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

All KC events will be approved for public using NASA Form 1676.

This synopsis provides information about the Knowledge Capture event below.

Topic: Gloves 101

Date: June 13, 2008 **Time:** Unknown **Location:** JSC/B5S/R3102

DAA 1676 Form #: 29748

This is a link to all lecture material and video: \\js-ea-fs-01\pd01\EC\Knowledge-Capture\FY08 Knowledge Capture\20080608_Gloves 101\For 1676 Review & Public Release

*A copy of the video will be provided to NASA Center for AeroSpace Information (CASI) via the Agency's Large File Transfer (LFT), or by DVD using the USPS when the DAA 1676 review is complete.

Assessment of Export Control Applicability:

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For 1676 review use_Synopsis_Ross_Gloves 101_6-13-2008.pdf

Presenter: Amy J. Ross

Synopsis: This presentation addressed the question "What is a spacesuit glove?" – a highly specialized mobility system. It is an excellent basic tutorial on the design considerations of a spacesuit glove and the many facets of developing a glove that provides good mobility and thermal protection.

Biography: Amy Ross has been with NASA for over 20 years, specializing in pressure garments. She has served as the Spacesuit Team lead, Spacesuit Hardware Technology Development lead, CxP Spacesuit System PGS manager, and Space Launch Initiative Crew Escape Suit Engineering lead, with most of her experience in advanced planetary spacesuit development and testing. Past projects include the Shuttle spacesuit gloves, launch and entry suit gloves, and STS-100 EVA tools. Amy earned a bachelor and master of science in mechanical engineering from Purdue University and a master of science in space studies from the University of North Dakota.

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Glove 101

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June 13, 2008

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Glove 101 Objectives

- What is a glove?
- Identify glove layers and their function
- Understand challenges of glove design through glove evolution history
- Familiarization with Phase VI glove design process
- How to perform a glove fit check
- How to connect/disconnect a glove to/from an arm
- Review of recent cut glove issues, if requested

Rules of Engagement

- **Take off all rings**
- **Take off all watches/bracelets**
- **Pick up gloves by their disconnect, if present**

What is a glove?

- **All of the challenges of space suit design magnified and in a little package**
  - Pressure vessel
  - Highly specialized mobility system
  - Protection against the space environment
- **Astronaut's interface to the world**
  - For micro-gravity EVA, gloves serve as hands and feet
- **Although a glove is tool, a glove is NOT:**
  - A hammer!
  - A perfect replication of human hand performance

Glove Layers and their Function

- **Bladder/restraint assembly**
  - Bladder = Pressure retention, mobility
  - Restraint = Shape, strength, and mobility

- **Thermal micrometeoroid garment = environmental protection**
  - **Teflon = snag prevention, chemical resistance**
  - **Room-temperature vulcanized rubber = sharp edge/cut protection**
  - **Vectran = sharp edges**
    - Kevlar
  - Multi-layer insulation = thermal and micrometeoroid/orbital debris (MMOD)
    - Aluminized mylar
      - No scrim
  - Orthofabric
    - gaunlet

TMG Lay-ups

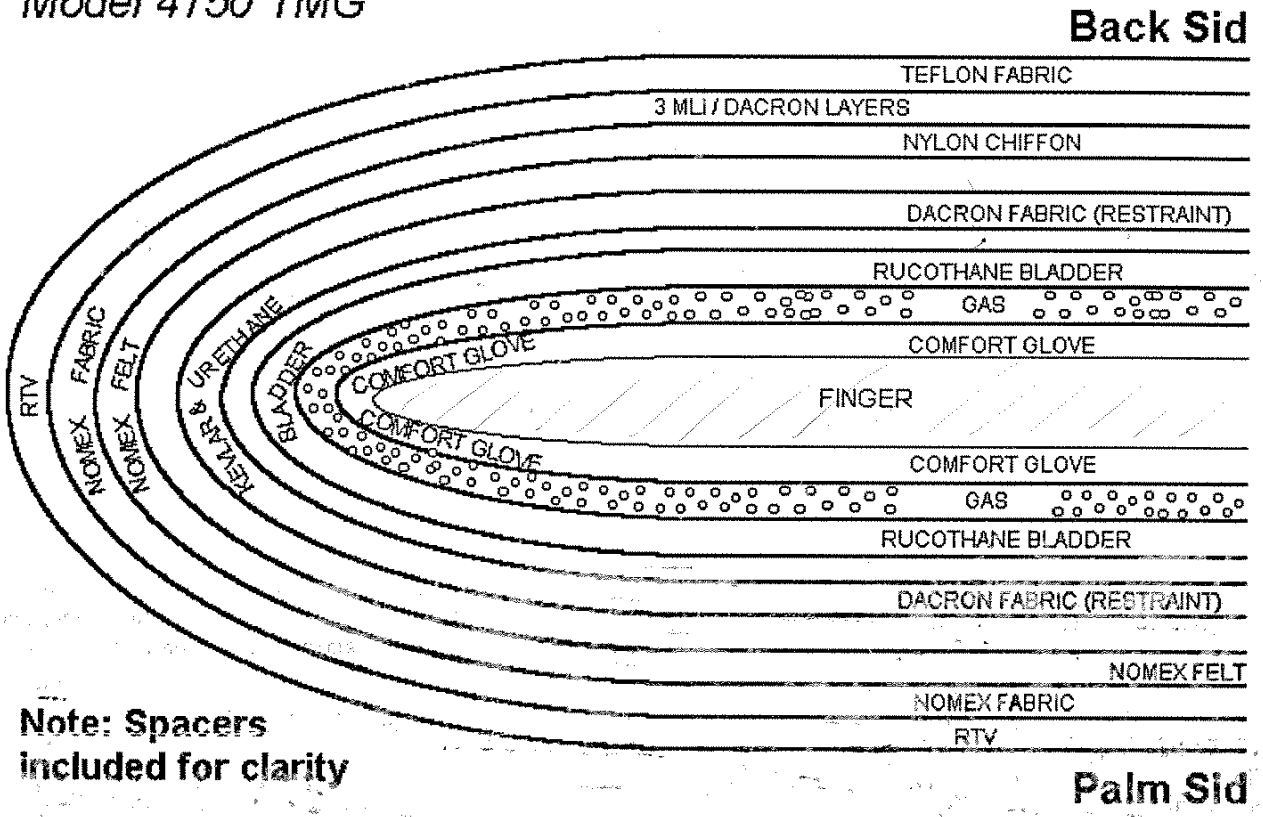
- Glove Finger Back:
- Teflon Cloth (T-162)
- Unreinforced Aluminized Mylar Non-Woven Dacron Spacer
- Unreinforced Aluminized Mylar Non-Woven Dacron Spacer
- Unreinforced Aluminized Mylar Non-Woven Dacron Spacer
- 3 oz. Dacron (Restraint) Rucothane (Bladder)

- Gauntlet over Arm:
- Teflon Cloth (T-162)
- Reinforced Aluminized Mylar (3 Layers)
- Teflon Cloth (T-162)
- Ortho Fabric

- Ortho Fabric
- Reinforced Aluminized Mylar (5 Layers)
- Neoprene Coated Nylon Ripstop
- 3 oz. Dacron (Restraint)
- Urethane Coated Nylon (Bladder)

EMU GLOVE CROSS-SECTION

Model 4750 TMG



Note: Spacers included for clarity

Glove Evolution

- **Glove development is evolutionary, not revolutionary**

- **Identify the following gloves and design features:**
  - **Apollo**
  - EMU Series
    - **4000 Series**
      - 4000 series TMG
      - 4750 TMG
  - **Advanced prototypes**
    - Active metacarpal
    - Rolling convolute wrist
    - Resulted in **Phase VI** glove

- **Not Discussed**
  - Orlan
  - ACES

EMU Series

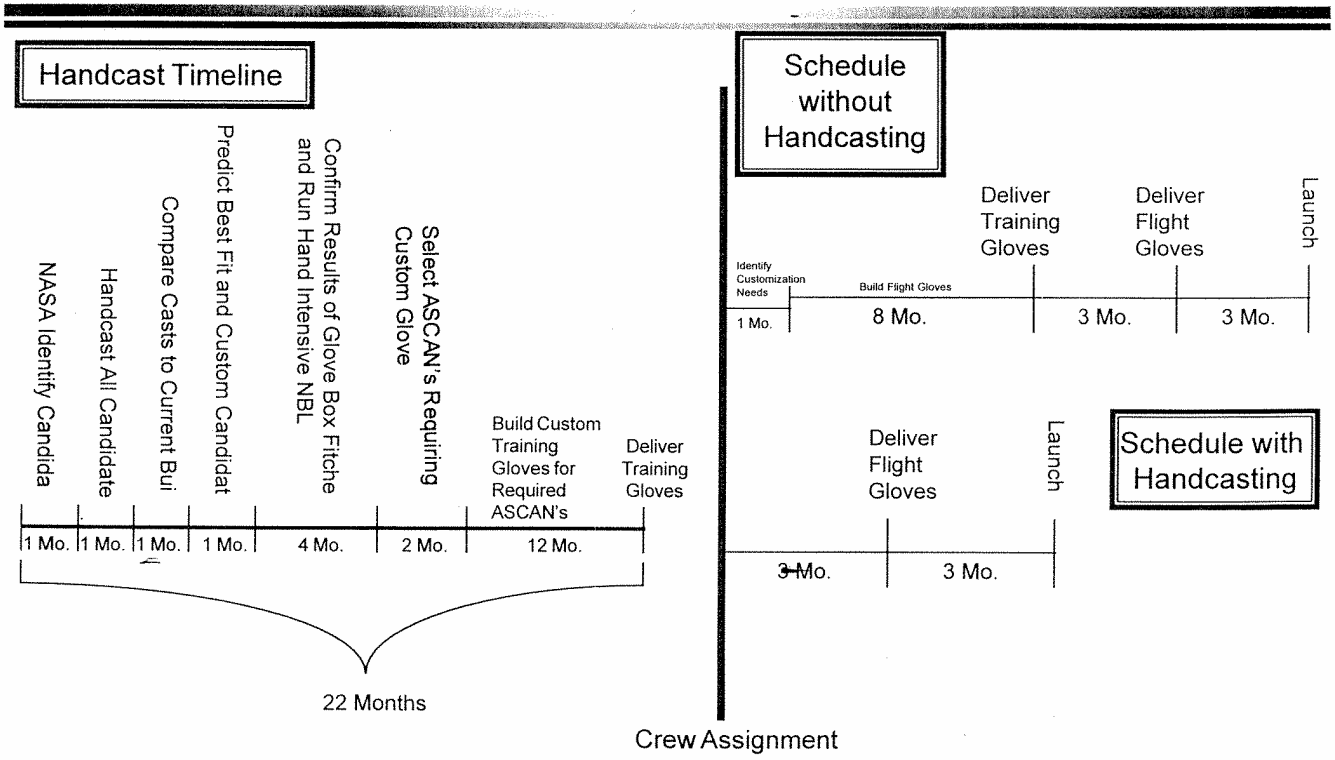
- **4000 Series**
  - Followed flight glove series progression
    - 1000
    - 2000
    - 3000
    - 4000
  - Developed and designed on the EMU contract
  - Evolution of one basic patterning philosophy
  - Philosophy - build standard size gloves for 4.3 psi operation

Advanced Prototypes

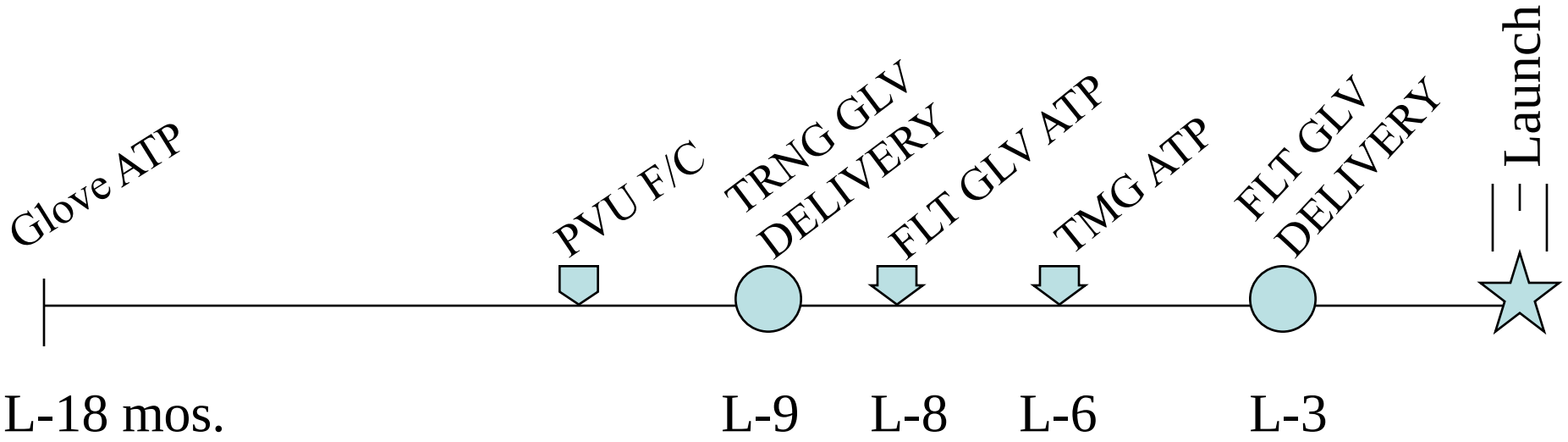
- **Phase VI**
  - Stand alone advanced development program
    - Phase IV
    - 5000 Series
    - Laserscan Process
    - Phase V
    - Phase VI
  - Developed and designed on the Advanced contract
  - Revolutionary patterning philosophy
  - Grounds up design of high performance/low torque glove
  - Philosophy - Build custom gloves for high performance 8.3 psi use

U.S. Gov't

Phase VI Glove Implementation



Phase VI Glove Timeline



Glove size developments require 9 months
Production copies require 5 months
TMG copies require 3 months
Training gloves must be delivered to USA at L-9 mos.
Flight gloves must be delivered to USA at L-3 mos.

Phase VI Glove Design Process

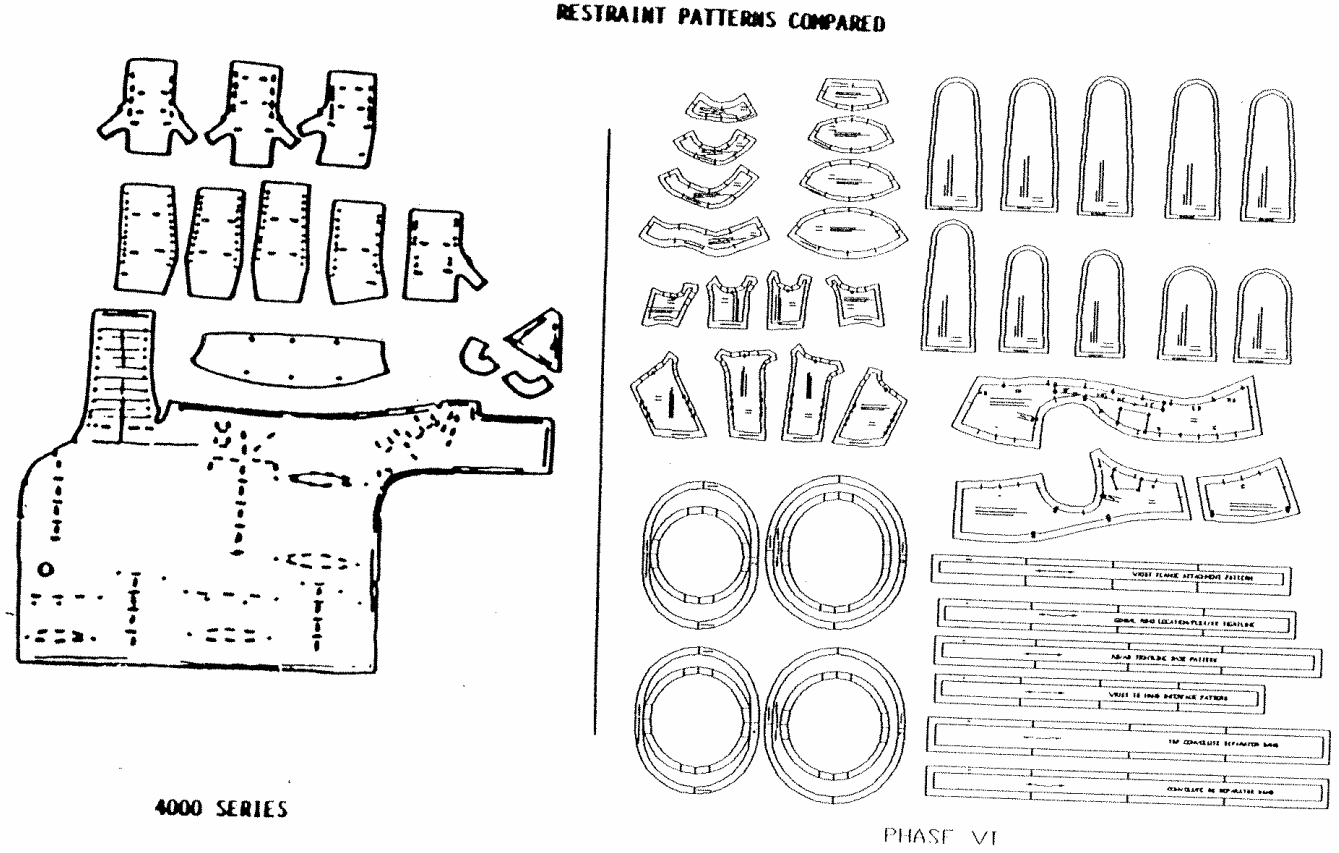
- **A Phase VI glove customization/size development includes:**
  - hand cast
  - hand mold
  - laser scan of hand mold → computer model of hand
  - additional hand data
  - pattern generation

    [Detailed steps on next slide]
  - Patten Verification Unit (PVU) fabrication
  - PVU fit check
  - pattern adjustments based on PVU fit check comments
    - one iteration
  - glove delivery/fit check

Phase VI Glove Design Process

- **Pattern Generation**
  - Build glove layers up from computer model
    - Bladder Dip Form >> File to SLA vendor
    - Restraint
      - Patterns >> Patterns file to laser cutting machine
      - Palm bar >> File to machine shop
      - Palm plate >> File to machine shop
    - TMG >> Patterns to laser cutting machine

Phase VI Glove Implementation



Glove Fit Check

DOC NO:	FEMU-R-005	REVISION:	Baseline	PAGE:	8
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2.2 4000 SERIES GLOVES

The 4000 series (4K) is not authorized for flight and may be used for test subjects and as a backup for crewmembers to the Phase VI Glove for Class III events. The 4K-Series Glove sizing plan consists of nine standard sizes, designated ZA through ZI. Standard 4K-Series gloves ***shall*** be obtained by selecting the appropriate size based on Crewmember/Glove Middle Finger Length (L) and Hand Circumference (C) from Figure 4 or the Custom 4000 Glove matrix, Appendix D.

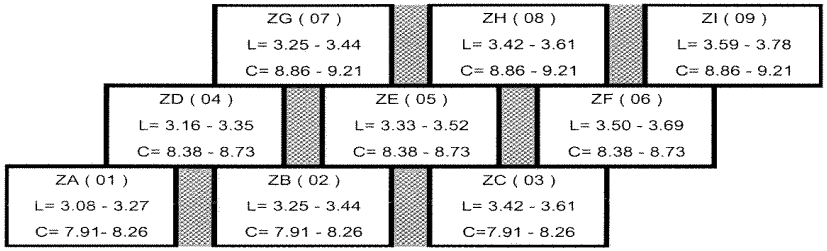
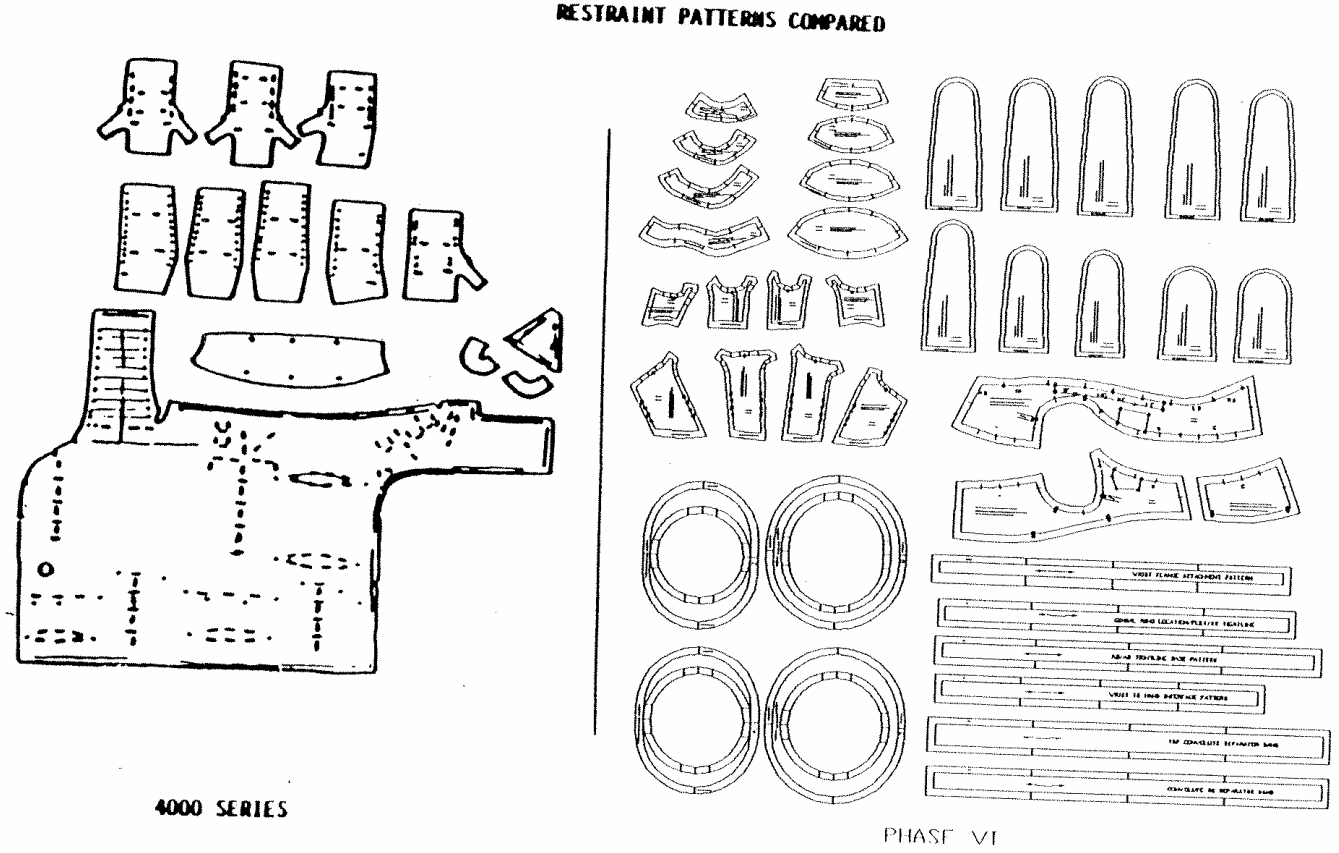


Figure 4: Standard 4000 Series Glove Sizing Table (inches)

2.3 **COMFORT GLOVES**

Comfort gloves are an optional piece of hardware that can have a significant influence on the overall fit of the hand in the glove. There are six styles of comfort gloves available to the crewmember: Lightweight (thin) and Heavyweight (thick) Spectra seamless, Lightweight (thin) and Heavyweight (thick) Manzella moisture wicking, silver flat-pattern, and flat-patterned nylon. The Heavyweight Spectra is recommended to the crewmember for the initial glove fit-check. However, a pair of each style comfort gloves should be available at the initial glove fit-check. All comfort gloves can be modified by adding pads or by altering/removing fingertip length. Alterations ***shall*** be identified by a custom size and tracked using a Comfort Glove Modification Sheet.

Phase VI Glove Implementation



Connect/Disconnect a Glove

--Or how to look like a steely-eyed space suit engineer

- **Connect**
  - Soft dock
  - Lock
- **Disconnect requires 3 separate actions**
  - Push in
  - Slide
  - Rotate

Review of Cut Glove Issues

See presentations provided by EMU Team/D. Watson

Conclusion

Questions?

Comments?

Actions?

Phase VI Sizes Mapped to Standard Sizes

G	H	I
Ross	Voss	Tanner
Barry	Reilly	Lee
L-A		Gernhardt
		Curbeam
		Smith
D	**E**	**F**
Chiao	McArthur	Hadfield
Foale	Nicollier	Parazynski
	Grunsfeld	Robinson
		Noriega
A	**B**	**C**
Wisoff	Helms	Harbaugh
Jernigan		
Usachev		

- Glove pattern comparison - dig in file cabinet
- 4K glove std sizing - ?
- Glove layers - mini data book
- Fabric lay up
- Nate’s fit check procedure

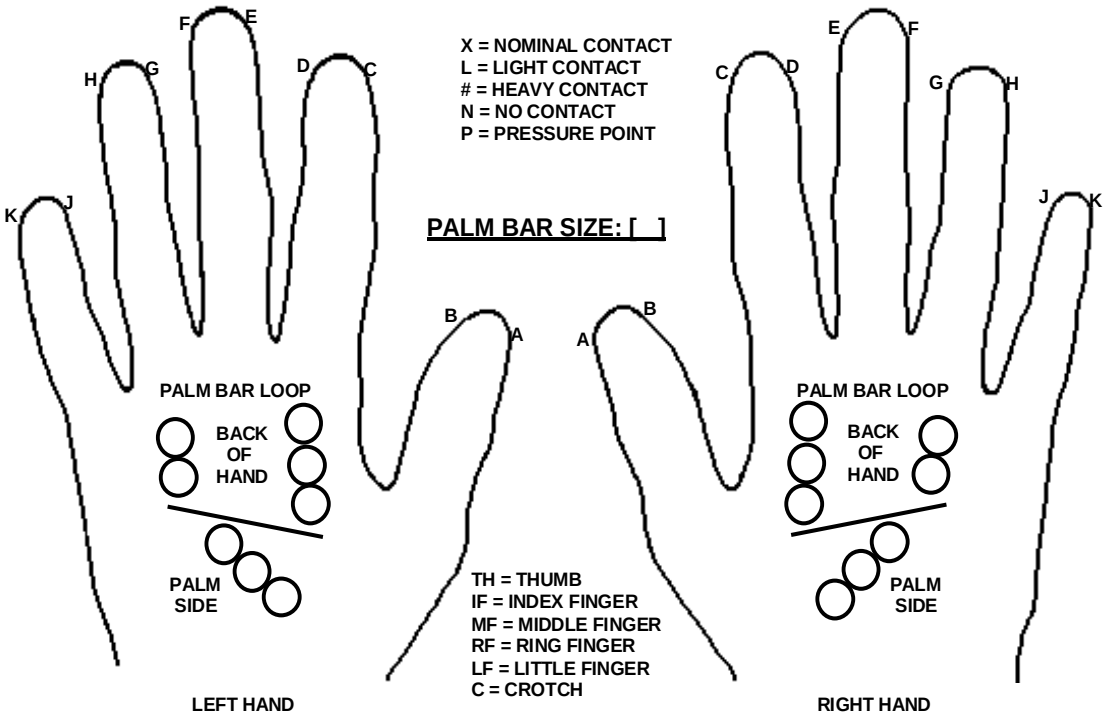
- Hand mold
- Arms

- Tape measure/scale

Glove Fit Check

GLOVE EVALUATION SHEET #1

PTS:
TPS:



GLOVE SIZE: _____ CLASS: ____ S/N _____ TEST DATE: _____

CREWMAN / SUBJECT: _____ TEST ENGINEER: _____

FINAL ADJUSTMENT CORD TAKE UP

HAND	THUMB A B	INDEX C D	MIDDLE E F	RING G H	LITTLE J K
LEFT					
RIGHT					

PALM BAR SHAPE TRACING

LEFT HAND
BUCKLE SIDE