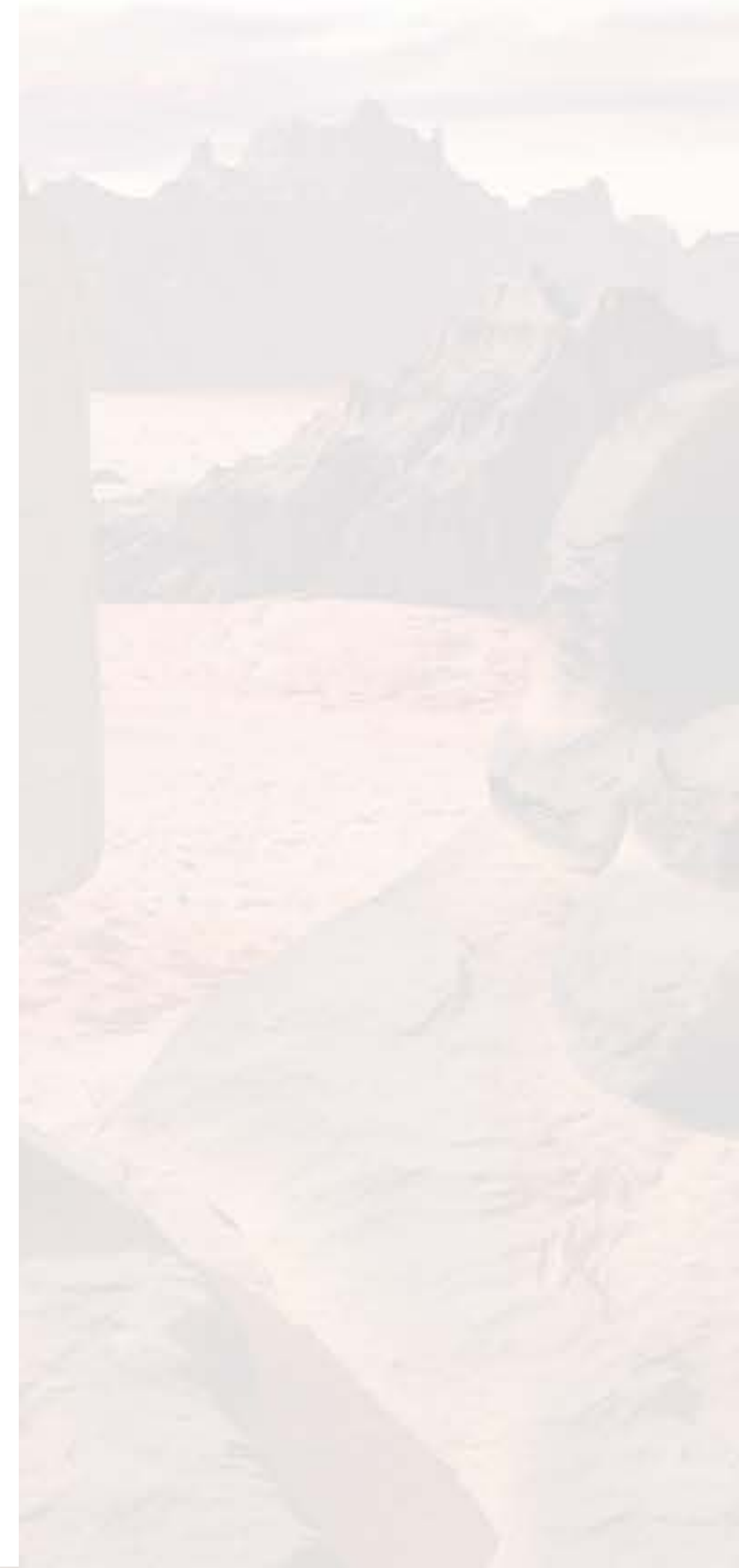
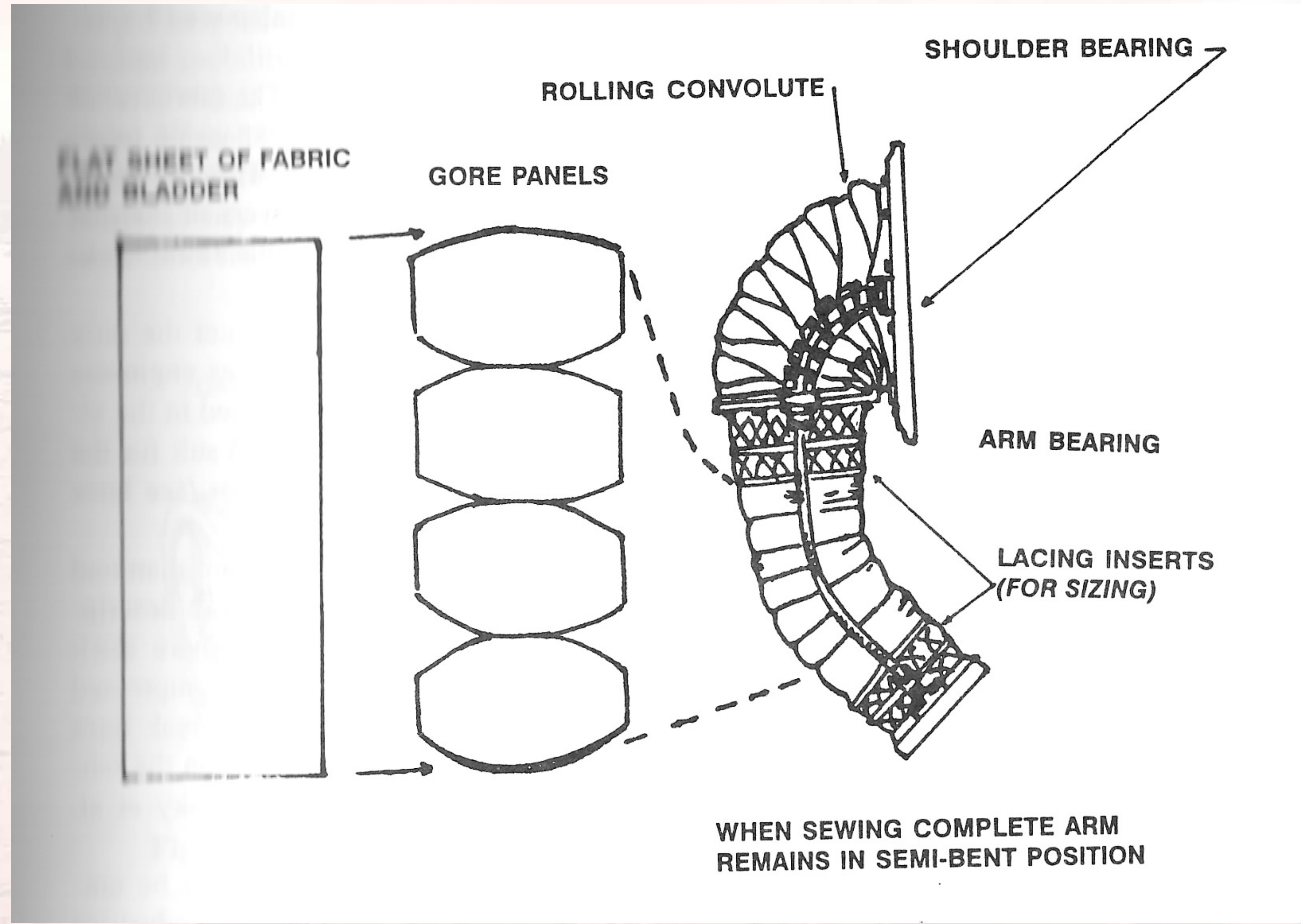


Extravehicular Activity 2

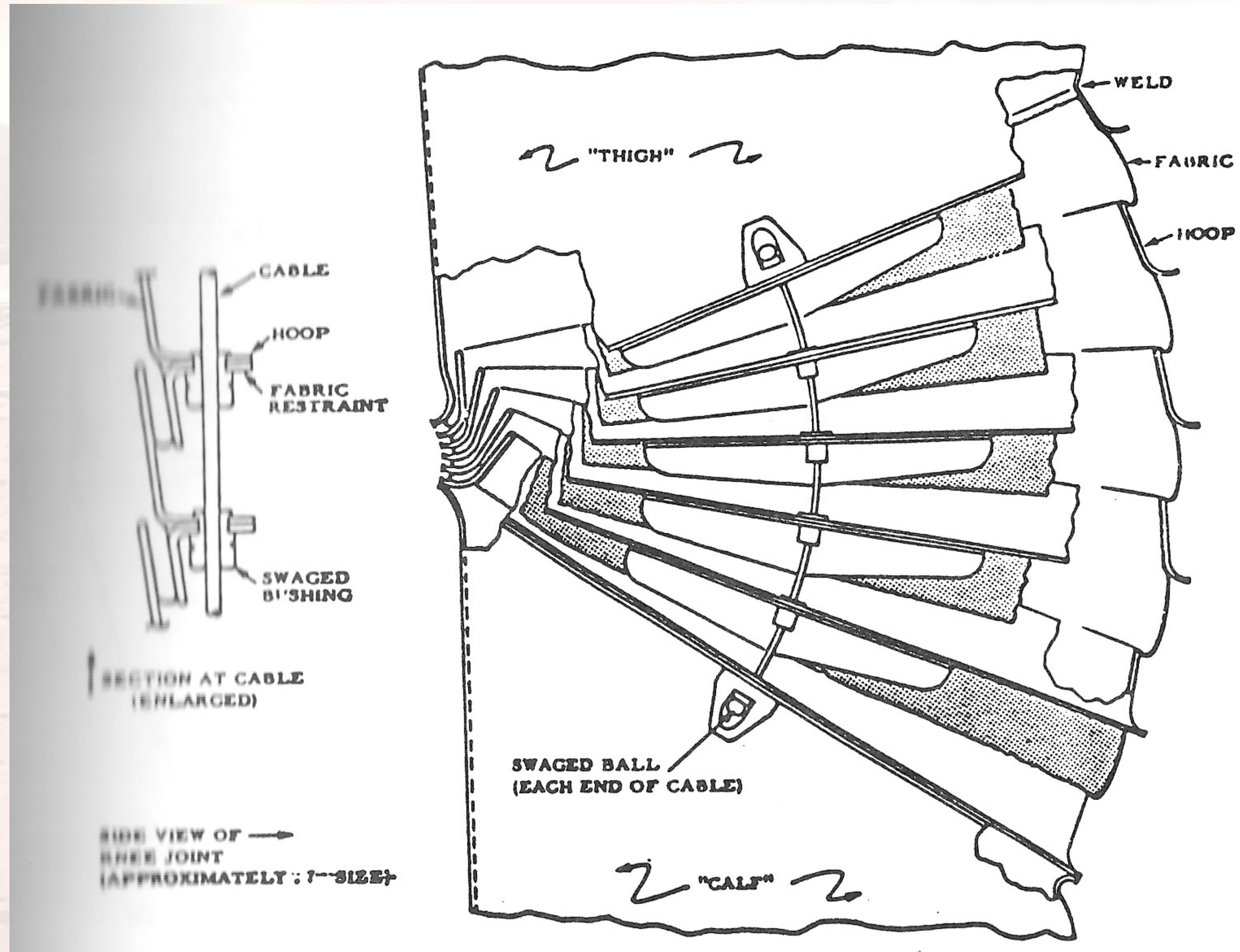
- Soft goods design approaches
- Hard suits
- AX-5/Mk. III competition overview
- Suit development post-ISS

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<http://spacecraft.ssl.umd.edu>

Flat Panel Joint



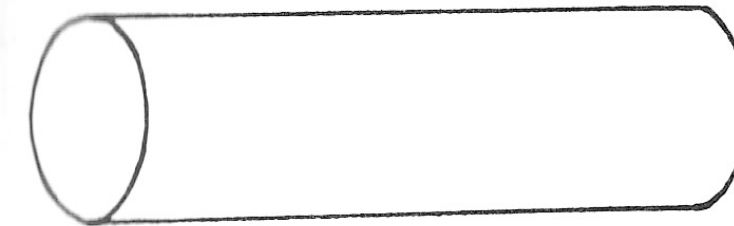
Rolling Convolute - Blade Joint



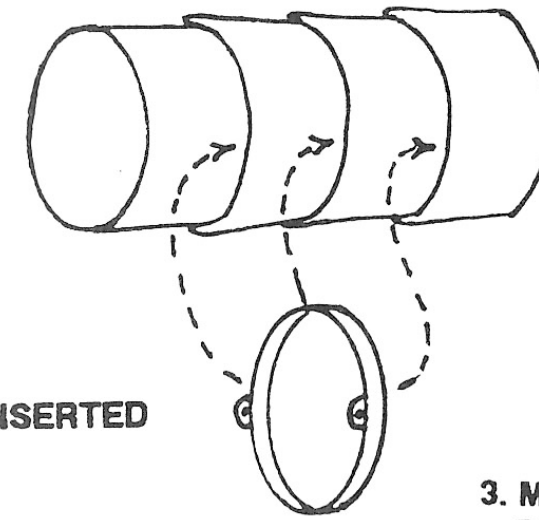
Rolling Convolute Arm

THE ROLLING CONVOLUTE IS CONFIGURED IN VARIOUS FORMS, THIS IS BUT ONE EXAMPLE THAT IS CLOSE TO THE ORIGINAL HANSEN JOINT (MINUS THE PIVOTAL FRAMEWORK).

1. CYLINDER OF SINGLE WALL LAMINATE (SWL) MATERIAL

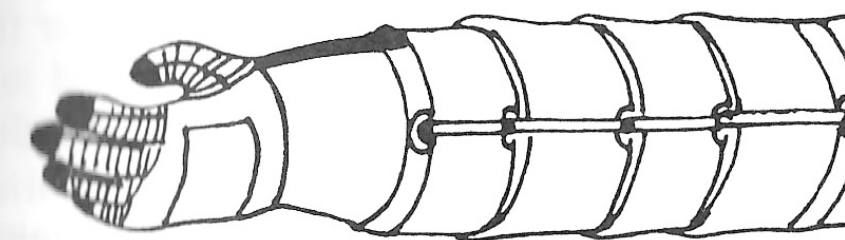


2. CYLINDER FORESHORTENED BY SERIES OF "TUCKS" OR FOLDS, TELESCOPE-LIKE

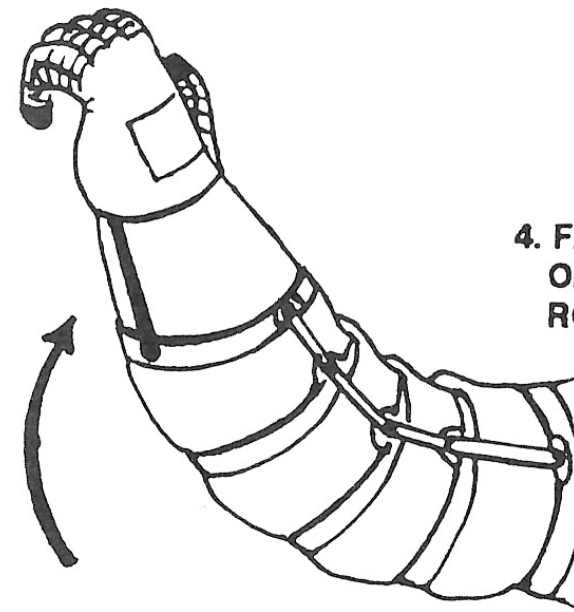


METAL BANDS INSERTED IN FOLDS

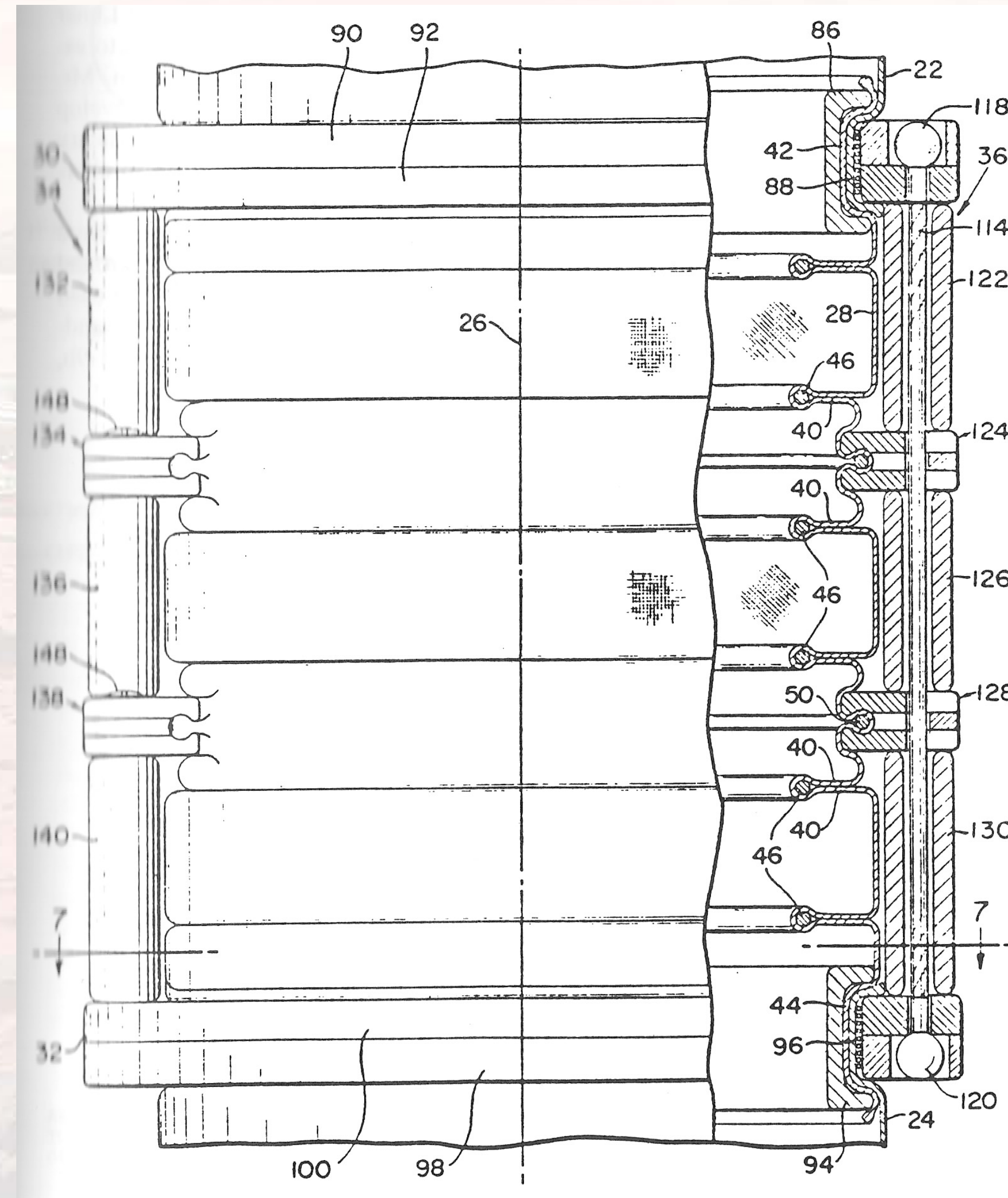
3. METAL BANDS CONNECTED BY LONGITUDINAL RESTRAINTS



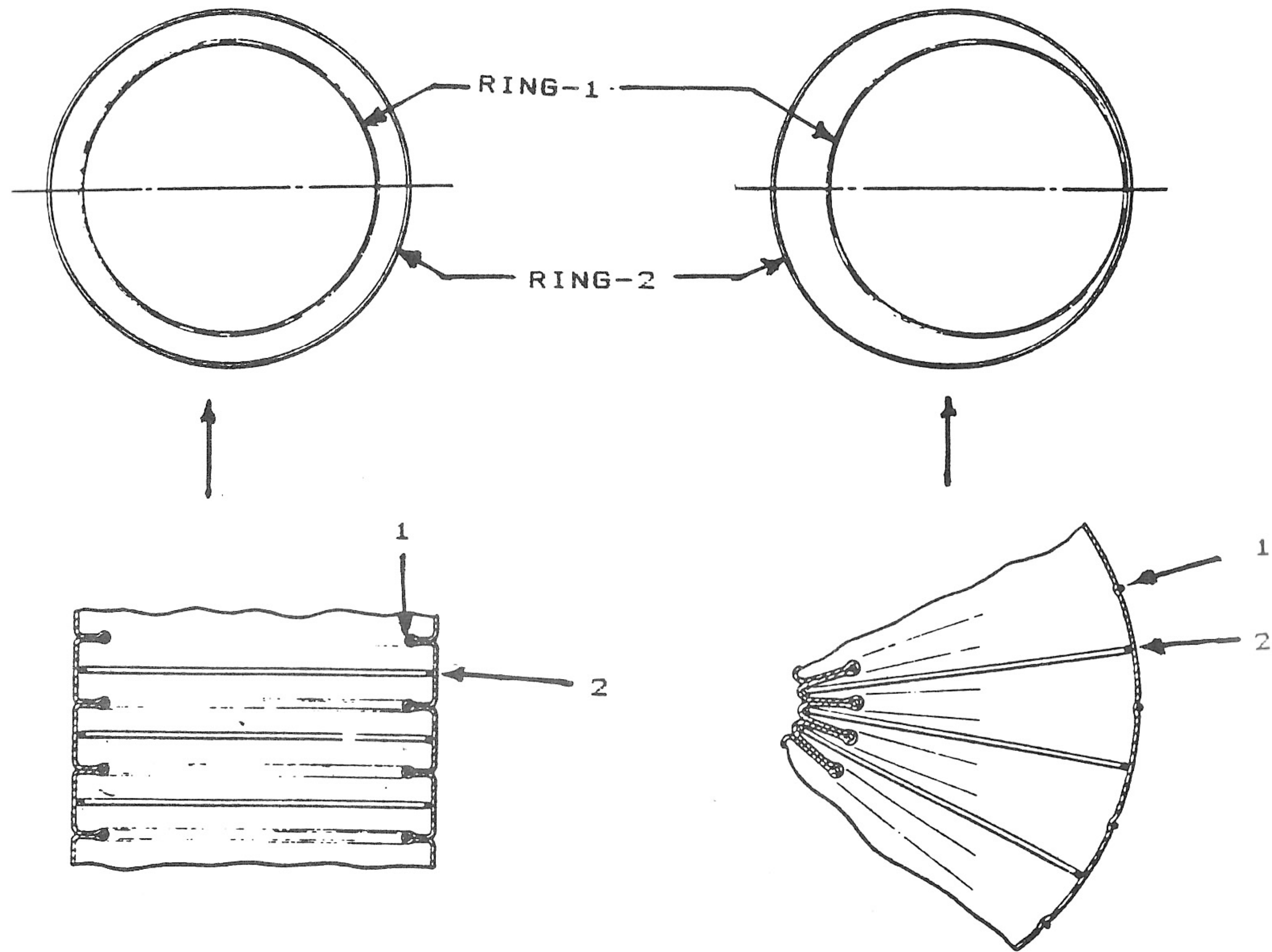
4. FABRIC ROLLS OVER BANDS ON FRONT OF JOINT, AND ROLLS OUT ON BACK OF JOINT



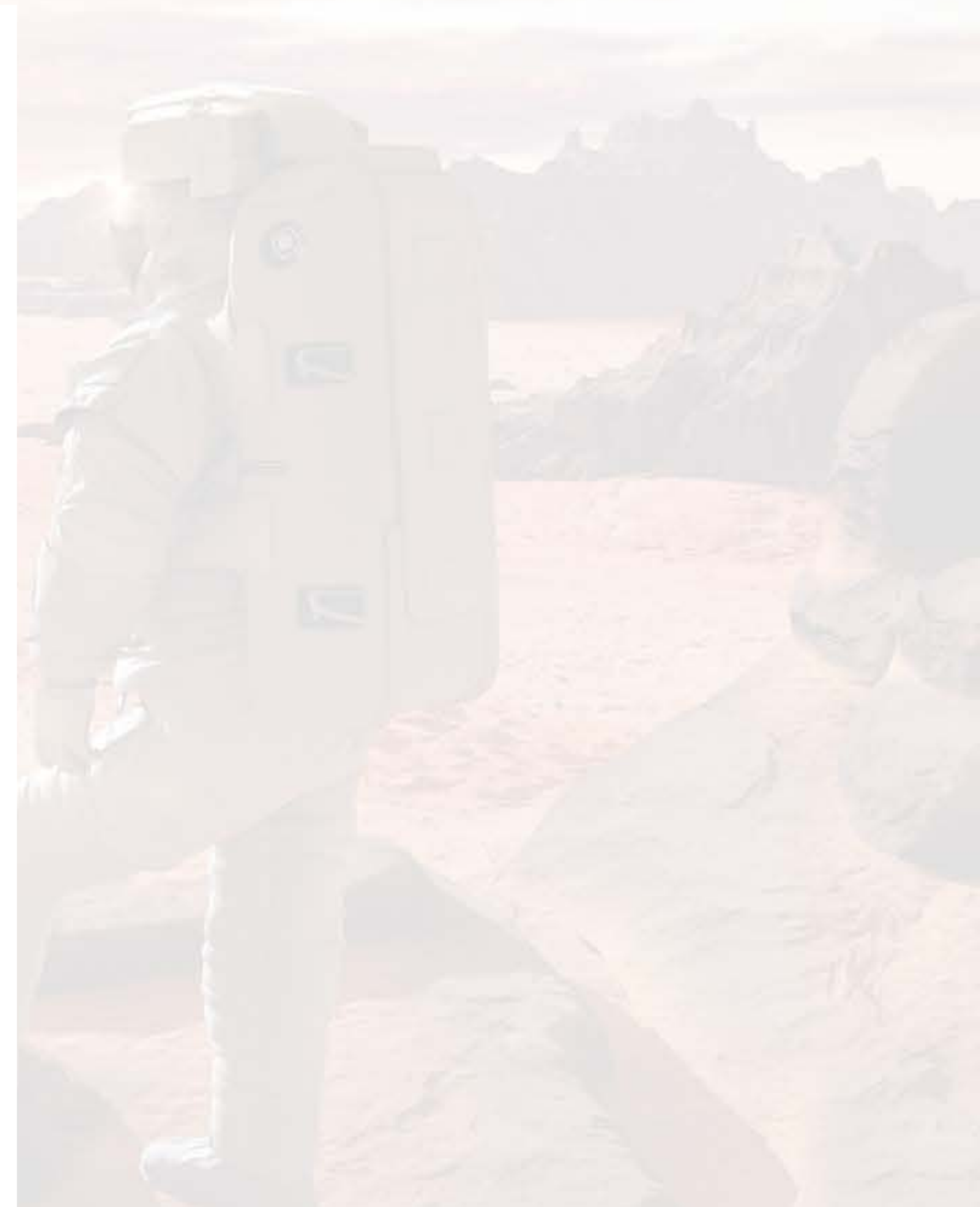
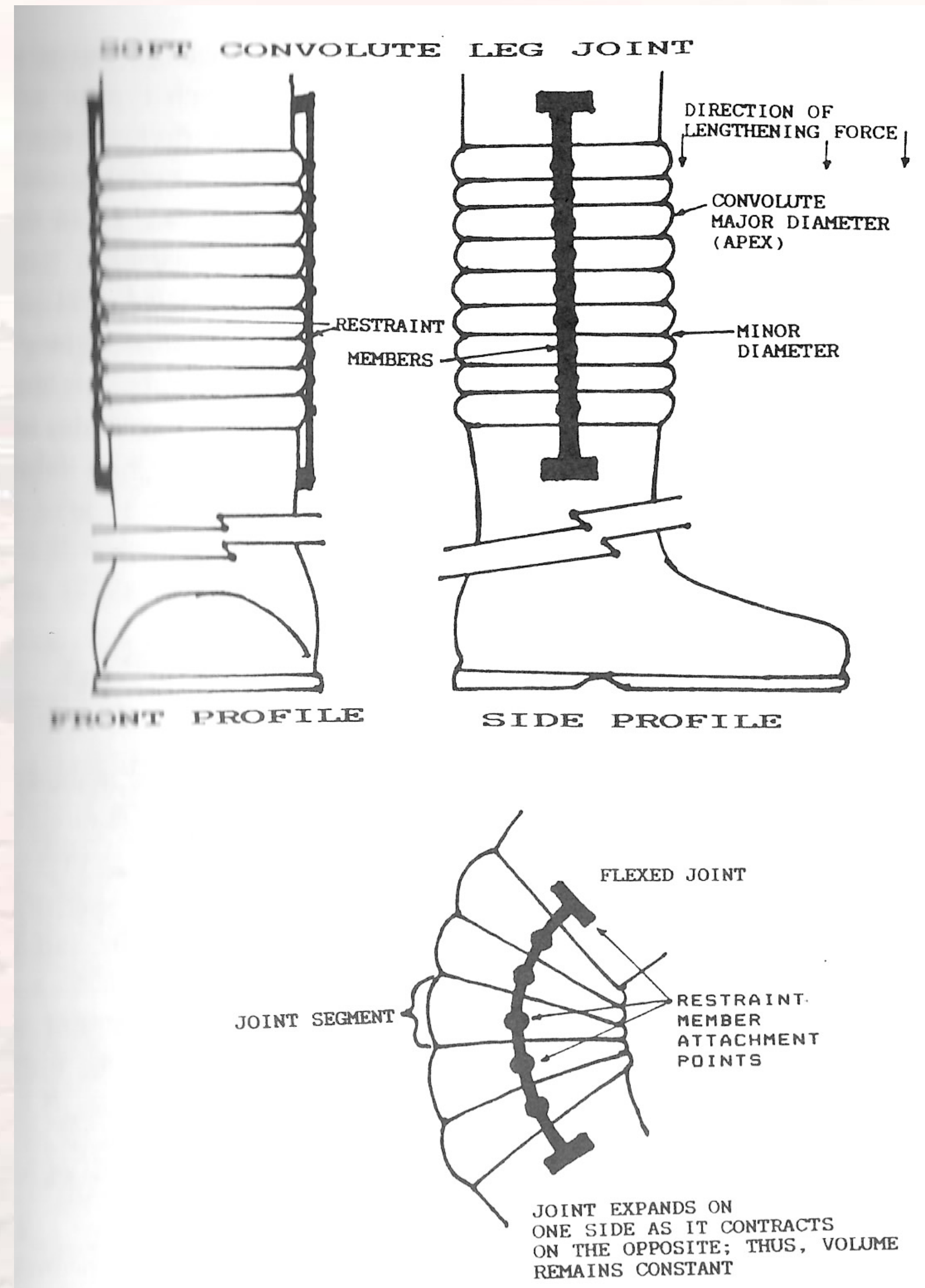
Toroidal Joint Construction



Toroidal Joint Actuation



Role of Neutral Axis Restraints



Soft Goods - Hardware Interfaces

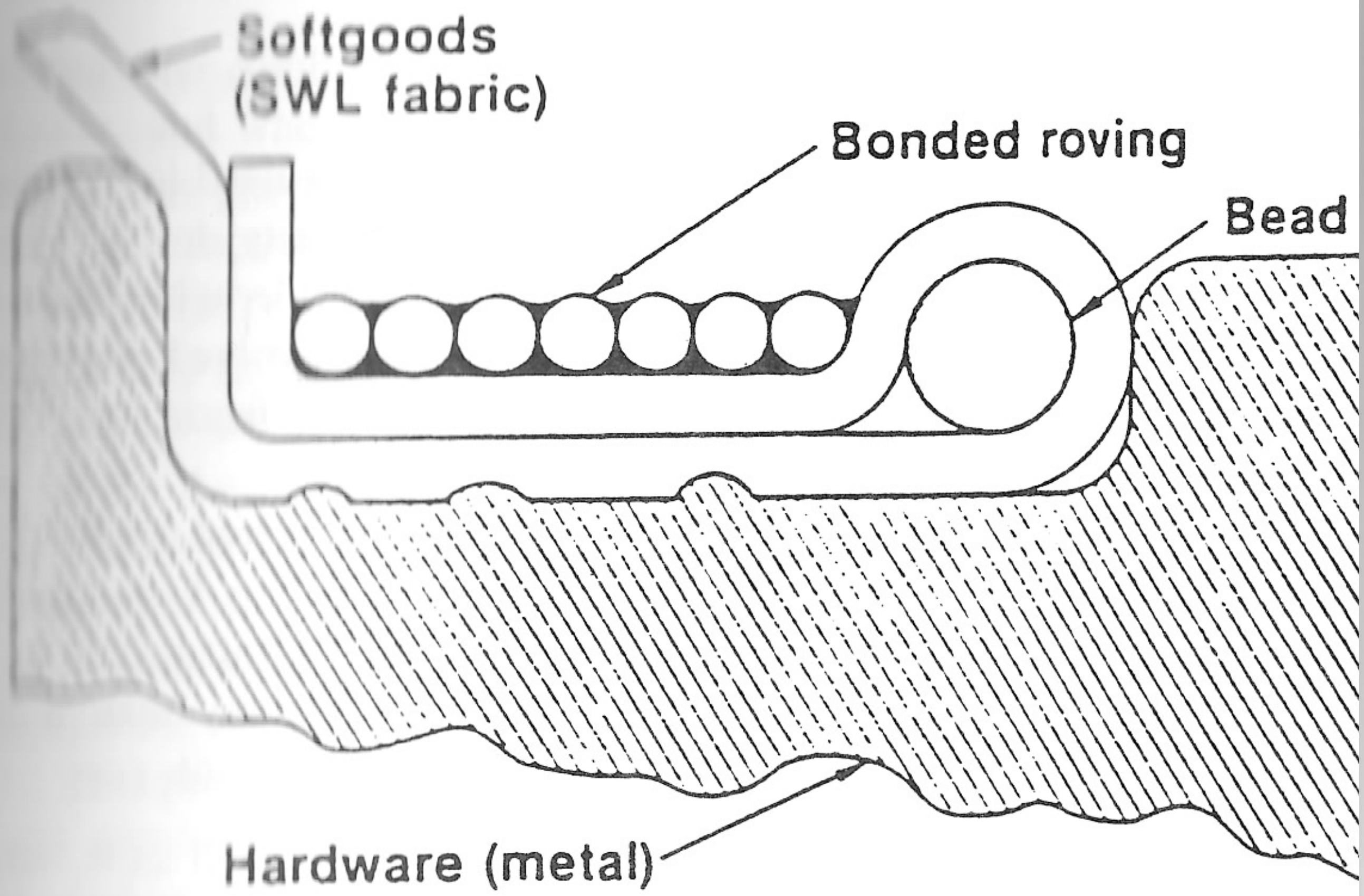


Figure 1-18 Bonded roving fabric element attachment method (courtesy of NASA).

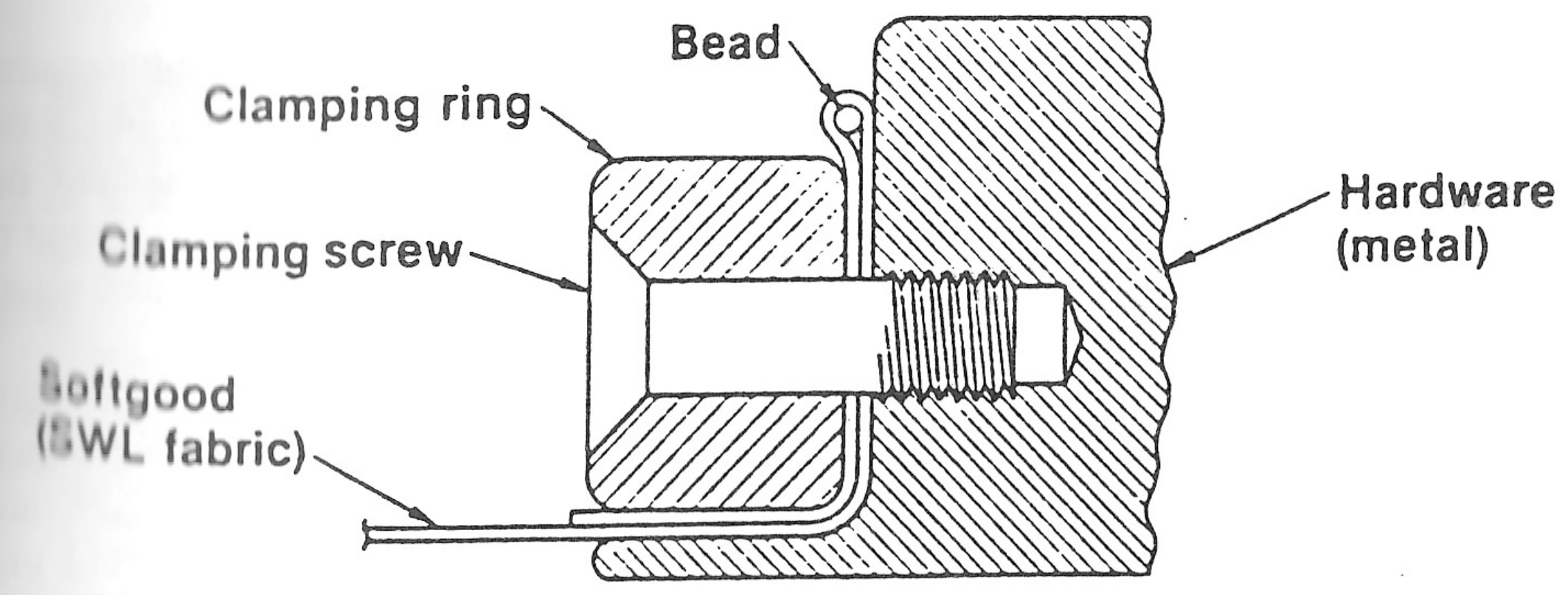
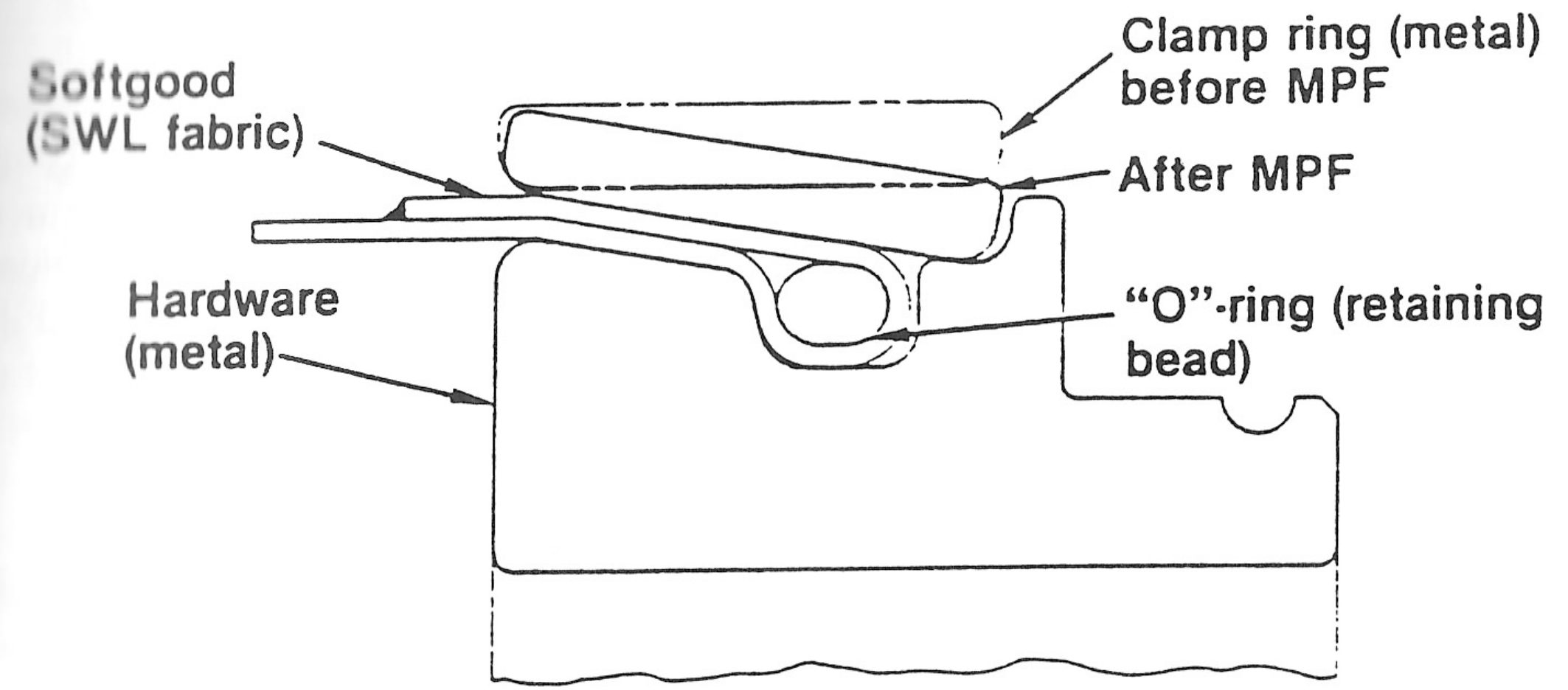


Figure 1-19 Bolted clamp and penetration fabric attachment method (courtesy of NASA).



Hard Suits - Not a New Idea (1882)



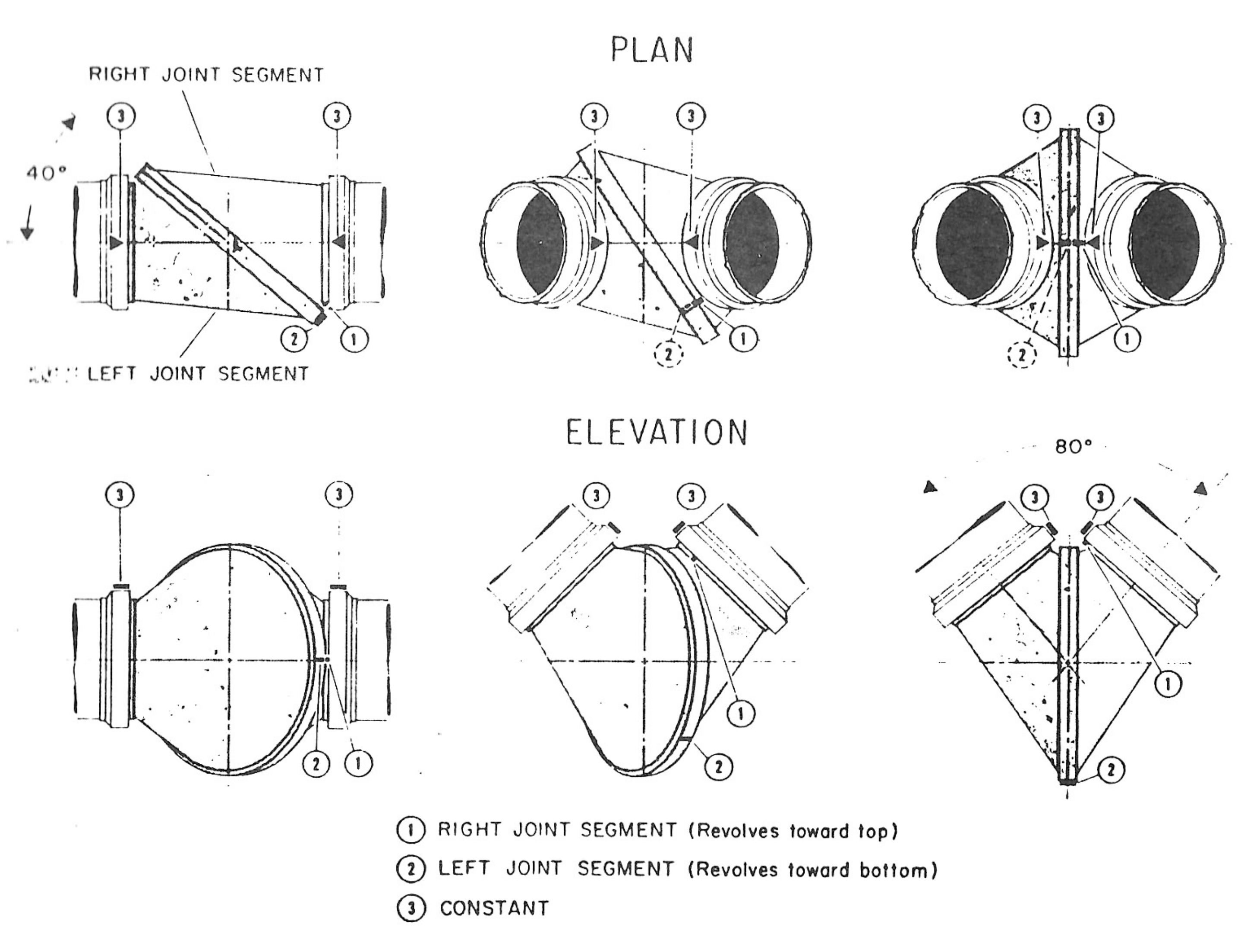
Draeger Suit (Germany - c. 1940)



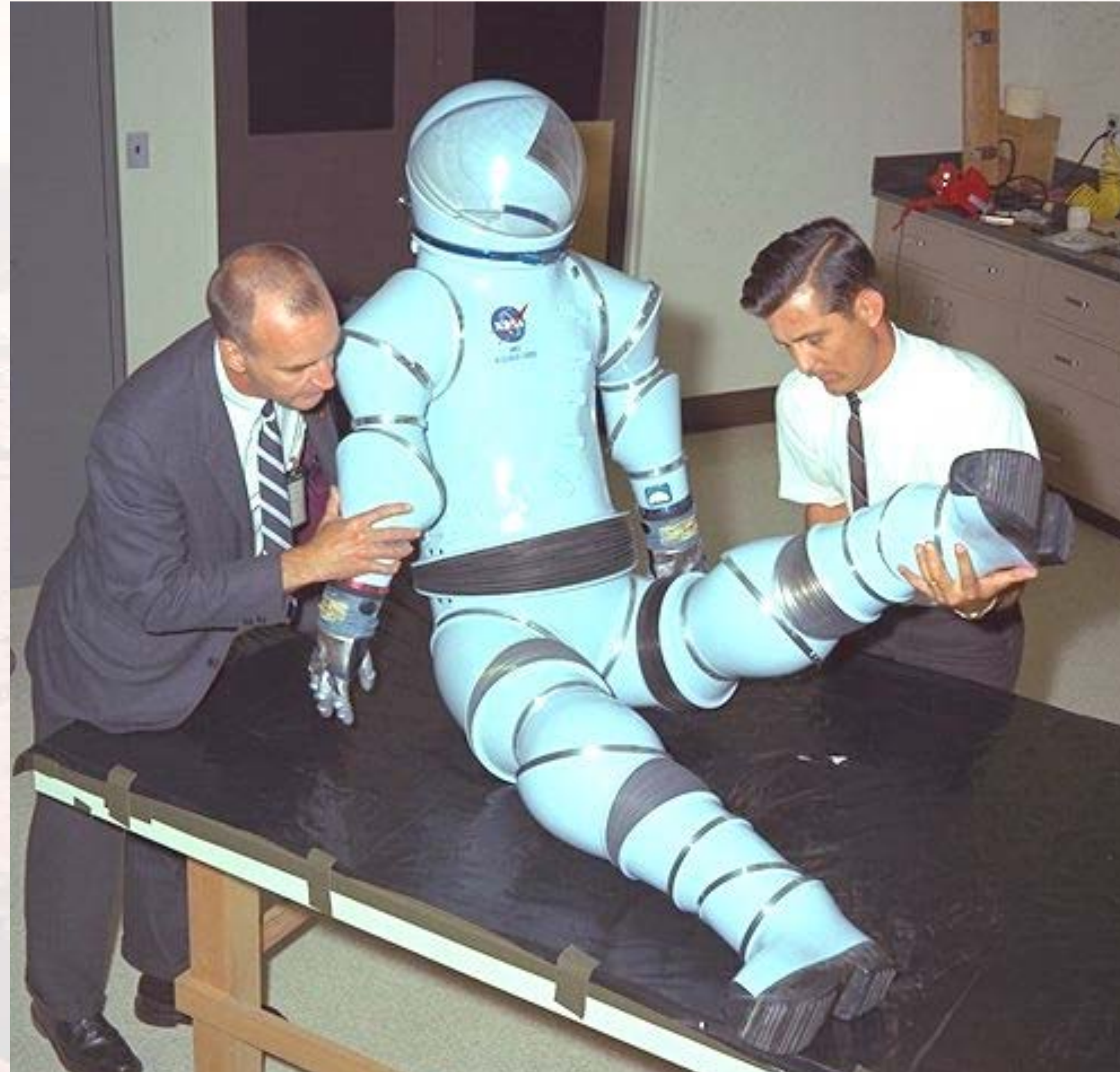
Litton RX-1



Wedge Joint Operations



NASA Ames AX-1 Hard Suit



AX-1



AX-1 Dual Planar HUT Entry



AX-1 Ingress



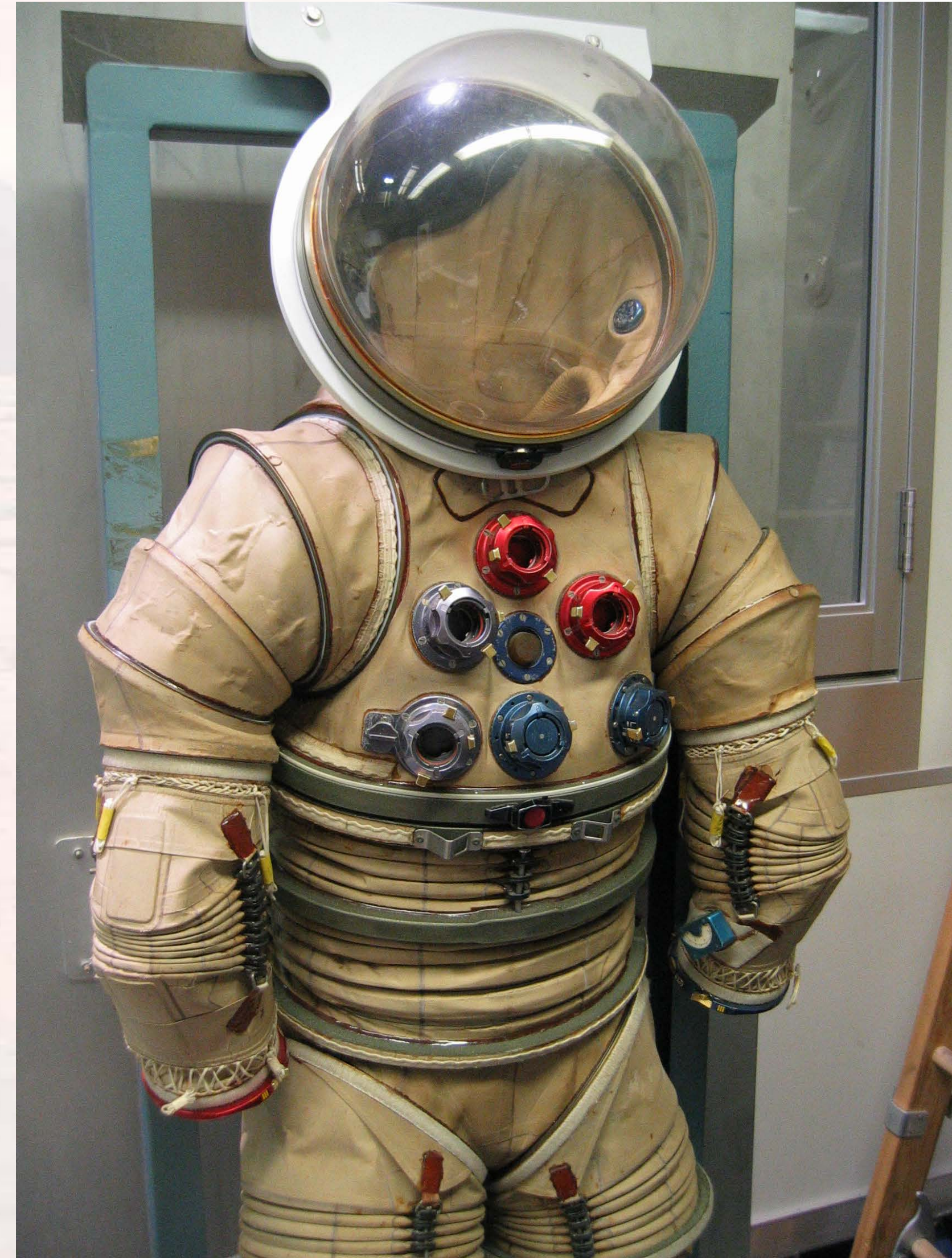
AX-3 Hybrid Suit



AX-3 Suit Ingress



AES Experimental Suit



AES Shoulder and Elbow Articulation



NASA Ames AX-5 Hard Suit



Mark III Suit (JSC)



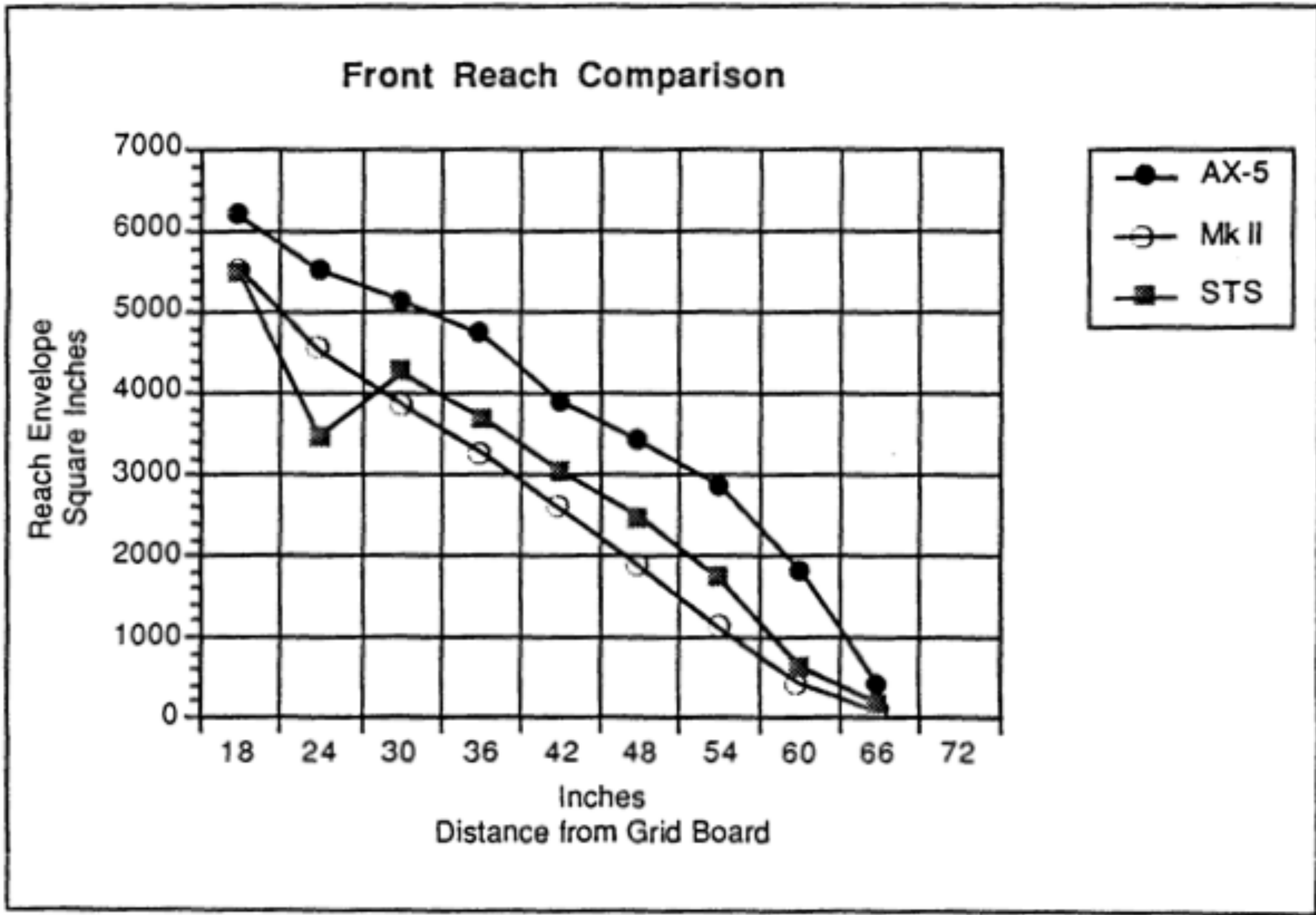
Comparative Suit Evaluations - 30 Years Ago



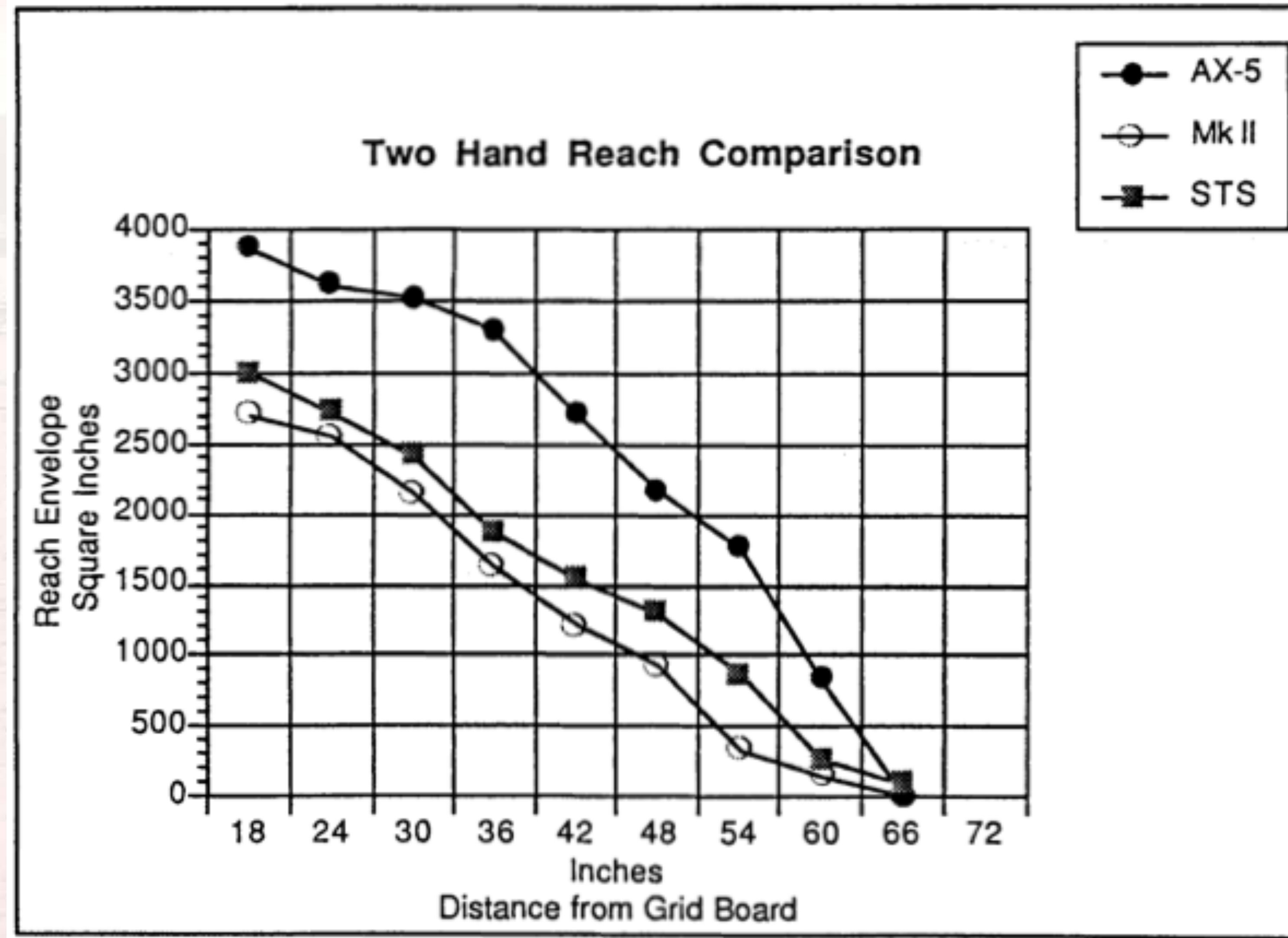
Spacesuit Design and Testing (NASA)



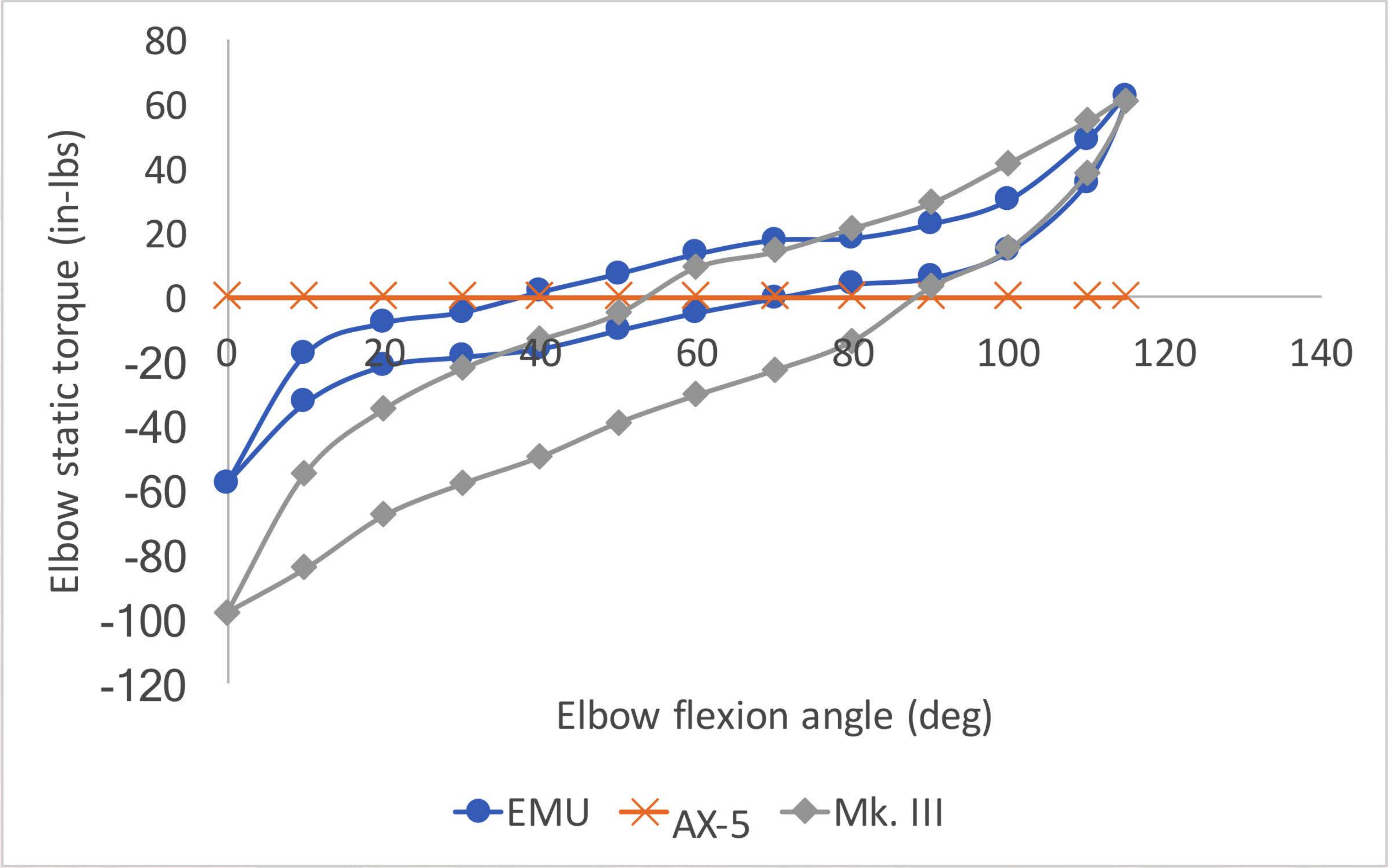
Single-Hand Reach Envelopes



Two-Hand Reach Envelope



Elbow Joint Torques



Comparative Evaluation Conclusions

- Both suits fully capable of all tasks, and comparable in performance to EMU
- AX-5 had more flexible lower torso, no restoring forces for limb motions
- Crew preferences:
 - Objected to “programming” of multi-roll joints in AX-5
 - Preferred soft components in elbows, knees, and feet
 - Did not think flexibility in lower body was desirable
- AX-5 was (apparently) heavier and required greater stowage volume
- Soft goods on Mk. III had limited operating lifetimes

Results of Comparative Assessment

- Point was moot - insufficient funding was available for next-generation suit
- EMUs adopted as standard U.S. suit on ISS
- NASA Ames suit development program terminated by the mid-1990's
- All suit development since that time has focused on soft or hybrid suit concepts

Rear-Entry Suit Donning



Waist-Entry I-Suit (ILC)



Waist-Entry Suit Donning



NASA Suit Concepts c.2000



JSC "H"



ILC "I"



David Clark "D"



Honeywell MCP



Recent NASA Suit Developments



Z-1 Experimental Suit (JSC)



NASA Z-2 Suit Concepts

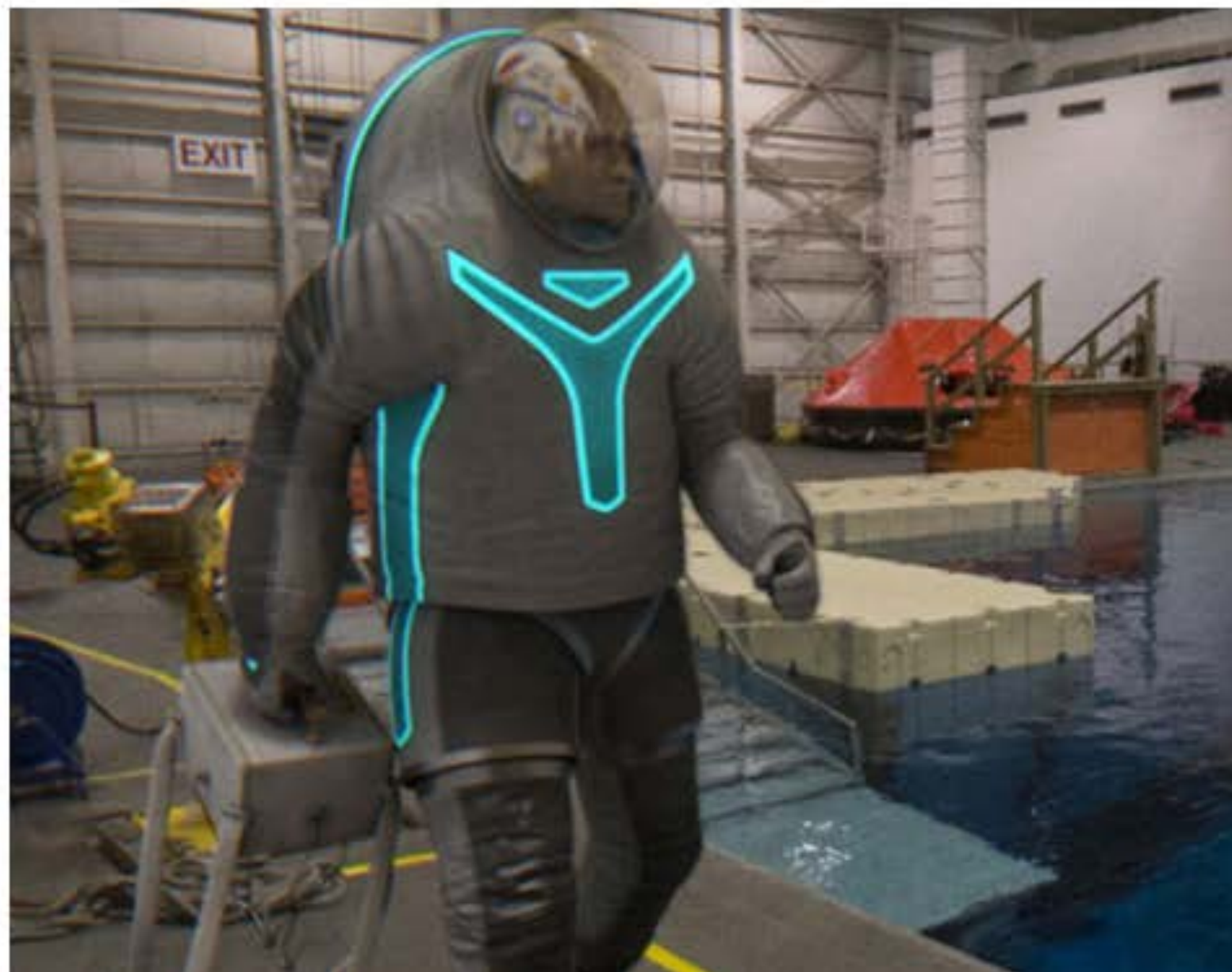


NASA Z-2 Crowd-Sourced Design

NASA wants you to choose its next spacesuit from three weird designs

By [Valentina Palladino](#) on March 25, 2014 03:21 pm [Email](#)

DON'T MISS STORIES [FOLLOW THE VERGE](#) [g+](#) [Like](#) 365k [Fol](#)



20
COMMENTS

 [DoorMarkedPirate](#)

Hmmm...I *guess* I'll pick the one with an arrow pointing at his penis.

Posted on Mar 25, 2014 | 3:30 PM

[Reply](#)

 [Colonel Sassy](#)

OR her...

Posted on Mar 25, 2014 | 4:08 PM

[Reply](#)

 [DoorMarkedPirate](#)

Good point; it could be pointing at *her* penis as well.

 [selfprofessedgeek](#) 

Moderator, [The Verge](#)

I may have laughed too hard at this....

Posted on Mar 25, 2014 | 4:51 PM

[Reply](#)

Modified ACES EVA Suit



EXPLORATION EXTRAVEHICULAR MOBILITY UNIT (xEMU)

National Aeronautics and
Space Administration



High Speed Data Comm.

HD Video and Lights

Informatics Display and Control

Integrated Communications
(No Snoopy Cap)

Automated Suit Checkout

Enhanced Upper Mobility

Environment Protection
Garment (EPG) w/Dust Mitigation

Planetary Mobility

4.3 – 8.2 psi Variable Pressure

1 Hr. Emergency Return

Vacuum Regenerative CO2
Removal System

Membrane Evaporation Cooling

Modular/ORU PLSS Design

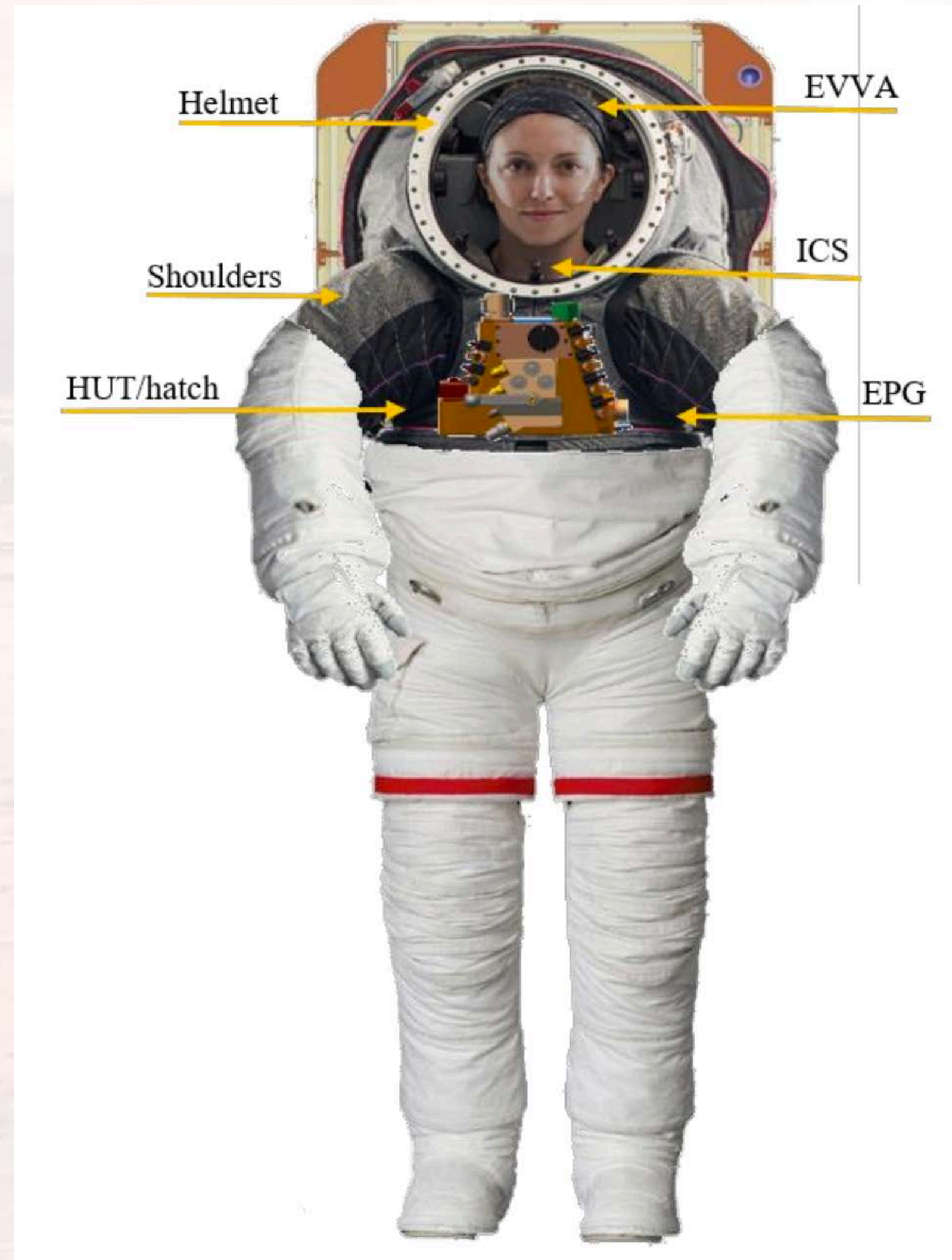
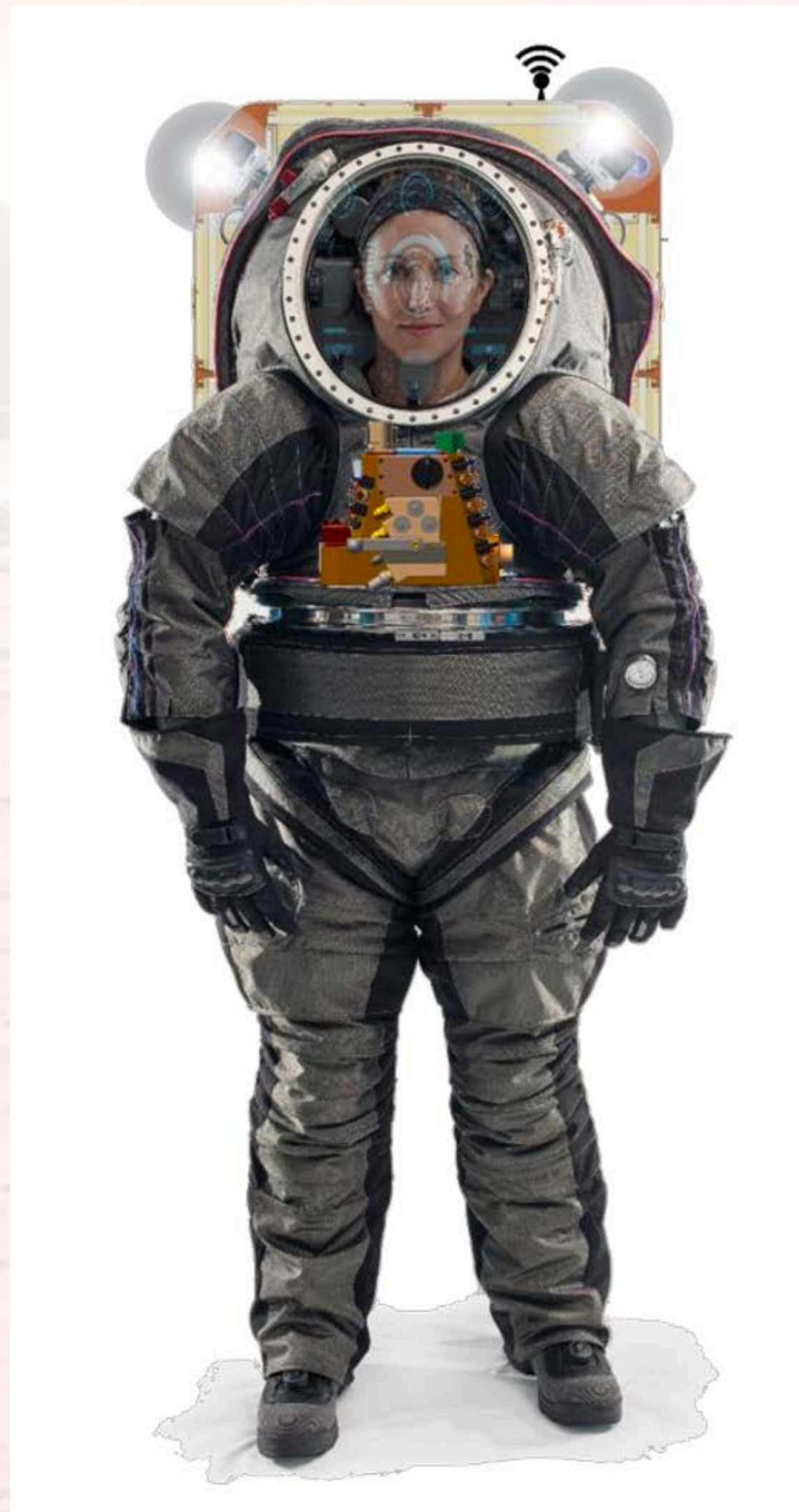
Rear Entry Ingress/Egress

The xEMU is the spacesuit that will be worn by the first woman and next man to walk on the Moon. The new generation of technologies and capabilities incorporated into this spacesuit enable spacewalks (EVAs) in deep space, on the lunar surface, and on Mars.

ARTEMIS

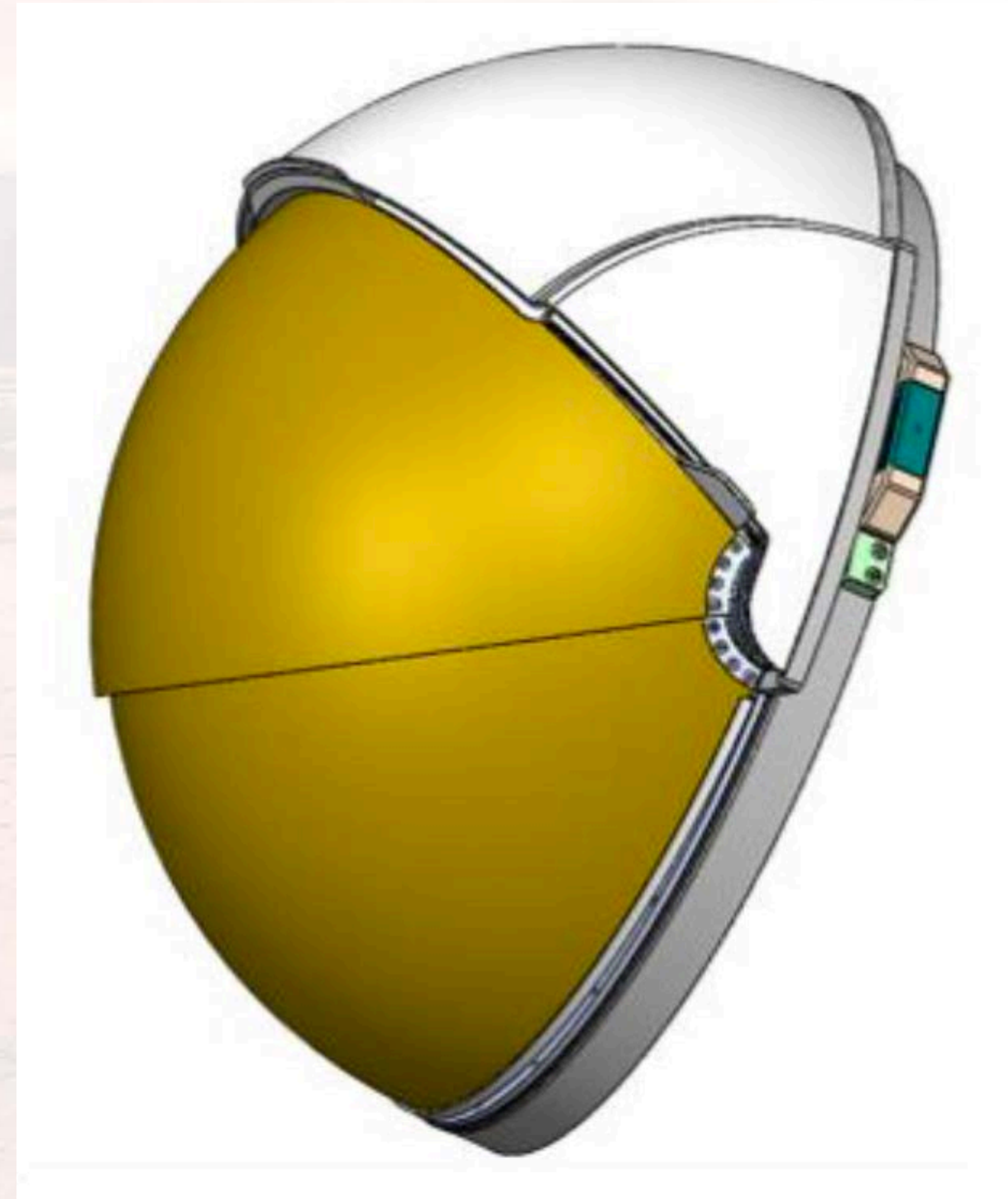
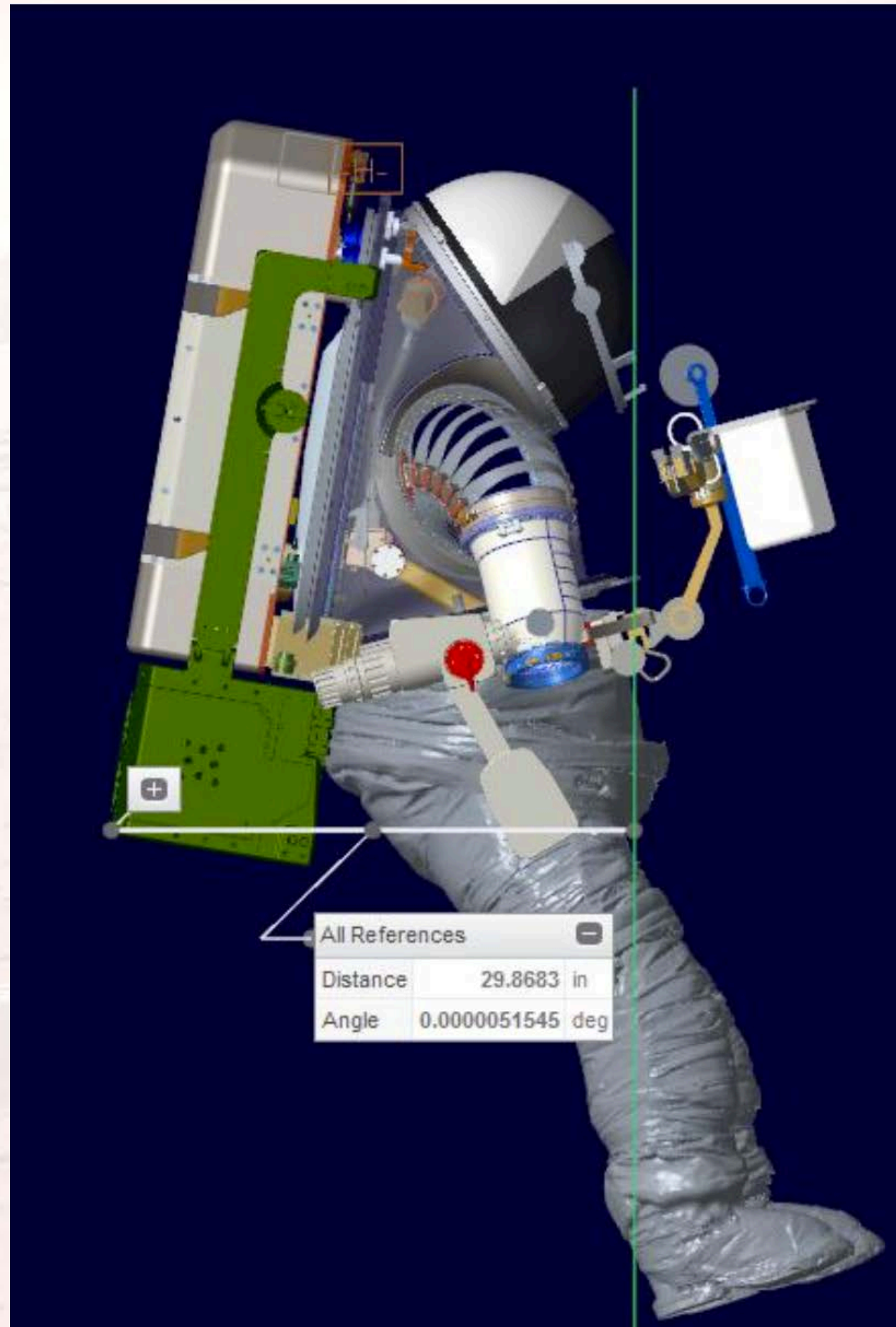
EVA SPACESUIT TECHNOLOGY AND DESIGN

Next Generation: xEMU



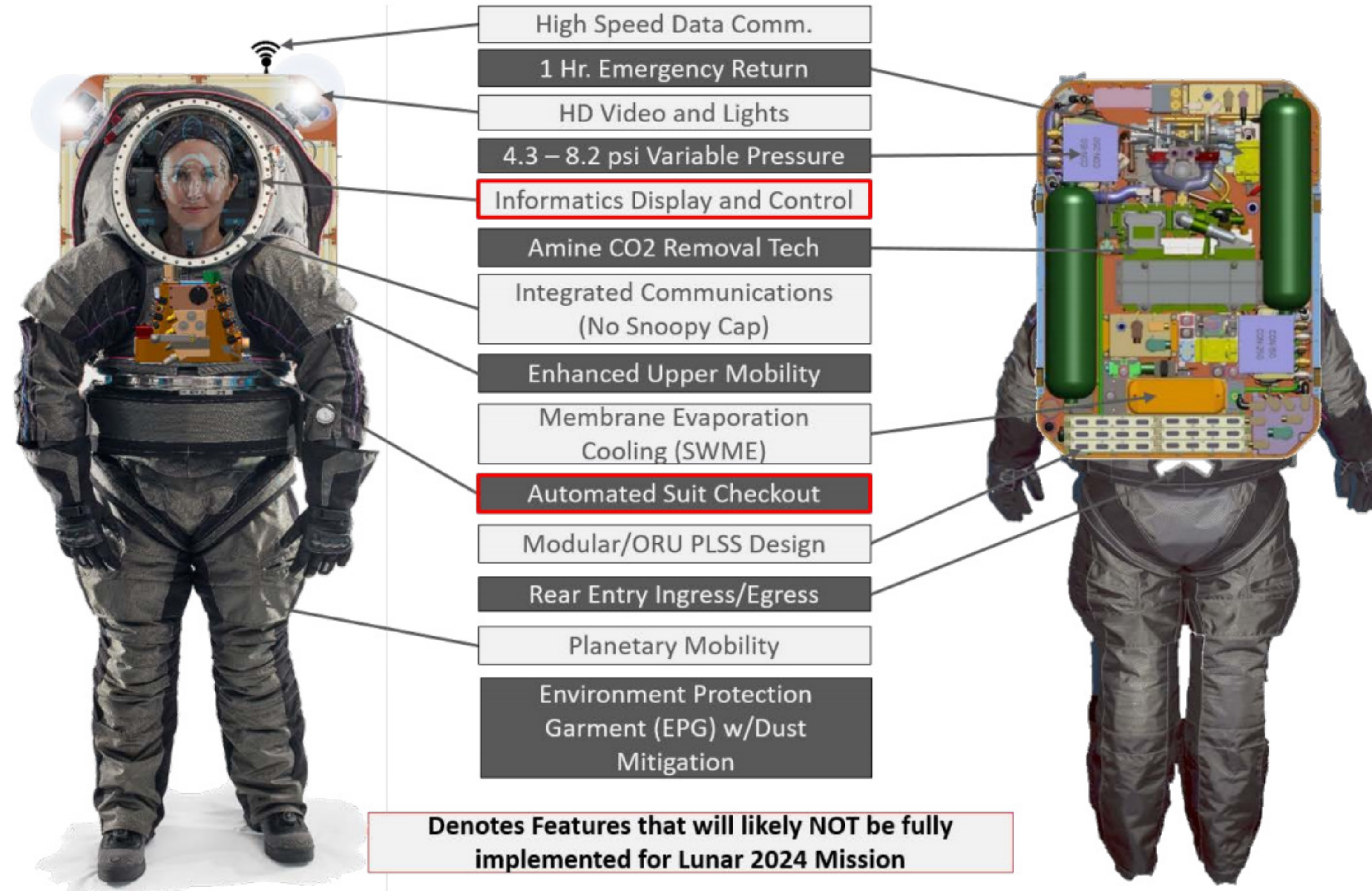
from Ross and Rhodes, "NASA's Advanced Extra-vehicular Activity Space Suit..." ICES-2018-273

xEMU HUT and Helmet



from Ross and Rhodes, "NASA's Advanced Extra-vehicular Activity Space Suit..." ICES-2018-273

xEMU Life Support and Informatics



Axiom Artemis Lunar Suit Prototype



References

- Kenneth S. Thomas and Harold J. McMann, US Spacesuits - Springer-Verlag, 2006
- Gary L. Harris, The Origins and Technology of the Advanced Extravehicular Space Suit - AAS History Series, Volume 24, American Astronautical Society, 2001