Human Capabilities for Lunar Surface Field Research

National Academies Meeting No. 3, November 2025

Tom Marshburn MD
NASA Astronaut

Pre-flight/Training

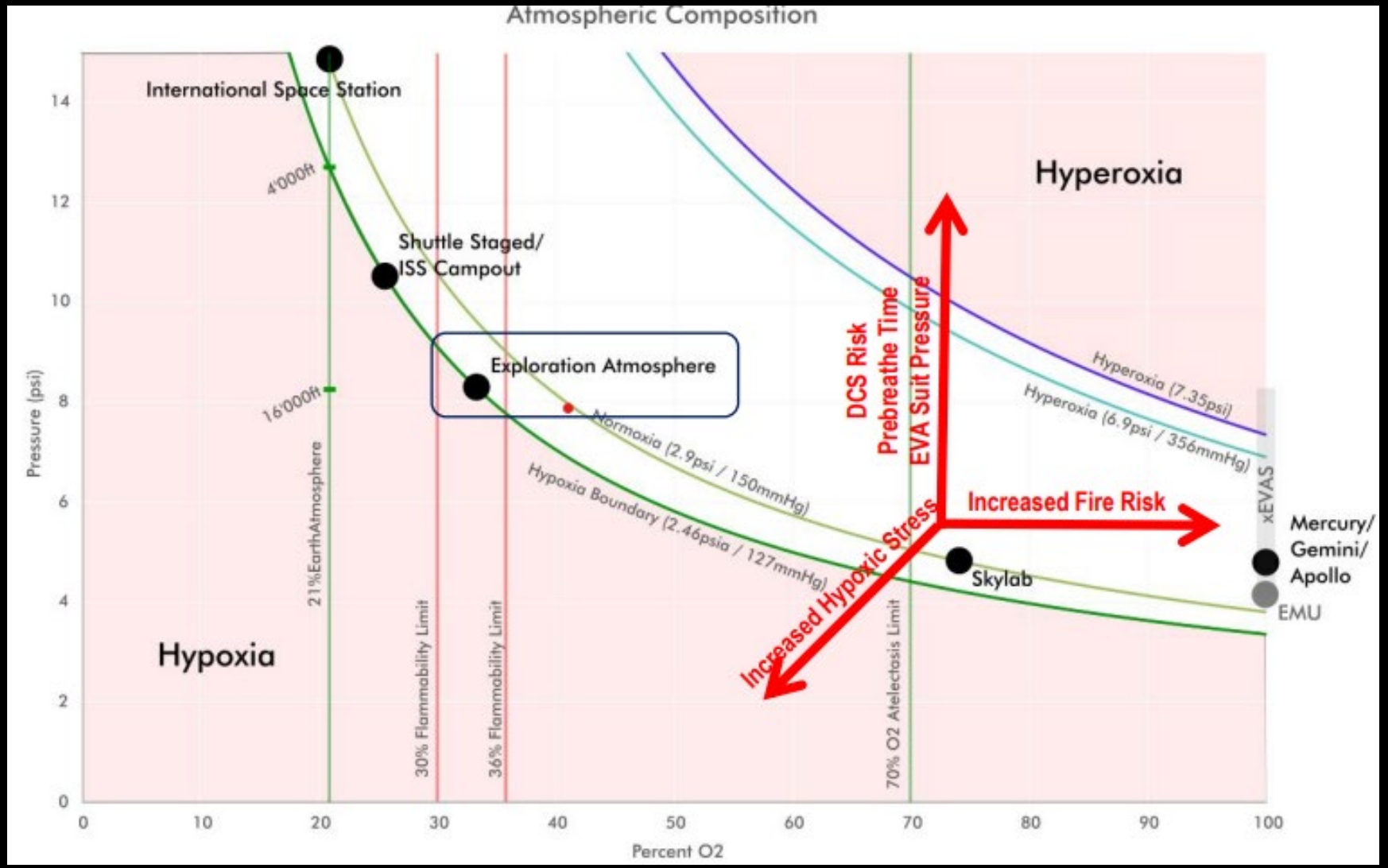

67
NASA
N967NA


Rab

Physiologic Stressors

Suit Fit and musculoskeletal injury

The Exploration Atmosphere



Compromise between

- Hypoxia
- Flammability
- Total pressure
- DCS risk
- Prebreathe time

Garbino et al: Exploration Atmosphere Working Group (2006, 2012):
8.2psia / 34% O2

Exploration Atmosphere Effects

Effects of the 8 psia / 32% O2 Atmosphere on the Human in the Spaceflight Environment. Norcross et al. NASA/TM-2013-217377. 2013.

- Cardiovascular
  - Systemic vasoconstriction
  - Increased blood pressure
  - Increased heart rate
  - Decreased stroke volume
  - Decreased cardiac output
  - **Decreased maximal O2 consumption (VO2max) exercise performance**
- Respiratory
  - Pulmonary vasoconstriction
  - **Increased respiratory drive**
  - Increased pulmonary blood pressure. No significant change in pulmonary mechanics and gas exchange compared to hypoxia alone.
- Hematological/Immunological
  - Reduced plasma volume
  - Increased hematocrit
  - Increased erythropoiesis
  - Polycythemia
  - **Increased blood viscosity**
  - **Increased thrombotic risk**
- Nutritional
  - **Reduced appetite, energy intake, and body mass irrespective of acute mountain sickness**

Imp

Improved Suit Design

ARTEMIS EVA Spacesuit Technology and Design

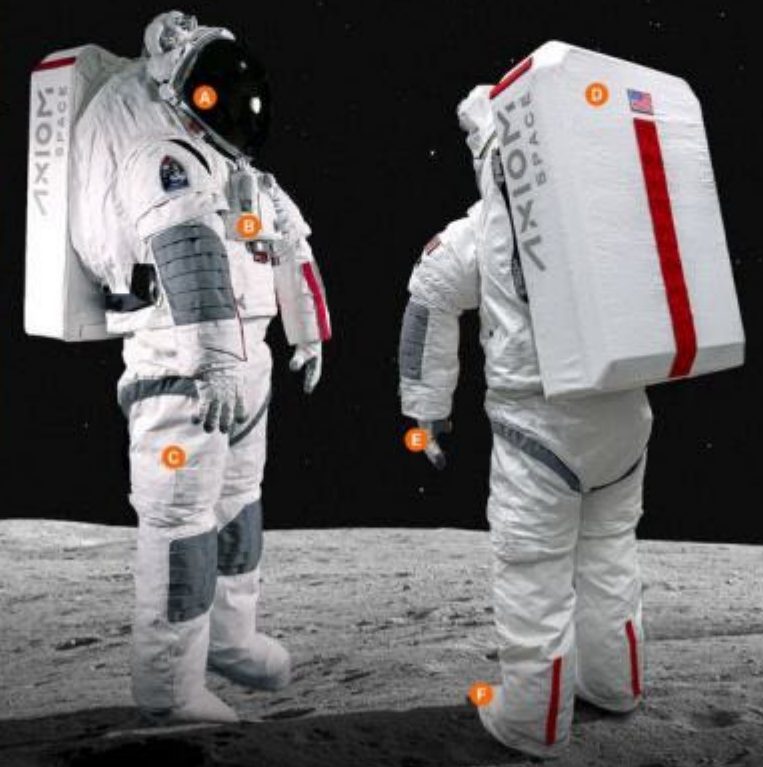
AXIOM SPACE

The Axiom Extravehicular Mobility Unit (AxEMU) spacesuit will be used for NASA's Artemis III mission, worn by the next humans to walk on the surface of the moon. The suit includes advanced technologies and provides unmatched flexibility, mobility, and safety for spacewalks on the lunar surface.

A
- Lights and HD Camera
- Helmet & Visor
- Advanced 4G/LTE Communication
- Endurance Athlete Based In-suit Nutrition

B
- Suit Control Interface
- Biometric Monitoring

C
- Advanced Textiles
- Accommodates Wide Range of Crewmembers (anthropomorphic sizing)
- Enhanced Flexibility, Mobility, Safety

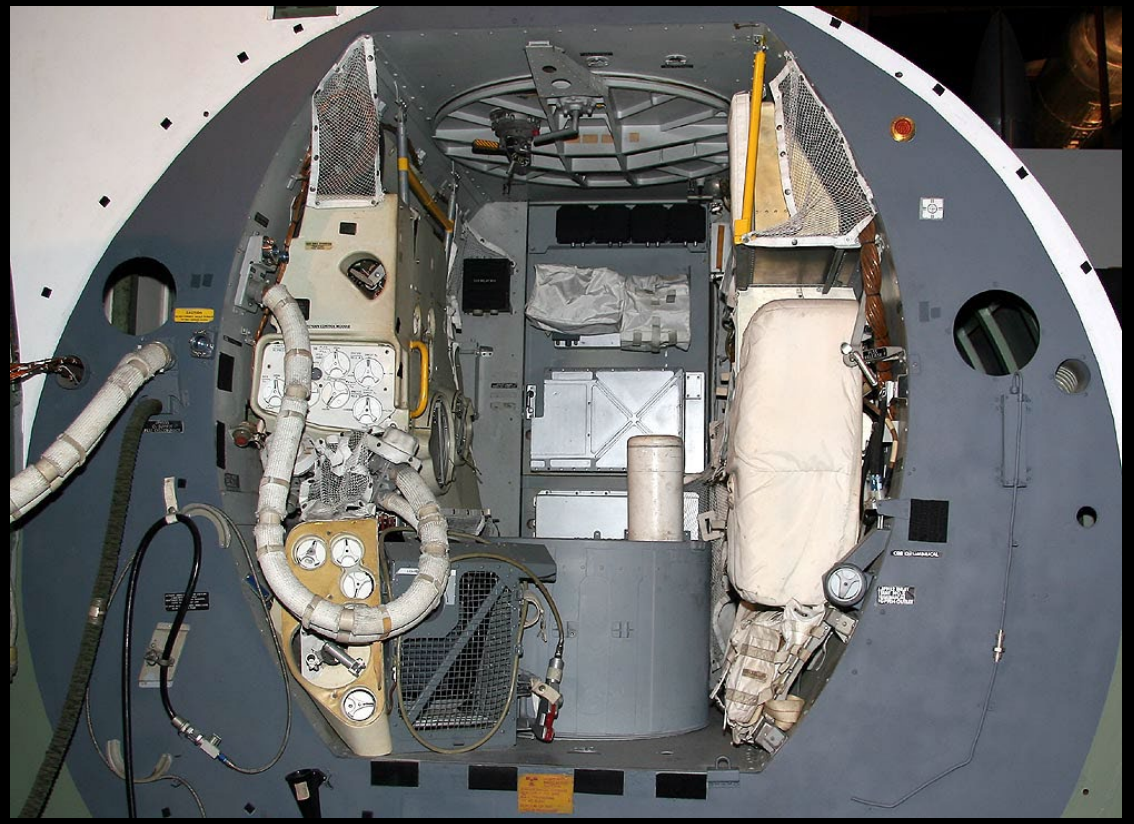


D
- Variable Suit Pressure
- Critical System Redundancy
- Regenerable CO2 Scrubbing System
- Maintained On-orbit/On-mission
- Modular, Evolvable Design
- Cellular Communication
- Portable Life Support System Backpack to Keep Astronauts Safe for Up to 8 Hrs
- Spacesuit Outer Layer Engineered/Designed by Axiom Space & Prada

E
- Custom-made Gloves

F
- Boots Engineered to Withstand Lunar Temps & Rough Terrain

Medical Events / Human Factors

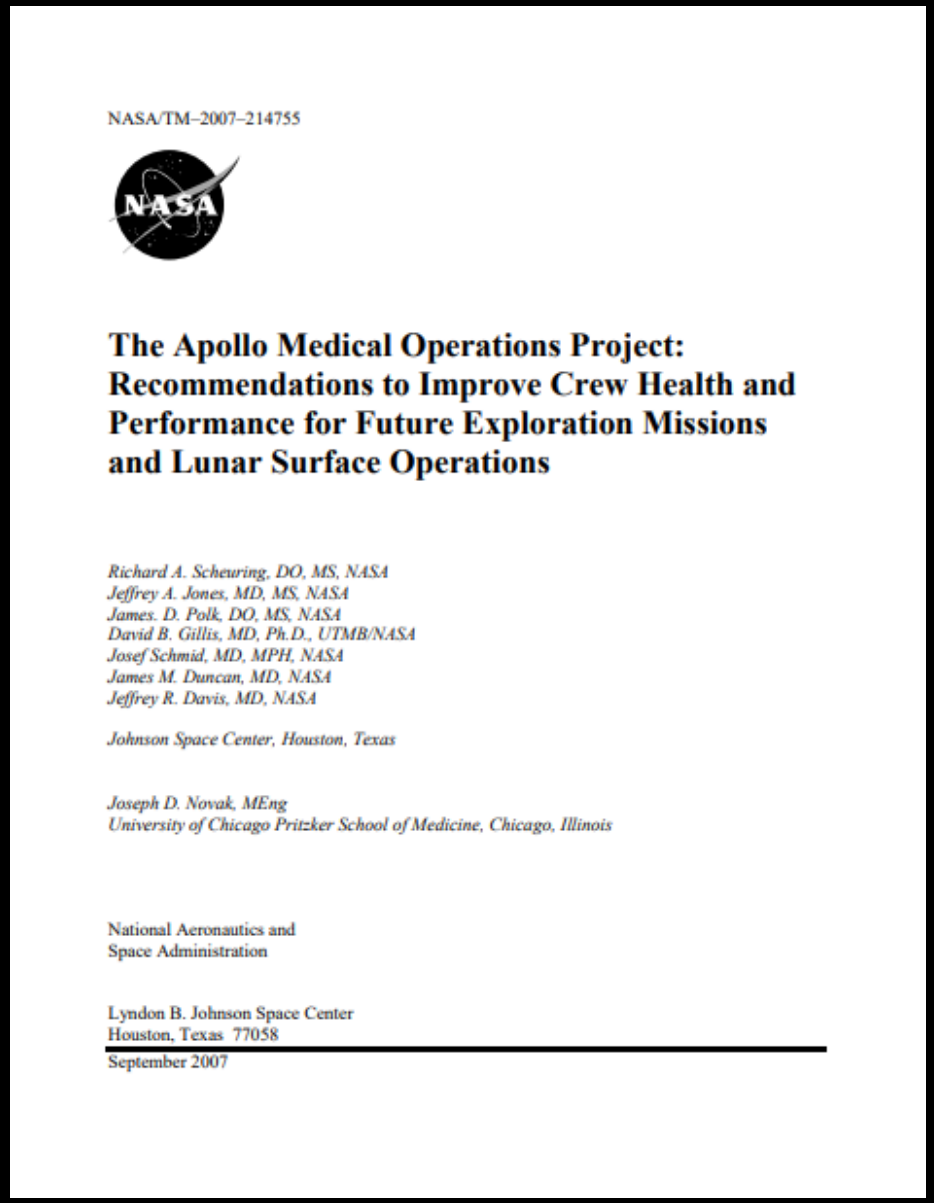


Nutrition:

Additional 200 kcal/hr during EVA

Nutritional requirements for Exploration Missions up to 365 days, Scott Smith 2020


11
MIRROR MOUNT



NASA/TM–2007–214755

The Apollo Medical Operations Project: Recommendations to Improve Crew Health and Performance for Future Exploration Missions and Lunar Surface Operations

Richard A. Scheuring, DO, MS, NASA
Jeffrey A. Jones, MD, MS, NASA
James. D. Polk, DO, MS, NASA
David B. Gillis, MD, Ph.D., UTMB/NASA
Josef Schmid, MD, MPH, NASA
James M. Duncan, MD, NASA
Jeffrey R. Davis, MD, NASA

Johnson Space Center, Houston, Texas

Joseph D. Novak, MEng
University of Chicago Pritzker School of Medicine, Chicago, Illinois

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058

September 2007

Summary of major concerns:

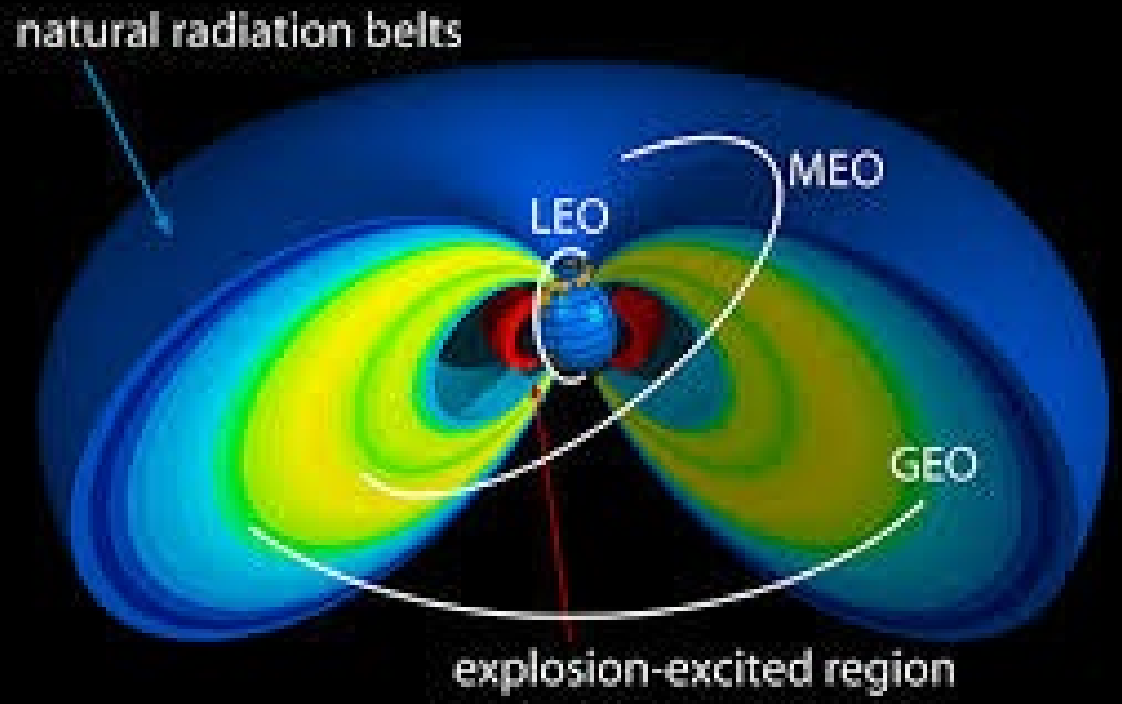
Medical:
Allergy (lunar dust)
Headache
Sleep
Hygiene
Nail delamination
Muscle soreness
Shoulder injury

Human Systems Integration:
In-suit nutrition
Hot water
Improved toilet
Suit overheating
External temperatures: +250 to -410 deg F

Radiation

11.4 mGy highest dose in Apollo (14)

Likely several cSv to BFOs during October 1989 flare



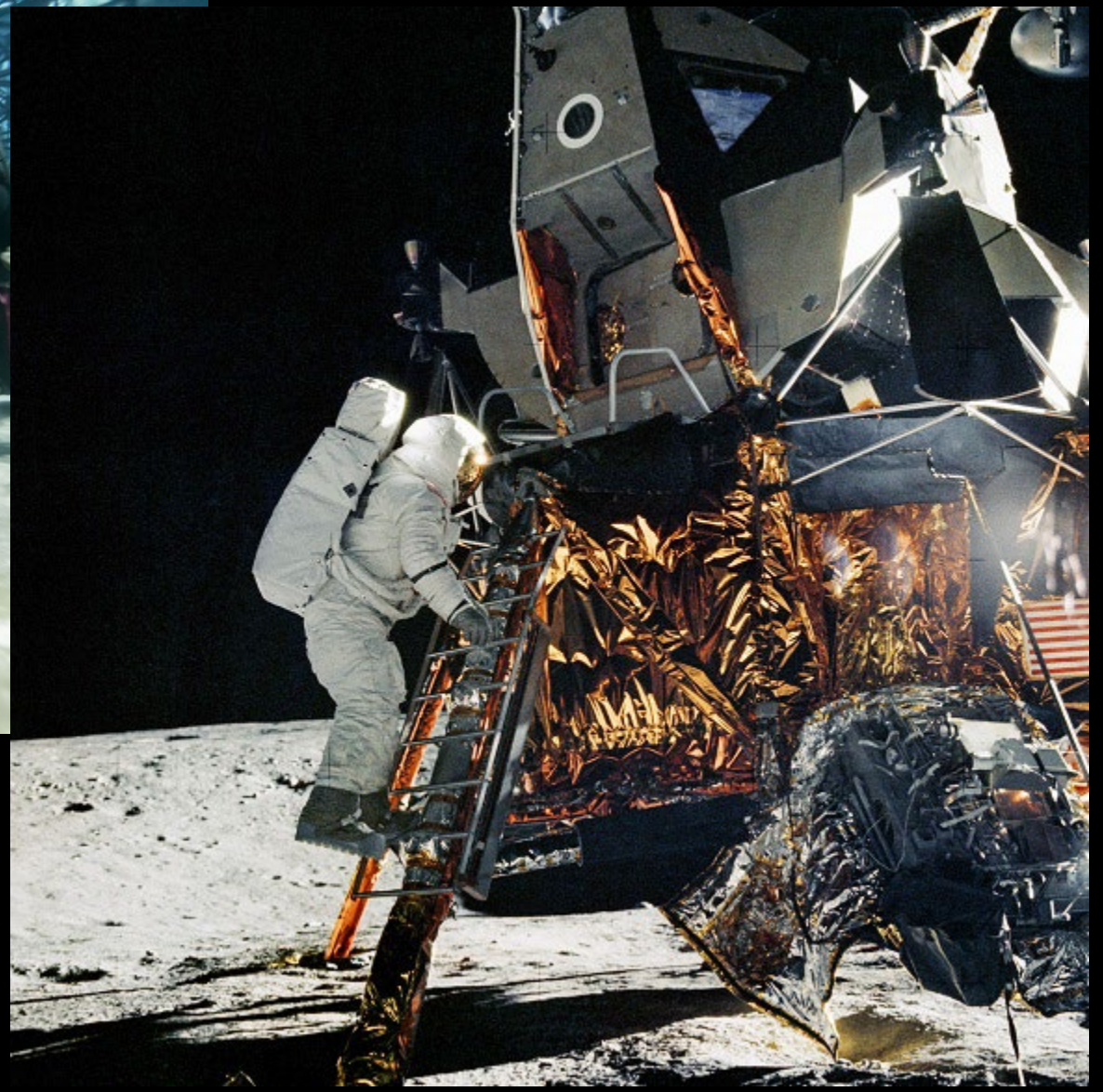
Performance Capabilities/Limits

10 km walkback performed in under 2 hours at 50% VO2 pk

Feasibility of Performing a Suited 10-km Ambulation on the Moon - Final Report of the EVA Walkback Test (EWT). Jason Norcross 2007, NASA/TP–2009–214796

Tasks took 70% more time than during training, with 20% more use of consumables

Apollo 16 Time and Motion Study, July 1972



Human Presence:

Larger sample Earth-return, and more sample volume/quality
    Human crawl is 13x Curiosity Rover avg speed - google
Greater sample identification/capture speed, over greater surface area
Repair hardware in the field
Identify unexpected areas of interest out of FOV of a camera
Garner greater public attention/support