



Occupant Protection in Human Spaceflight

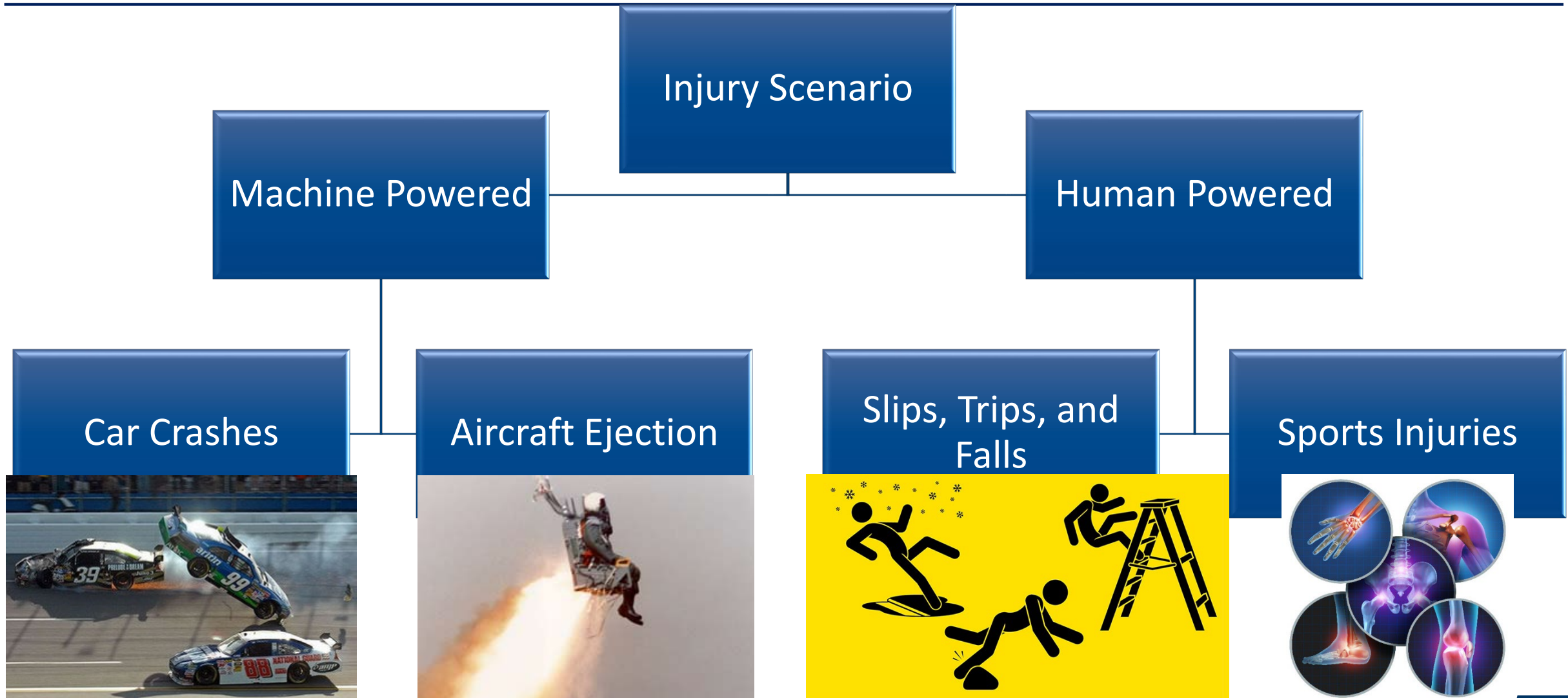
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Human Performance Engineer

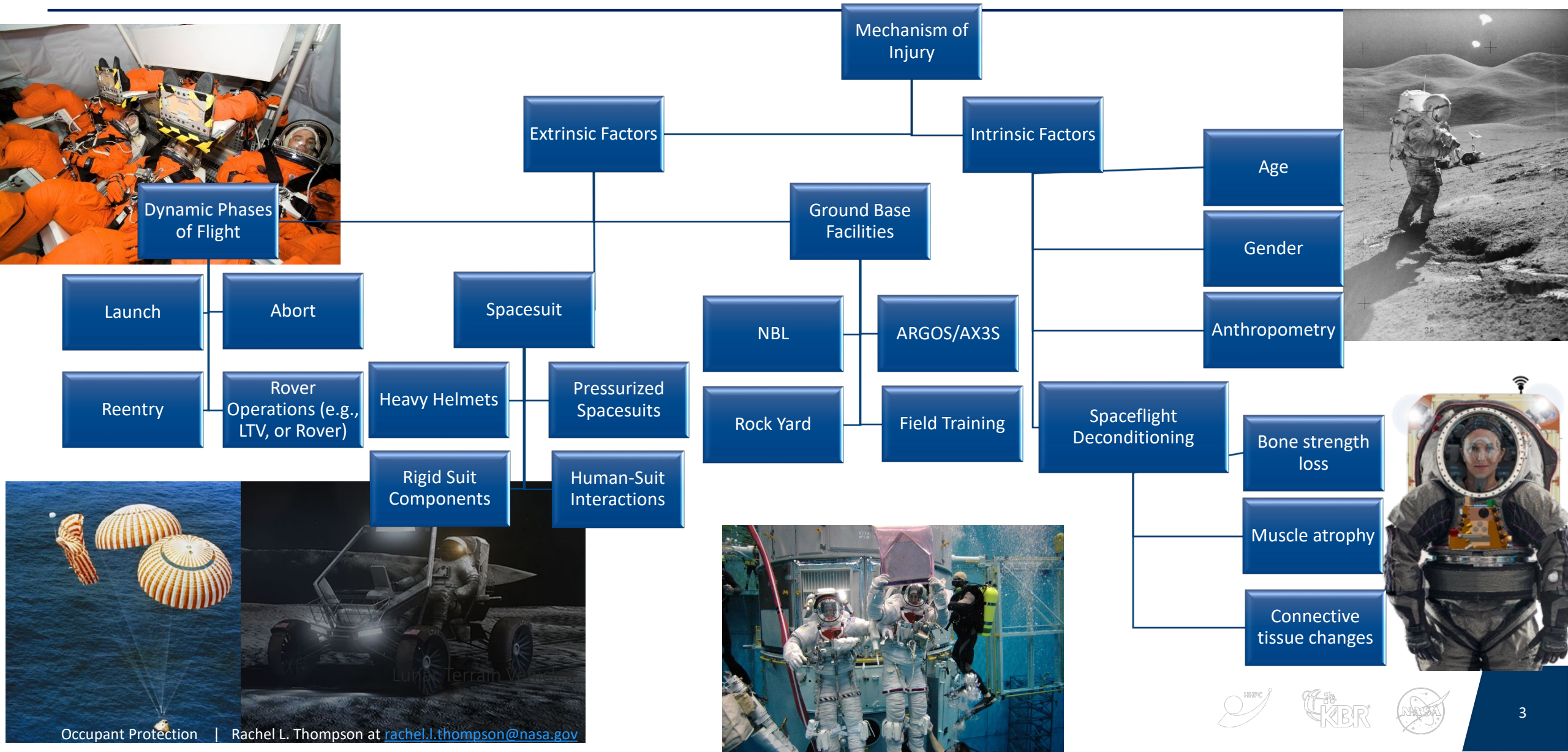
Applied Injury Biomechanics

KBR at NASA Johnson Space Center

Real World Occupant Protection



Occupant Protection at NASA



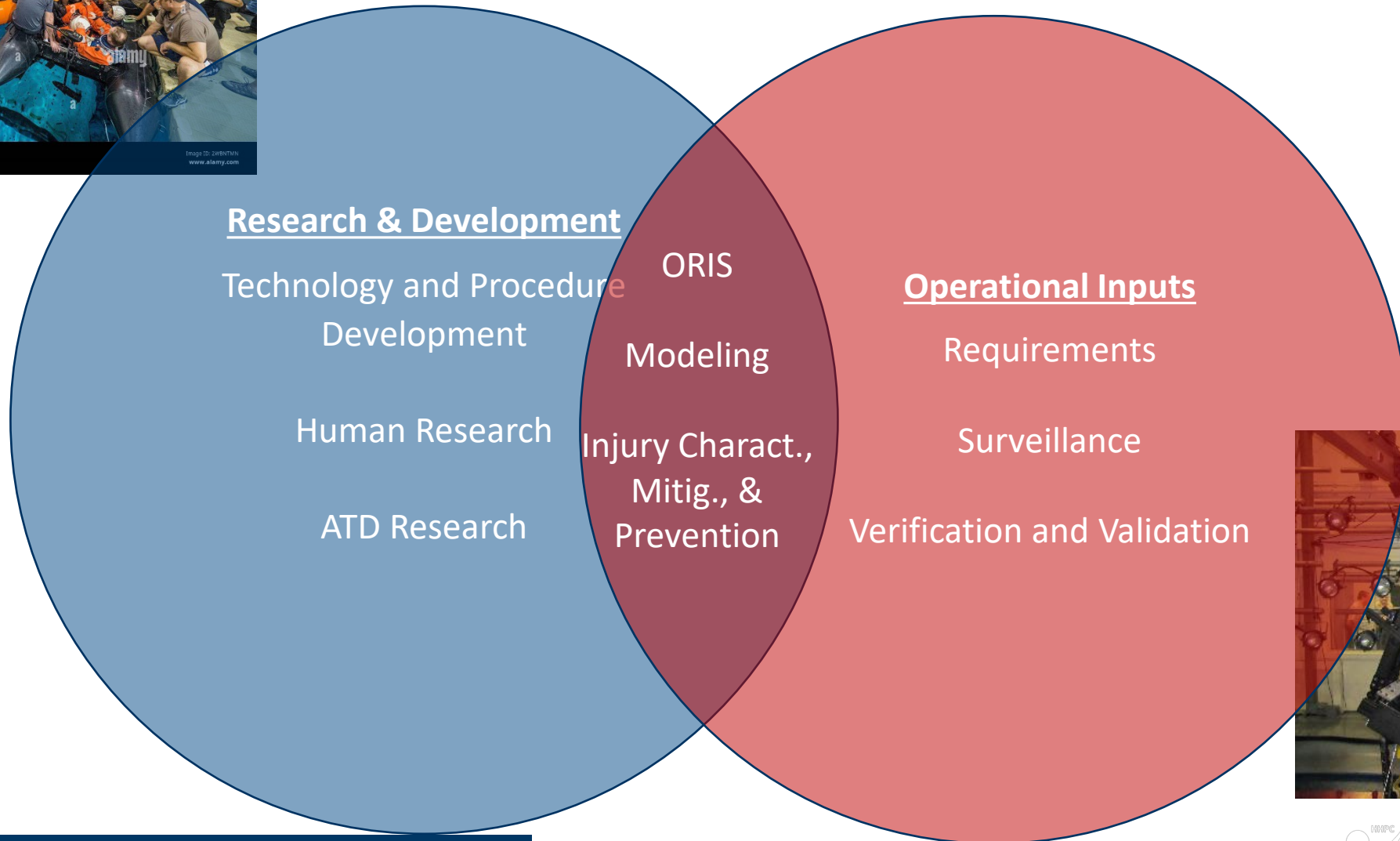
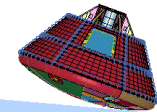


How do we Protect Crew Members/Test Subjects given the Vast Array of Environments/Analog?





CASE 52251
Time = 0



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

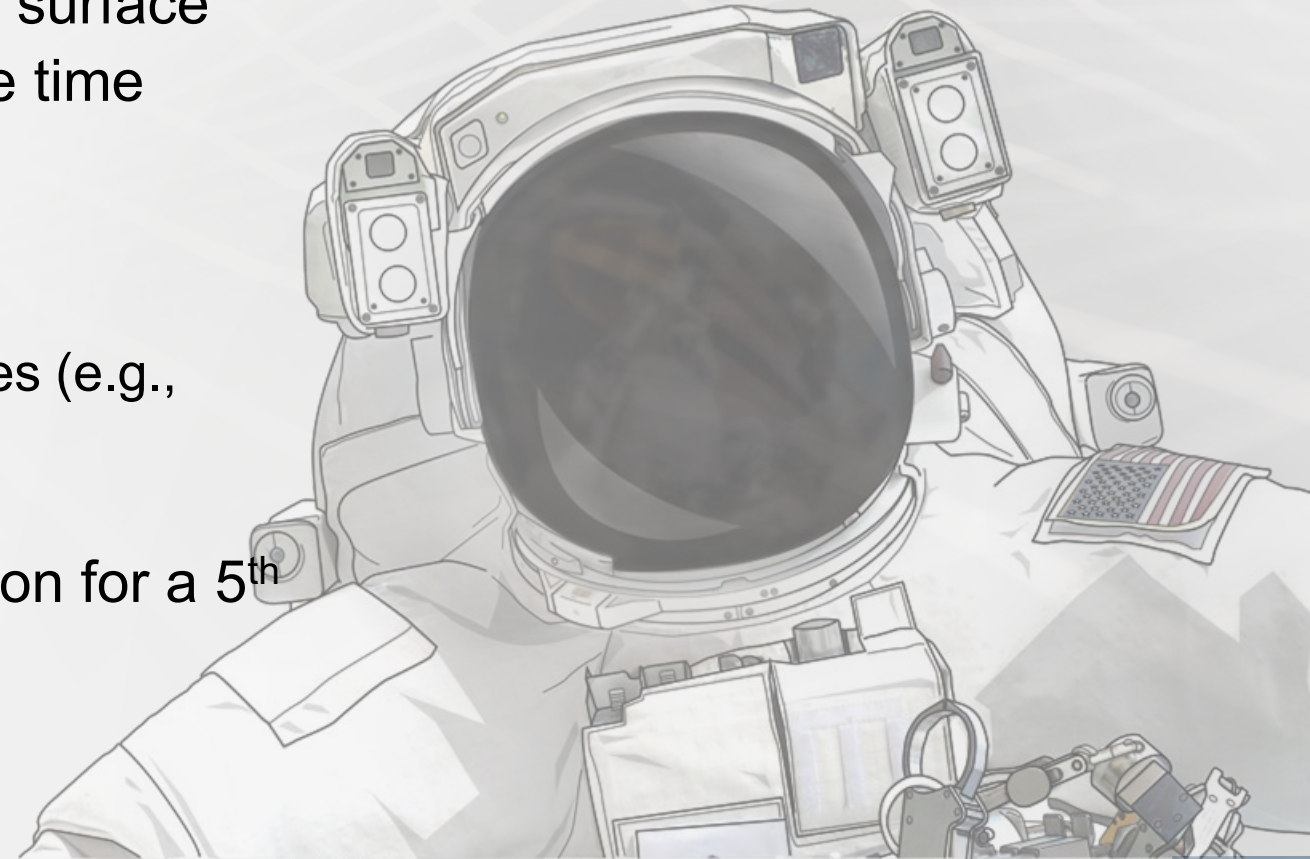
- Gravitational forces
 - Microgravity
 - Lunar?
- Radiation
- Exercise
- Nutrition

Effects of Deconditioning

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

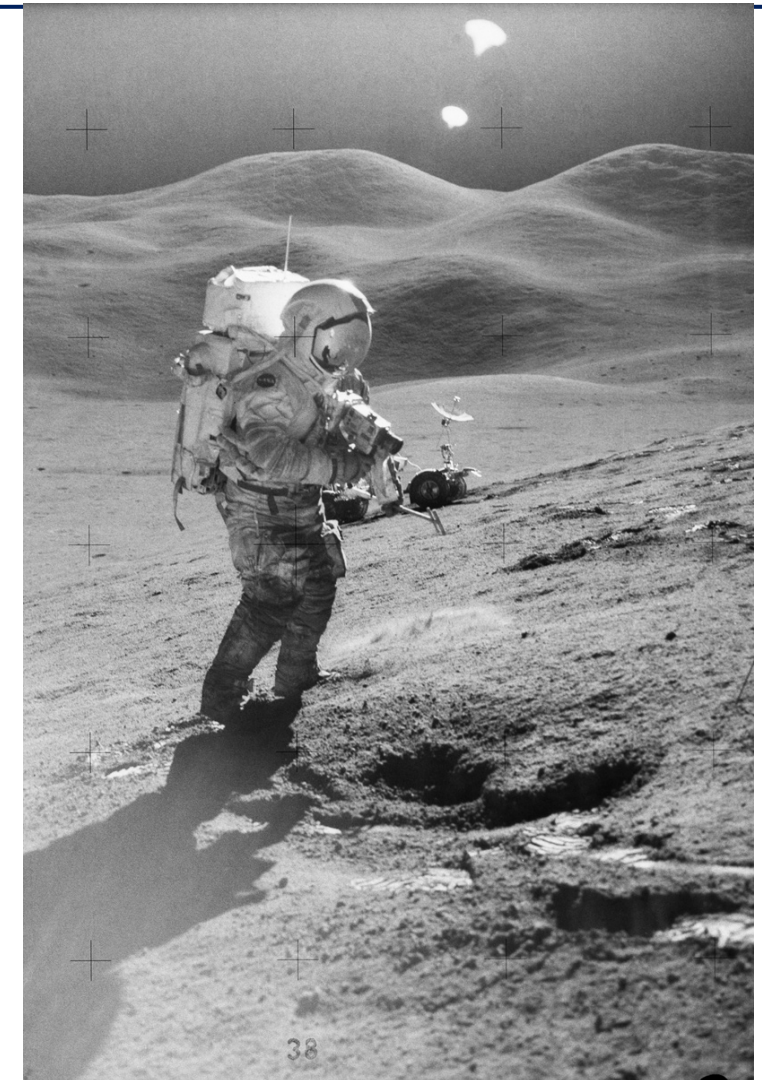
Surface EVA Operations

- 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



NASA funding sources:
MCO, CHS, MPCV, NESC, HRP, CCP, EHP, HLS, HSRB

Questions?

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