Surface EVA Readiness and Performance Optimization (SERPO): An Integrated Human Performance Approach

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Funded by Mars Campaign Office (MCO)

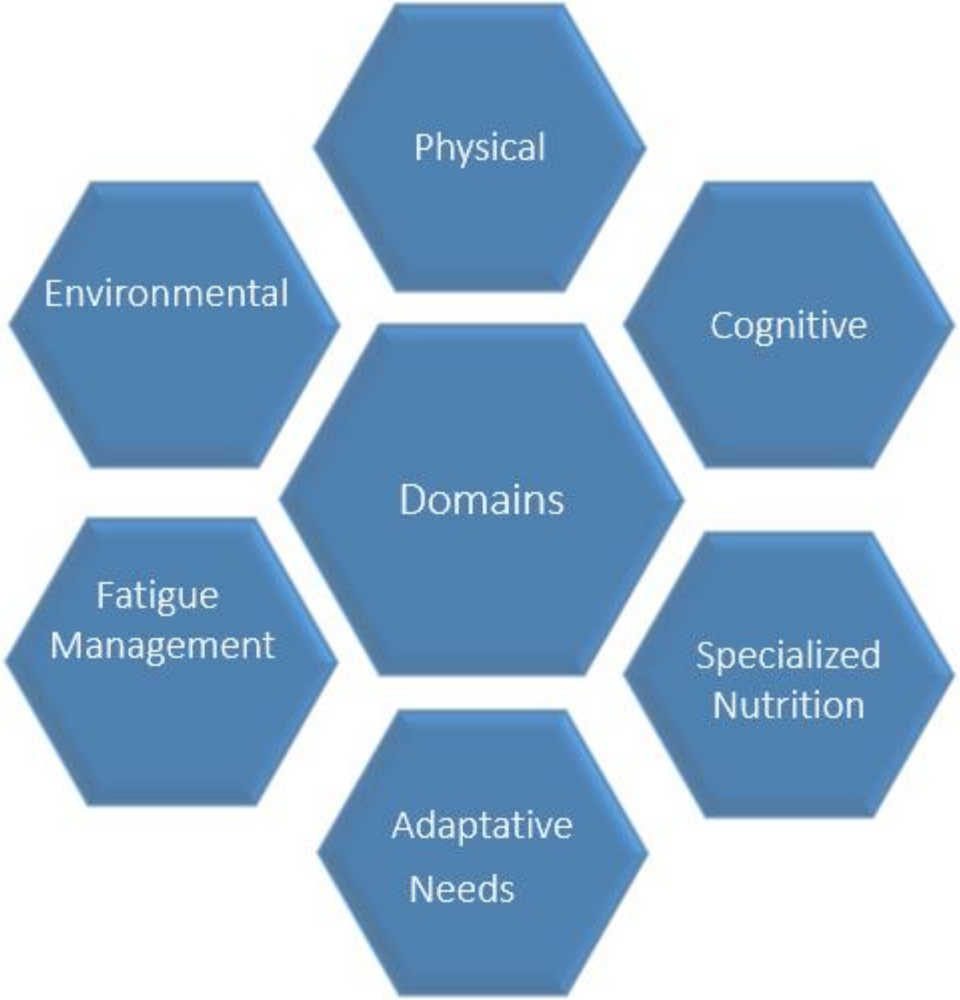
Human Performance Optimization…. Defined

"the process of applying knowledge, skills and emerging technologies to improve and preserve the capabilities of 'individuals' and organizations to execute essential tasks"

Nindl, 2015

Needs Assessment

Identify the Domains



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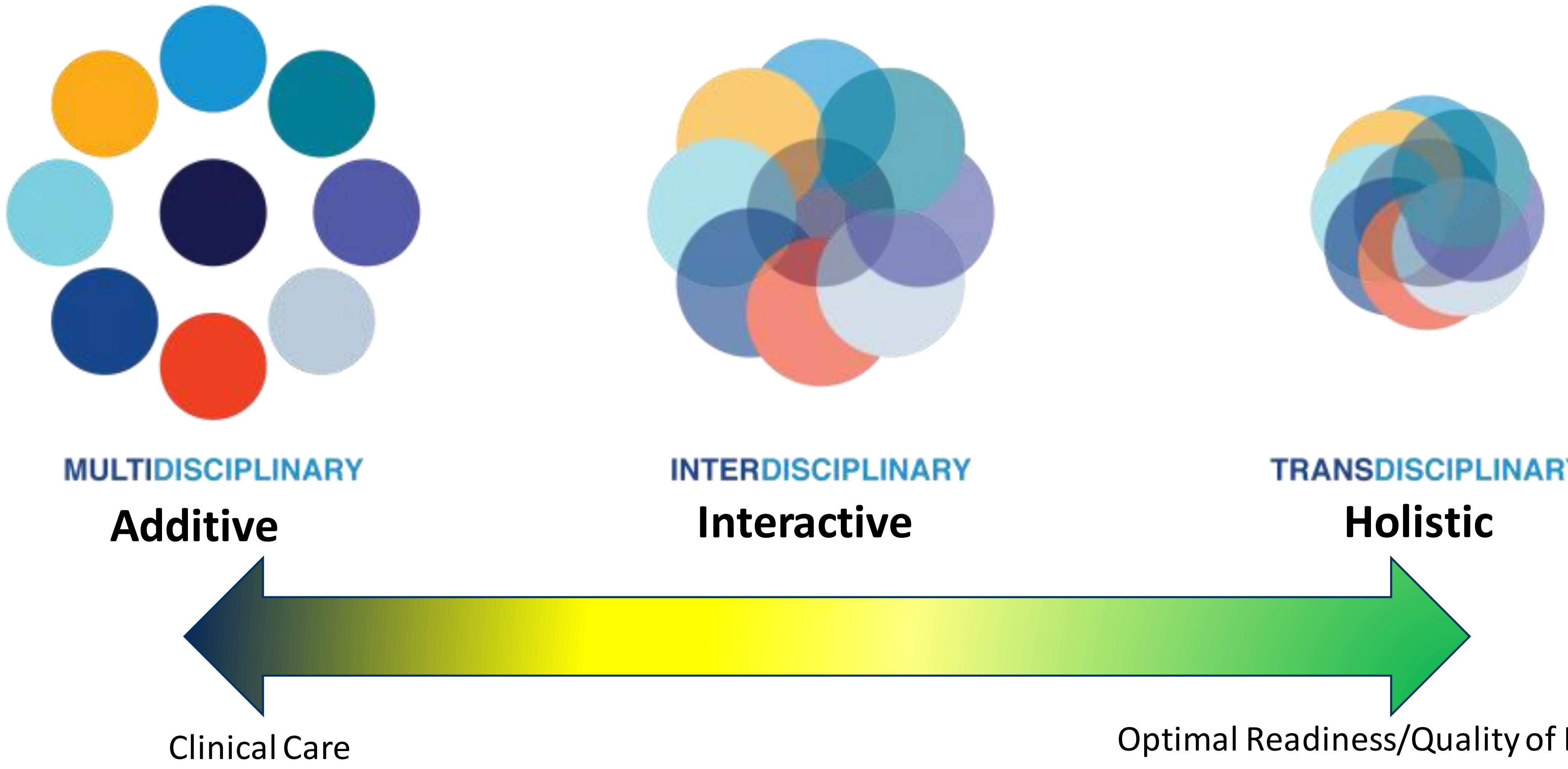
Team Collaboration



Choi, 2006

Program Effectiveness

End-product and Need Fully Understood

Reliable, valid tools that utilize as few measurements to tell you many things and keep you mission focused

Leverages Technology for End User Feasibility and Data Driven Decisions

Interdisciplinary Nature- each domain represented

Data is quickly and easily accessible to the user and the team!!

Nindl, 2015

Leadership Support

"Shared Responsibility"

Travis, 2023 and Nevin, 2022

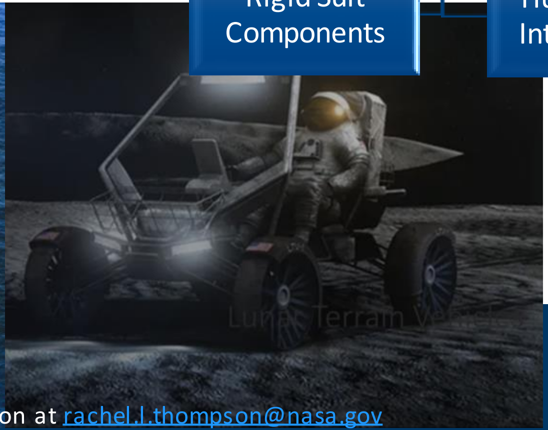
Real World SERPO

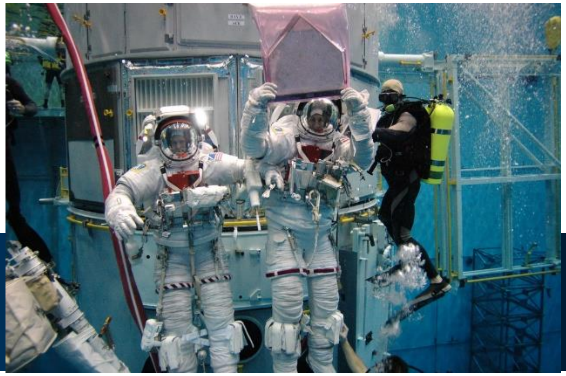
Injury Scenario

- Machine Powered
  - Car Crashes
  - Aircraft Ejection
- Human Powered
  - Slips, Trips, and Falls
  - Sports Injuries

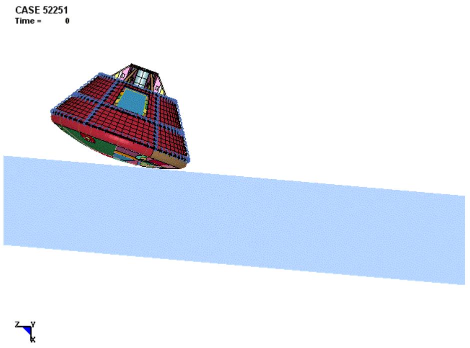
SERPO at NASA

- Mechanism of Injury
  - Extrinsic Factors
    - Dynamic Phases of Flight
      - Launch
      - Abort
      - Reentry
      - Rover Operations (e.g., LTV, or Rover)
    - Ground Base Facilities
      - NBL
      - ARGOS/AX3S
      - Rock Yard
      - Field Training
    - Spacesuit
      - Heavy Helmets
      - Pressurized Spacesuits
      - Rigid Suit Components
      - Human-Suit Interactions
  - Intrinsic Factors
    - Age
    - Gender
    - Anthropometry
    - Spaceflight Deconditioning
      - Bone strength loss
      - Muscle atrophy
      - Connective tissue changes





How do we Protect Crew Members/Test Subjects given the Vast Array of Environments/Analogs?



Research & Development

Technology and Procedure Development

Human Research

ATD Research

ORIS

Modeling

Injury Charact., Mitig., & Prevention

Operational Inputs

Requirements

Surveillance

Verification and Validation

Operationally-Relevant Injury Scale

- Operationally-Relevant Injury Scale (ORIS) Development
  - Developed Injury scale that considers not only severity, but also self-egress ability and flight status impact
  - AIS tells us severity with regard to survival, but not SIGNIFICANCE within a certain operational context
  - Uses a weighted algorithm to calculate a composite score indicating the appropriate injury level
  - Example: Clavicle Fracture is a minor injury by AIS standards, but could prevent a crewmember from self-egressing the vehicle immediate after landing

Injury Severity (IS)

0	1	2	3	4	5	6
None	Minor	Moderate	Serious	Severe	Critical	Maximal

Self-Egress Capability (SE)

0	1	2	3	4
No Impact	Able with Minor Impact (within 3min req)	Able with Major Impact (not within 3min req)	Unable without assistance	Unable, requires rescue and/or stabilization

Return to Flight Status Estimate (FS)

0	1	2	3	4
No Delay in Return	Short Delay in Return (<3mo.)	Intermediate Delay in Return (<1y)	Long Delay in Return (>1y)	Ended Flight Status/ DQ'd

Operationally Relevant Injury Class

0	I	II	III	IV
No Injury	Minor Injury	Moderate Injury	Severe Injury	Life-Threatening or Fatal Injury

Deconditioning and the Overall Effect on Injury

Contributing Factors

- Gravitational forces
  - Microgravity
  - Lunar
- Radiation
- Exercise
- Nutrition

Effects of Deconditioning

- Bone geometry and remodeling
- Distribution of fat and muscle
- Muscle strength
- Postural changes
- Neurovestibular

Surface EVA Readiness and Performance Optimization




9 April 2024- All photos available on the web

Surface EVA Readiness and Performance Optimization

Goals:

- Identifying musculoskeletal (MSK) injury mechanisms in ***anyone*** training in the xEMU or analog suits/environments
- ***Mitigating*** training related MSK injuries through early reporting, ongoing tracking AND protective barriers during training (i.e currently limit inverted time in the EMU)
- Enhance ***performance*** in the xEMU in training and on the lunar surface with a holistic approach to human performance optimization
- Improving crew ***readiness*** for training and surface EVA through integration of comprehensive human performance strategies

Surface EVA Readiness and Performance Optimization

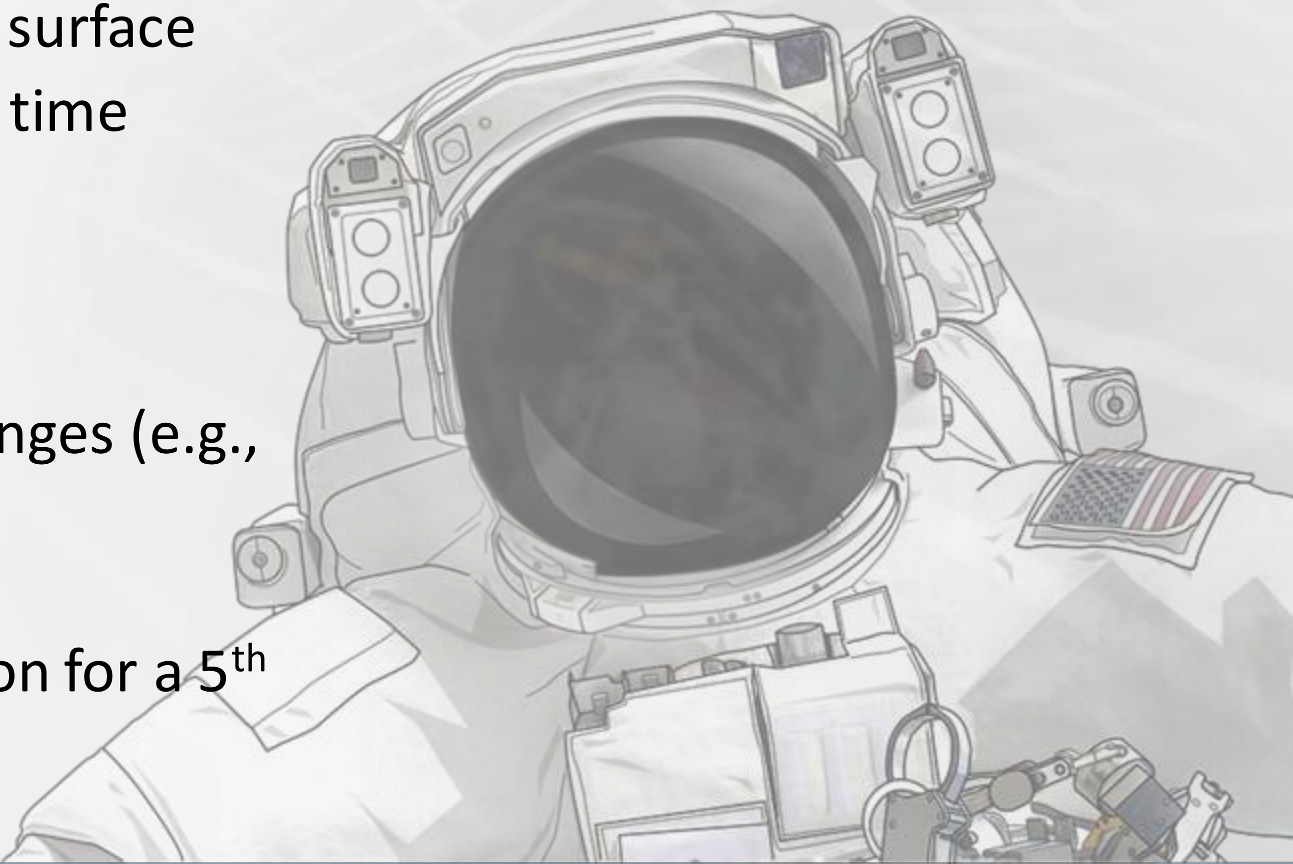
Desired Outcomes:

- Integrate various stakeholders to provide characterization of physical demand in different suit, analog environment and operational considerations and tempos
- Identify potential tasks and physical/mental demands that could increase risk of injury
- Provide recommendations for training to reduce risk of injury
- Implement a comprehensive physical preparedness program
- Integrated and accurate data management - SUITs survey – for injury surveillance/direction

ASCR Rock yard run, October 2023

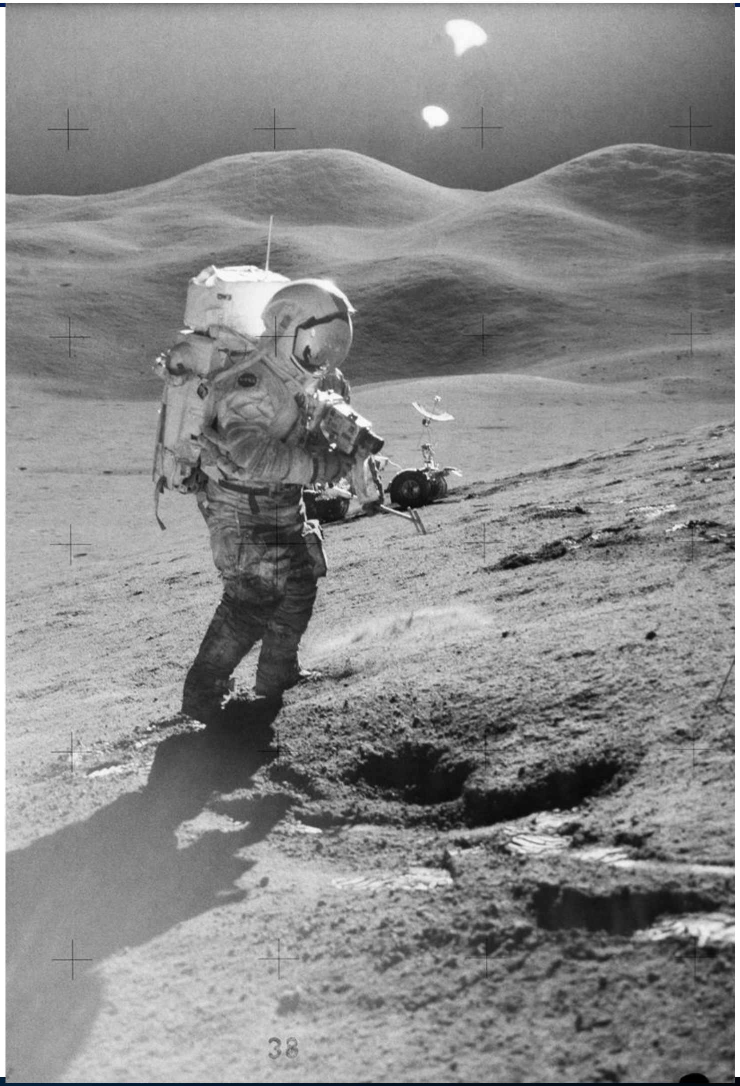
Surface EVA Operations

- 12 Astronauts have performed a lunar EVA
- 14 EVA in total
- Apollo 17 spent 75 hours total on the lunar surface
- Totaled just over 22 hours of suited surface time across 3 EVAs
- Artemis III will set new records
  - First lunar South Pole landing
    - Which comes with numerous challenges (e.g., Lighting, thermal, etc.).
  - 6.5 total surface days
  - 4 EVAs planned nominally, with an option for a 5th

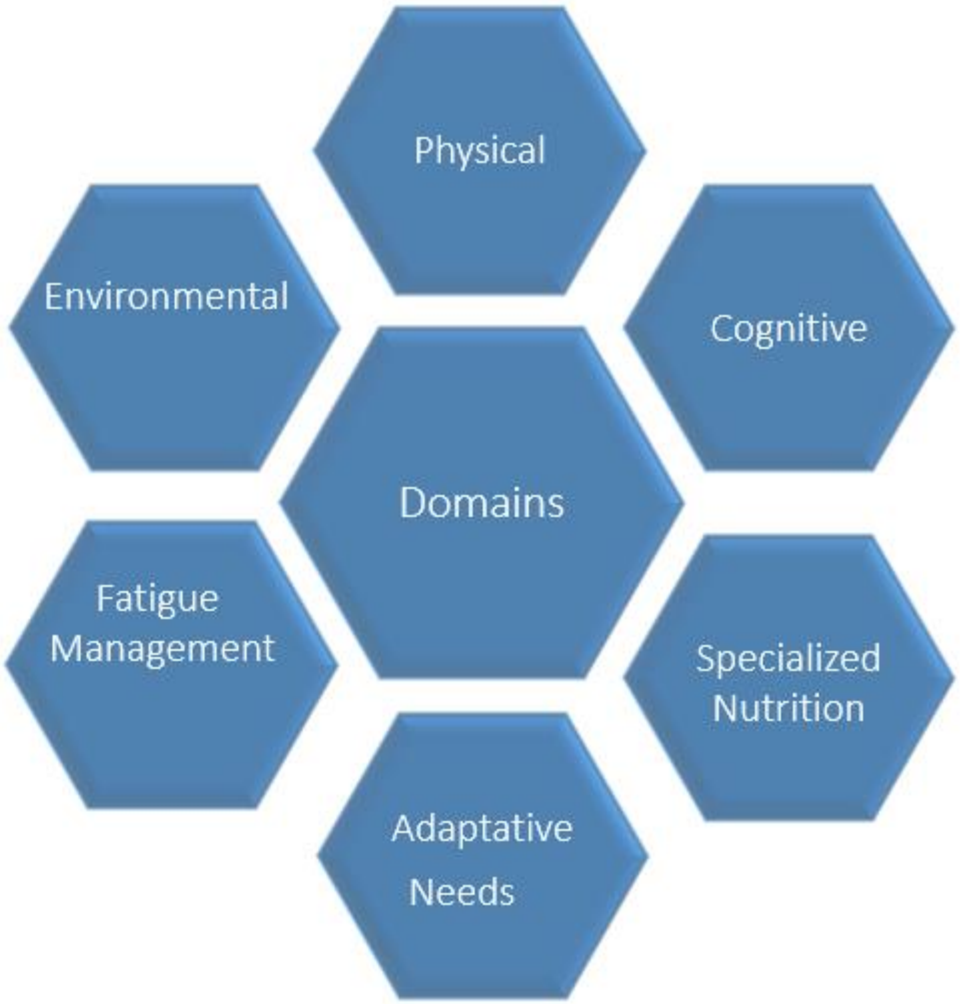


Lunar Activities with Potential Injury Risk

- Suit don/doff
- Training environments (field, ARGOS, NBL)
- Lunar landing
- Ambulation falls
- Falls from heights (ladders, craters, sloped terrain)
- Tool use
- EVA tasks (shoveling, sample retrieval, etc.)
- Rover loads
- Repetitive contact abrasions, foot blisters, etc.
- Repetitive use injuries
- High cadence EVA



Identify the Domains



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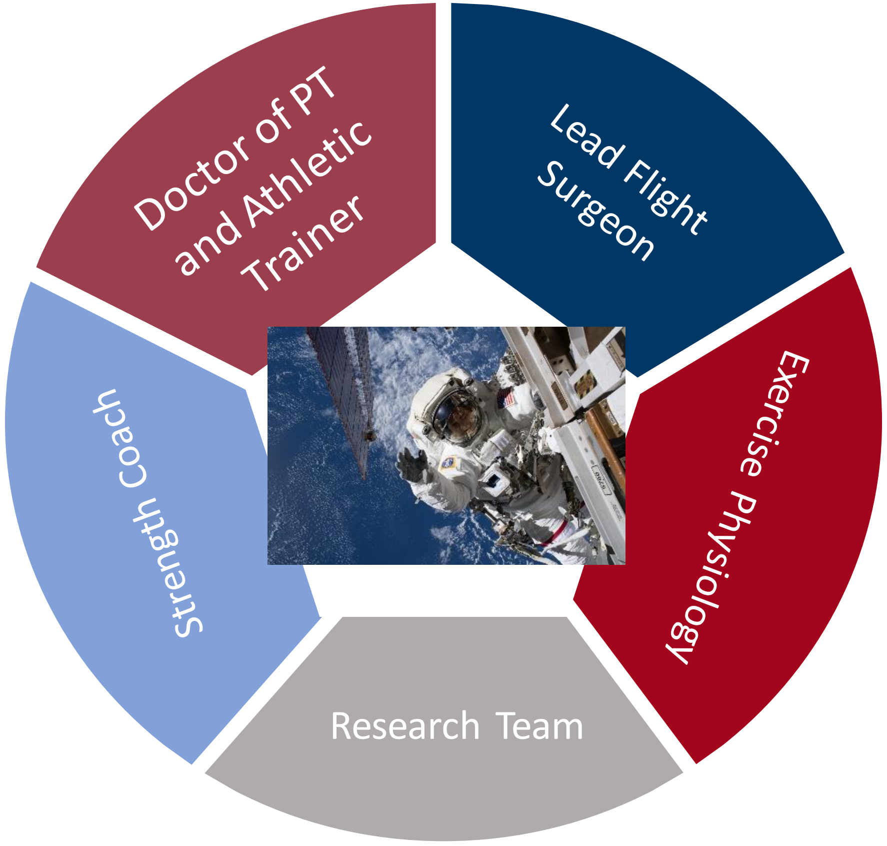
Surface EVA Readiness and Performance Optimization

<u>Physical Domain Example:</u>

*Steps:

1. Comprehension of Task and Physical Demand
2. Assessment of Individual Needs
3. Program Development Tailored to 1 and 2
4. Program Implementation (Training)
5. Ongoing Monitoring of Performance, Fitness and Injury Status
    1. ***<u>Athlete Model of Human Performance Support</u>***



Surface EVA Readiness and Performance Optimization

Physical Domain Example:

*Steps:

1. Current Understanding (Top Priorities):
    1. Large ***Cardiovascular*** Demand
    2. Large ***Strength and Endurance*** demand from the ***Axial Skeleton***
    3. Large demand for ***Strength and Power*** through and at ***End Ranges of Motions of the Lower Extremity***
    4. Large demand for ***Lower Extremity Coordination*** on varying surfaces and terrain
2. Assessment of Individual Needs
    1. Assessed through subjective interview and objective fitness and clinical exams (ex. IMTP, countermovement jump, static jump, mobility assessment, etc)

JETT 3 NASA Stock Photo

Surface EVA Readiness and Performance Optimization

Program Example:

Artemis Analog Fitness Goals and Template

Phase 1 Goals	Phase 2 Goals	Phase 3 Goals
1. Fundamentals of fitness/education 2. Basic muscular strength and endurance development of upper body, lower body and spine (isometric) 3. Development of general flexibility progressing to expression of mobility (flexibility under load) 4. Aerobic base (I.e Low, slow aerobic work)	1. Progression of medium to maximum strength of upper body, lower body, and spine 2. Progression to speed and power-based movements 3. Agility training as it applies to the task 4. Transition of flexibility to mobility with load through full ranges where appropriate 5. Maintain aerobic base (I.e Loaded Low, slow aerobic work (ruck marching)/incline walking) 6. Threshold emphasis (I.e intervals, threshold work)	1. Continued advancement of the abilities from phase 1 and phase 2 2. Maximum Muscular Strength, Muscular Endurance, Aerobic Endurance, Threshold, Mobility, Power, and Agility

Phase 1 (2 weeks prep, 4 weeks GPP)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	
Rest	Aerobic Zone 2- 60-90 min	Lift A	Aerobic Zone 2- 45-60 min	Lift B	Aerobic Zone 2- 45-60 min (with light load)	Active recovery	Estimated 7 hours Total time

Optional Deload in Week 4

Phase 2 (4 weeks)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	
Rest	Dynamic WU/Agility Interval/Threshold	Lift A	Dynamic WU/ Agility Aerobic Zone 2- 45 min-60 min	Lift B	Aerobic Zone 2- 60-90 min (loaded)	Active recovery	Estimated 8-9 Hours Total time

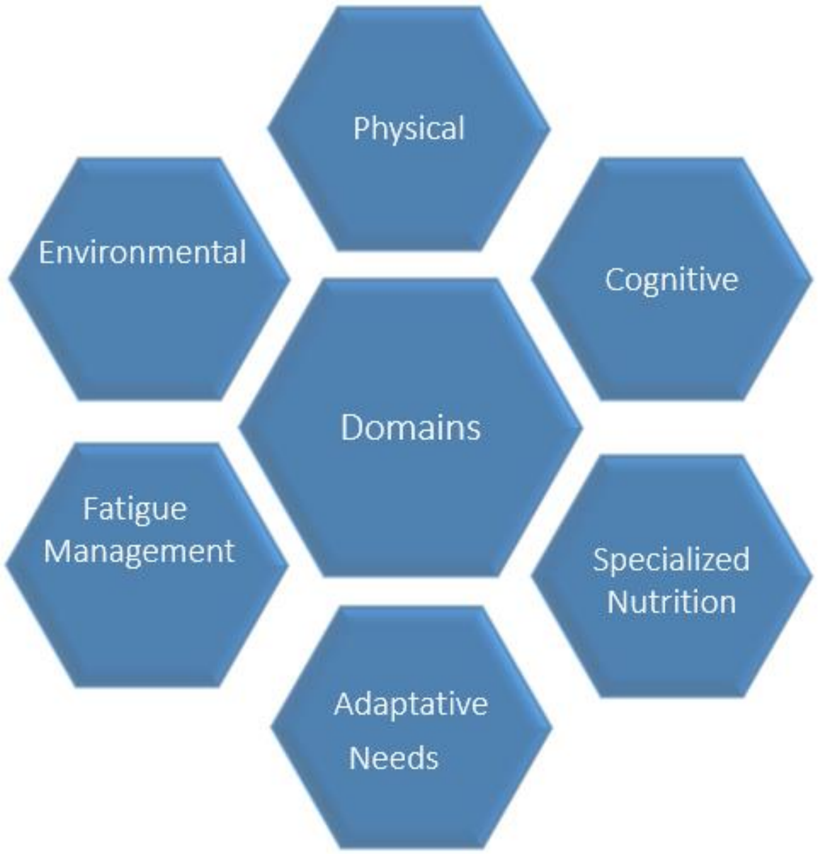
Optional Deload in Week 4

Phase 3 (6 weeks)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	
Rest	Dynamic WU/Agility High Intensity Interval Training	Lift A- Heavy LQ with Metabolic Conditioning	Tempo Work	Lift B- Heavy UQ with Metabolic Conditioning	Aerobic Zone 2- 60-90 min (loaded)	Active recovery	Estimated 8-9 Hours Total time

Surface EVA Readiness and Performance Optimization

<u>Desired End State:</u>
Optimize all domains of human performance and enhance injury resiliency!



Nindl, 2015

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Questions?

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