



A Trip to Mars Wish List for Apparel and Habitat

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Overview

- Needs for new space suit
- Mars environment
- Needs for cabin apparel
- Needs for habitat
- Review of past and current studies



Space Suit

Materials that protect against:

Thermal extremes

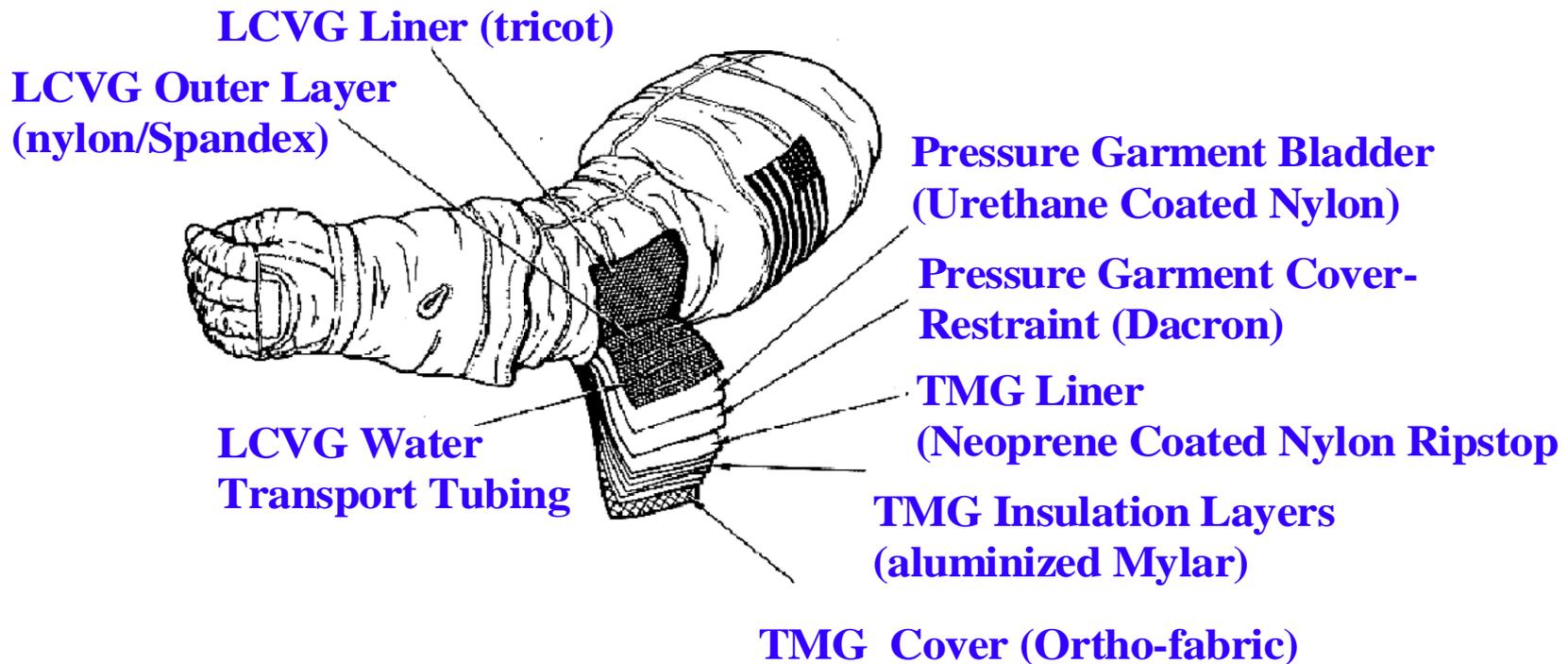
Secondary Ejecta

Cuts and Punctures

Abrasion and wear from dust



Current Suit Arm Segment -Details Of Protective Garment-





Needs For Mars Insulation

-Comparison of Environments for Human Exploration-

| | <u>Earth</u> | <u>LEO/Moon</u> | <u>Mars</u> |
|--------------------|---|---------------------------------|-------------------------------|
| Temperature | -60/ +130 F | -250/ +250 F | -150/+60 F |
| Pressure/ Gases | 760 torr N ₂ , O ₂ | <10 ⁻⁶ torr trace | 8 torr 95% CO ₂ |

Surface Heating/Cooling Relative Effects

| | | | |
|-------------|---|--|---|
| Convection |  |  negl. |  |
| Solid Cond. |  |  |  |
| Radiation |  |  |  |

Mars Environment and Space Suit Thermal Parameters



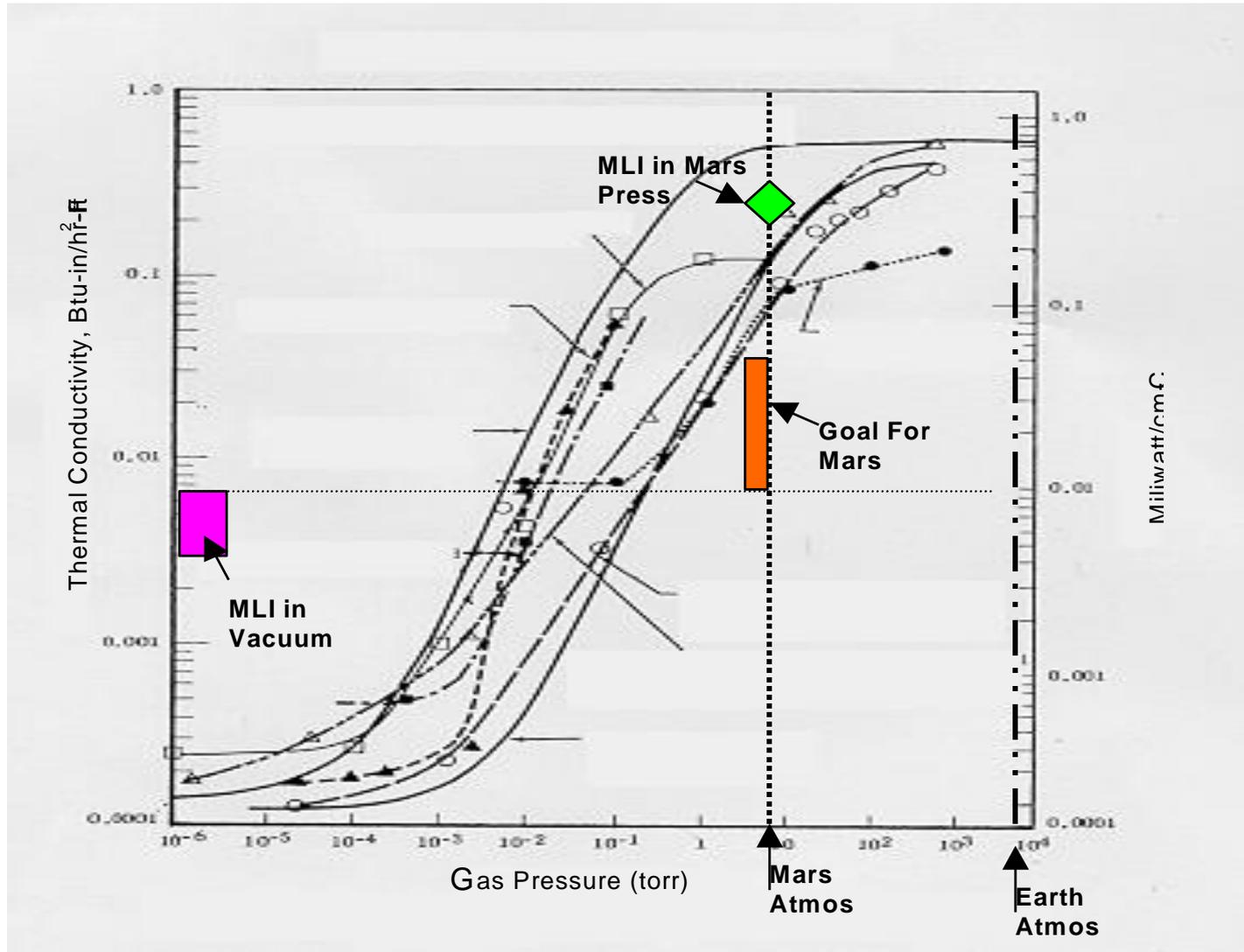
| | Parameters |
|----------------------|--|
| Location | (Representative Cold Mars Environment) |
| Atmos./ Surface Temp | 189 to 227 K (-120 to -50 F) |
| Sky Temp | 142 K (-203 F) |
| Suit Sink Temp | 211 to 227 K (-80 to -50 F) |
| Radiator Sink Temp | 177 to 205 K (-150 to -90 F) |
| Atmos. Press. | 8.5 hPa (6.4 torr) |
| Wind Speed (m/s) | 10 |



Basis For Materials Selection

- Traditional spacesuit MLI for vacuum applications **DOES NOT** work
- Lofty non-wovens **DOMINATE** garment applications for extremely cold environments

Effect of Gas Pressure On Thermal Conductivity --Multi-Layer and Cryogenic Insulation--





Cabin Apparel

Routine wear

Exercise wear

Sleepwear

Special occasions





Clothing Usage Rates on the International Space Station (1998-present)

| Name | Mass (kg) | Usage Rate (No. of days) | No. of Items for 1 Year |
|---|------------------|---------------------------------|--------------------------------|
| Crew Preference Shirt (Long Sleeve) | 0.55 | 15 | 13 |
| Crew Preference Shirt (Short Sleeve) | 0.45 | 15 | 13 |
| Cargo Shorts | 0.35 | 30 | 5 |
| Cargo Pants | 0.65 | 30 | 7 |
| Trousers | 0.6 | 30 | 3 |
| X-Static T-Shirt | 0.3 | 14 | 27 |
| Colored T-Shirt | 0.25 | 7 | 53 |
| Underwear | 0.1 | 2 | 183 |
| X-Static Crew Socks | 0.08 | 14 | 27 |
| Crew Socks, White | 0.08 | 7 | 53 |
| Athletic Shorts | 0.15 | 7 | 53 |
| Total Mass (kg) - 1 Crew | | 75 | |
| Total Mass (kg) - 6 Crew | | 451 | |



Recent changes to the Crew Provisioning Catalog

- A changing Joint Crew Provisioning Catalog with
 1. introduction of new items (i.e. polyester exercise tops, belts per crew preference)
 2. disappearance of some items
(i.e. X-Static shirts, and custom made shuttle pants per depletion of inventory)
- A beginning of on-orbit clothing studies



Needs for Cabin Apparel

Lightweight knitted and woven durable and washable fabrics made of inherently flame retardant long staple fibers and microfibers, dyeable or printable, UV, high frequency microwave, and ozone resistant.

Fast drying fabric in air

Garments with bio-monitoring and drug delivery functions



Needs for Routine Wear fabrics

Inherently flame retardant and non toxic
lightweight, comfortable, aesthetically pleasing
Dyeable, printable, and colorfast
Washable and resistant to UV, high frequency
microwaves, and ozone
Dry fast in air



Needs for Exercise Wear Fabrics

Lightweight breathable

Fast drying

Non clammy when wet

Washable, and resistant to chemical and physical
sanitation methods

Bio-monitoring



Needs for Sleepwear and Special Occasions

For sleepwear

comfortable inside a sleeping bag

flame retardant, non toxic

soothing colors and prints

For special occasions

medical use, drug delivery, fever reduction

public appearance, private events



Needs for Habitat

Multi-purpose Cargo Transfer Bags (MCTB)

inherently flame retardant materials are preferable. While preserving the acoustic quality of the MCTB, a choice of colors may be desirable, pleasant appearance and texture of the two outer layers may be desirable whether the MCTB is in a bag or blanket configuration (looks clean or not), etc.



Needs for Habitat

Crew Quarters

Fabrics that are cleanable/wipe-able

Fabrics that are air permeable enough to allow the noise to travel through the top layer and reach the acoustic treatment layer to absorb sound

Fabrics where particles do not become embedded especially for those instance where there is high crew contact (like clothing, CQs, etc.). This would help with the pleasant appearance of items especially if different colors are an option

Colored fabrics that have higher reflectivity to increase visible light (we currently use mostly white fabrics because it has high reflectivity). Typically don't use colored fabrics because they absorb light (decrease amount of visible light) which results in needing more lighting (increases heat, power, mass, volume, etc.)

Any combinations of these needs would also be ideal.



Concluding Remarks

Needs for new fibers, yarns, and fabrics to address safety, logistics reduction, duration of Mars mission, health and human factors