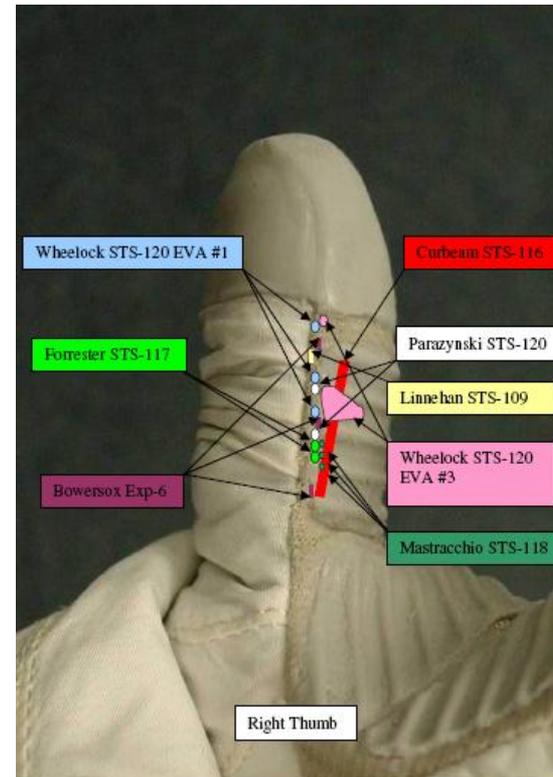
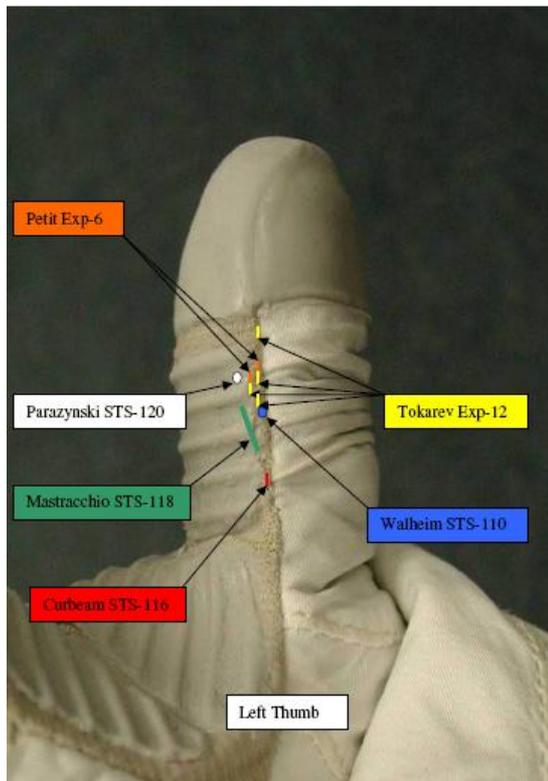


# STS-124 Glove TMG Protective Patches



# Background

- Since STS-116 there have been several instances of glove TMG damage while EVA
  - Subsequent to STS-116 all available flight gloves were inspected for damage





# Background

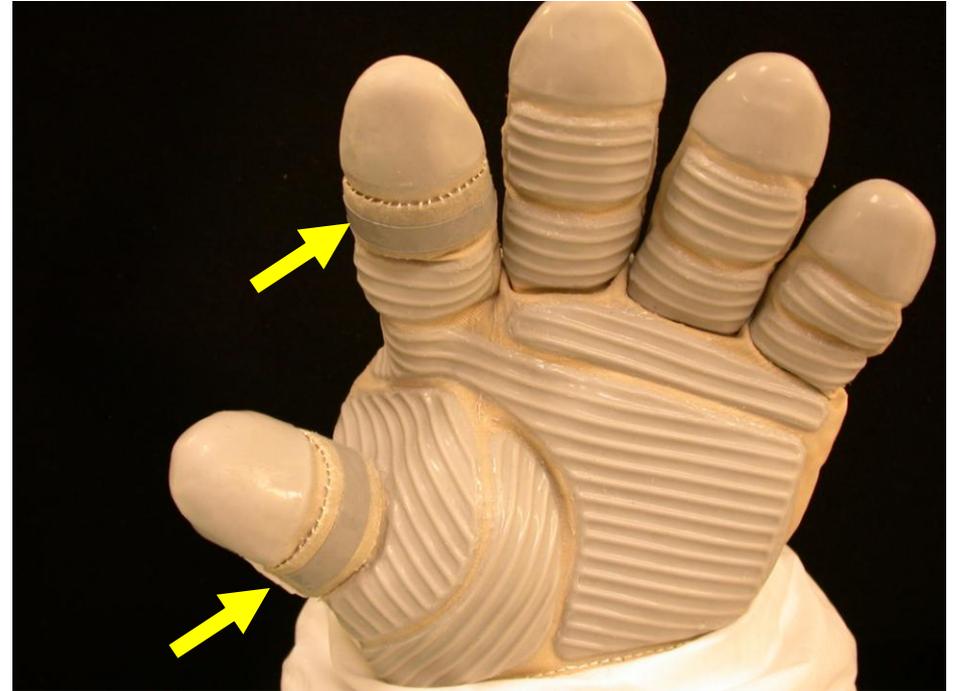
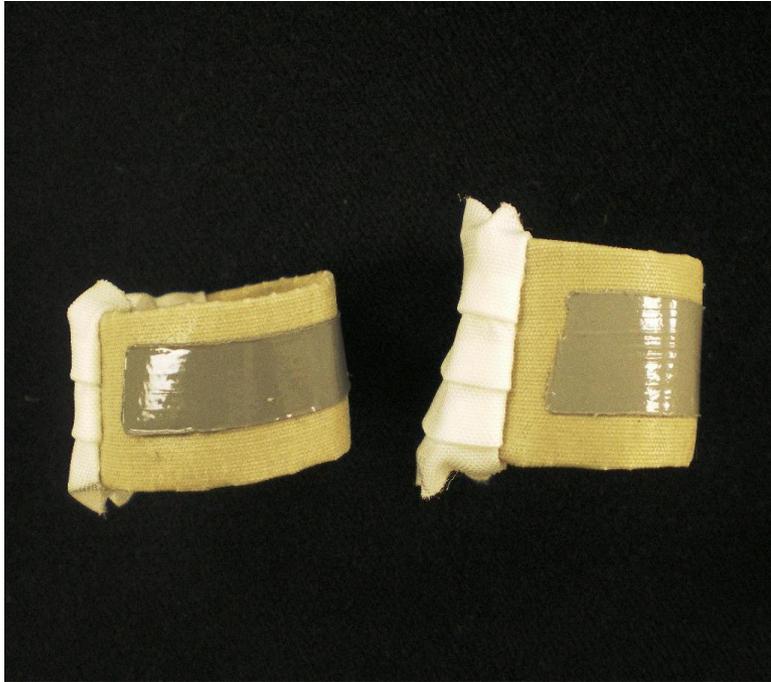
- In order to mitigate the risk, the EVA community has implemented several different measures:
  - STS-120/10A, Overglove first flight; Glove inspections
  - STS-122/1E, Implemented RTV loss criteria, Redesigned Overglove
    - Reduced excess material in the thumb and index finger
    - Implemented a second smaller size Overglove
  - STS-124/1J, Glove TMG protective patches first flight



# STS-124 Glove TMG Protective Patches

- The Turtleskin® patch was developed as an alternative to the Overglove
  - Designed to harden the glove against sharp edge exposure
- Turtleskin® is a tightly woven Vectran that has a significantly higher cut and puncture resistance than the knit Vectran currently used in the glove palm
- The Turtleskin® patch is a field retrofittable modification that is sewn over the existing RTV pad
- Individual patches will be installed on the prime gloves in the areas of concern (i.e. the thumb and index finger)

# Glove TMG Protective Patches



- The patch consists of TurtleSkin® fabric wash-coated with RTV 3145, a Teflon pleated back, and an additional strip of RTV 3145
  - Two to four times more cut resistant than the Phase VI glove knit Vectran
  - Higher puncture resistance than the Phase VI glove knit Vectran



# Turtleskin® Material Testing

Cut Test Comparison		
Blade radius	Material	
	<i>Current Vectran</i>	<i>Turtle Skin (100% Vectran)</i>
<0.0005" (Box cutter)	0.4 lbs.	1.0 lbs.
0.0010"	9.0 lbs.	30.0 lbs.
0.0075" (ISS req. 0.01")	15.0 lbs.	>60 lbs.

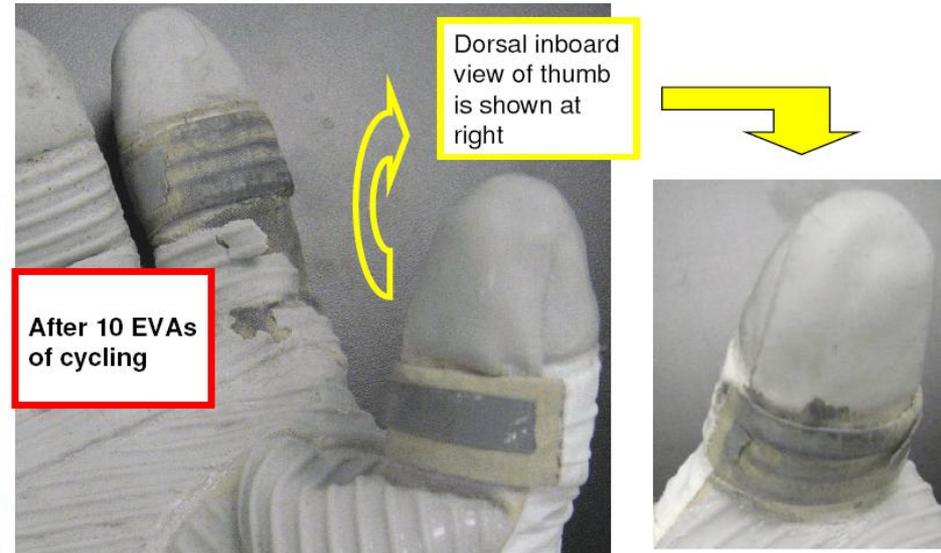
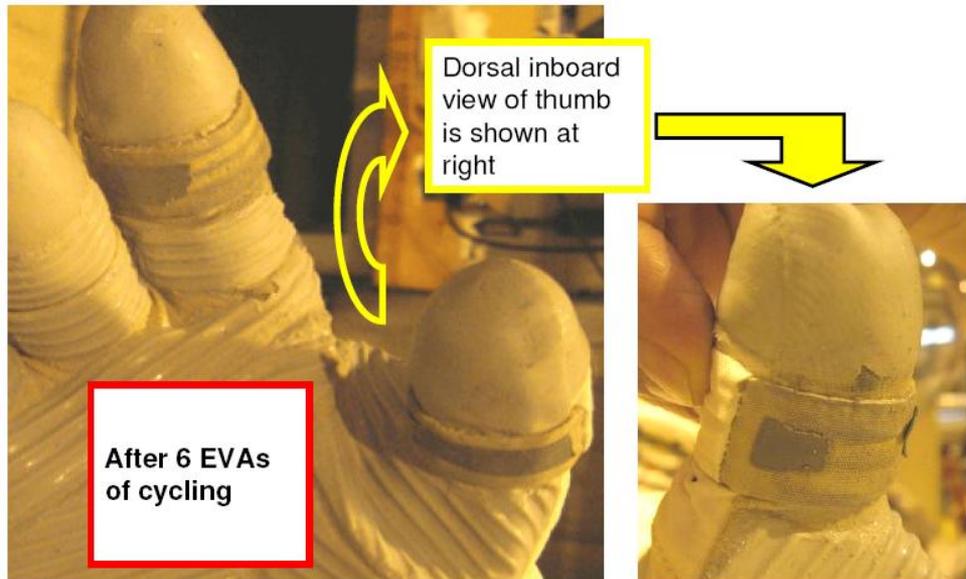
Puncture Test Comparison		
Puncture probe diameter	Material	
	<i>Current Vectran</i>	<i>Turtle Skin (100% Vectran)</i>
0.085" (Ball point pen)	No resistance	58.3 lbs.



# Confidence Cycling Evaluation

- A pair of flight configuration patched glove TMGs were subjected to ten simulated EVAs at ILC Dover
- RTV loss occurred as expected, but overall glove TMG integrity remained intact
  - RTV loss is a known condition and occurs mainly due to the forces involved in hand contact with various surfaces
- Throughout the cycling tests, patches remained in place as stitched, with no damage to attachment stitches
- TurtleSkin® endured the tests with no damage and exhibited remarkable tenacity as expected

# Confidence Cycling Results





# STS-124 Crew Patch Experience

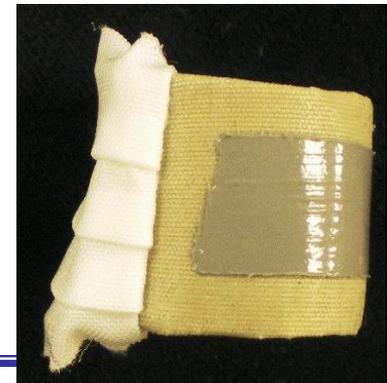
- Glove box evaluations conducted to gain crew concurrence prior to retrofitting STS-124 and Increment 17 crewmembers training gloves with initial patch design
- NBL evaluations concluded that the design was acceptable for flight with the addition of some minor modifications:
  - Crew and engineering requested the addition of a thin RTV strip to the top of the patch to increase grip.
  - Crew also requested that the patch be made slightly smaller in order to decrease contact between the patch and the lower RTV pad.
- Successful glove box evaluations were conducted to evaluate the modifications
- Crew and engineering comments were incorporated into the final design



Initial Patch Design



Interim Patch Design



Flight Patch Design



# Evaluations with MMOD and Vectran

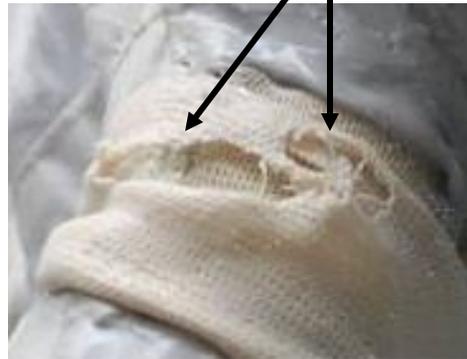
- Objective: Evaluate and compare damage created by simulated MMOD hits on handrails to knit Vectran and Turtleskin®
  - WSTF shot handrails with hypervelocity particles simulating on orbit impacts
  - Knit Vectran and Turtleskin® were exposed to the MMOD strikes in a pressurized suited event attempting to induce glove damage
- Phase VI Glove Knit Vectran (Molded Palm) Results:
  - Cuts were induced on Knit Vectran after a single exposure
    - Subject was not able to cut the Vectran with slow high force gripping motions
    - Subject cut Vectran using a quick sliding motion across the MMOD impact site while pushing into the handrail
- TurtleSkin® Patch Results:
  - Attempted to cut the TurtleSkin® using the same motion that cut the knit Vectran
    - One attempt broke off a large burr that caused a  $\frac{3}{4}$ " cut in the knit Vectran
    - No damage beyond surface abrasion and RTV loss (after 10 attempts on each glove)
  - Continued to cycle the same area of the TurtleSkin® against MMOD hits
    - The left thumb patch showed only abrasion damage and RTV loss after 50 cycles
    - After 50 cycles an abrasion hole was created on the right thumb patch
      - Cycling as tested is more abusive than nominal glove use on orbit

# Engineering MMOD Vectran Results

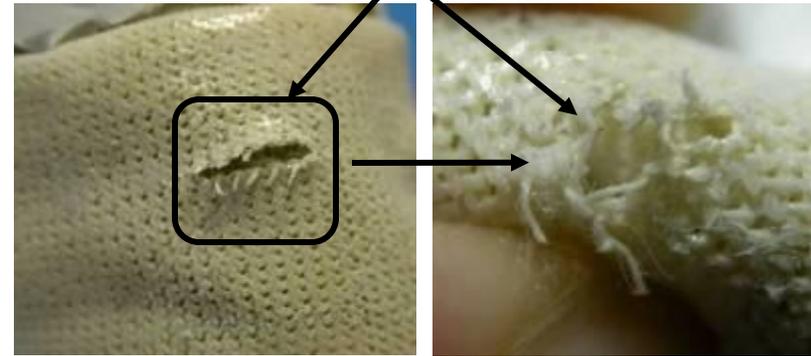
Simulated MMOD



Vectran Damage ~3/4"

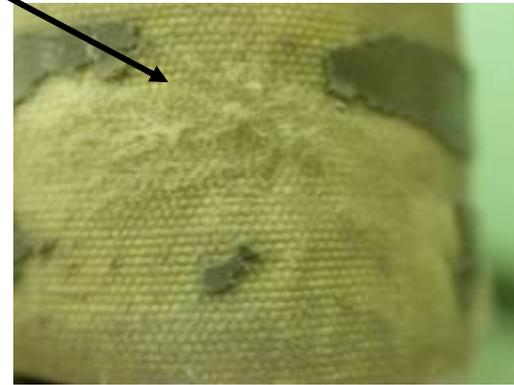


Vectran Damage ~1/4"

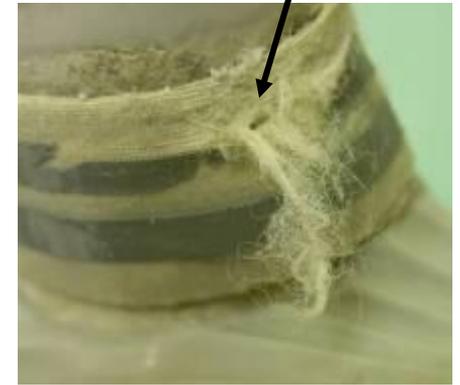


Phase VI Glove Vectran damage from simulated MMOD

Abrasion



Abrasion Hole ~1/8"



On orbit MMOD damage



TurtleSkin® Patch after cycling on simulated MMOD



# Glove Patches Summary

- Patch successfully evaluated during 5 NBL runs by STS-124 and Increment 17 crews
- Confidence cycling (10 EVAs) results indicate glove TMG integrity remains intact
- MMOD engineering evaluations indicate that the patch is significantly more robust than the original glove material
- STS-124 and Increment 17 prime gloves have been retrofitted with the Turtleskin® patch
  - Crewmembers have completed Class I glove fit checks and have accepted their patched prime gloves for EVA



# Supporting Material



# Glove Logistics

Flight	Crewmember	Patched Glove	Phase VI Glove & Overgloves	Redesigned TMG
STS-124	EV1 Fossum	Prime	Backup & 3rd option	N/A
	EV2 Garan	Prime	Backup & 3rd option	N/A
Increment 17	EV1 Chamitoff	Prime	Backup	N/A
	EV2 Kononenko	N/A	Prime & Backup	N/A
STS-125/HST	EV1 Grunsfeld	Prime & Backup	3rd option	N/A
	EV2 Feustel	Prime & Backup	3rd option	N/A
	EV3 Massimino	Prime	Backup	N/A
	EV4 Good	Prime	Backup	N/A
Increment 18	EV1 Fincke	Prime	Backup & 3rd option	N/A
	EV2 Sharipov	Prime	Backup & 3rd option	N/A
STS-126 Plan under review	EV1 Piper *3rd option TBD	Backup	N/A	Prime
	EV2 Bowen *3rd option TBD	Backup	N/A	Prime
	EV3 Kimbrough	N/A	Backup	Prime

# Background Examples



STS-120  
Overglove first flight



Increment 16  
On-orbit modification to Overglove



STS-122  
Redesigned Overglove



STS-124  
Glove TMG protective patches first flight