

Glove 101

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June 13, 2008

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- ◆ **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**

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

- ◆ **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

◆ 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
 - gauntlet



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)

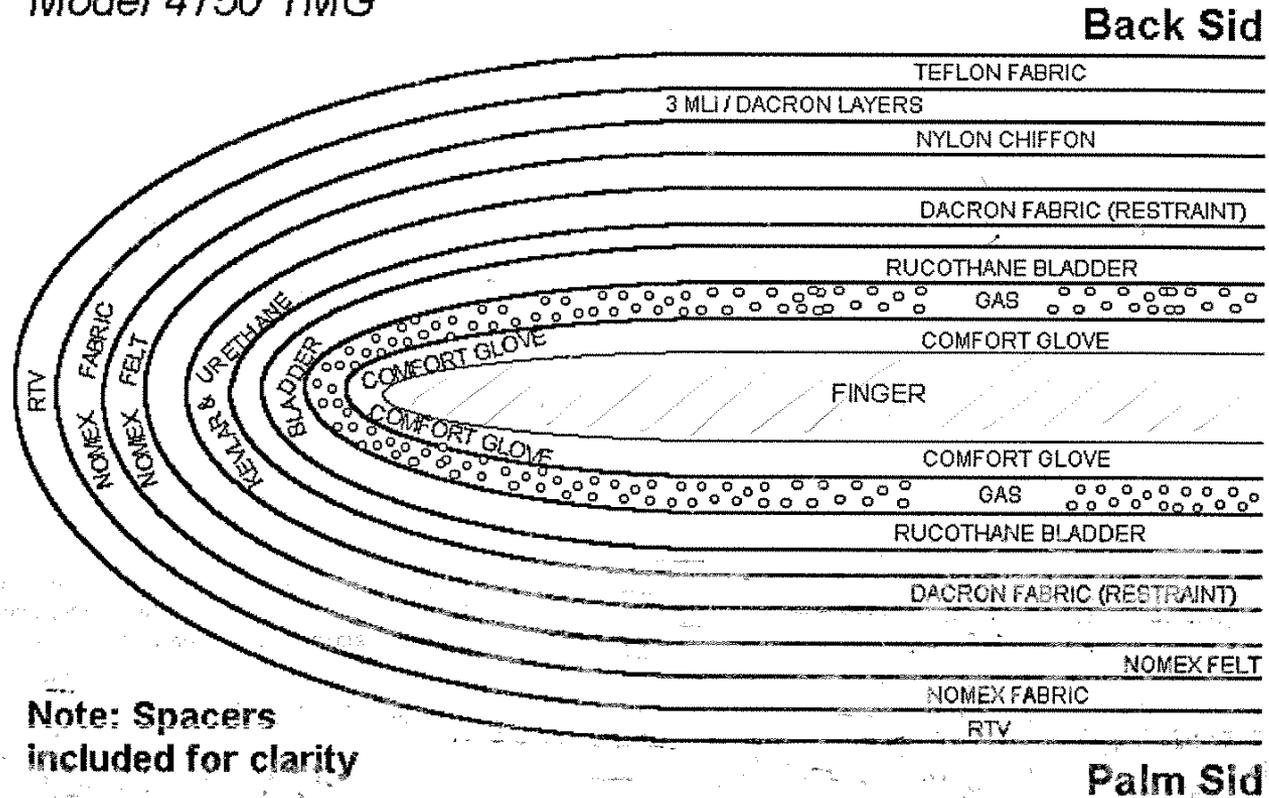
- ◆ Gauntlet over Arm:
- ◆ Teflon Cloth (T-162)

- ◆ 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 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

◆ 4000 Series

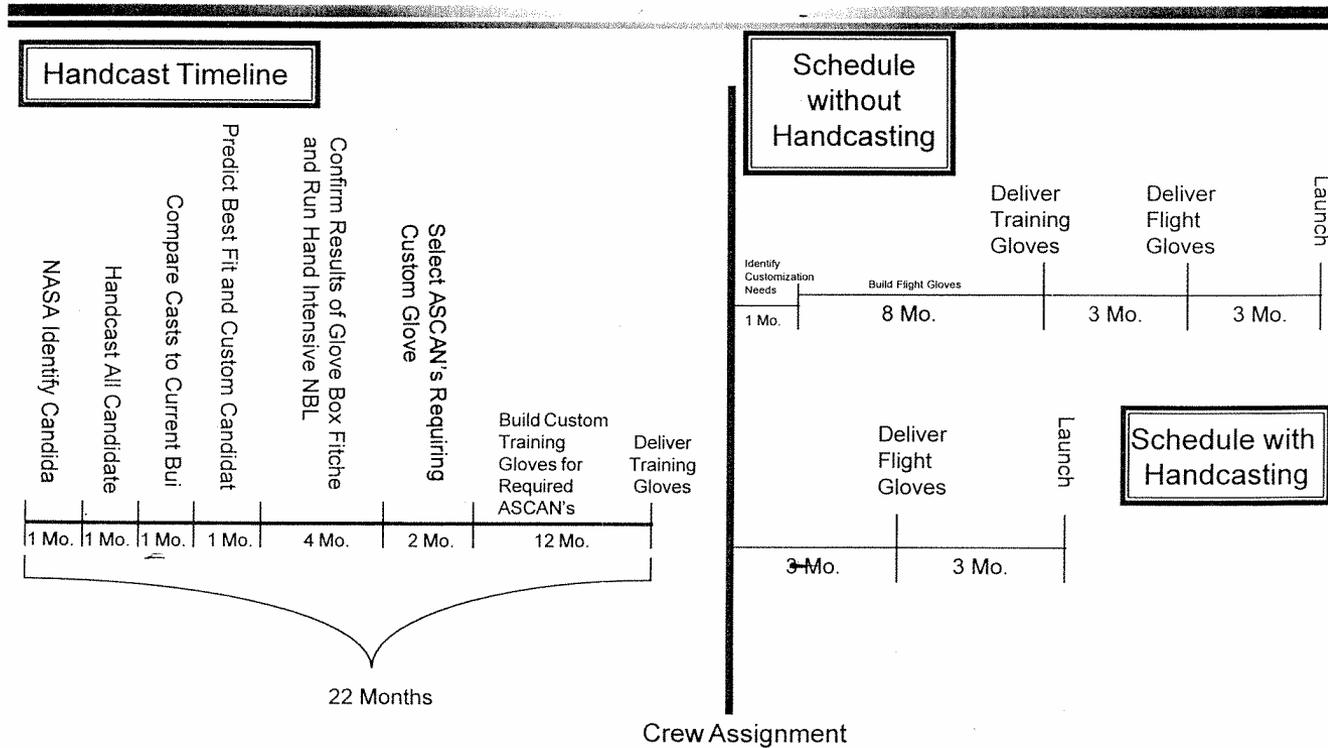
- Followed flight glove series progression
 - 1000
 - 2000
 - 3000
 - 4000
- Developed and designed on the EMU contract
- Evolution of one basic patterning philosophy
- Philosophy - build standard size gloves for 4.3 psi operation

◆ Phase VI

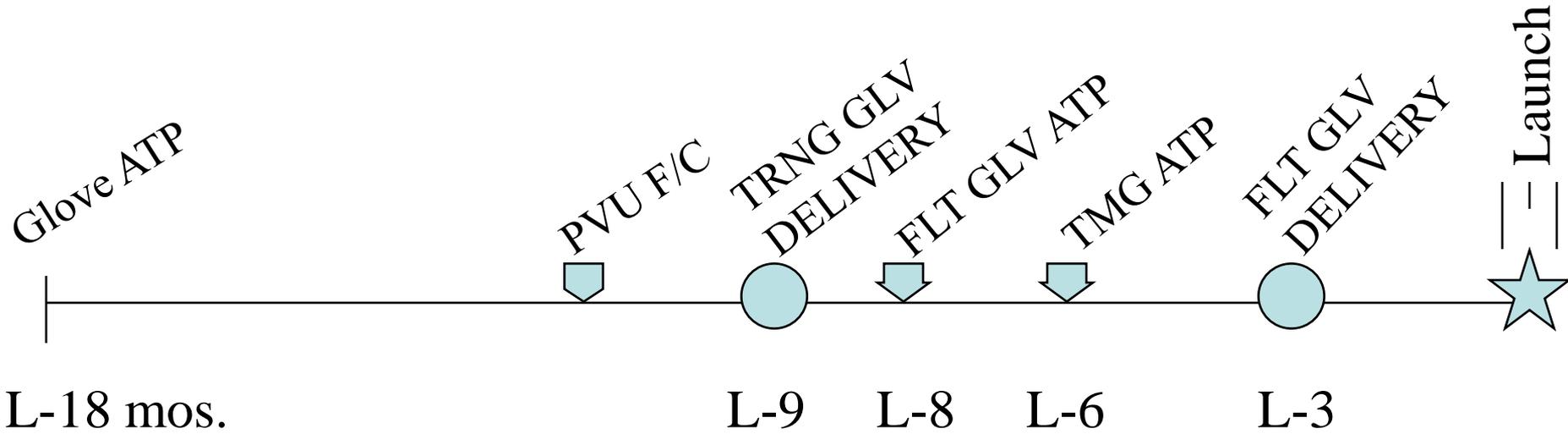
- Stand alone advanced development program
 - Phase IV
 - 5000 Series
 - Laserscan Process
 - Phase V
 - Phase VI
- Developed and designed on the Advanced contract
- Revolutionary patterning philosophy
- Grounds up design of high performance/low torque glove
- Philosophy - Build custom gloves for high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

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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.

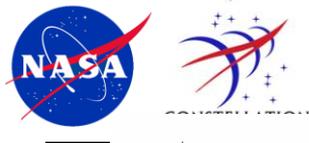
Flight gloves must be delivered to USA at L-3 mos.

◆ 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]
- Pattern Verification Unit (PVU) fabrication
- PVU fit check
- pattern adjustments based on PVU fit check comments
 - one iteration
- glove delivery/fit check

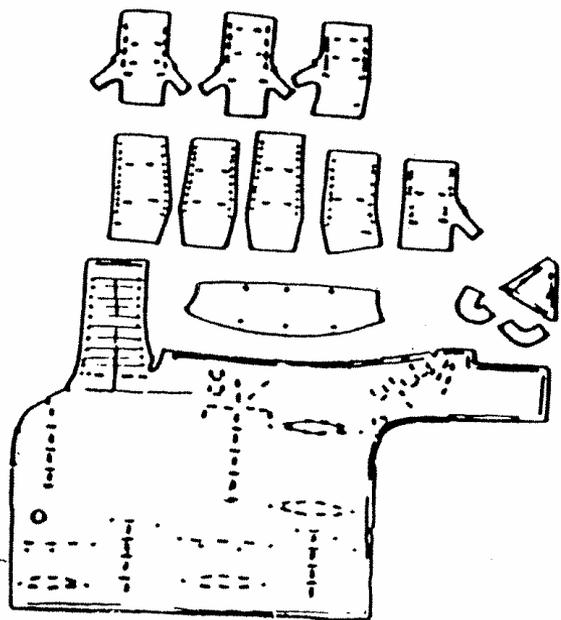
◆ Pattern Generation

- 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

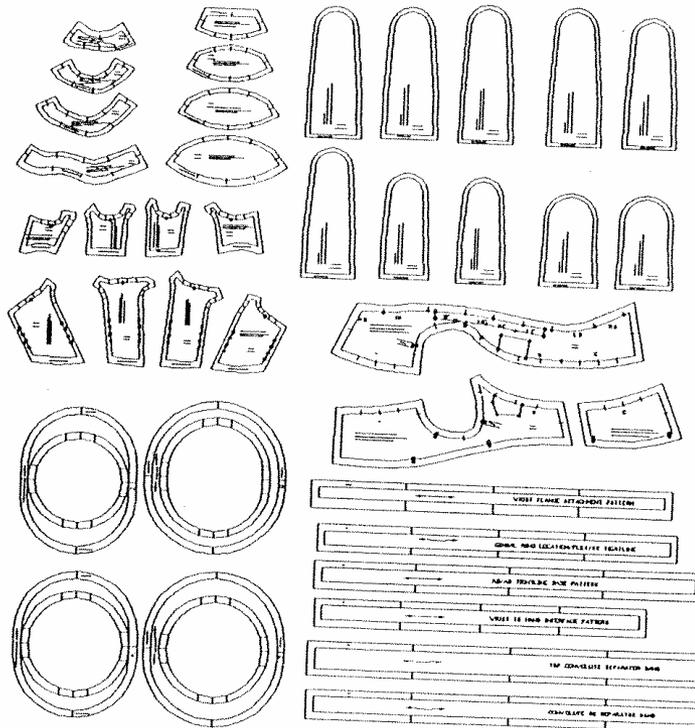


Phase VI Glove Implementation

RESTRAINT PATTERNS COMPARED



4000 SERIES



PHASE VI

Glove Fit Check

DOC NO:	FEMU-R-005	REVISION:	Baseline	PAGE:	8
JSC #	65011	CHANGE NO:	~	RELEASE DATE:	3/1/07

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.

ZG (07) L= 3.25 - 3.44 C= 8.86 - 9.21		ZH (08) L= 3.42 - 3.61 C= 8.86 - 9.21		ZI (09) L= 3.59 - 3.78 C= 8.86 - 9.21	
ZD (04) L= 3.16 - 3.35 C= 8.38 - 8.73		ZE (05) L= 3.33 - 3.52 C= 8.38 - 8.73		ZF (06) L= 3.50 - 3.69 C= 8.38 - 8.73	
ZA (01) L= 3.08 - 3.27 C= 7.91 - 8.26		ZB (02) L= 3.25 - 3.44 C= 7.91 - 8.26		ZC (03) L= 3.42 - 3.61 C= 7.91 - 8.26	

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.

--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

Ross
Barry
L-A

H

Voss
Reilly

I

Tanner
Lee
Gernhardt
Curbeam
Smith

D

Chiao
Foale

E

McArthur
Nicollier
Grunsfeld

F

Hadfield
Parazynski
Robinson
Noriega

A

Wisoff
Jernigan
Usachev

B

Helms

C

Harbaugh

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

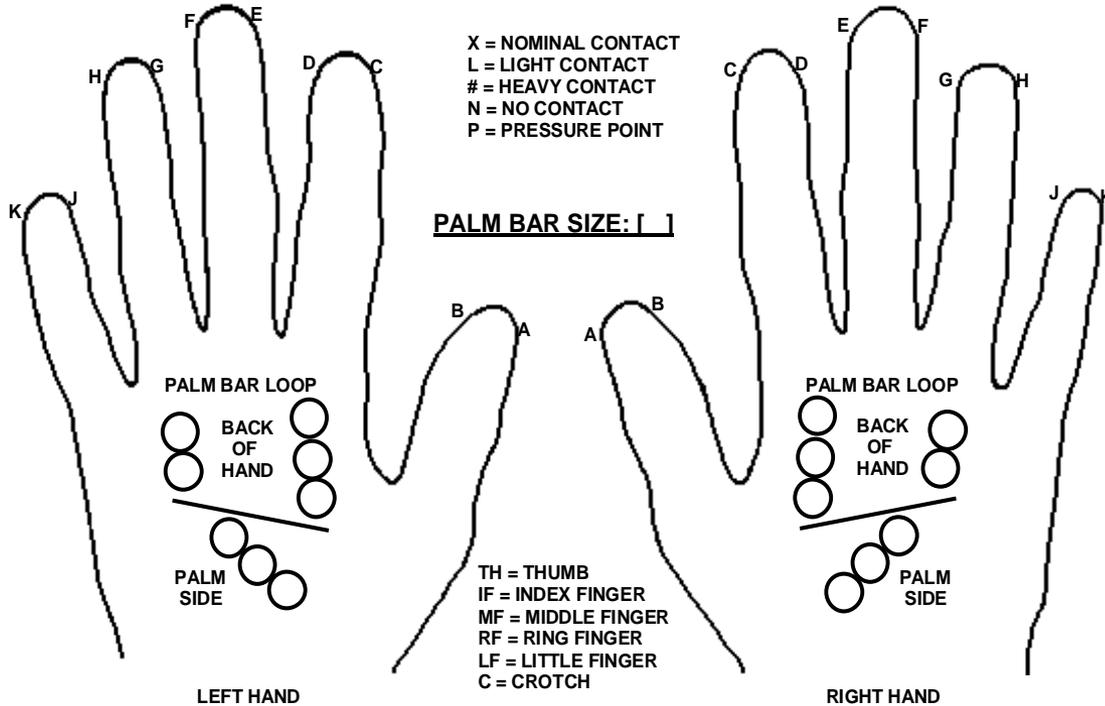
- ◆ **Hand mold**
- ◆ **Arms**

- ◆ **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		INDEX		MIDDLE		RING		LITTLE	
	A	B	C	D	E	F	G	H	J	K
LEFT										
RIGHT										

PALM BAR SHAPE TRACING