Human Exploration Technologies for the Second Space Age: Private Development of Space Suits for Earth Orbit and Beyond

Cameron M Smith, PhD
Dept. of Anthropology, Portland State University & Pacific Spaceflight
21 March 2018

Arizona State University
School of Earth and Space Exploration

Portland State UNIVERSITY

Human Exploration Technologies for the Second Space Age (1)

The title:

Human Exploration Technologies for the Second Space Age

Exploration	Settlement
individuals	populations
organism time	ecological time
temporary	permanent
Looking In (Earth)	Looking Out (beyond Earth)
Terrestrial Culture	Extraterrestrial Culture

In aid of the larger goal of *Perpetuation of the Enlightenment through Space and Time*

Human Exploration Technologies for the Second Space Age (2)

The title:

Human Exploration Technologies for the Second Space Age

Not at Settlement Yet

Still Require Generation (s) of Exploration

Cannot begin serious preparation too soon

My goal: OPEN SOURCE THE EXPLORATION TECHNOLOGIES

Get them out of the exclusive hands of the Federal Acquision Process

How to achieve the goal?

Reinvent the basic technologies

Human Exploration Technologies for the Second Space Age (3)

Reinvent the Basic Exploration Technologies

Like technologies of sails, or pottery, or stone tool-making…these technologies will not be containend, they will 'leak iouot'; and proliferate.

Still, requires time to learn the technologies.

I have put in the time.

The knowledge is in my mind.

Now demonstrate, and distribute.

Why?

Why not a costly, high-tech suit for such a project as space access?

Because that is not needed.

Reduce cost of space access = more people in space = more likely for humanity to succeed.

Human Exploration Technologies for the Second Space Age (4)

Human perpetuation through SPACE

The Evolutionary Significance of Aerospace Research and Applications

Alternative title:

Aerospace Research and the Fate of Humanity in Space and Time

Cameron M. Smith

Department of Anthropology

Portland State University

27 October 2017

Text: 1,920 words

Text, Captions and References: 3,120 words

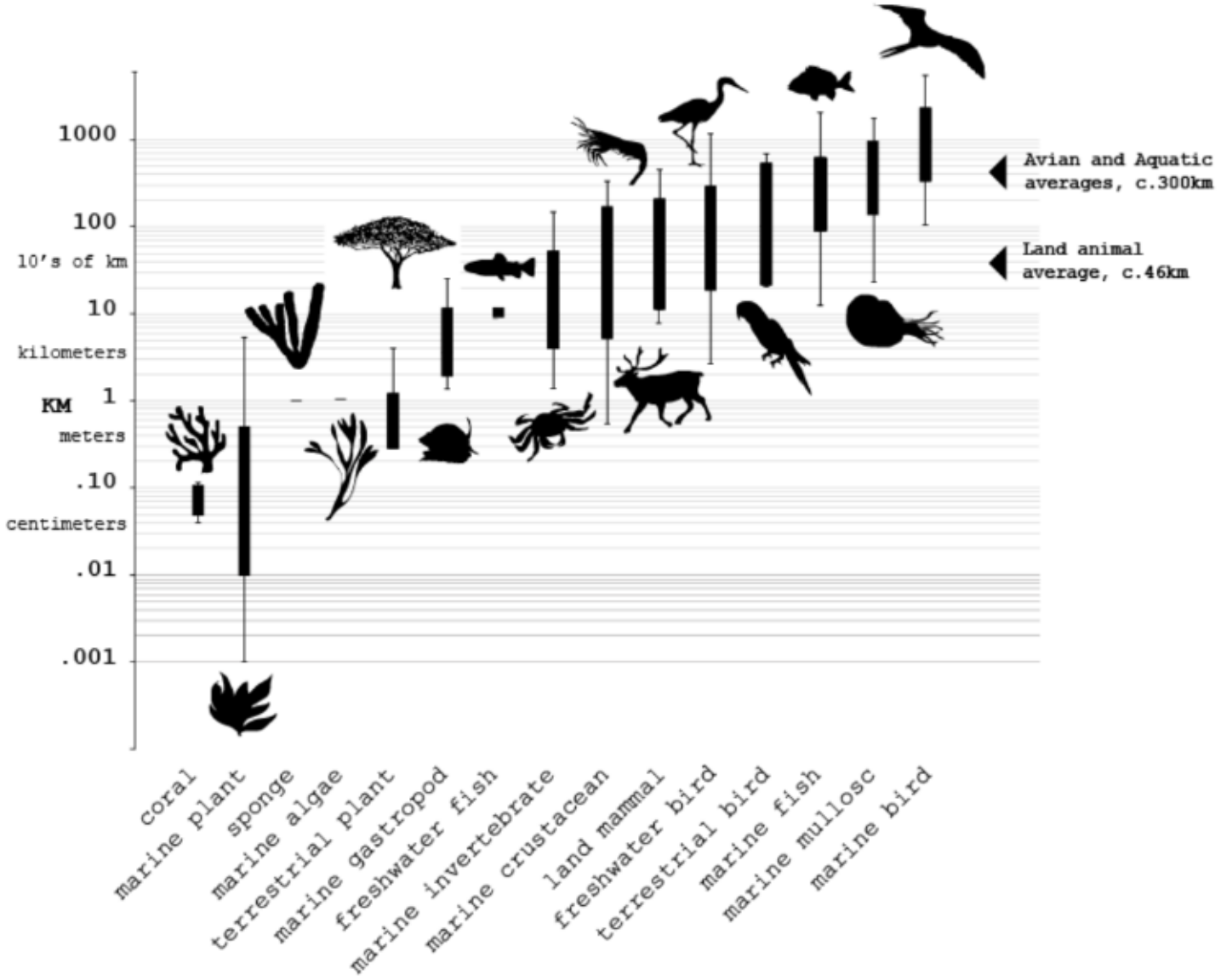
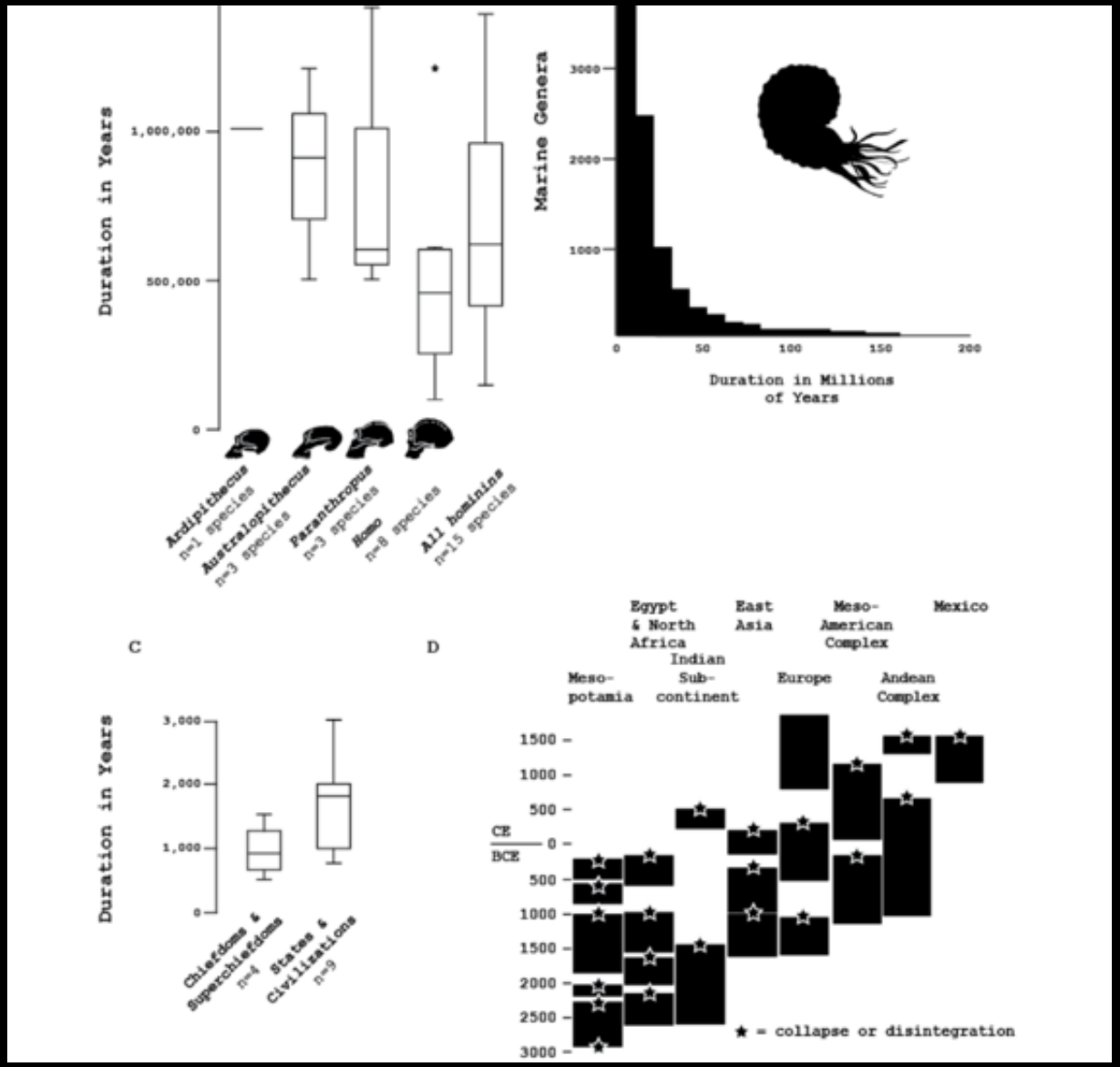
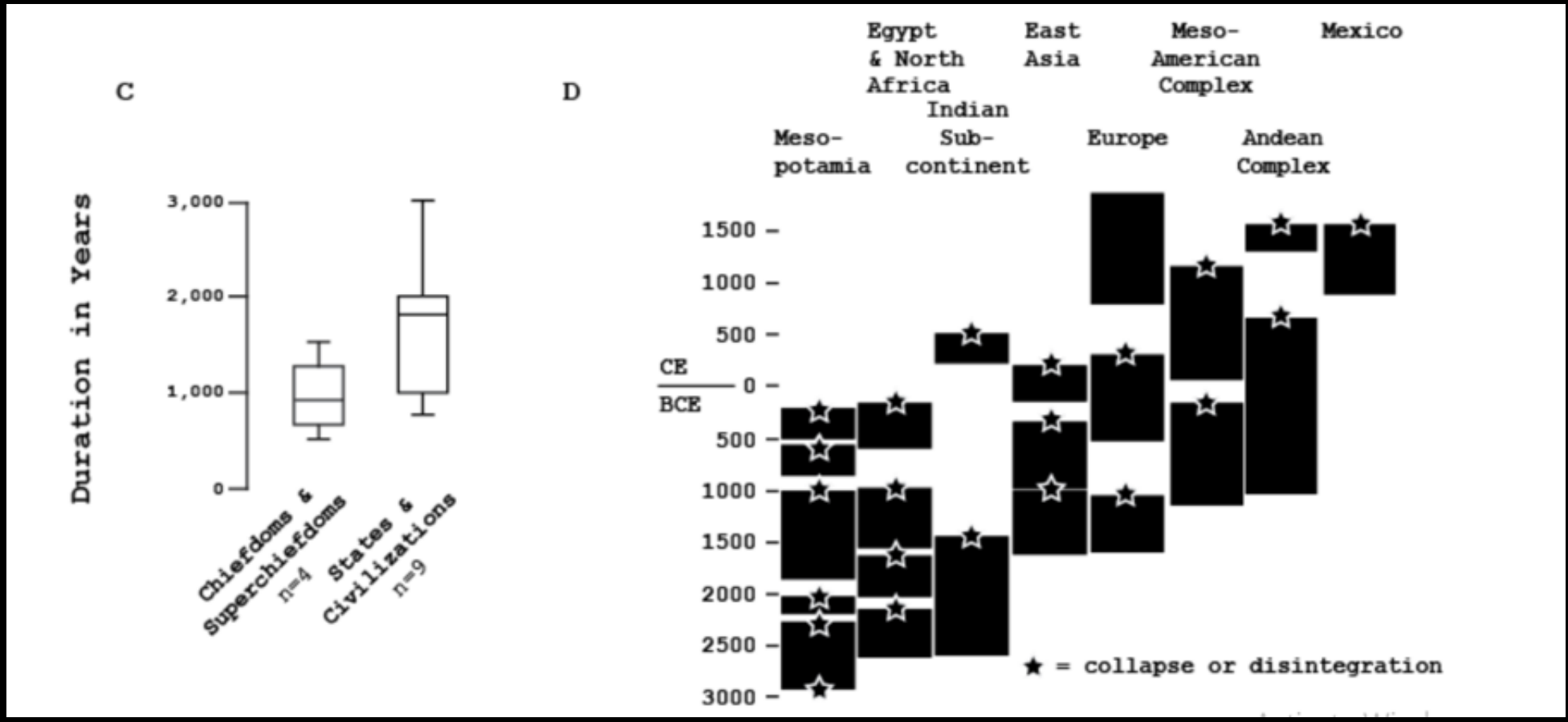


Figure 7. Natal Dispersal Distances Summarized for 311 Species of Earth Life. Raw data were selectively drawn from Daniel, Schmidt and Hughes (2013), Paradis et al (1998), Sutherland et al (2000) and Kinlan and Gaines (2003), after which they were statistically

Human Exploration Technologies for the Second Space Age (5)

Human perpetuation through TIME




C
Duration in Years
3,000
2,000
1,000
0
Chiefdoms & Superchiefdoms
n=4
States & Civilizations
n=9
D
Meso-potamia
Egypt & North Africa
Indian Sub-continent
East Asia
Europe
Meso-American Complex
Andean Complex
Mexico
1500
1000
500
CE
0
BCE
500
1000
1500
2000
2500
3000
★ = collapse or disintegration

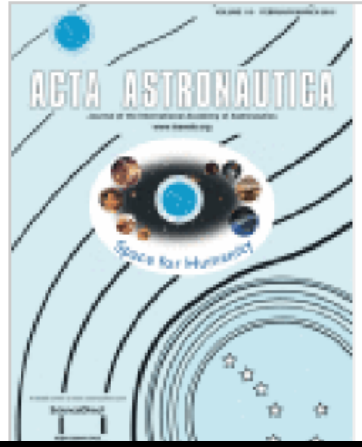
Book

Principles of Space Anthropology: Establishing a Science of Human Space ...

(2017)

Cameron M. Smith

Human space settlement will be the extension of human adaptation from terrestrial to extraterrestrial (off-Earth) environments. Space settlement should therefore ...



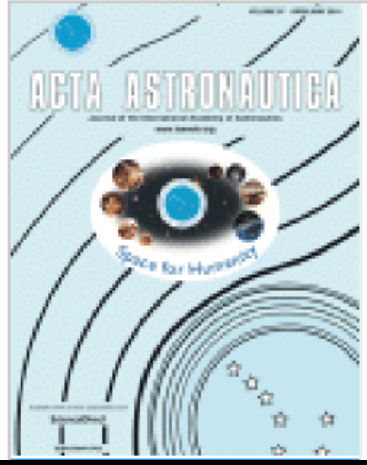
Article

An Adaptive Paradigm for Human Space Settlement

Acta Astronautica (2016)

Cameron M. Smith

Because permanent space settlement will be multigenerational it will have to be viable on ecological timescales so far unfamiliar to ...



Article

Estimation of a Genetically Viable Population for Multigenerational Interstellar Voyaging ...

Acta Astronautica (2014)

Cameron M. Smith

Designing interstellar starships for human migration to exoplanets requires establishing the starship population, which factors into many variables including closed-ecosystem ...

Human Exploration Technologies for the Second Space Age (6)

Cost-to-orbit

NASA

$10,000 / lb
ACES suit = 70lb
= $700,000 to orbit

Roscosmos

$8,000 / lb
Sokolsuit = 20lb
= $160,000 to orbit

Human Exploration Technologies for the Second Space Age (7)

Cost-to-orbit

SpaceX

$4,000 / lb
SpaceX suit = ?lb
= $? to orbit

Pacific Spaceflight

$4,000 / lb
Mark VI suit = 10lb
= $40,000 to orbit

Human Exploration Technologies for the Second Space Age (8)

Suit Costs

NASA $100,000 / unit for Modified ACES suit (David Clark Company)

Roscosmos $50,000 / unit for Sokol suit (Roscosmos)

Human Exploration Technologies for the Second Space Age (9)

Suit Costs

SpaceX ?
(internal development underway)

Pacific Spaceflight $1,000 goal

Human Exploration Technologies for the Second Space Age (10)

Total Costs:
A Suit to
Orbit

NASA
suit + launch

= $800,000

Roscosmos
suit + launch

= $210,000

SpaceX
suit + launch

= ?

Pacific
Spaceflight
suit + launch

= c. $40,000

Human Exploration Technologies for the Second Space Age (11)

These costs
are still too
high!

But we must
start
somewhere.

Human Exploration Technologies for the Second Space Age (12)

Radically Reducing Suit Costs:

* ‘design by taxpayer’
* phobia of of failure
* military-industrial-political Old Boy Networks → UNEXAMINED CONTRACTS
* ignorance of public
* obfuscation and misinformation by space agencies

‘only we can do it’

* propagation of RSF by space agencies

Human Exploration Technologies for the Second Space Age (13)

The Right Stuff Fallacy

Space access is for the chisel-chinned space hero, only NASA can do it.

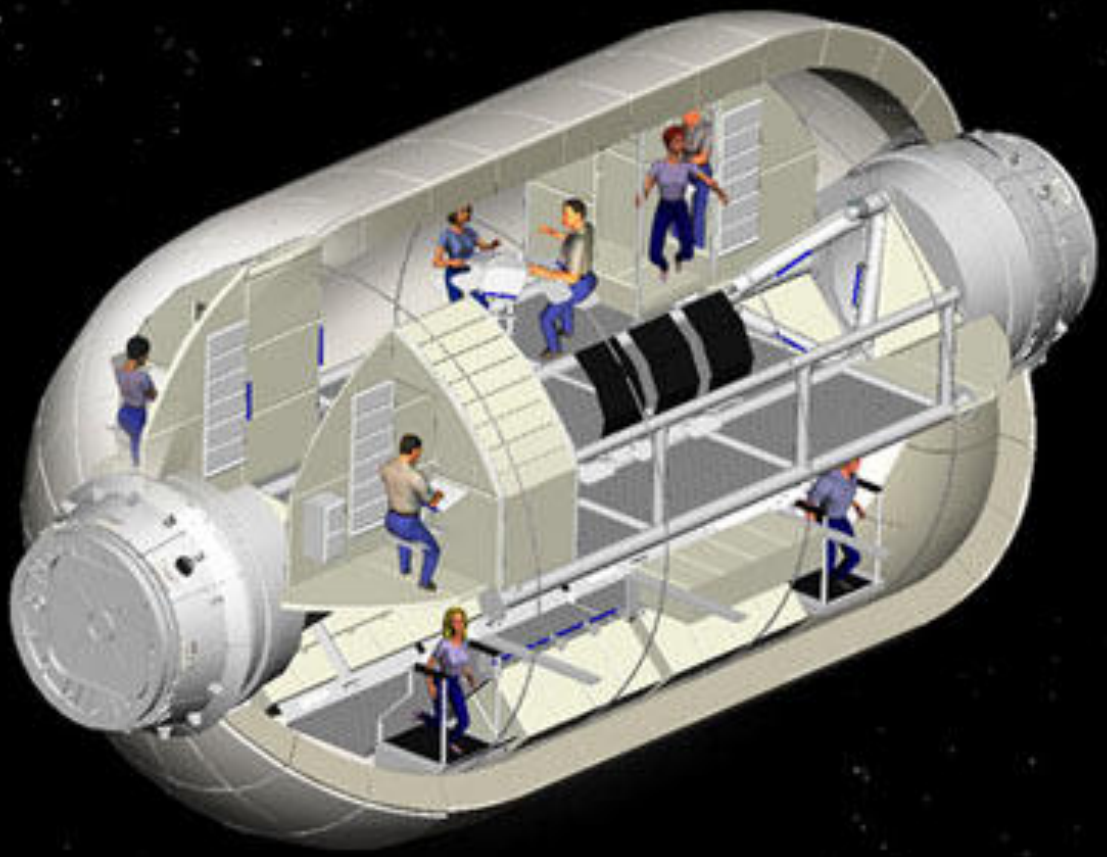
Human Exploration Technologies for the Second Space Age (14)

DISMANTLING The Right Stuff Fallacy

Many worldwide now dismantling this exclusive approach.
e.g. Copenhagen Suborbitals
(there are others)

Human Exploration Technologies for the Second Space Age (15)

DISMANTLING The Right Stuff Fallacy



Many worldwide now dismantling this exclusive approach.
e.g. Bigelow Aerospace

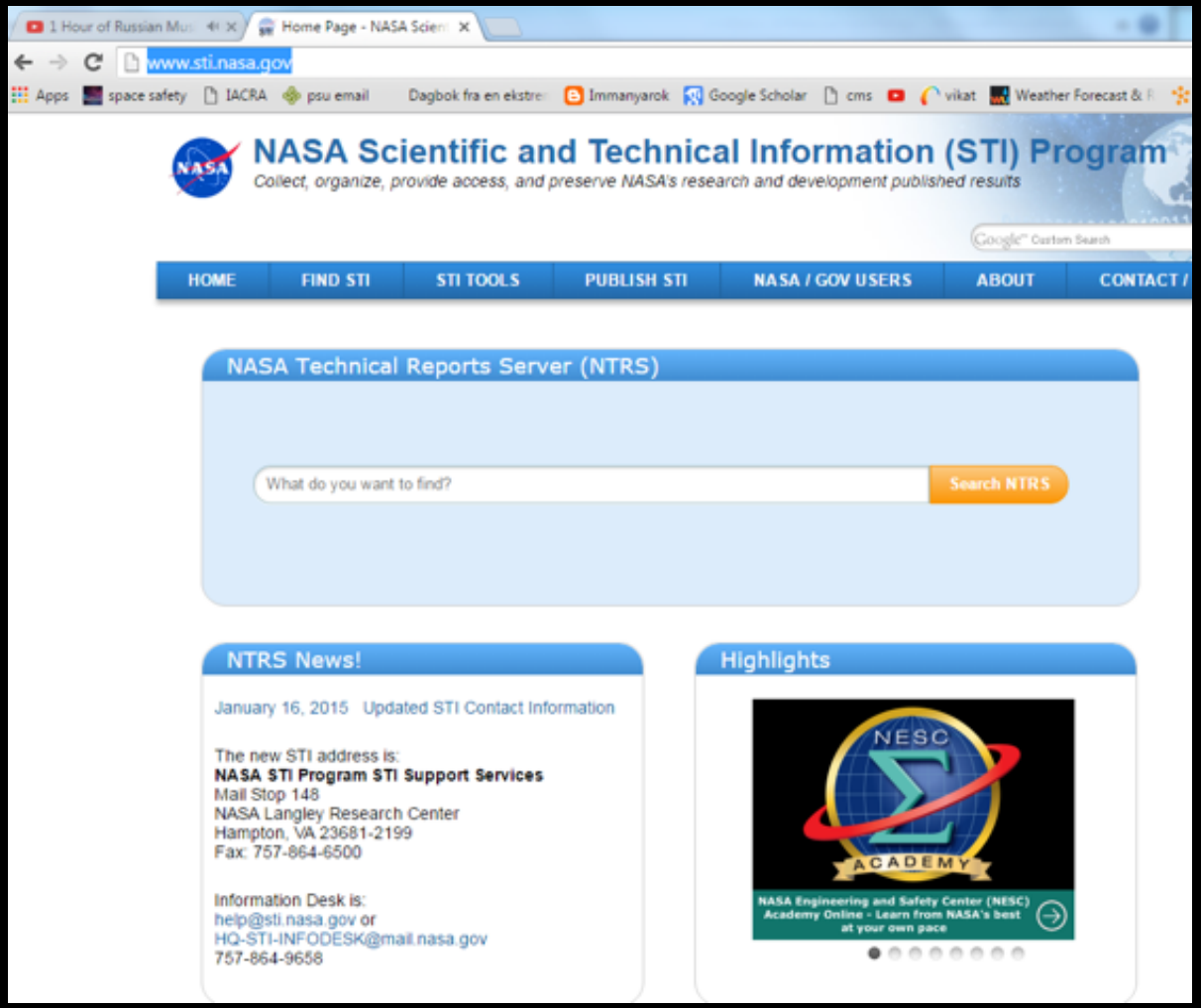
Human Exploration Technologies for the Second Space Age (15)

DISMANTLING The Right Stuff Fallacy

Many worldwide now dismantling this exclusive approach.
e.g. Final Frontier Design

Human Exploration Technologies for the Second Space Age (16)

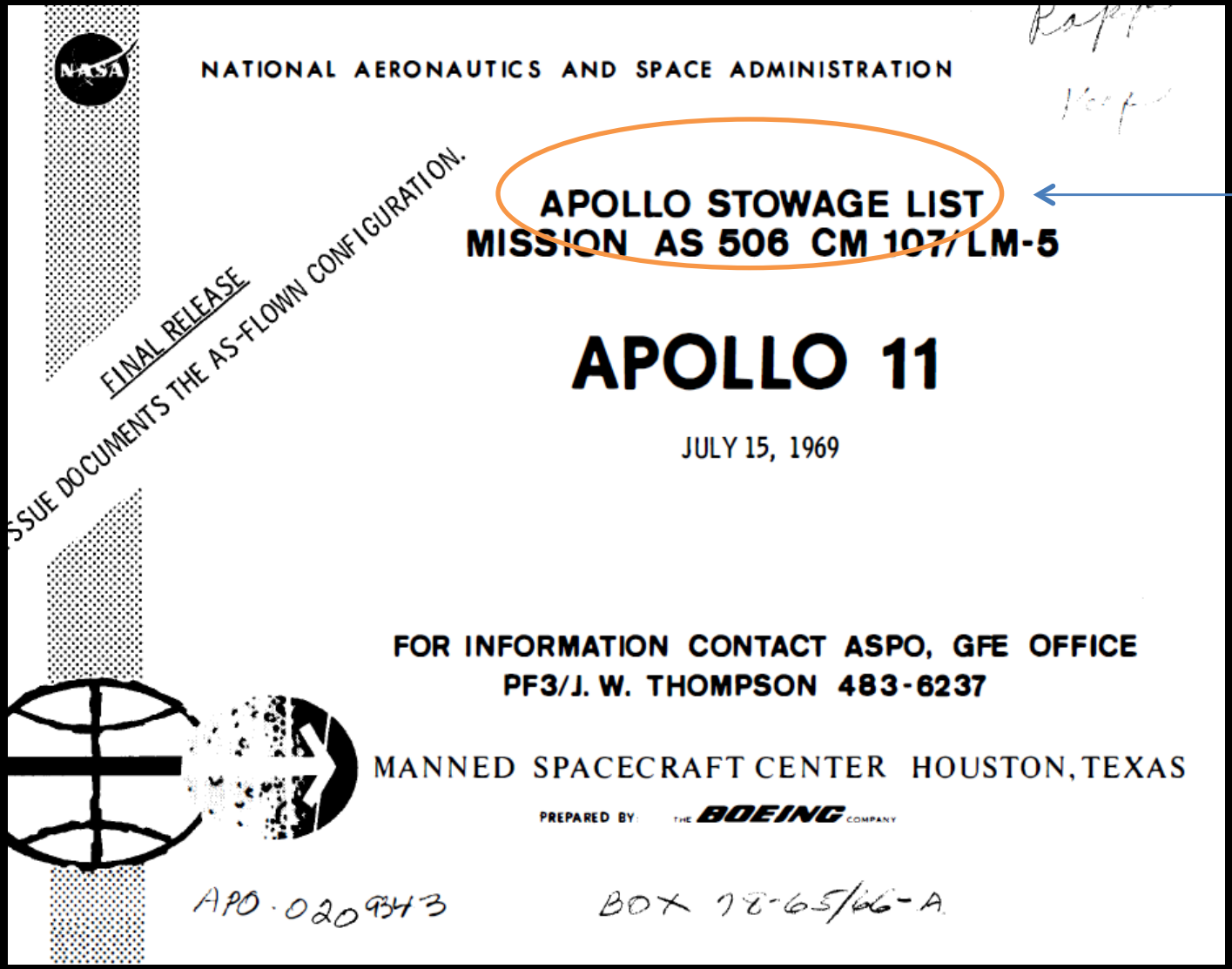
Radically Reducing Cost of the Launch-Entry Garment



Learn from >50 years of archived NASA Technical Report Server

Human Exploration Technologies for the Second Space Age (17)

Radically Reducing Cost of the Launch-Entry Garment



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FINAL RELEASE

SSUE DOCUMENTS THE AS-FLOWN CONFIGURATION.

APOLLO STOWAGE LIST
MISSION AS 506 CM 107/LM-5

APOLLO 11

JULY 15, 1969

FOR INFORMATION CONTACT ASPO, GFE OFFICE
PF3/J. W. THOMPSON 483-6237

MANNED SPACECRAFT CENTER HOUSTON, TEXAS

PREPARED BY: THE BOEING COMPANY

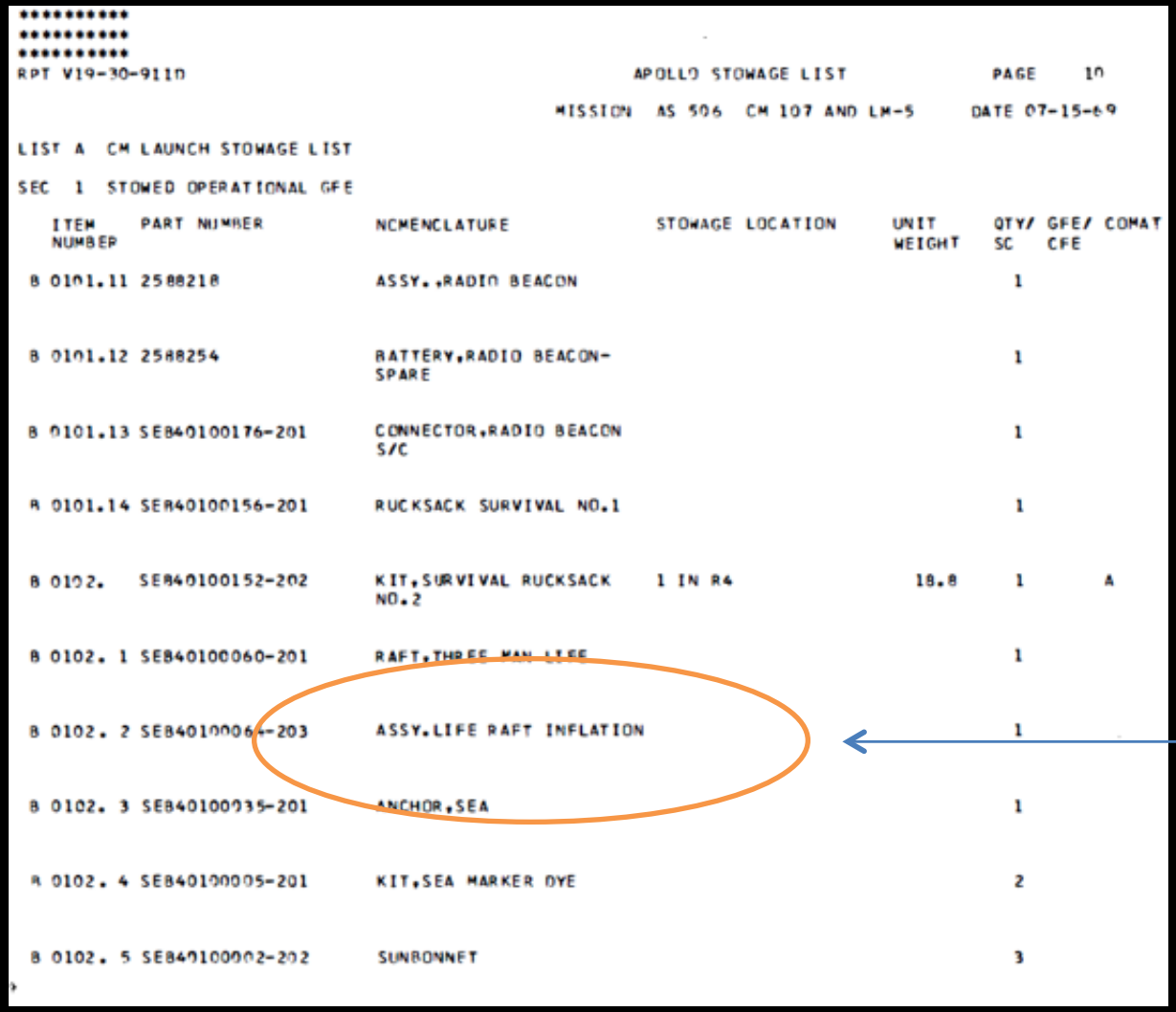
APO-020943

BOX 12-65/66-A

Mission Reports and Flight Plans

Human Exploration Technologies for the Second Space Age (18)

Radically Reducing Cost of the Launch-Entry Garment



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RPT V19-30-9110 APOLLO STOWAGE LIST PAGE 10

MISSION AS 506 CM 107 AND LM-5 DATE 07-15-69

LIST A CM LAUNCH STOWAGE LIST

SEC 1 STOWED OPERATIONAL GFE

ITEM NUMBER	PART NUMBER	NOMENCLATURE	STOWAGE LOCATION	UNIT WEIGHT	QTY/ SC	GFE/ CFE	COMAT
B 0101.11	2588218	ASSY.,RADIO BEACON			1		
B 0101.12	2588254	BATTERY,RADIO BEACON-SPARE			1		
B 0101.13	SE840100176-201	CONNECTOR,RADIO BEACON S/C			1		
B 0101.14	SE840100156-201	RUCKSACK SURVIVAL NO.1			1		
B 0102.	SE840100152-202	KIT,SURVIVAL RUCKSACK NO.2	1 IN R4	18.8	1		A
B 0102. 1	SE840100060-201	RAFT,THREE MAN LIFE			1		
B 0102. 2	SE840100064-203	ASSY.LIFE RAFT INFLATION			1		
B 0102. 3	SE840100035-201	ANCHOR,SEA			1		
B 0102. 4	SE840100005-201	KIT,SEA MARKER DYE			2		
B 0102. 5	SE840100002-202	SUNBONNET			3		

Learn from >50 years of archived NASA Mission Reports and Flight Plans

Human Exploration Technologies for the Second Space Age (19)

Radically Reducing Cost of the Launch-Entry Garment

'Escafandra Estratonautica'

Spain

Col Emilio Herrera 1935+

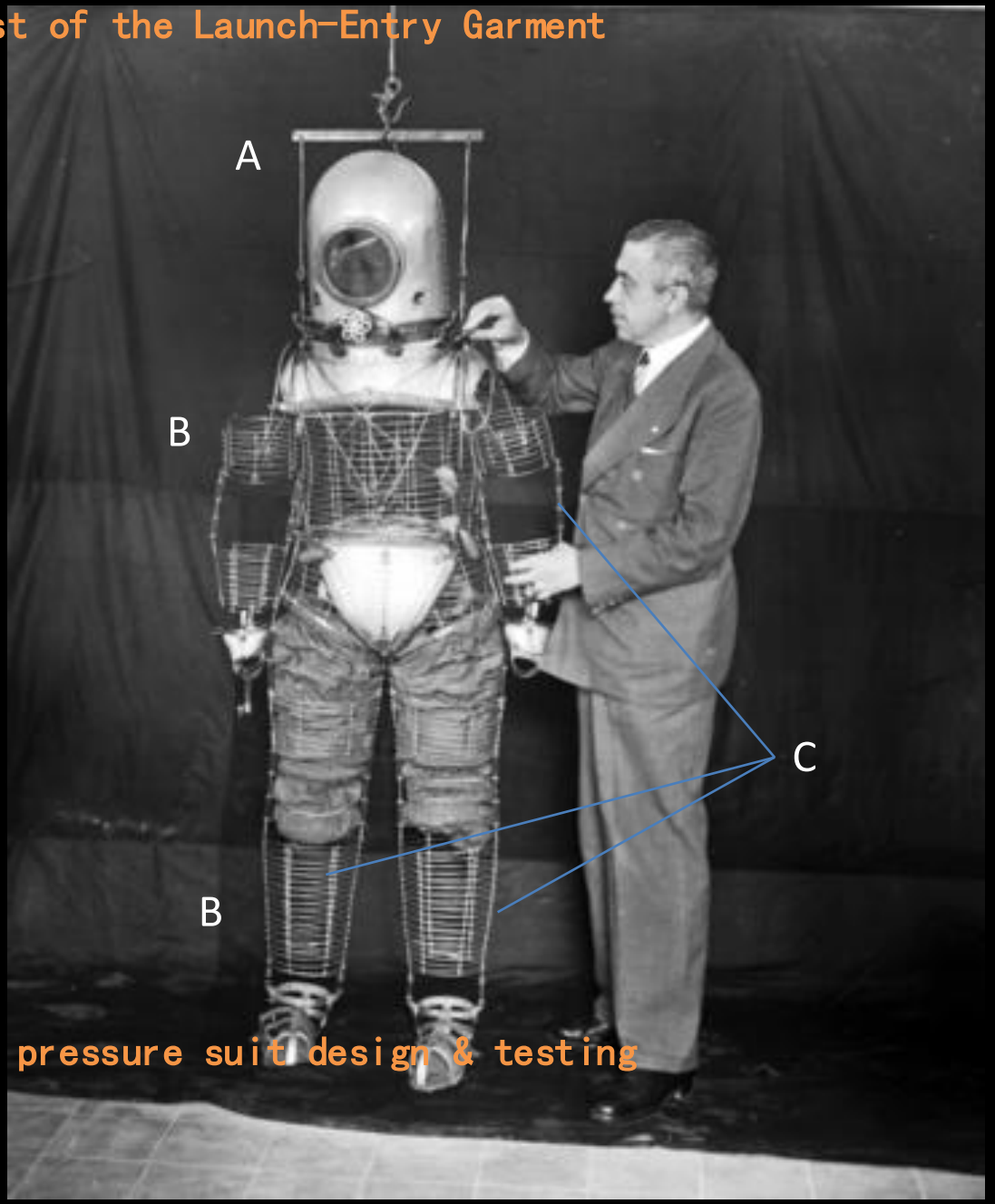
Simulated to c. FL800 (thus *high* suit pressure)

A. hard helmet

B. bellows / convolutes for constant volume

C. anti-elongation cabling

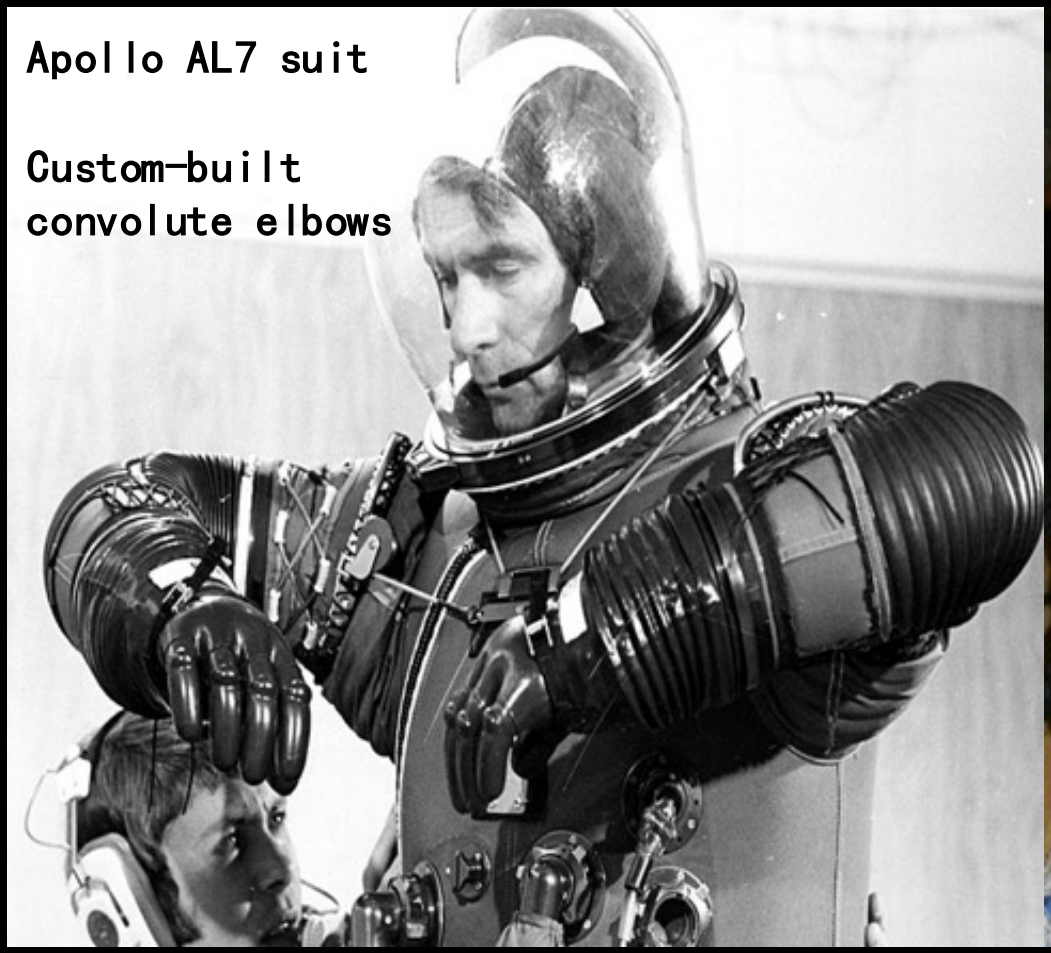
D. 3 hours at FL800 indicated no cold, rather heat was the issue



Learn from >50 years of pressure suit design & testing

Human Exploration Technologies for the Second Space Age (20)

Radically Reducing Cost of the Launch-Entry Garment



Apollo AL7 suit

Custom-built convolute elbows

PS Mark III

Sewage hose or reinforced butyl drybox sleeves

performance same at high suit pressures

New Materials / Building Supplies

Human Exploration Technologies for the Second Space Age (21)

Radically Reducing Cost of the Launch-Entry Garment

Learn from the Pros!
M. Mosely, 44 years a Boeing
Project Gemini space suit technician.
“This all looks exactly right.”

Human Exploration Technologies for the Second Space Age (22)

Radically Reducing Cost of the Launch-Entry Garment

PS Mark III

Testing in-house

Get results to
NASA Gemini levels.

Set appropriate performance criteria.

Sufficient for
Launch-Entry suit.

Human Exploration Technologies for the Second Space Age (23)

Radically Reducing Cost of the Launch-Entry Garment

Parachute
& 10 min 02 supply

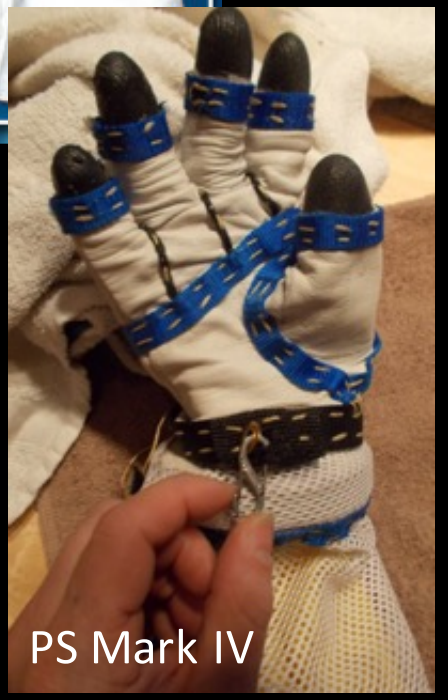
Eliminate, of course,
costly & weighty extras.

Set appropriate performance criteria.

NASA employee: “Nobody ever expected that to work for the Shuttle.”

Human Exploration Technologies for the Second Space Age (24)

Radically Reducing Cost of the Launch-Entry Garment

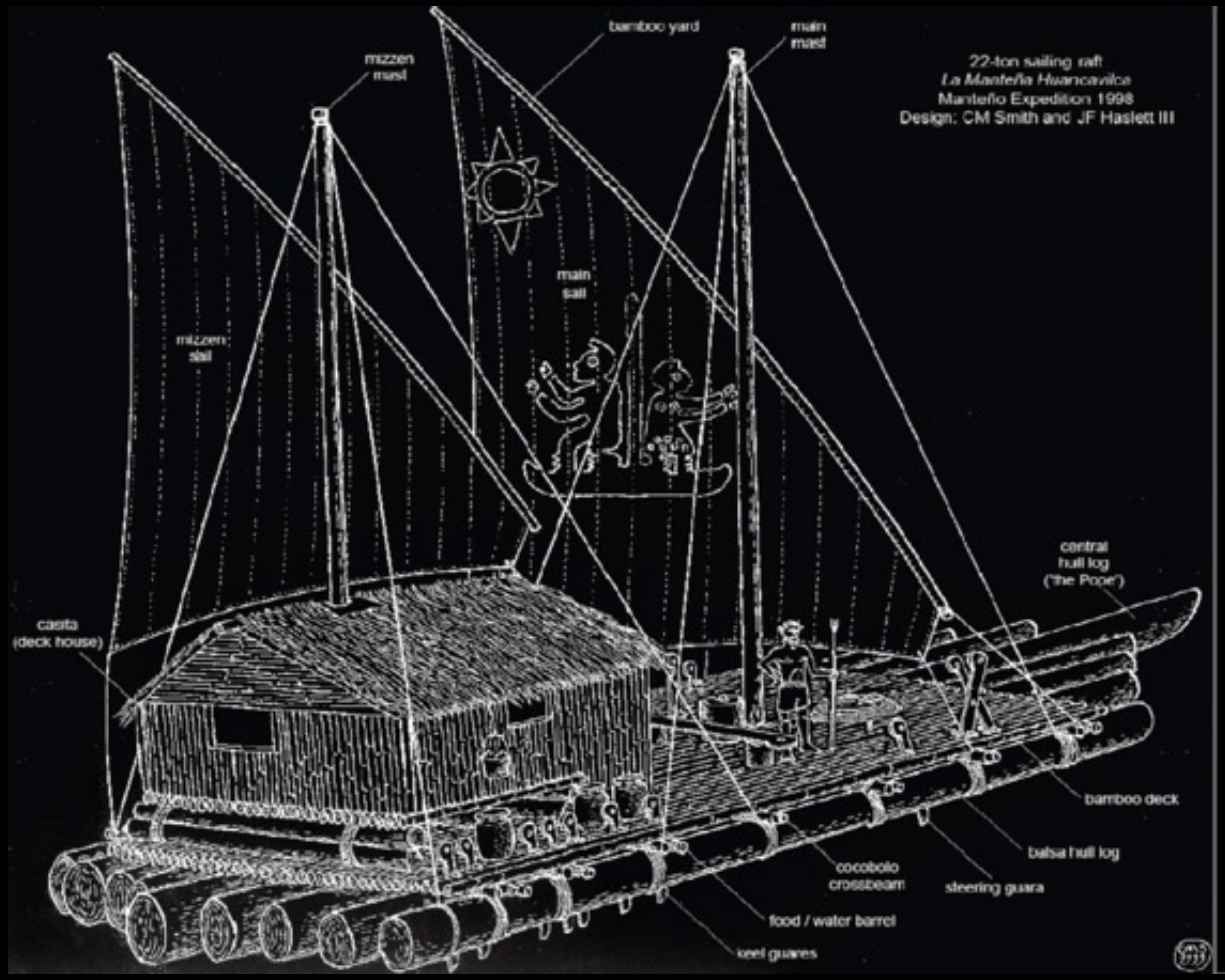


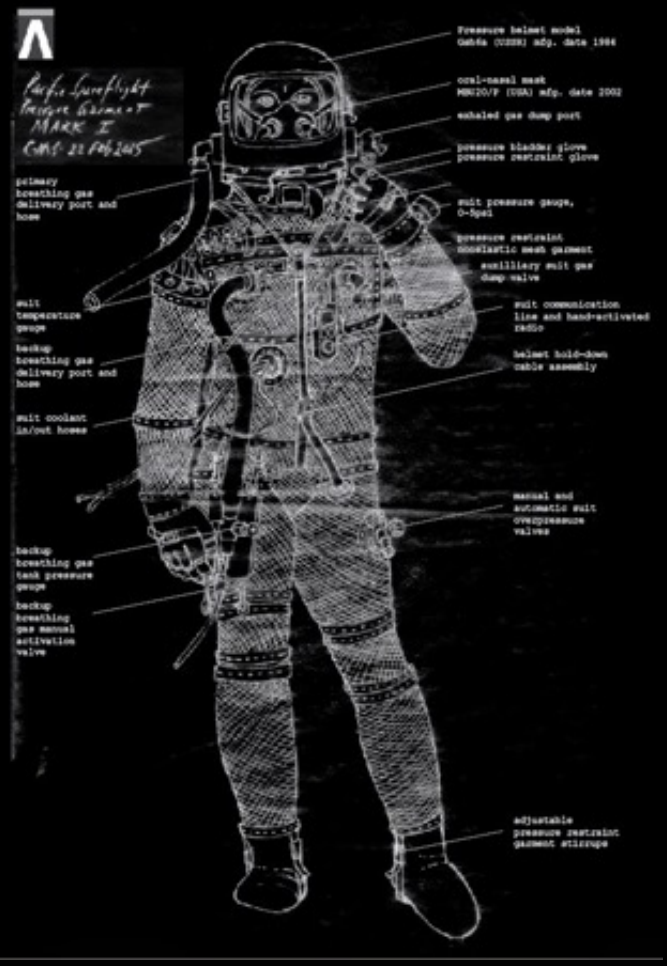
Eliminate, of course,
costly & weighty extras.

Set appropriate performance criteria.

Extremely high-dexterity glove not required for Return-to-Earth scenarios.

Radically Reducing Cost of the Launch-Entry Garment
Applying my experiences to Fundamental Exploration Technologies

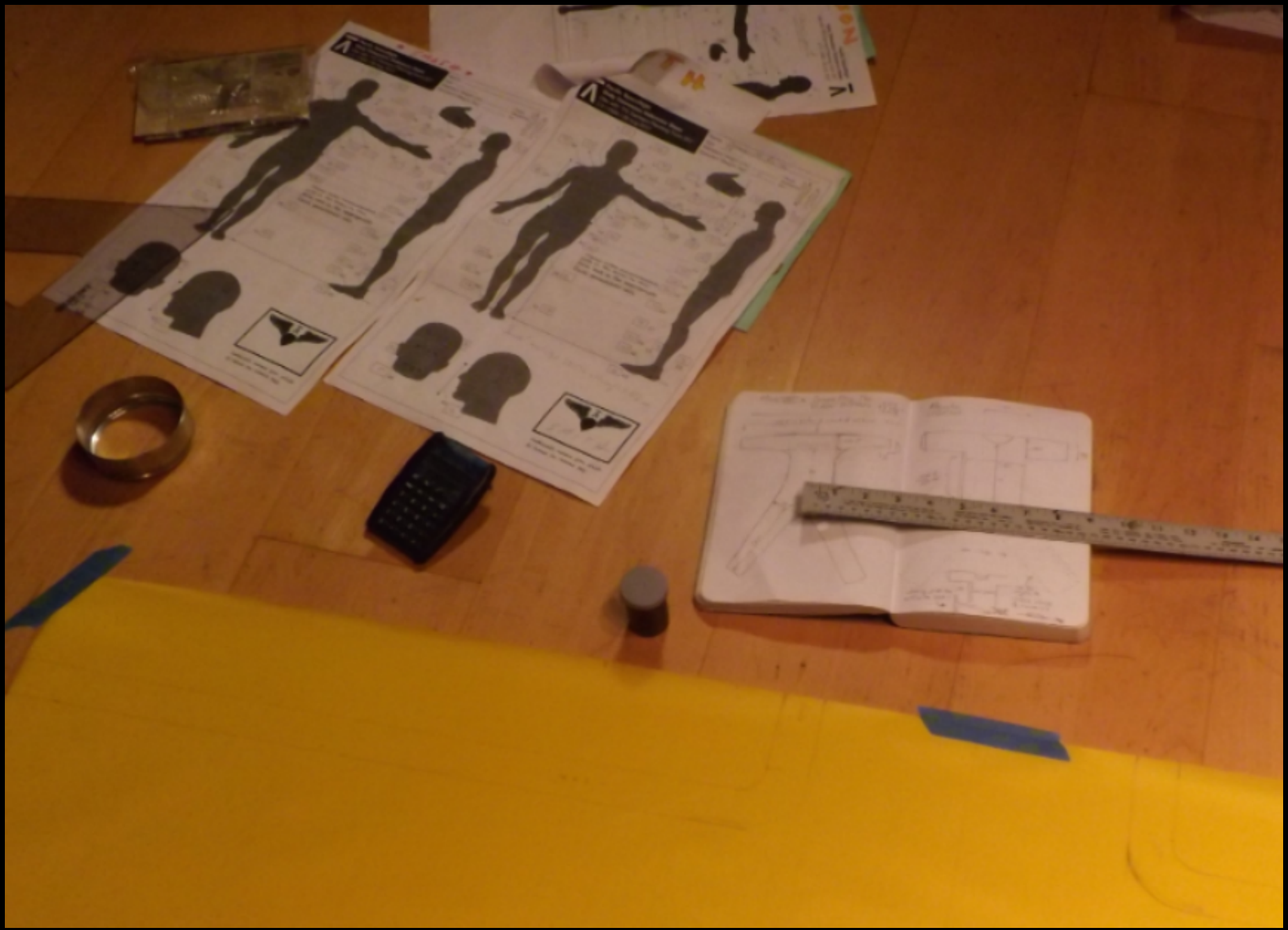




Radically Reducing Cost of the Launch-Entry Garment

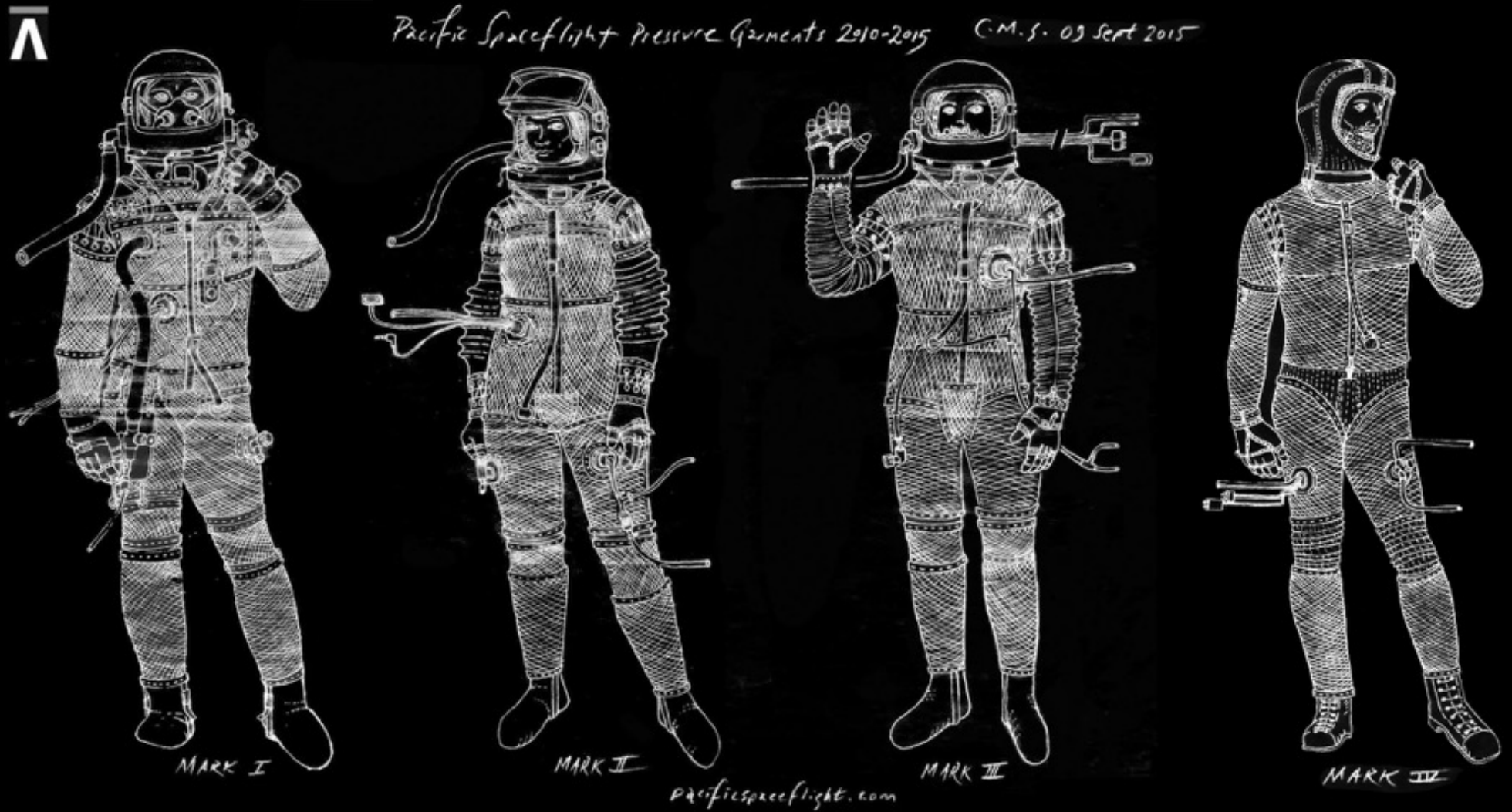
Learn and Master the Fabrication Technologies and Techniques

We do it all under one roof, in 750-sq foot studio condominium in downtown Portland, Oregon.



Human Exploration Technologies for the Second Space Age (25)

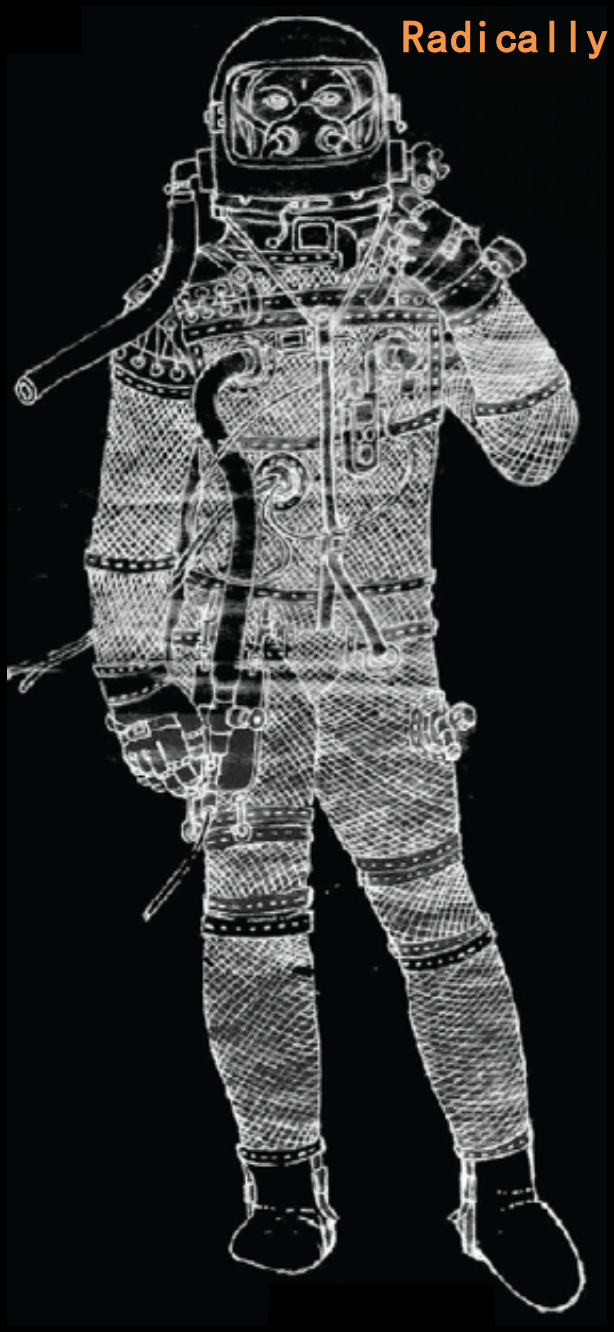
Radically Reducing Cost of the Launch-Entry Garment



Reiterate & Rebuild

Human Exploration Technologies for the Second Space Age (26)

Radically Reducing Cost of the Launch-Entry Garment

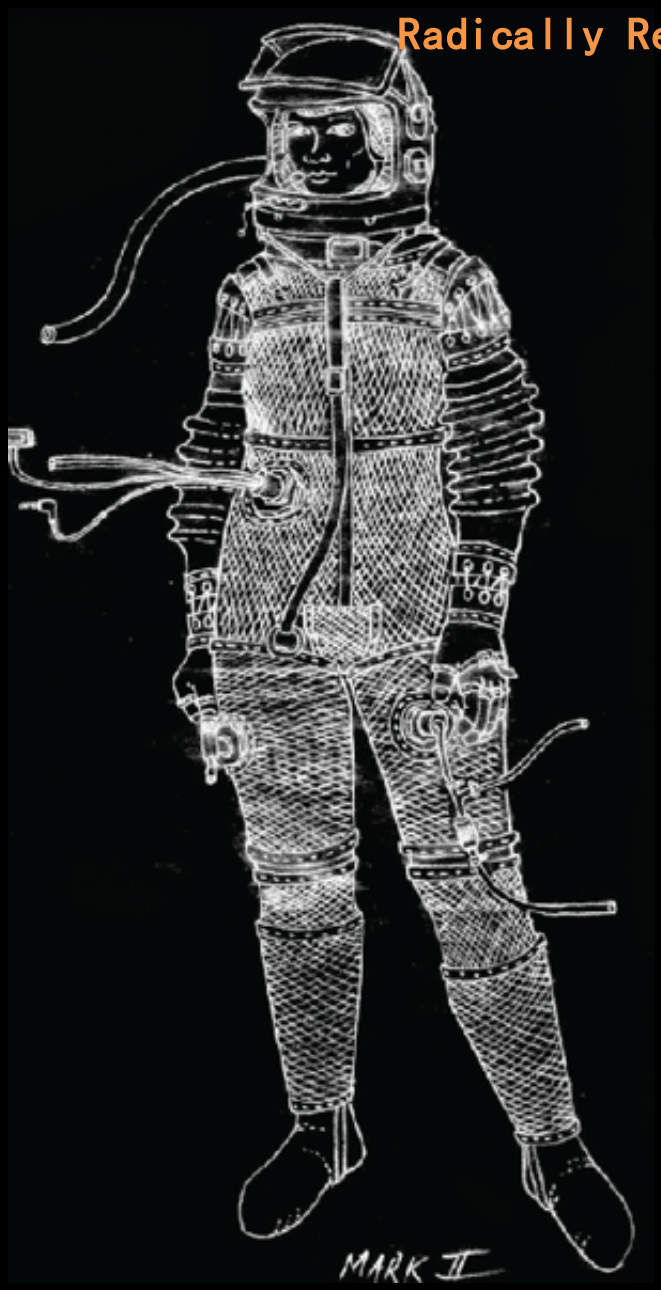


Metal helmet	Assumed needed!
Clutter of Ports	Assumed needed
Redundant O2 System	Assumed needed
Heavy boots	Assumed needed

Mark I

Human Exploration Technologies for the Second Space Age (27)

Radically Reducing Cost of the Launch-Entry Garment

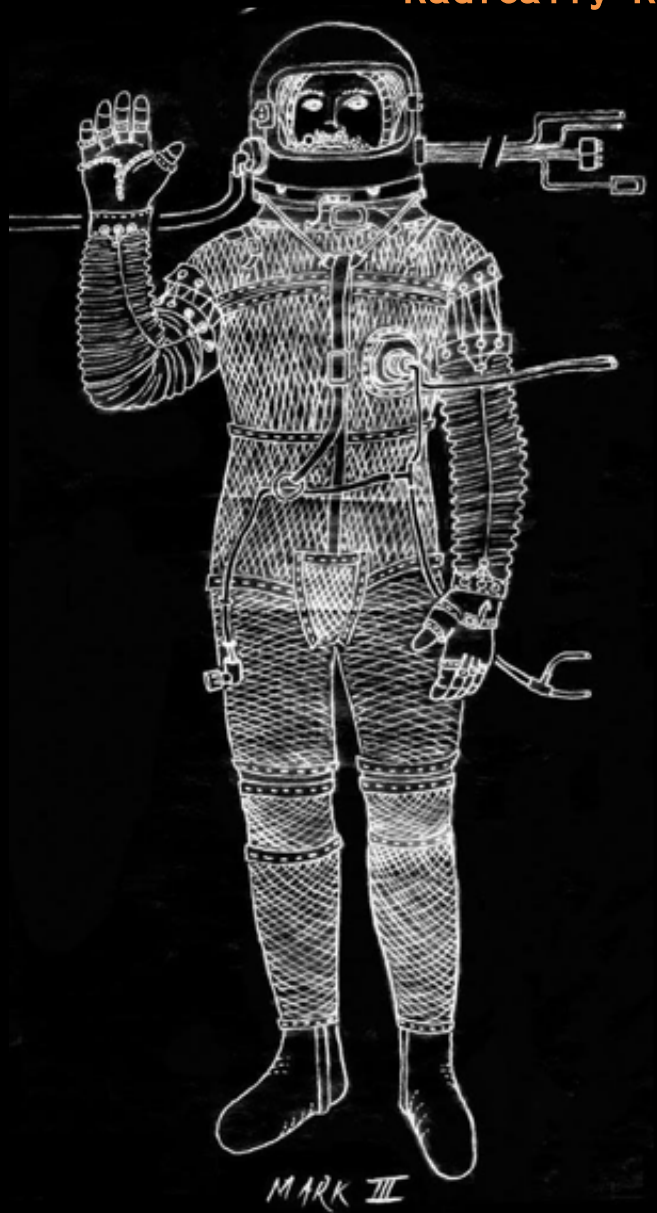


Metal helmet	Assumed needed!
Clutter of Through-ports	Reducing
Redundant O2 System	Gone
Elbow mobility	Improved

Mark II

Human Exploration Technologies for the Second Space Age (28)

Radically Reducing Cost of the Launch-Entry Garment

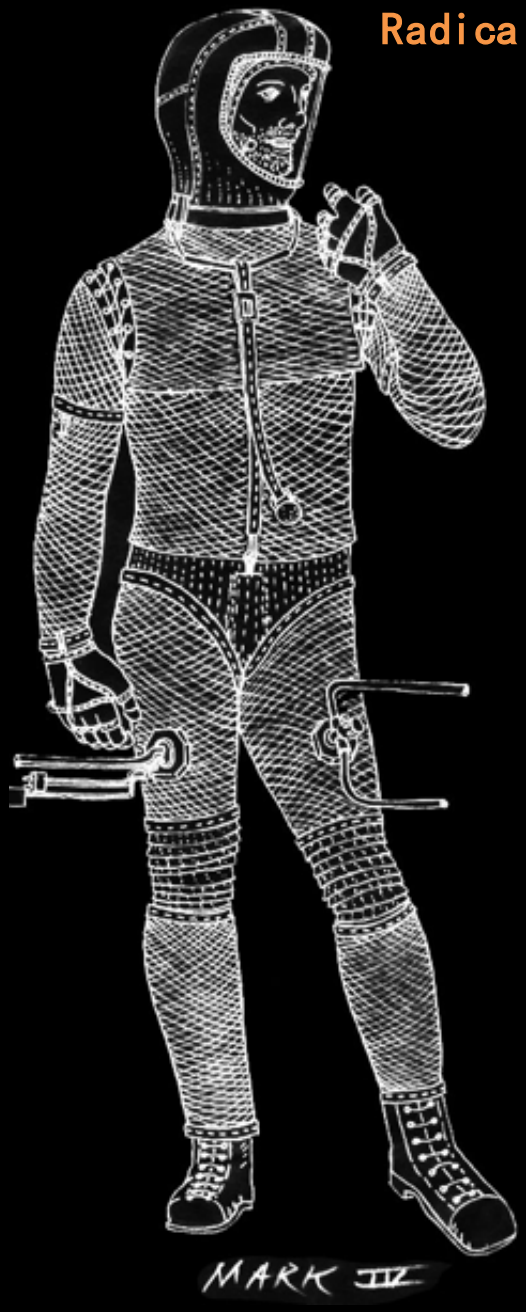


Metal helmet	Assumed needed!
Clutter of Through-ports	Reducing
Redundant O2 System	Gone
Elbow mobility	Improved w/ slimmer convolutes
Suit Pressure Gauge	Gone

Mark III

Human Exploration Technologies for the Second Space Age (29)

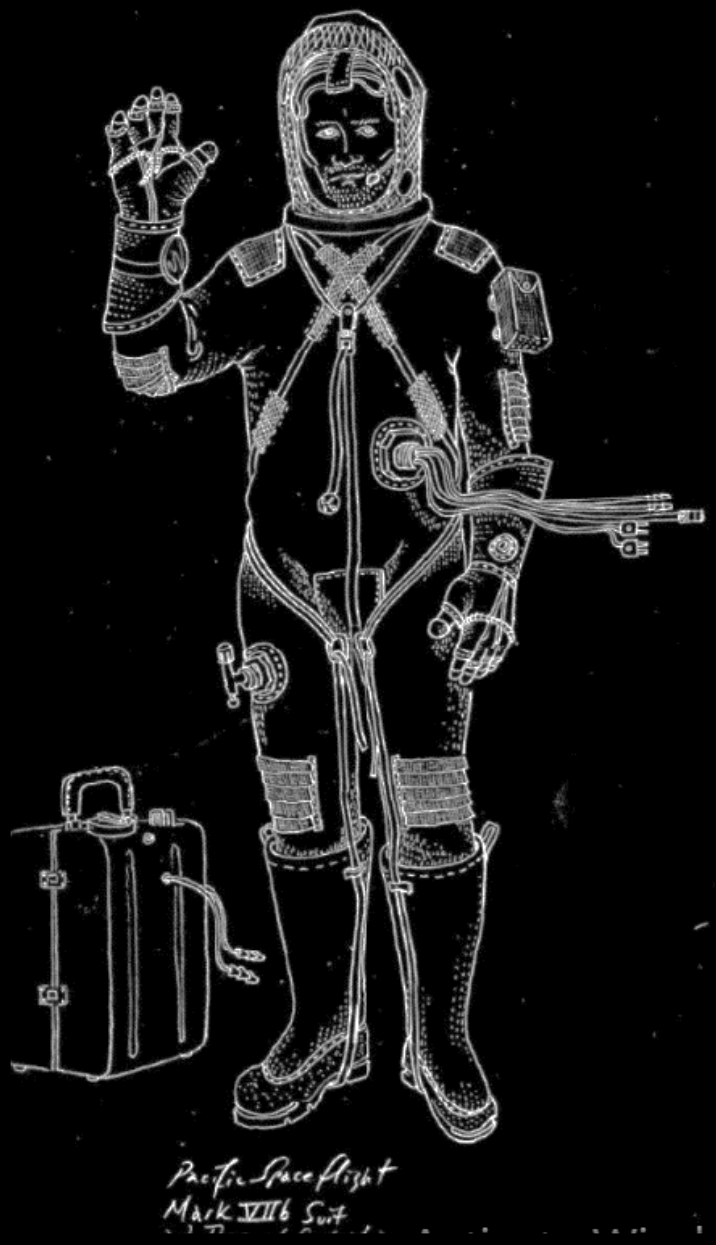
Radically Reducing Cost of the Launch-Entry Garment



Metal helmet	Gone!
Clutter of Through-ports	Two only
Redundant O2 System	Gone
Elbow mobility	Improved w/ yet again slimmer convolutes
Mark IV	

Human Exploration Technologies for the Second Space Age (30)

Radically Reducing Cost of the Launch-Entry Garment



Metal helmet	Textile only
Clutter of Through-ports	Two only
Redundant O2 System	Gone
Elbow mobility	Improved w/ yet again slimmer convolutes
Simpler Don/Doff	Moved Zipper
Mark VIIb	

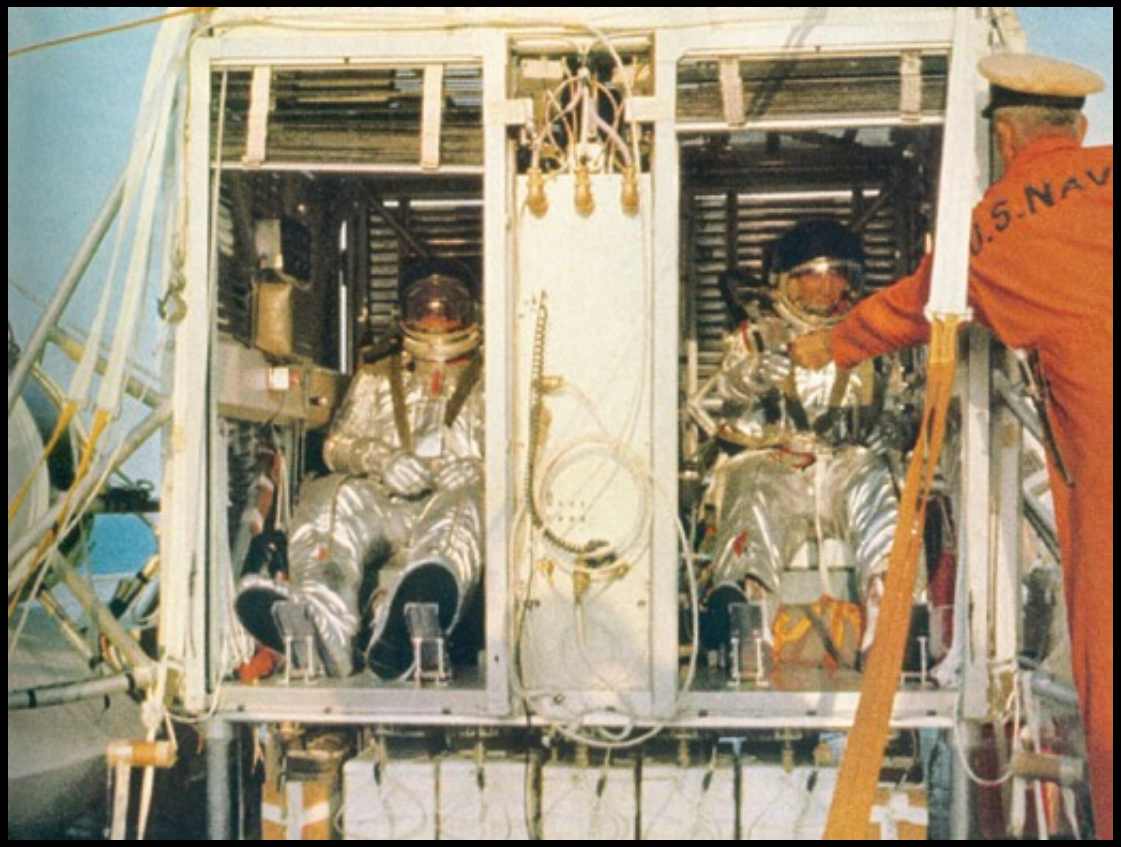

LOCK
UNLOCK

Human Exploration Technologies for the Second Space Age (31)

Now:

1. Continue designing, building, testing.

2. Test flights to high altitude = NASA method = CREDIBILITY.



Malcom Ross, Victor Prather 04 May 1961

Human Exploration Technologies for the Second Space Age (32)

Test in non-sterile conditions.

What wears out soonest?

What routine maintenance is needed?

Will only know with extensive field testing.

Human Exploration Technologies for the Second Space Age (35)

Keep upping the ante.

Looking for access to vacuum and thermal chambers.

Apollo PLSS ‘Baked’ several hours at +200F, ‘frozen’ 12 hours at -22F.

Thermal range testing with dry ice sublimating at -91F.

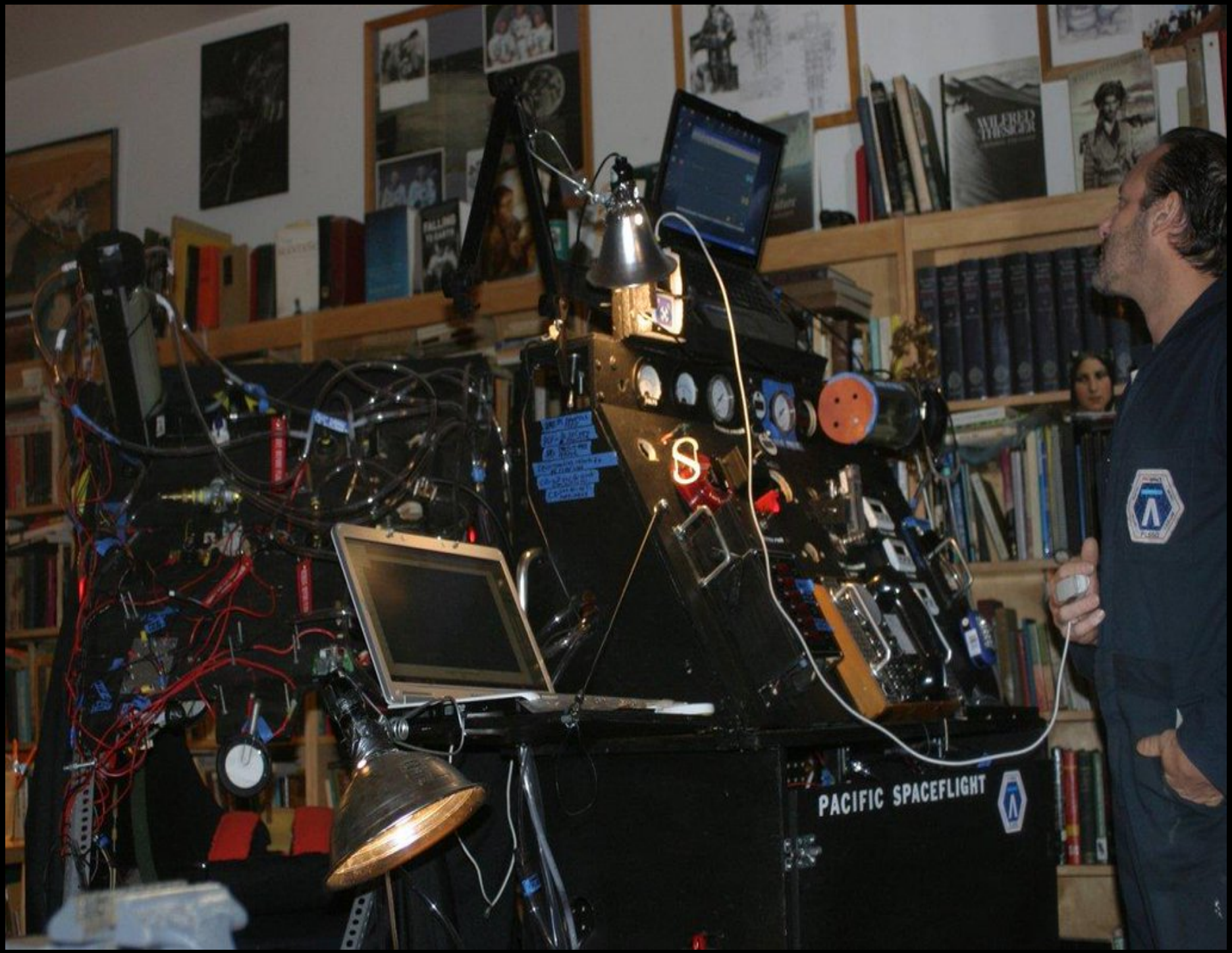
Achieved -50 in crude chamber, good test over 110 minutes.

-44 inside the suit * Teflon & rubber seals OK * PVC hoses dangerously rigid * need to replace quick-commeect o-rings

Human Exploration Technologies for the Second Space Age (36)

Now:

1. Continue designing, building, testing.
2. Test flights to high altitude = NASA method = CREDIBILITY
3. Produce good technical reports.


PACIFIC SPACEFLIGHT

Pacific Spaceflight Research Brief #2016-1

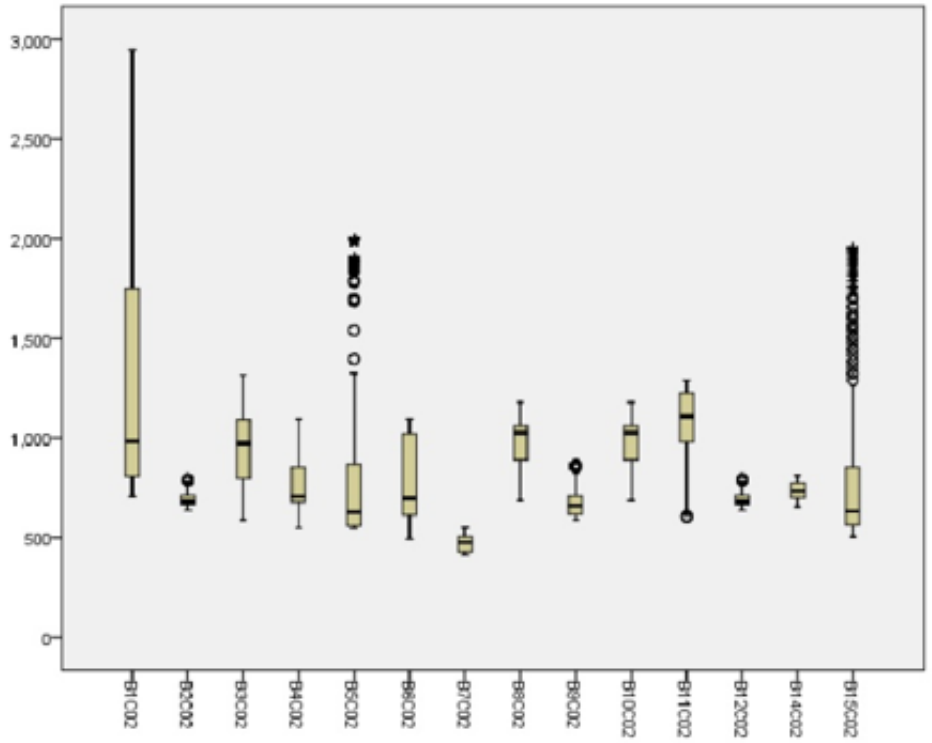
Biomedical Data and Analysis for 16 Pacific Spaceflight Pressure Garment Tests

Cameron M. Smith, PhD
b5cs@pdx.edu
05 December 2016

Abstract

Biomedical and suit environment recorded in 16 Pacific Spaceflight Mark IV pre pressurized tests averaging a suit pressure duration of 25 minutes, using normal air as delivered at a base rate of 28 liters per minute levels averaged 1,194ppm (c.0.10% of brea standard deviation of 453ppm; these figures, some important variation, are well within exposure levels indicated by OSHA, NA Roscosmos EVA suit parameters for durations the planned duration of Pacific Spaceflight's altitude pressure garment test flights. Biomed pulse rate, suit exhaust gas temperature and b all of which were acceptable during the pressu

FIGURE 5. Box Plots of Carbon Dioxide Values per Pressurized Test. Vertical axis is C02 level in PPM, horizontal axis is test number (see Table 1). Display from *IBM SPSS Statistics 22*.



Human Exploration Technologies for the Second Space Age (37)

Now:

1. Continue designing, building, testing.
2. Test flights to high altitude = NASA method = CREDIBILITY
3. Produce good technical reports.
4. Beat BOEING! And Beat SPACEX!

Boeing suit 2017

- 12-20lb (Gemini G5C, 1966, 16lb)
- Gemini-type helmet zipper
- ‘supple sneakers’
- gloves for touchpad use

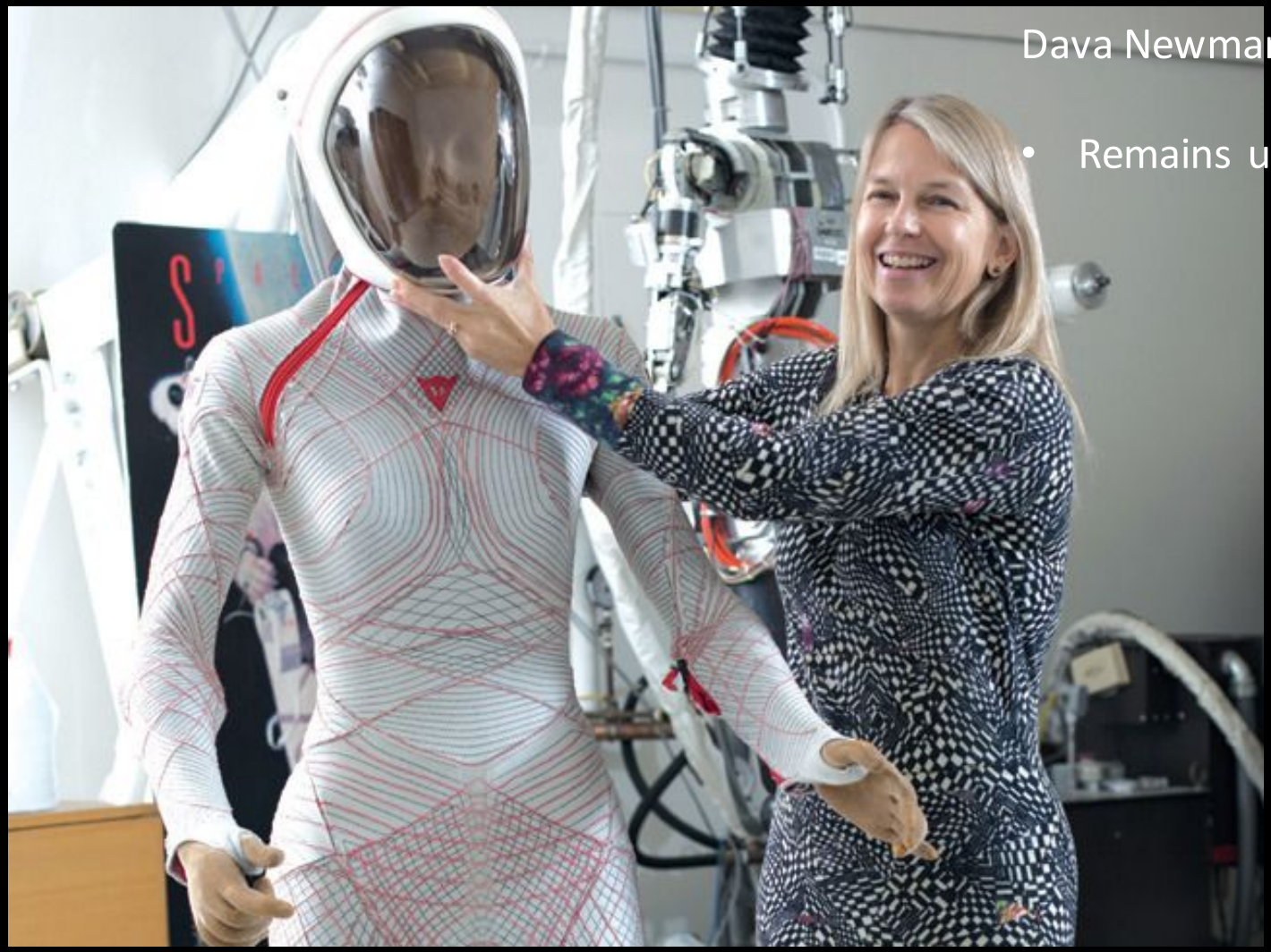
…if those are the Design Revolutions worth mentioning…

Then, sheesh!!!

SpaceX suit 2018

- No concrete details on its weight
- Form-fitting neck EXPOSES most vulnerable part of the body to danger!
- No gas in/out ports etc.
- If there are great revolutions here, Let's see them!


SPACEX
CAMERON
SMITH
02/26/2015



Dava Newman (MIT) Biosuit 2018

- Remains underway

2011

Human Exploration Technologies for the Second Space Age (38)

Now:

1. Continue designing, building, testing.
2. Test flights to high altitude = NASA method = CREDIBILITY
3. Produce good technical reports.
4. Beat BOEING! And Beat SPACEX!
5. Open-Source the Essential Design s

Open-sourcing the design.

More variations on the central theme = more ideas.

Many will be bad ideas, some will be good.

The more minds at work, the more likely fundamental revolutions will occur.

* leak prevention
* increased mobility
* less vulnerable closures
* safe self-suitup
* the Ford Pickup of space suits

Human Exploration Technologies for the Second Space Age (39)

Now:

1. Continue designing, building, testing.
2. Test flights to high altitude = NASA method = CREDIBILITY
3. Produce good technical reports.
4. Beat BOEING! And Beat SPACEX!
5. Open-Source the Essential Design
6. Eliminate the Launch-Entry Suit!

Eliminating the Launch-Entry Suit.

Yes, ride to space and back like airline passengers.

Radically reduces cost to orbit.

But flight crew, you might want to have them ready for cabin depressurization.

Human Exploration Technologies for the Second Space Age (40)

Now:

1. Continue designing, building, testing.
2. Test flights to high altitude = NASA method = CREDIBILITY
3. Produce good technical reports.
4. Beat BOEING! And Beat SPACEX!
5. Open-Source the Essential Design
6. Eliminate the Launch-Entry Suit!
7. Get Mars Analog Sites (Hawaii, Poland, Arizona, Utah, Iceland) to use pressurized suits for their studies (MARS SUIT)


3

Thanks for your attention!

Daily updates at Pacific Spaceflight on Twitter