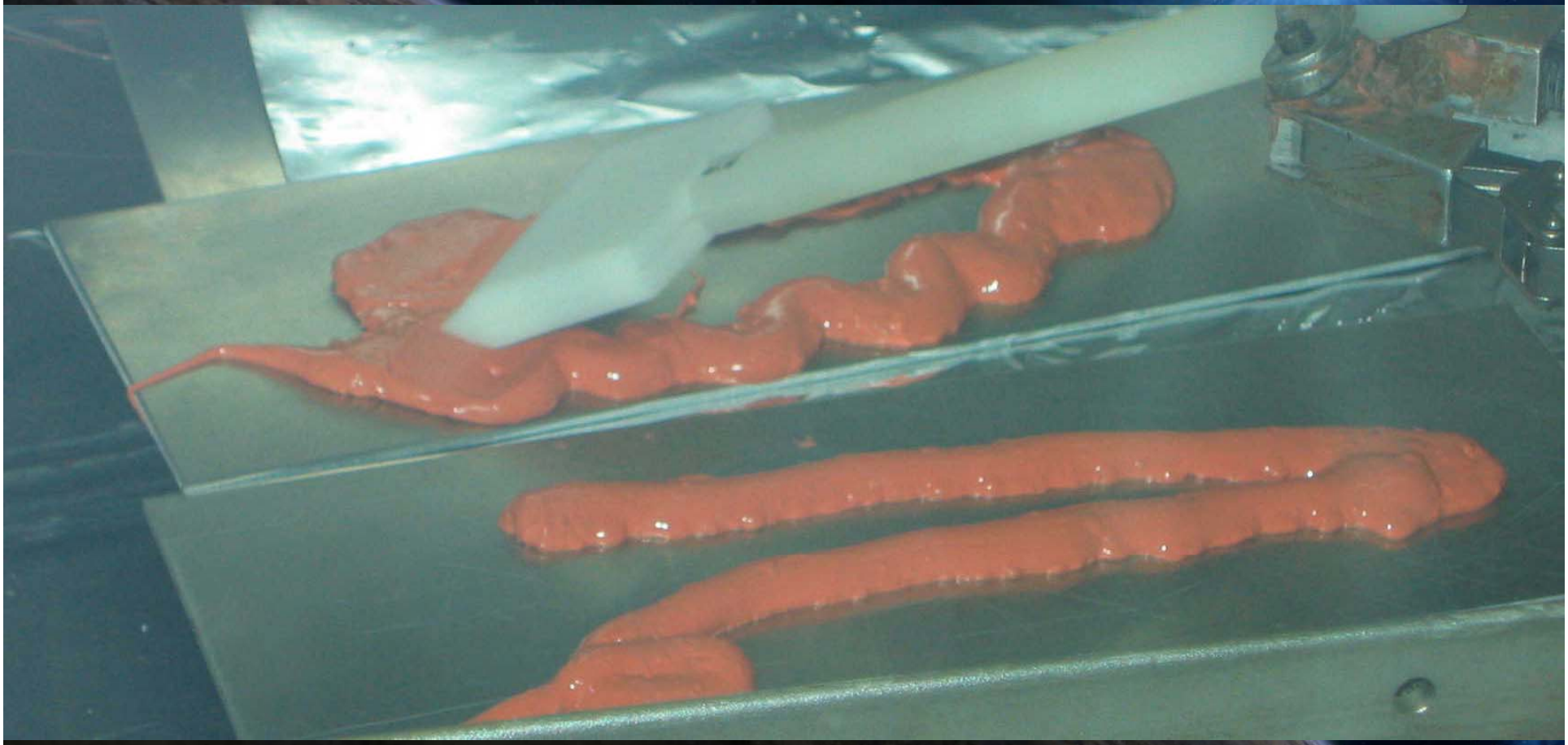
Tile Repair & STA-54 Uncertainties

- 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



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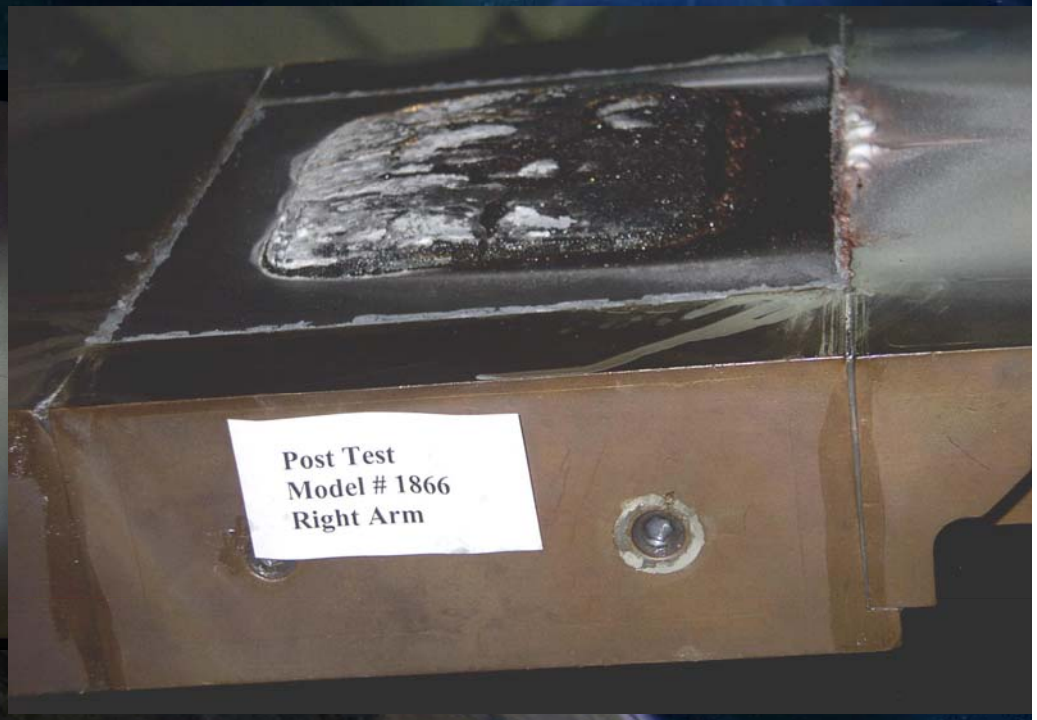
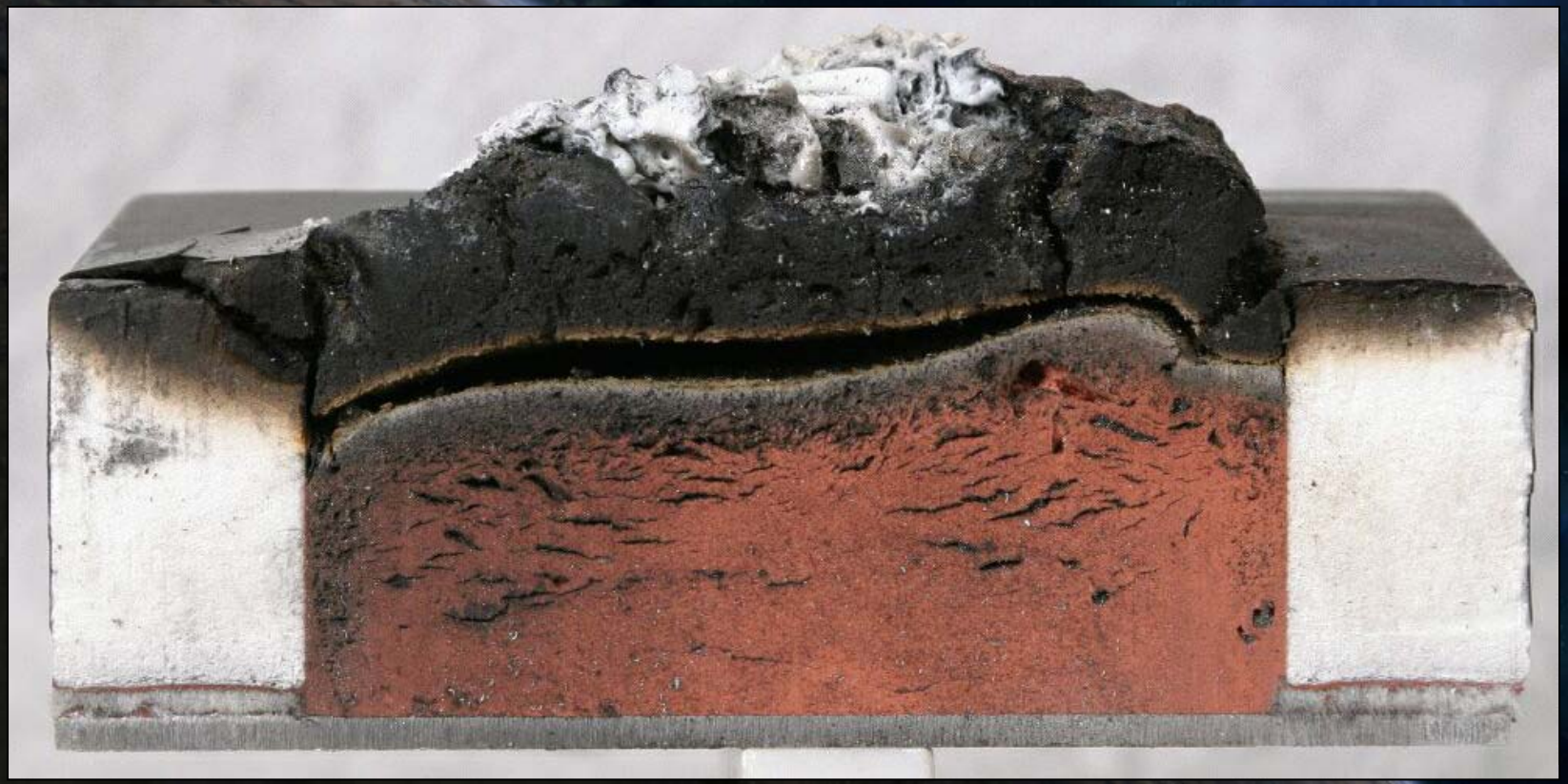
Arc Jet Testing



Char Layer



Human Thermal Vacuum Testing

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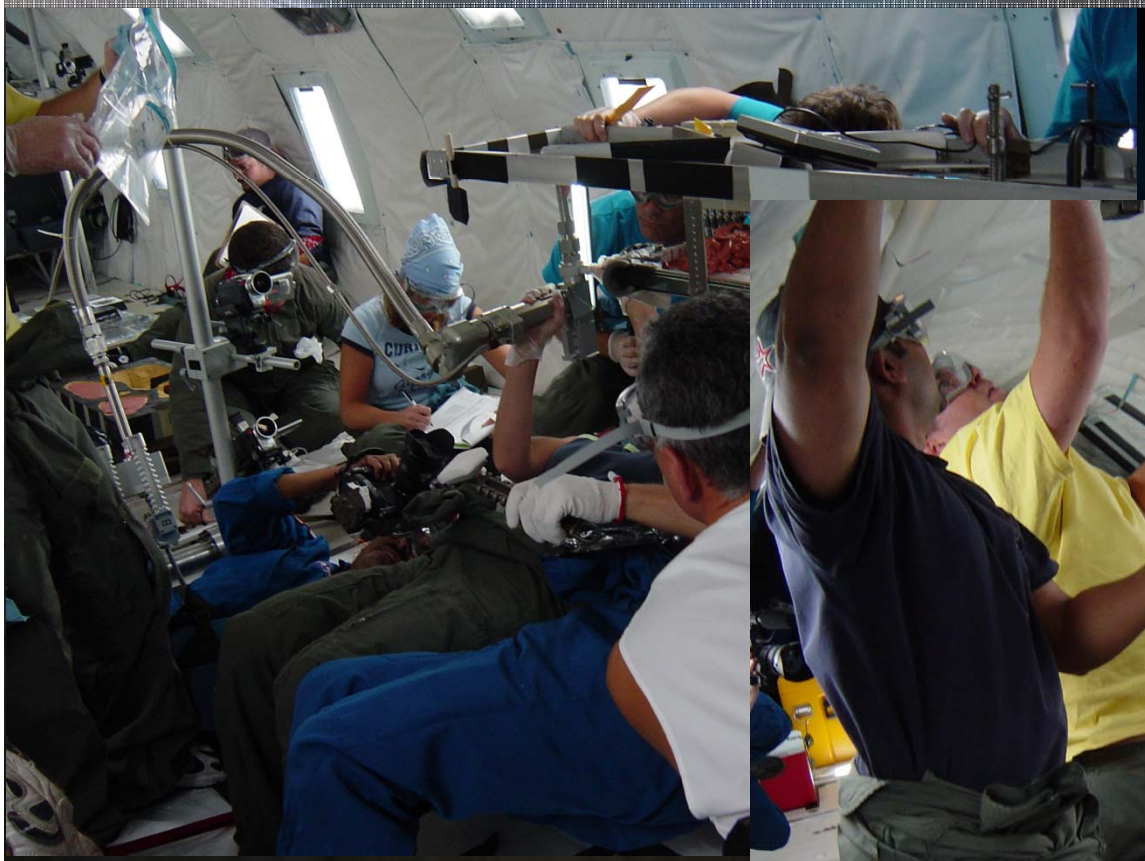
Thousands of Parabolas



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0-G Adherence and Technique Testing

UNITED STATES
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MISC-794-433
-042 M43342
MISC-794-433
-025 M43325
MISC-794-432-001
M43201
MISC-794-433
-033 M43333
MISC-794-432-005
M43205
3M
3M
TPST-041

Suited KC-135 Parabolic Tests

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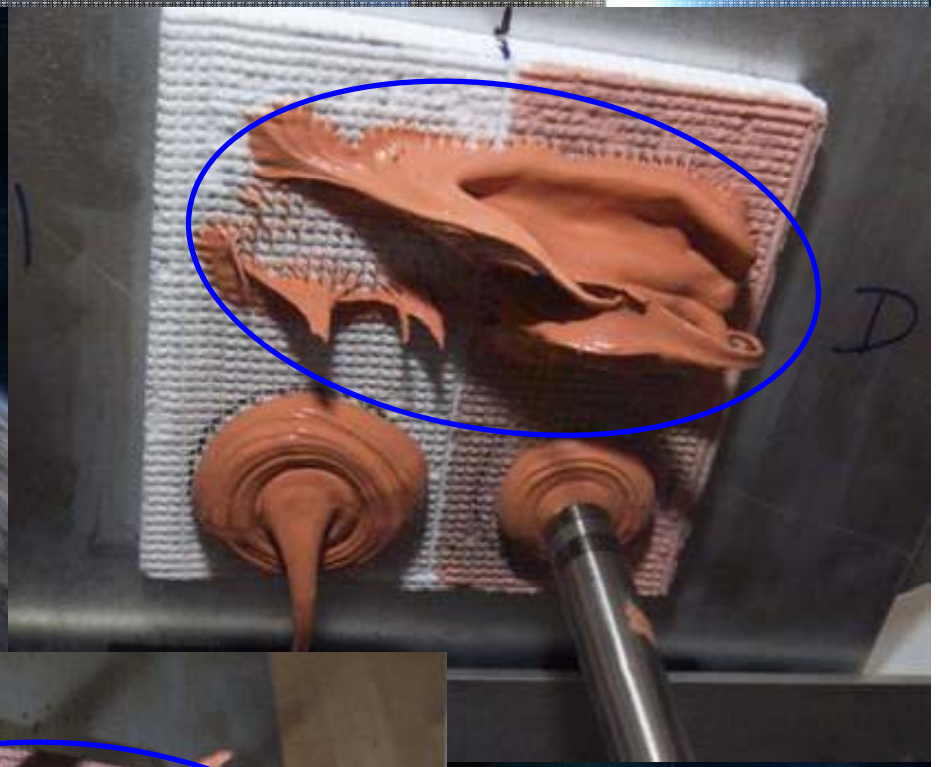
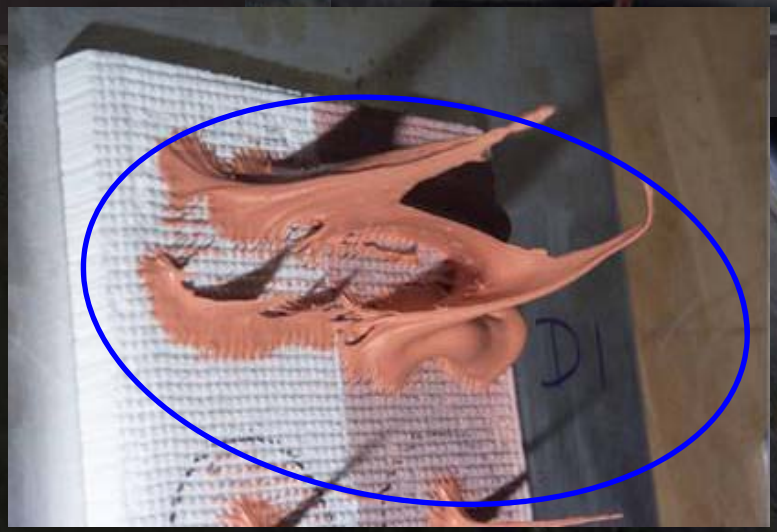
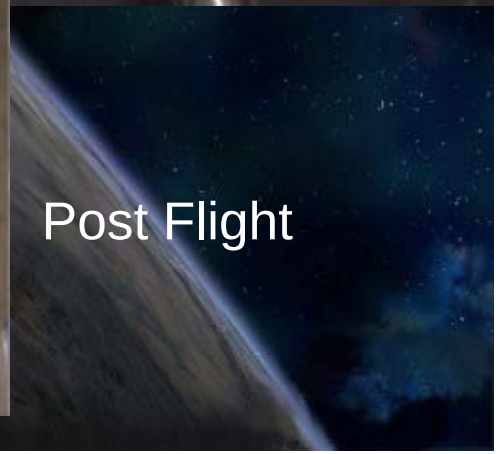
Tamp and Dot Techniques



Marginal Adhesion
Flat, Raked Tile





Post Flight

Another Day @ The Office

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Dual Glovebox Thermal Vacuum

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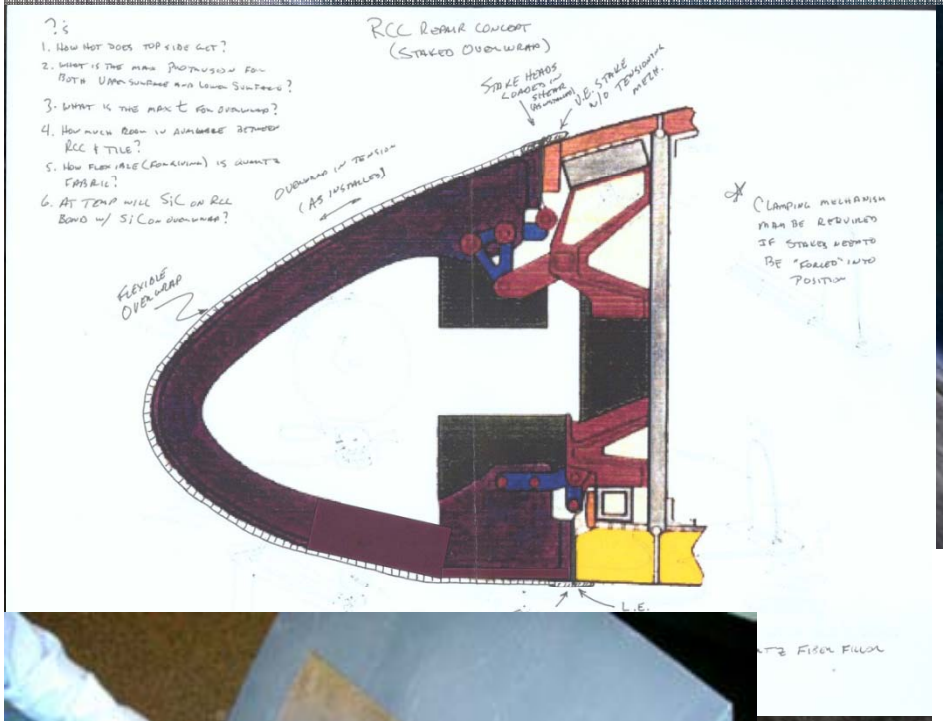
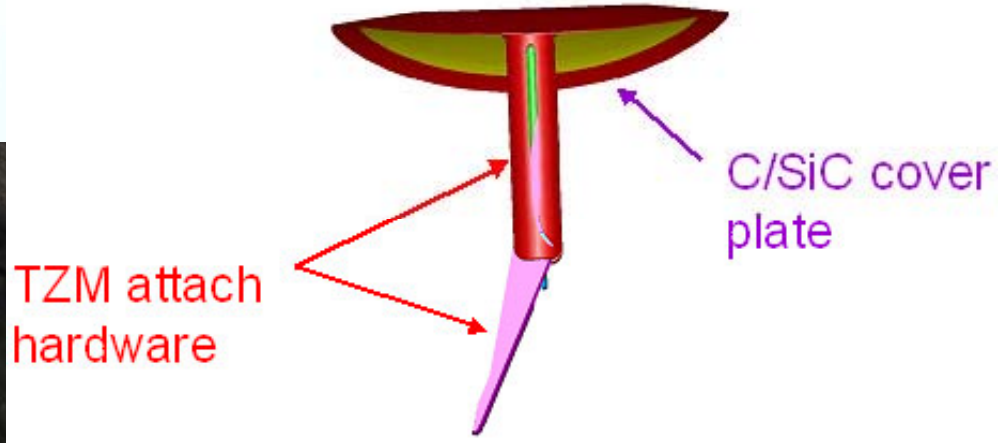
RCC Repair Strategies



- Fillers/Caulks
- Plugs
- Balloons
- Overwraps



EVA Inspection Techniques

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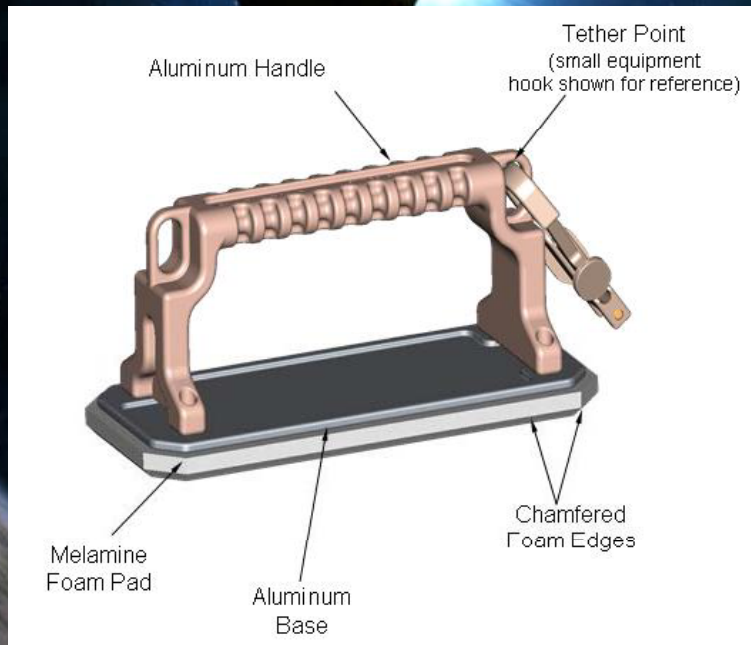
Dozens of Tools Designed, Tested

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



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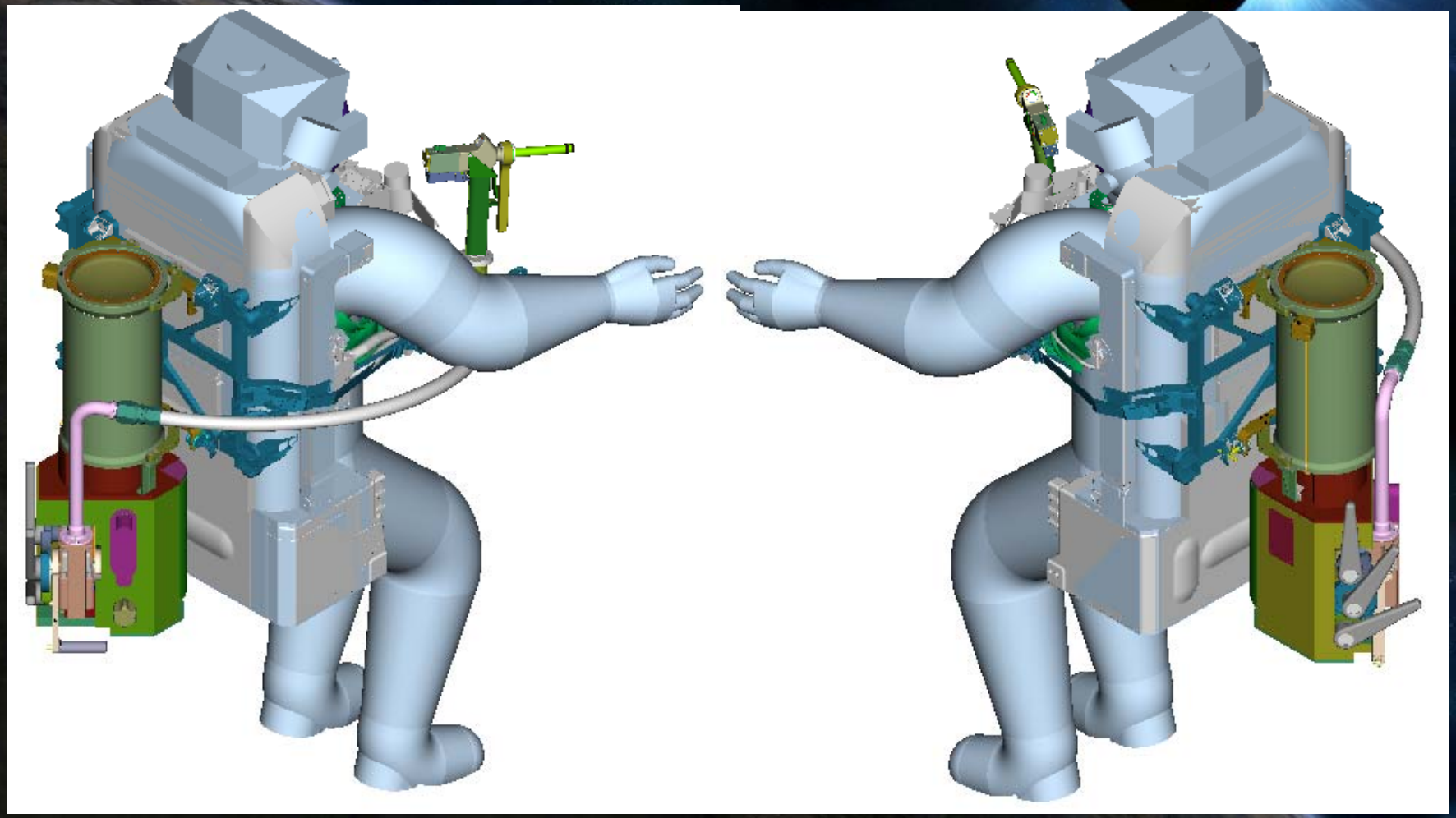
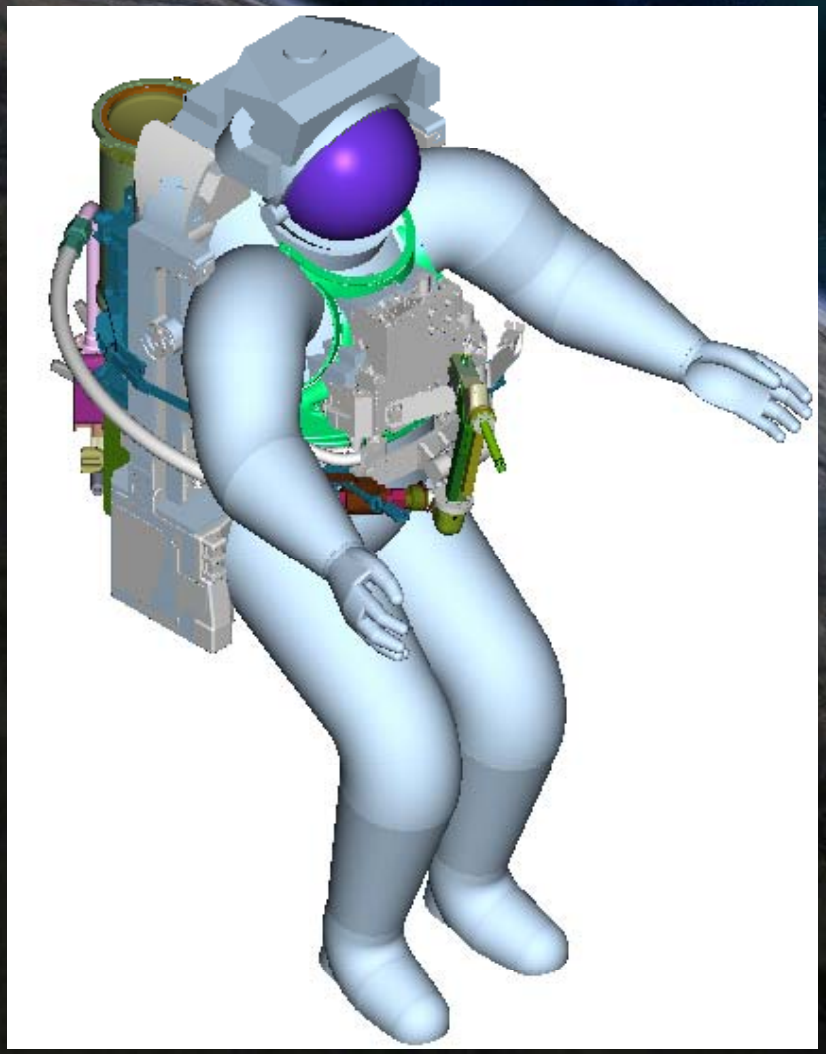
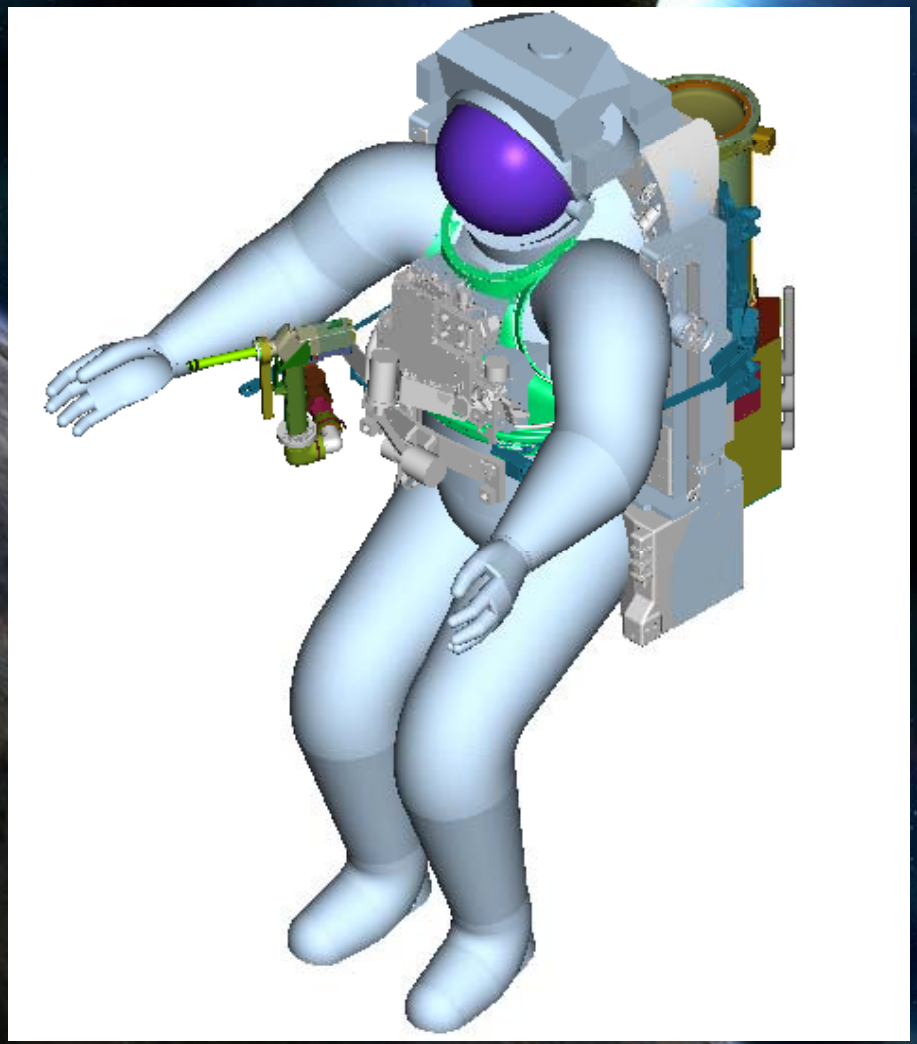
CIPAA Backside Views

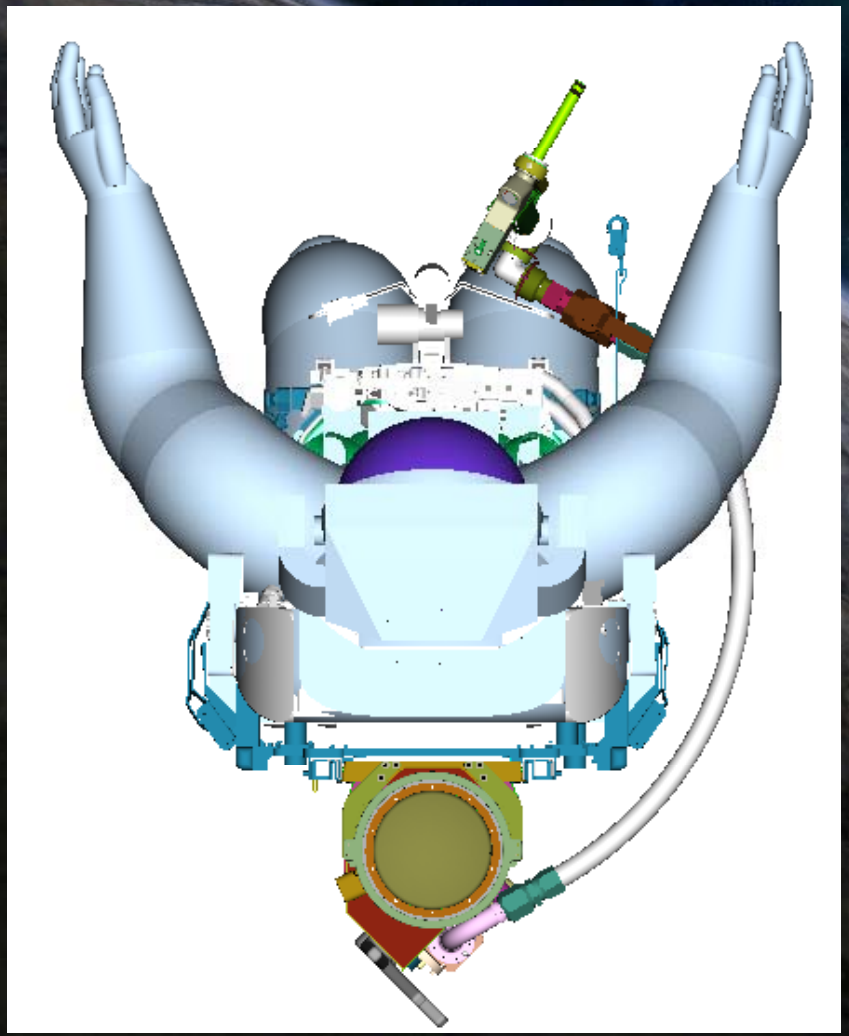


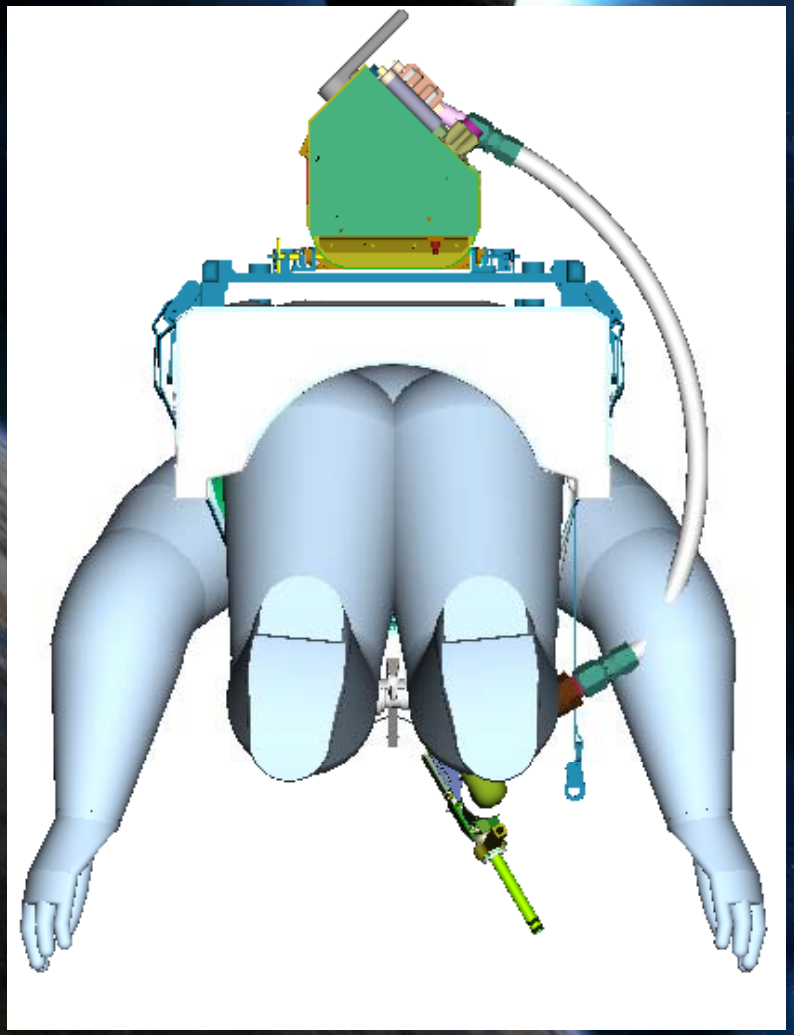
CIPAA Frontside Views



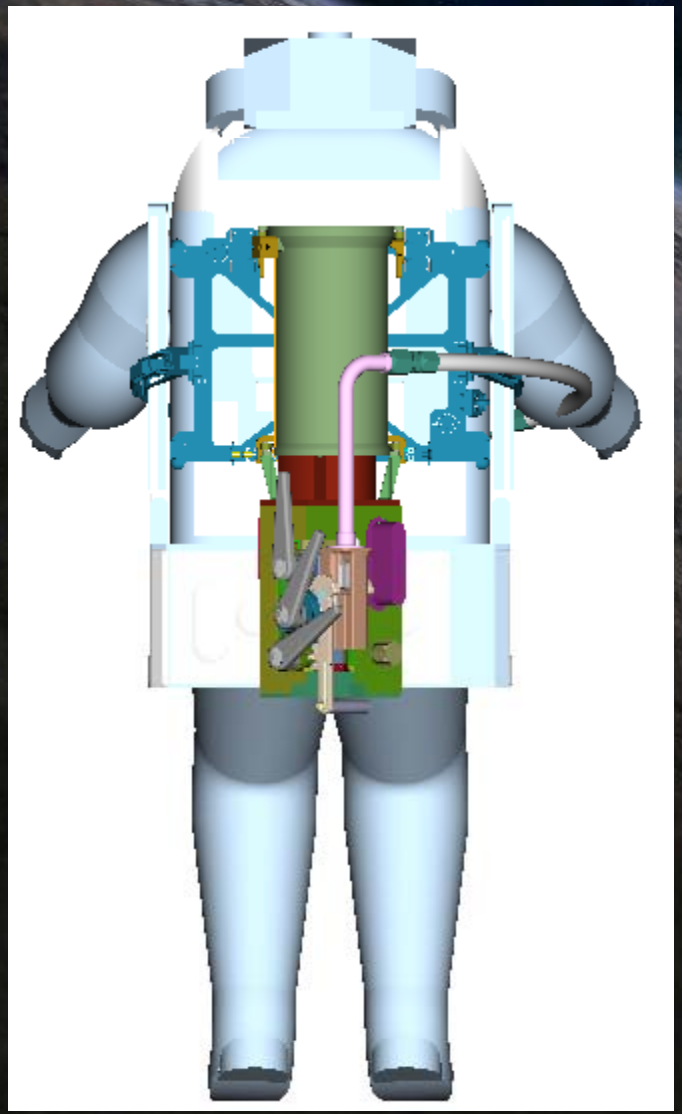


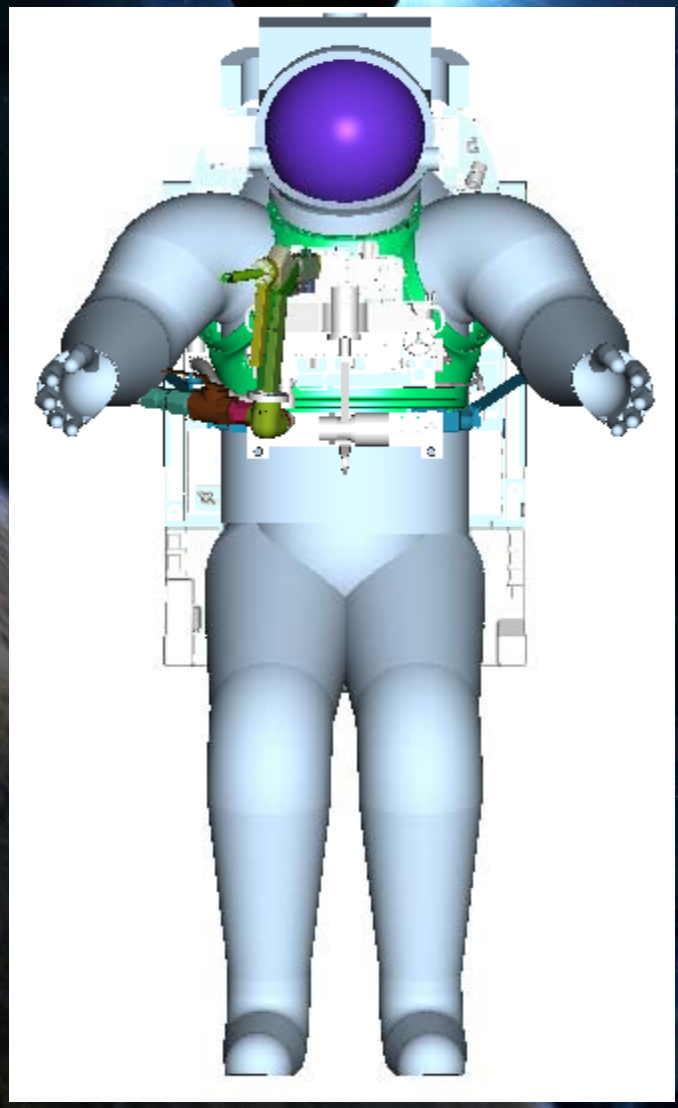
CIPAA Top/Bottom Views





CIPPA Front/Back Views





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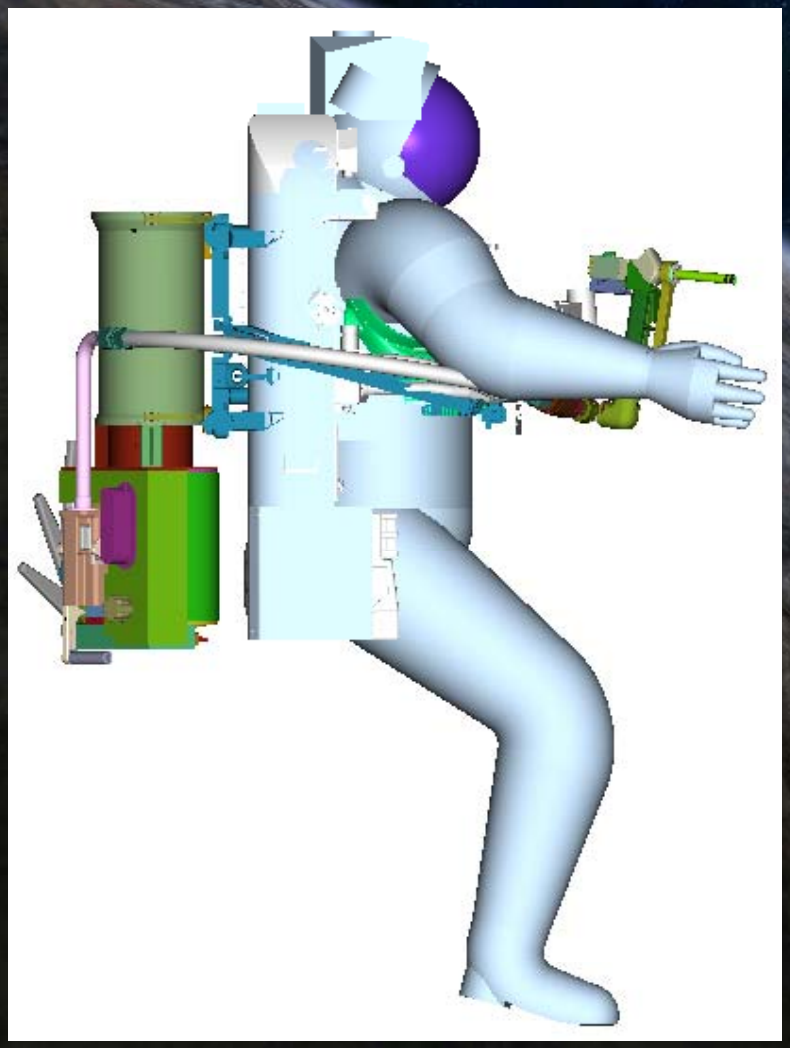
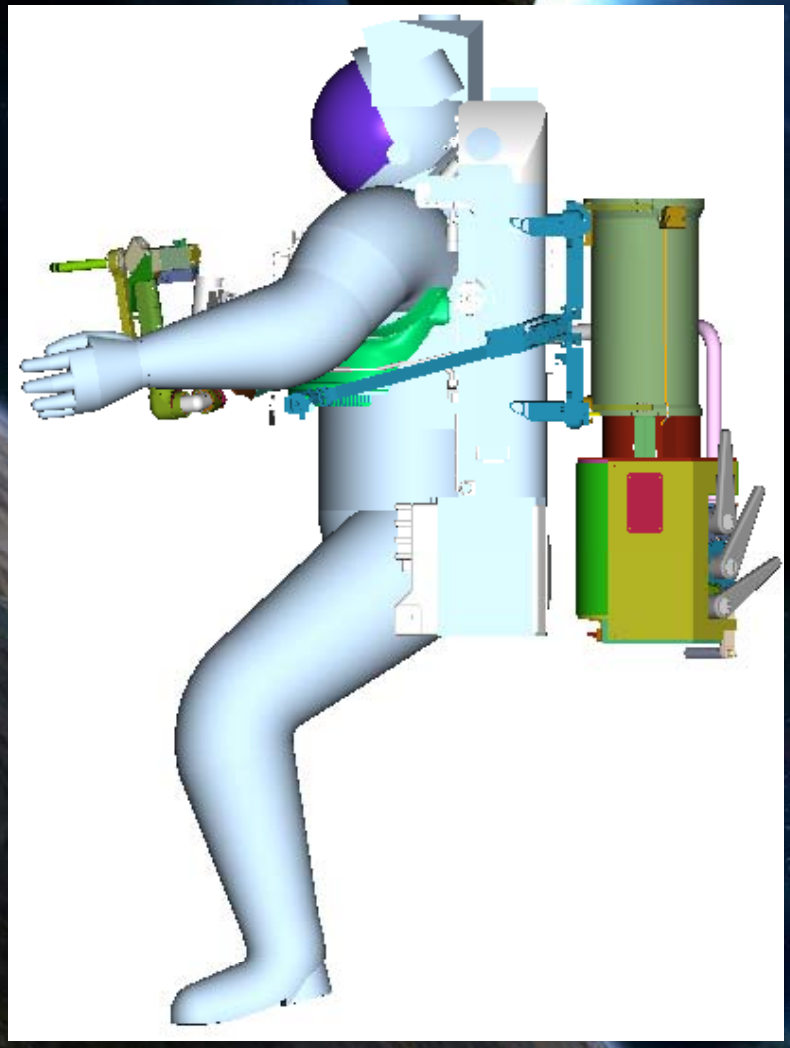
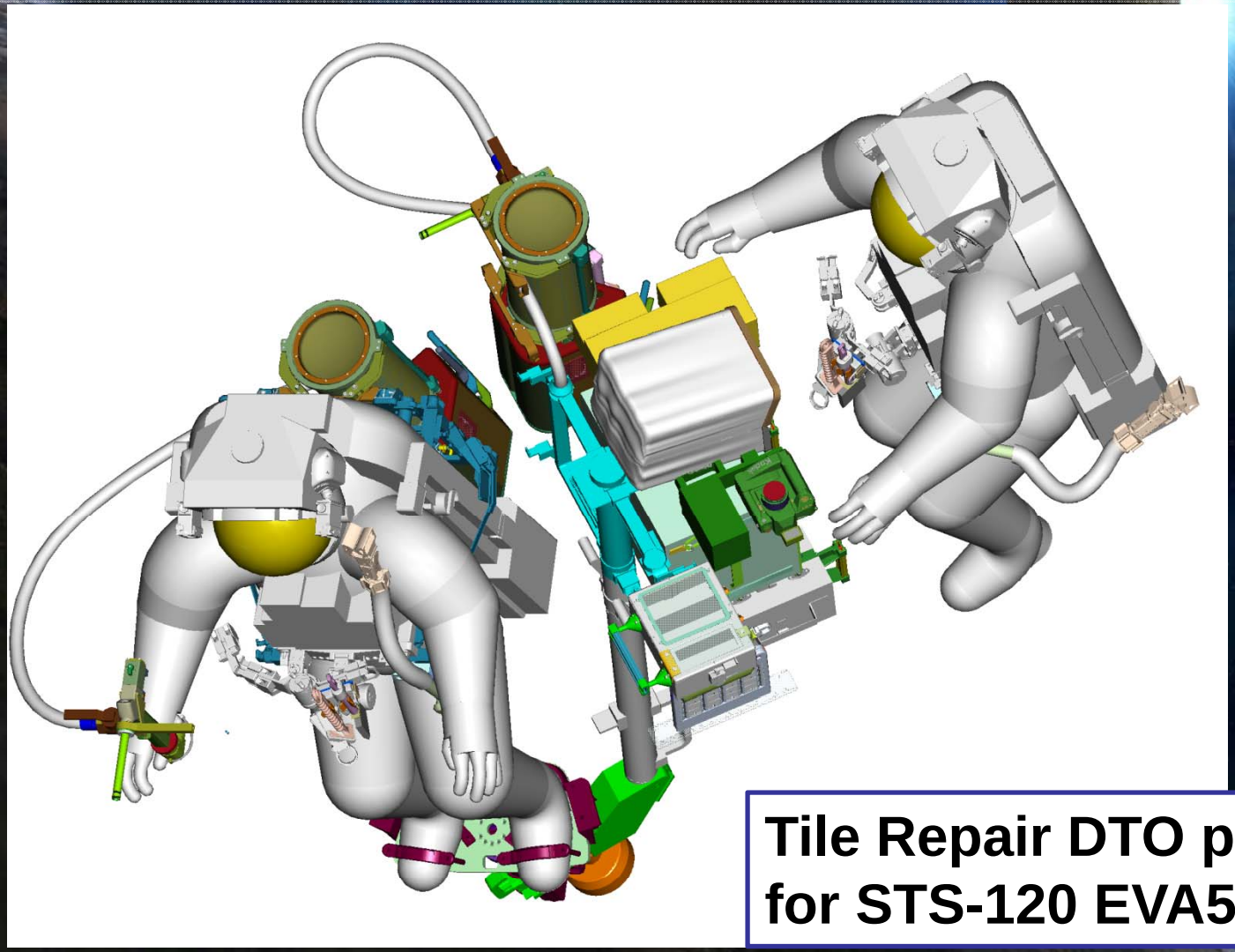
CIPAA Left/Right Views





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

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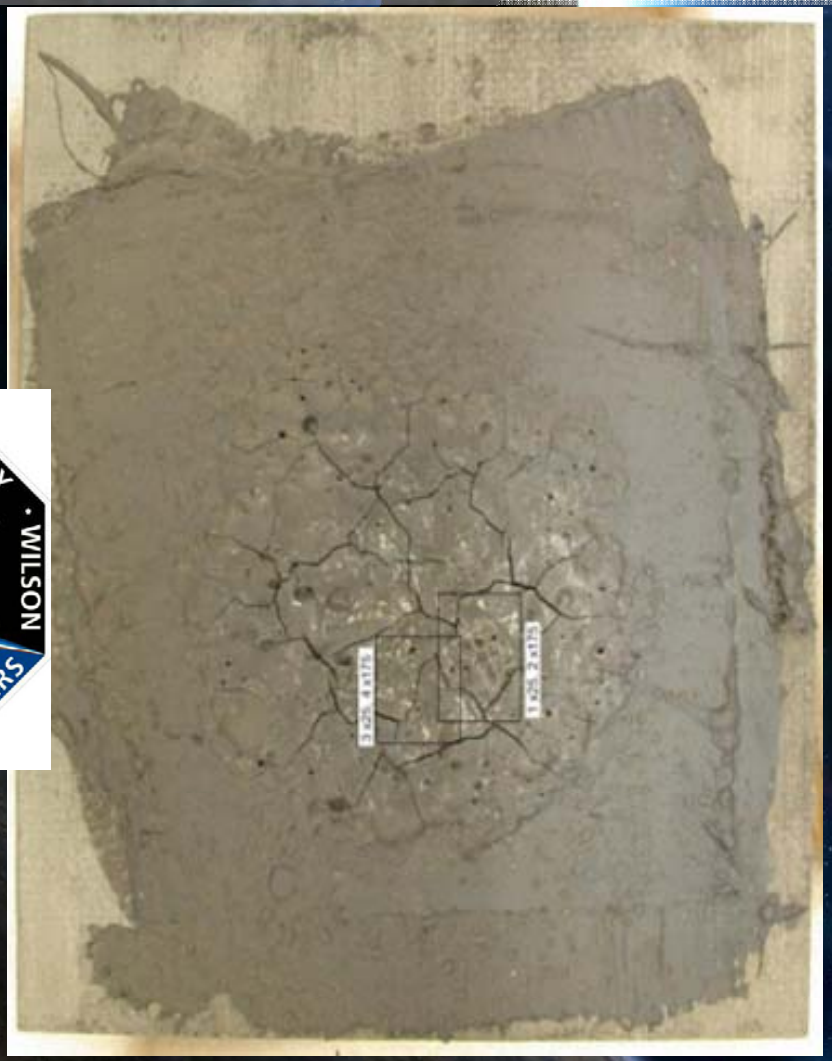
STS-121 RCC Repair DTO (NOAX ceramic): Mike Fossum & Piers Sellers



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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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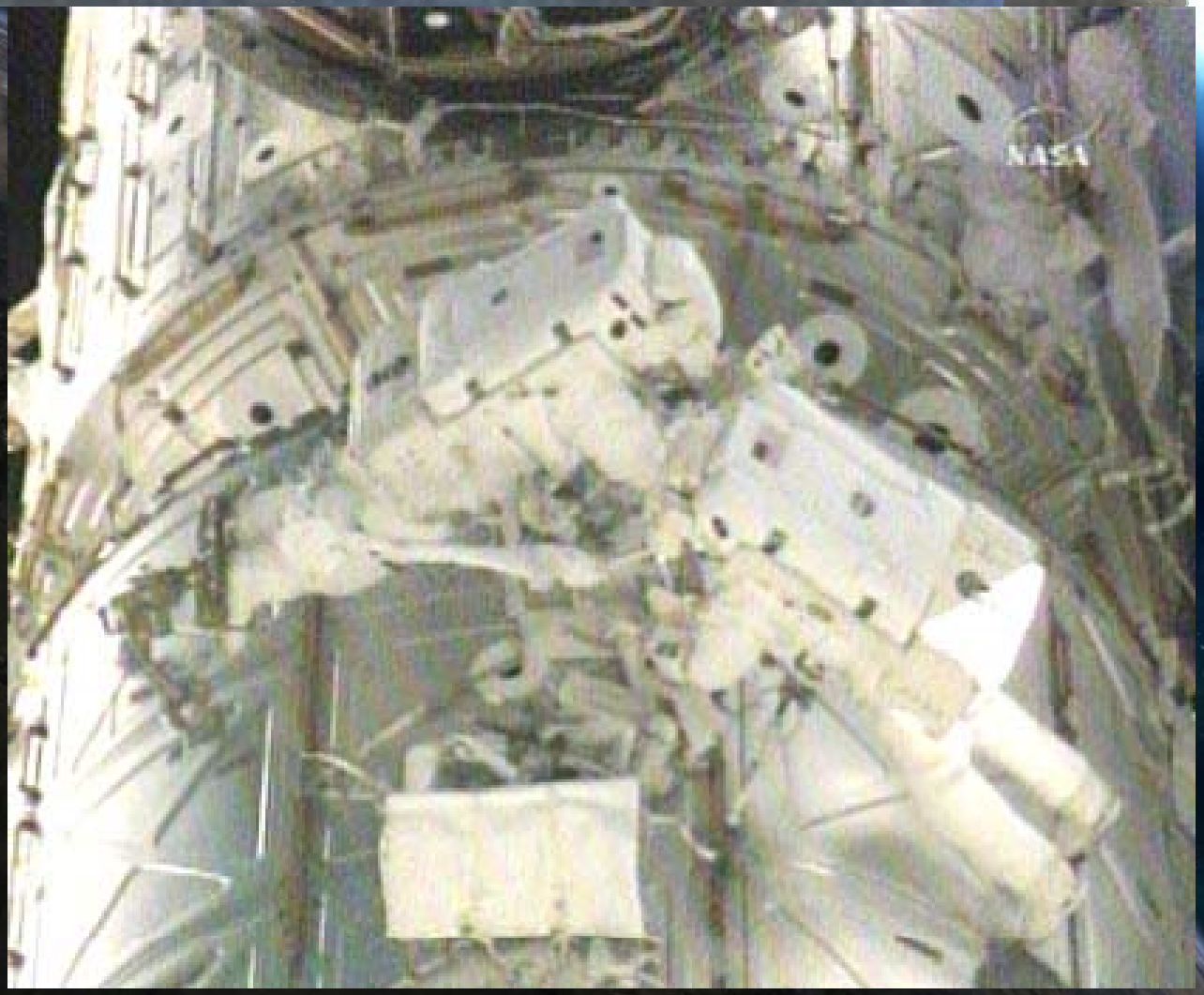
STS-123 Tile Repair Ablator Dispenser (TRAD)
DTO: Mike Foreman & Bob Behnken



QUESTIONS/DISCUSSION

Contact Info:
Twitter: twitter.com/#!/SPOTScott

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