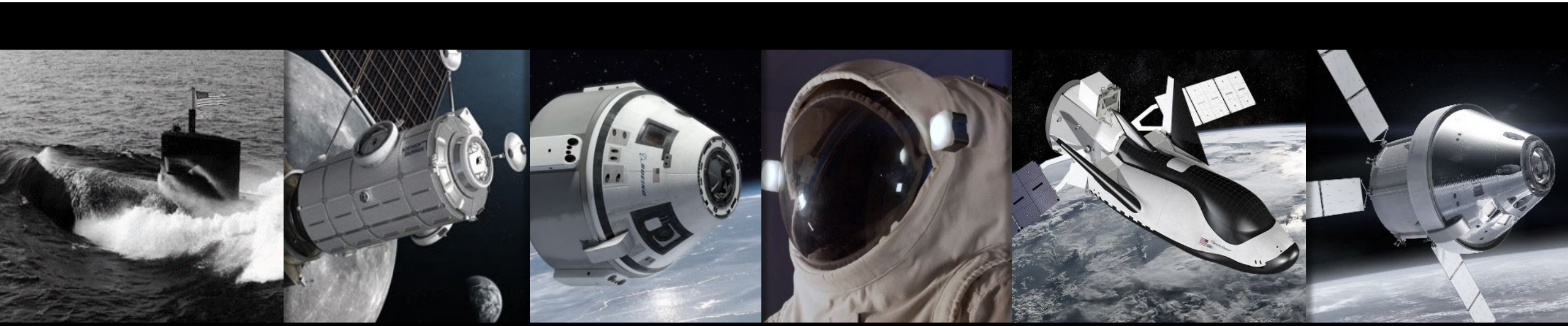
SPACE • DEFENSE • COMMERCIAL

PARAGON®

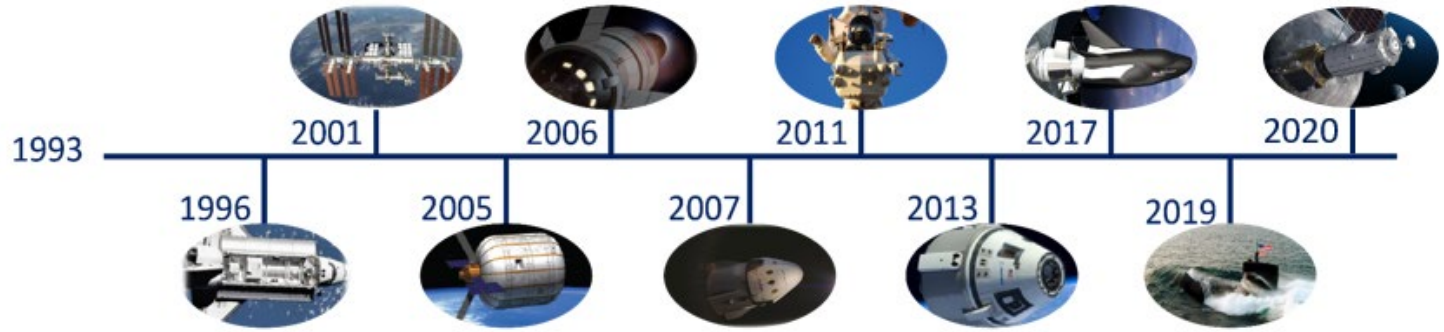
SPACE DEVELOPMENT CORPORATION

2023 Humans to Mars
ECLSS Orientation and Topics

Grant Anderson, P.E., President & CEO, Co-Founder



Paragon's Long History



SPACE:

Paragon has worked every major human space flight program since 1999. Our hardware and subsystem designs have flown on NASA spacecraft (Orion, the International Space Station), foreign spacecraft (Soyuz and Mir) as well as commercial spacecraft (CST-100, Bigelow Aerospace, StratEx, and SpaceX). Our *firsts* include the first commercial experiment on the Space Shuttle (in 1996) and the first commercial International Space Station payload on Progress 4 from Russia in 2001.

Current programs include Boeing's CST-100, Lockheed Martin's Orion, NASA's ISS, SNC Dream Chaser, & NG HALO

DEFENSE:

Past defense programs include Lockheed Martin Blackswift Hypersonic Cruise Vehicle, ORS-1 minisatellite, GeoEye2 (now WorldView4) commercial Earth observation satellite, and ATTILA satellite.

Current programs include BICS & CHIMERA.

COMMERCIAL:

Commercial deep space ventures include Mars One and Inspiration Mars. Other programs include the historic StratEx Mission which set world records that still stand today. Other commercial programs are in various stages of development.

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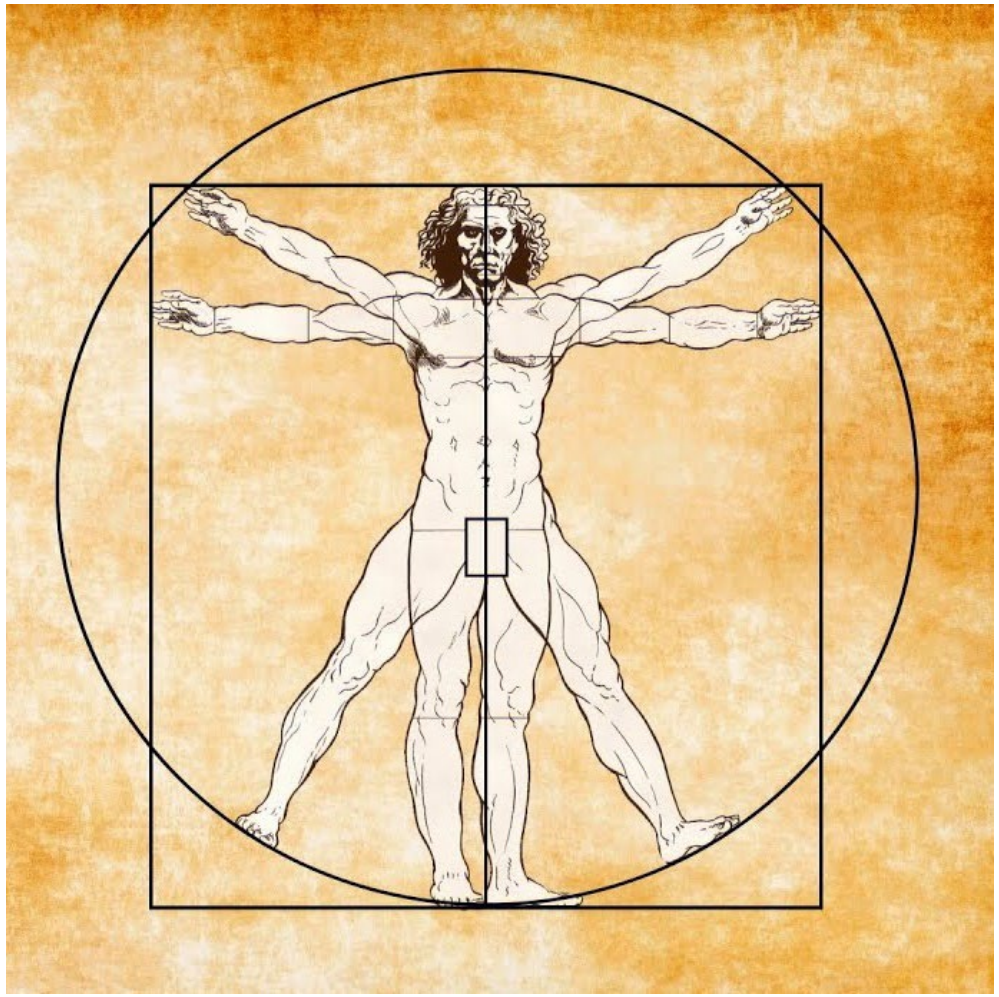
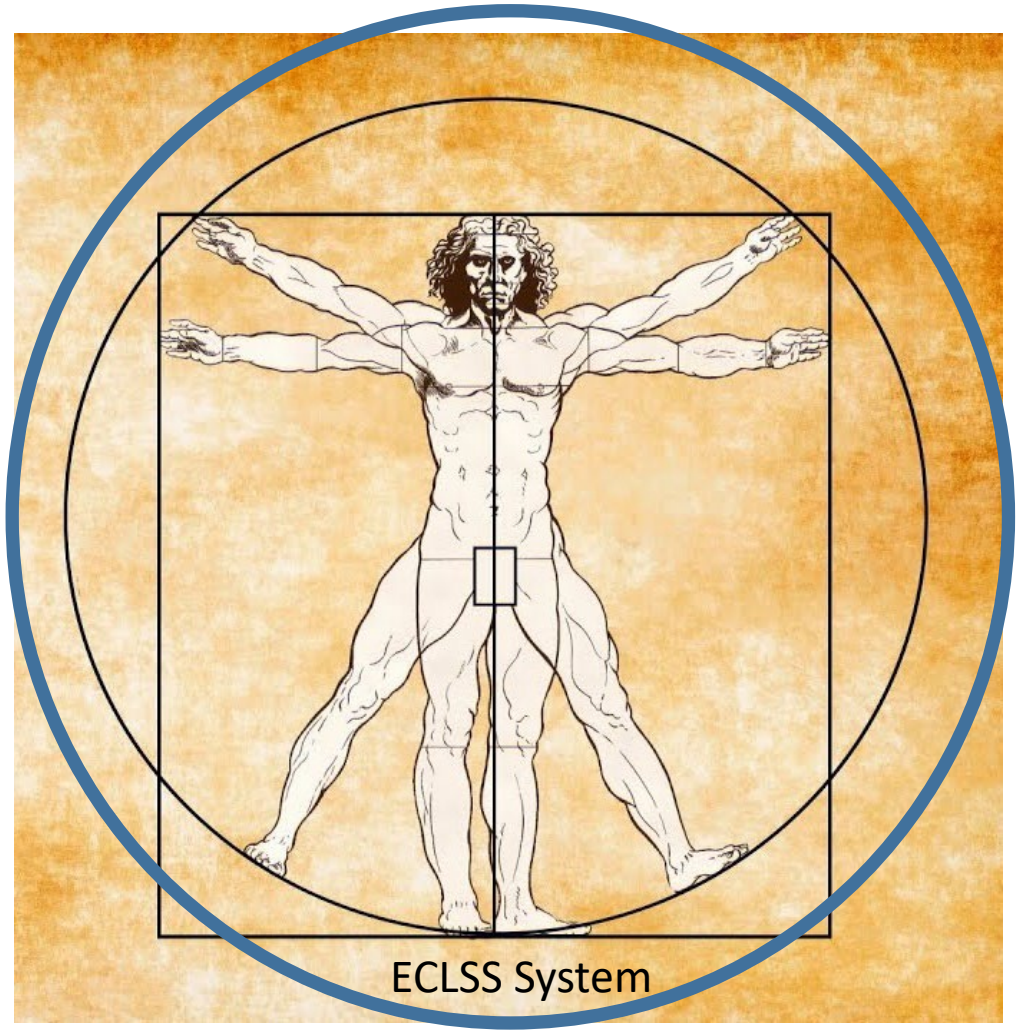
ECLSS—the forgotten subsystem



Human Payload?

NO, NO, NO!



Human Payload!!

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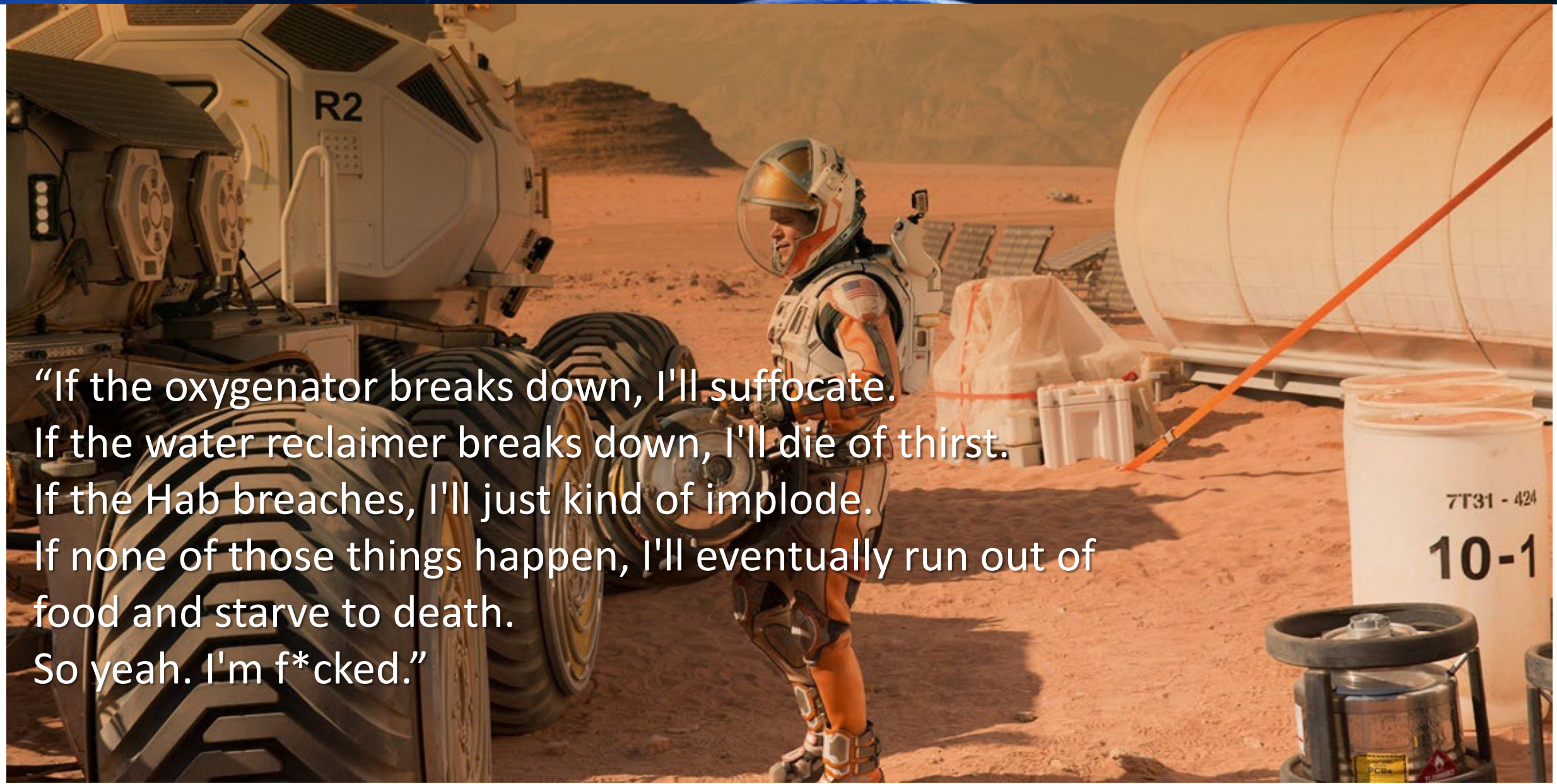
The Martian



"If the oxygenator breaks down, I'll suffocate.
If the water reclaimer breaks down, I'll die of thirst.
If the Hab breaches, I'll just kind of implode.
If none of those things happen, I'll eventually run out of food and starve to death.
So yeah. I'm f*cked."

ECLSS—The Key Subsystem to Prove

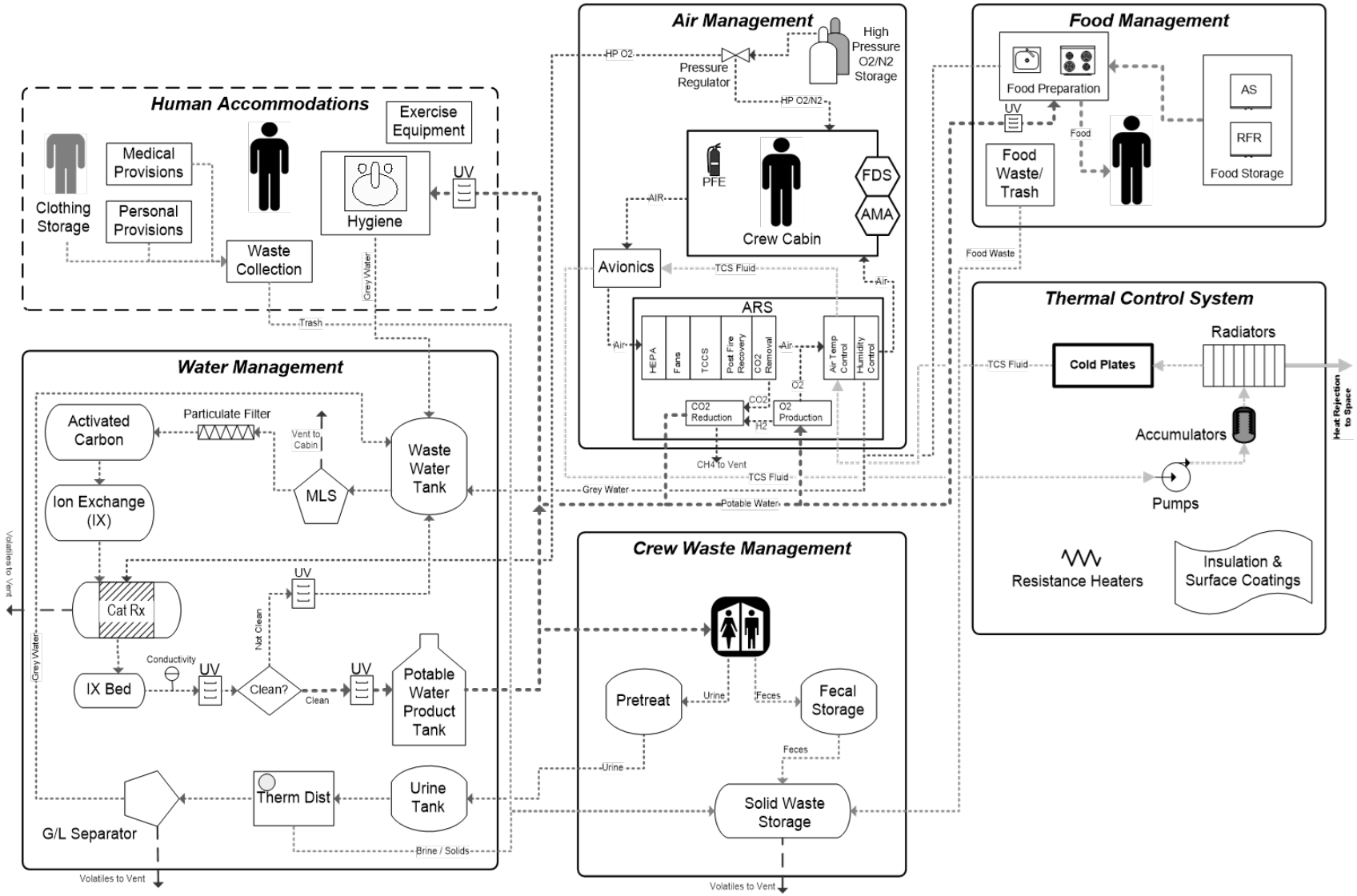
*"A piloted Mars flyby affords the best opportunity for performing manned planetary exploration with minimal cost and at an early date. The attractiveness of this type of mission stems from the relatively light burden which it imposes on the propulsion system. The usefulness of the flyby mission becomes clearly established when viewed as an in-situ test-bed for evaluating the performance of various subsystems such as navigation, **life support**, and communications to be used in later landing missions."-- George Mueller (Associate Administrator for NASA Manned Space Flight) in Testimony before Congress, **1966***

While navigation and communications are now proven by our spectacular robotic program, the ECLSS remains the challenge to surmount.

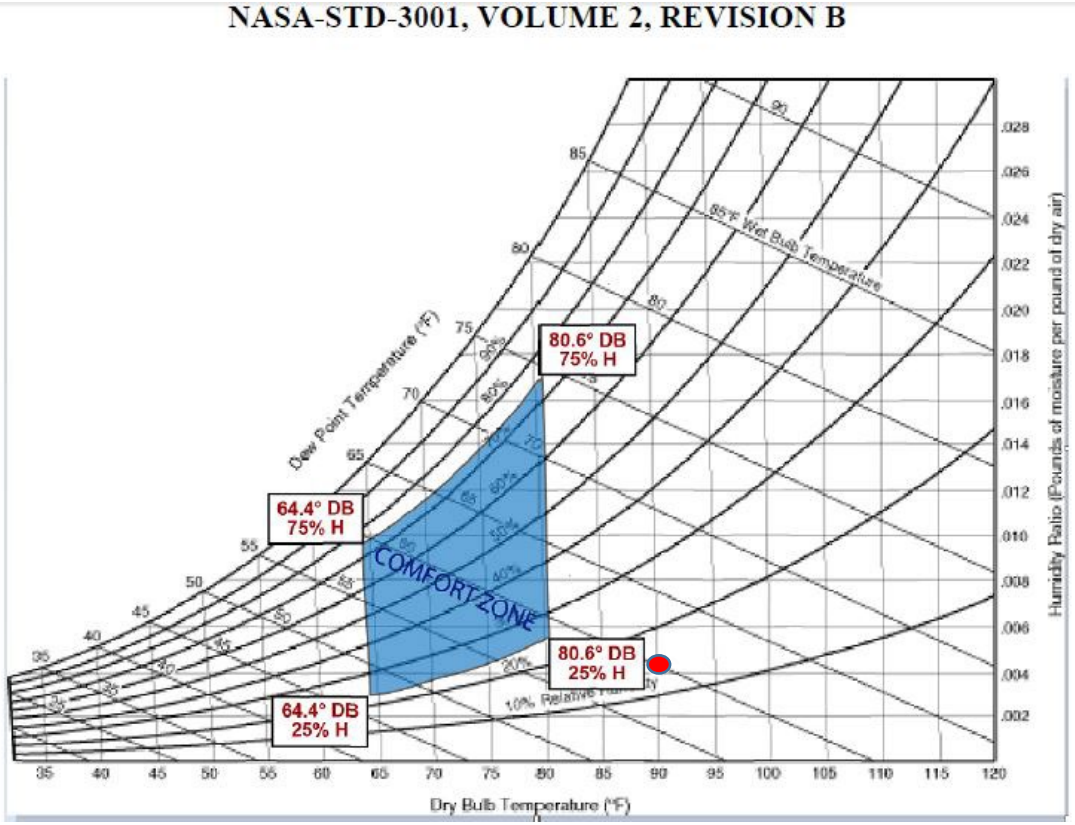
ECLSS—Major Elements

ECLSS subsystem diagram

- Life Support
- Thermal Control
- Crew Systems



Human Accommodations: Details and Simple



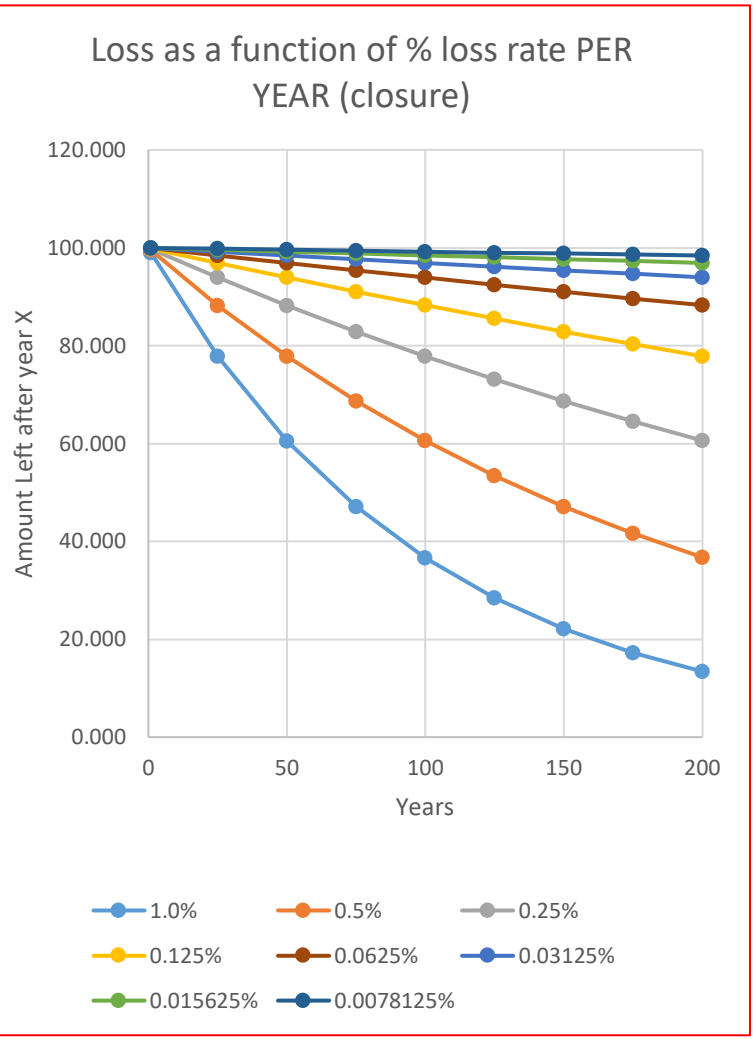
NASA Comfort Zone, Figure 2 of NASA-Std-3001 Volume 2

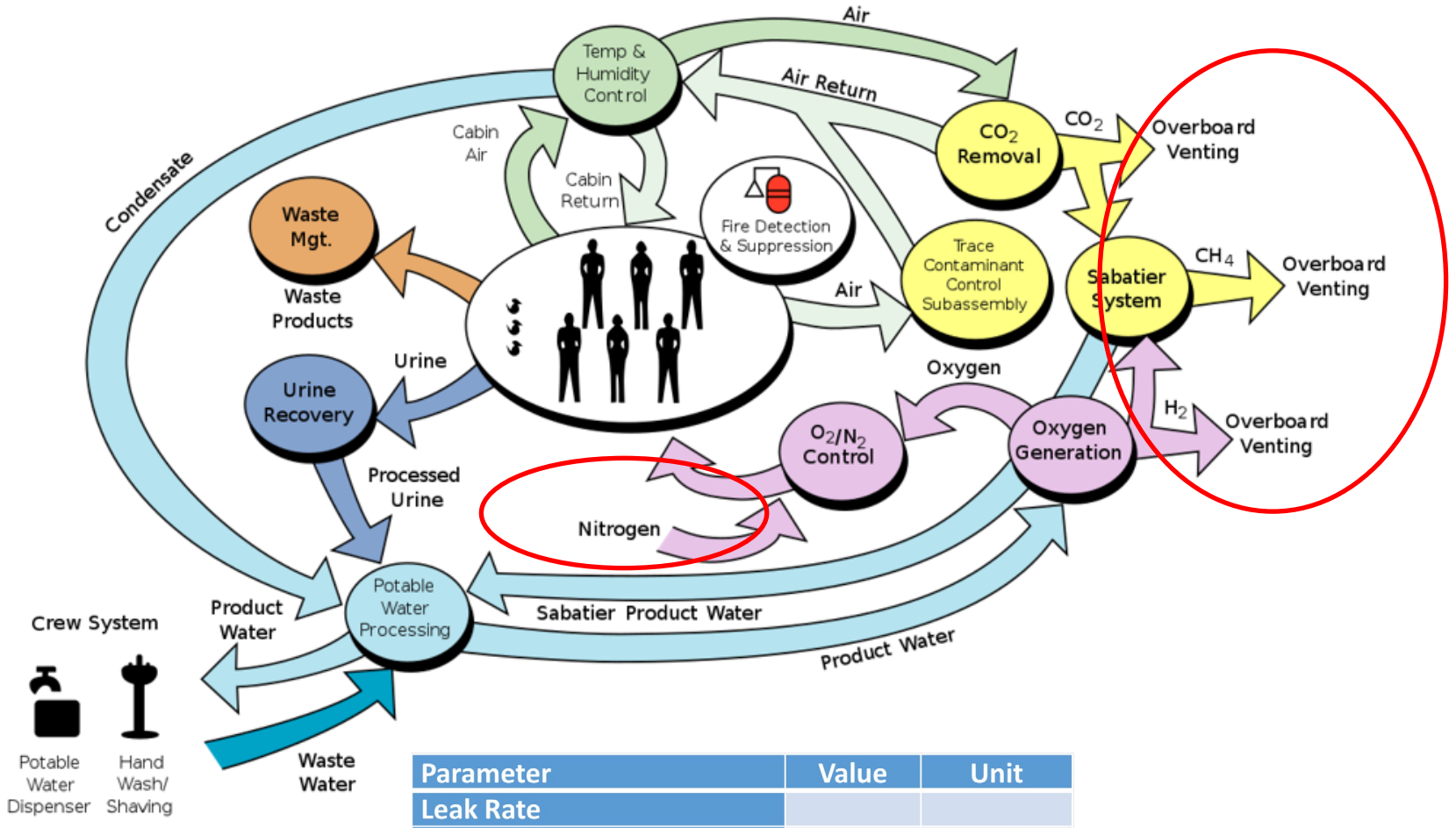
Balance [36]	Interface	Units	Nominal Value
	Basis		
	Overall Body Mass	kg	70.0
	Respiratory Quotient		0.869
	Air		
– m	Carbon Dioxide Load	kg/CM-d	0.998
+ m	Oxygen Consumed	kg/CM-d	0.835
	Food		
+ m	Food Consumed; Mass [37]	kg/CM-d	0.617 [38]
+ E	Food Consumed; Energy Content	MJ/CM-d	11.82
+ m	Potable Water Consumed [39]	kg/CM-d	3.909 (1)
	Thermal		
– E	Total Metabolic Heat Load [40]	MJ/CM-d	11.82
	Sensible Metabolic Heat Load	MJ/CM-d	6.31
	Latent Metabolic Heat Load [41]	MJ/CM-d	5.51
	Waste		
– m	Fecal Solid Waste (dry basis)	kg/CM-d	0.032
– m	Perspiration Solid Waste (dry basis)	kg/CM-d	0.018
– m	Urine Solid Waste (dry basis)	kg/CM-d	0.059
	Water [42]		
– m	Fecal Water	kg/CM-d	0.091
– m	Respiration and Perspiration Water [43]	kg/CM-d	2.277
– m	Urine Water	kg/CM-d	1.886 (1)

Human Metabolic Needs courtesy NASA (Hanford 2004)

- 3 Seconds—How long you can survive at vacuum unprotected
- 3 minutes—How long you can survive without Oxygen (roughly) before permanent damage
- 3 days—How long you can survive without Water
- 3 weeks—How long you can survive without food (depending on your starting reserves)

The Concept of Closure





Parameter	Value	Unit
Leak Rate		
Lower	0.00	%/d
Nominal	0.05	%/d
Upper	0.14	%/d

Credits: NASA

What are the Gaps? Can we go Tomorrow?

- **Reliability, Maintainability and Emergency Repair:**
  - ORU Philosophy. Replace the o-ring, or the resister, or PCB, but NOT the assembly.
  - Reliability has to be weighed against severity. ECLSS failures are measured in hours and days, rarely minutes.
- **Medical Provisions:**
  - Medicine- Radiation resiliency, field hospital philosophies
  - Preventive medicine—What do you remove BEFORE you go? Wisdom Teeth, breast tissue, appendix?
  - Phycological problems: 30 years ago, this wasn't on the list, now it's a top-5 problem!
- **Integrated, Long-term Testing in a Relevant Environment:**
  - AWAY from Earth—the nearness of escape and safe havens alters the psychology, immediacy, urgency.
  - Microgravity—80% of failures on ISS have been due to microgravity environment—no other place to test long term.
  - For Surface: Form Follows Function. The LAYOUT of the surface systems has to have detailed Ops analysis.
- **Logistics and Command:**
  - There is no Mission Control, there is only mission monitoring once 5 light-seconds from Earth!!

Some References

- **Volume 1, Interstellar Travel: Purpose and Motivations**, published April 7. The Life Support Chapter is in Volume 2 which will be published this fall.

  Interstellar Travel: Purpose and Motivations: Johnson, Les, Roy, Kenneth: 9780323913607: AmazonSmile: Books

- **Grant Anderson TedX WinterPark 2019: "Human Space Flight Takes Humanity with it to the Stars"** https://youtu.be/XaOEcTRyeS8

- **ISPCS 2019 - Grant Anderson 2019 "Environmental Control Systems: Getting You There is Half the Story"** https://youtu.be/Tj3FwIfpdmI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