Ergonomics and Human Factors for the Restraints and Mobility Aids on the International Space Station

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Overview

- Space Flight Environment
- The ISS Restraints and Mobility Aids
- Ergonomics and Human Factors for Space flight
- Suggested Improvements
- Recommendations

Space Flight Environment

- Which direction is up?
- Zero Gravity
  - Translations
  - Station Keeping
- Operations 24/7
  - Working Laboratory 5/8
  - Off Duty time
- Crew time cost escalated annually
  - $65,000 – $95,000/hr

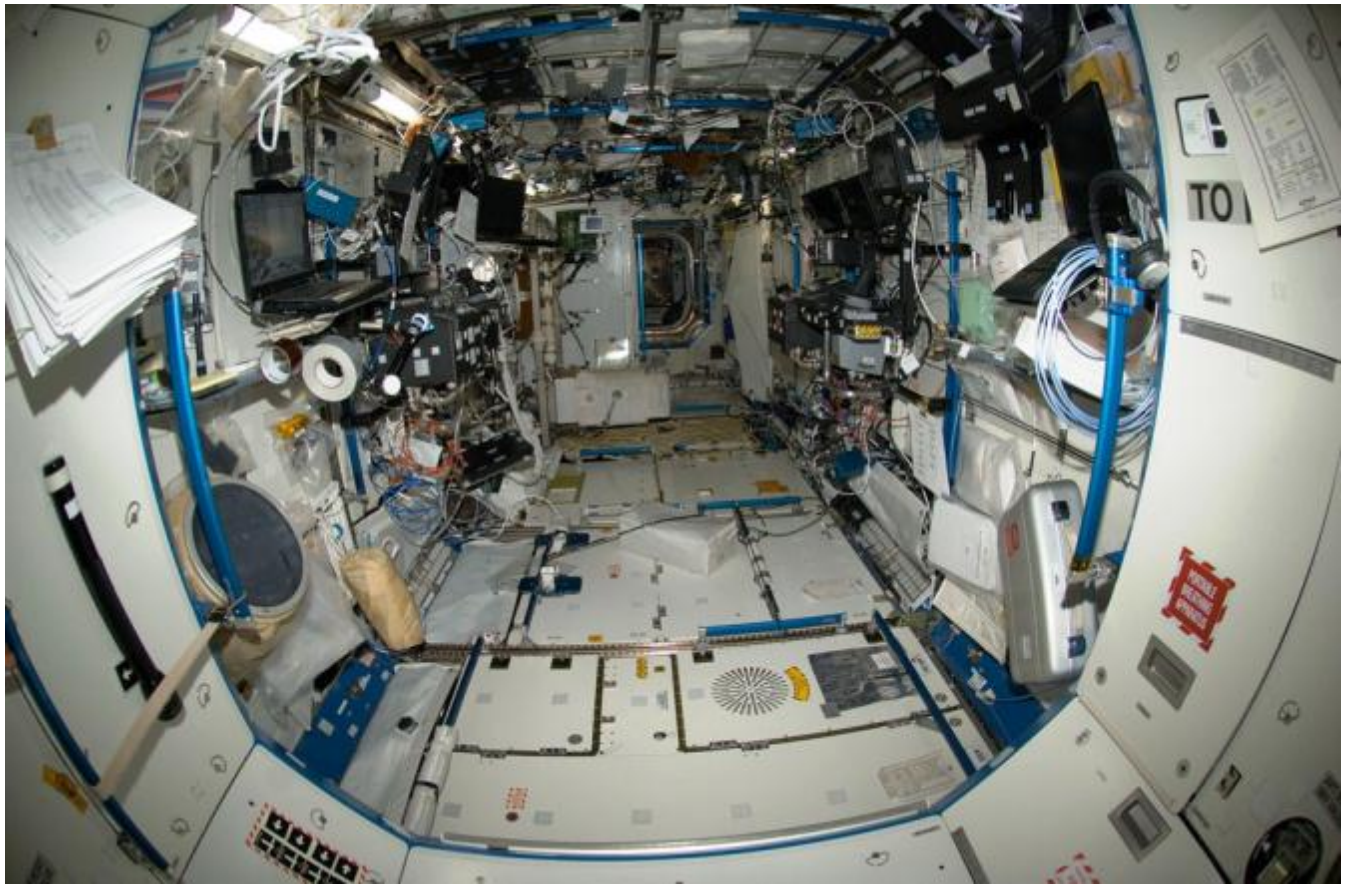
International Space Station (ISS) Restraints and Mobility Aids

- How do crew members get around and secure themselves?
  - Handrails
    - USOS
    - Russian
  - Foot Restraints
    - Short Duration
    - Long Duration
    - Cupola Crew Restrains
  - Tethers
    - Bungees
    - Straps
    - Harness
  - Shoes/Socks

International Space Station (ISS) Restraints and Mobility Aids

- USOS

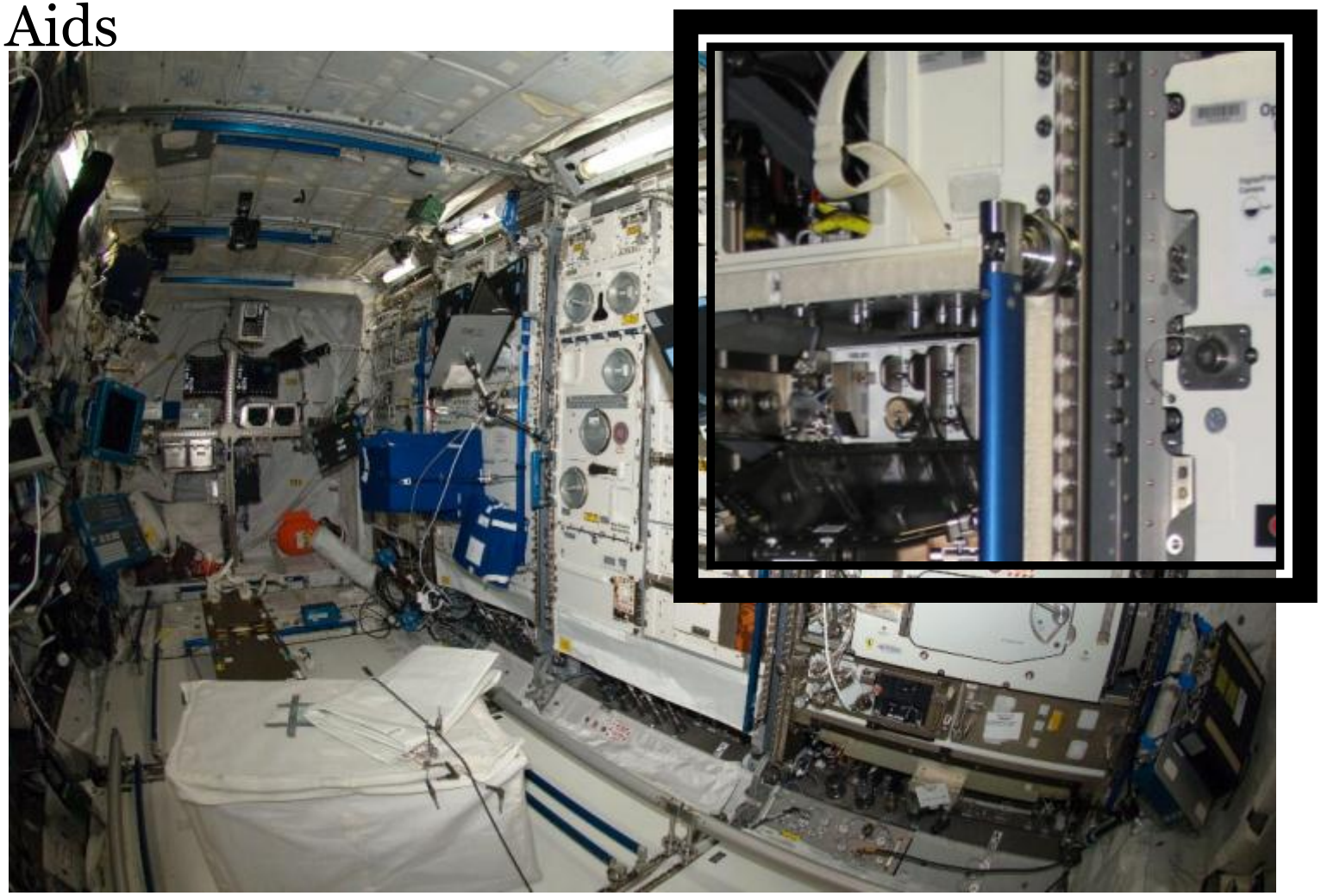
Handrails



International Space Station (ISS) Restraints and Mobility Aids

- USOS

Handrails



International Space Station (ISS) Restraints and Mobility Aids

- Russian

SM/Handrails

Bungee

International Space Station (ISS) Restraints and Mobility Aids

- Russian

FGB/Handrails

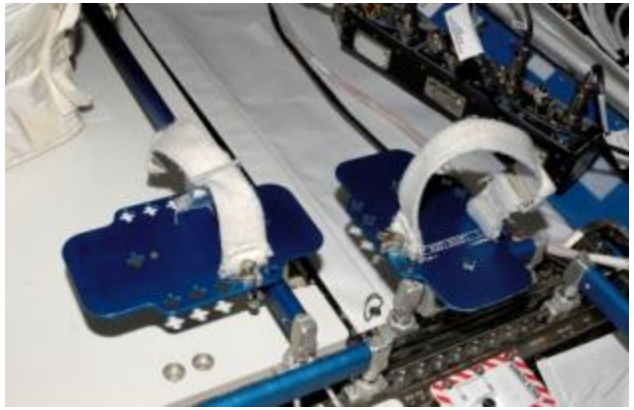
Bungee

International Space Station (ISS) Restraints and Mobility Aids

- USOS

Foot

Restraints



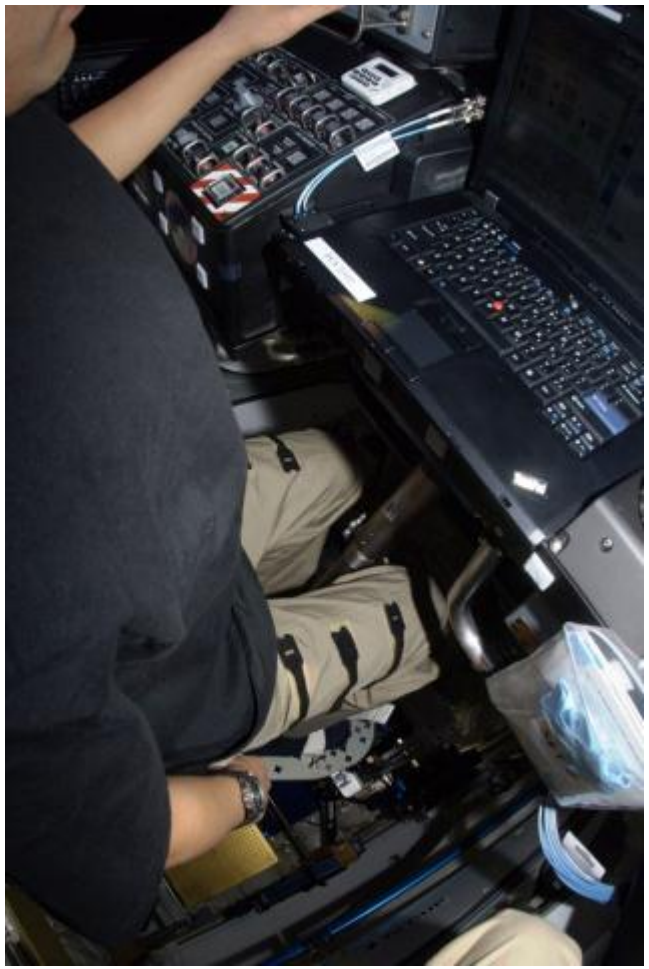
International Space Station (ISS) Restraints and Mobility Aids

- USOS

Cupola

Crew

Restraints



International Space Station (ISS) Restraints and Mobility Aids

- Strap/bungee
- Slippers/socks

International Space Station (ISS) Restraints and Mobility Aids

- Harness
- Exercise shoes

Ergonomics and Human Factors for Space flight

- Body posture
  - Neutral position
- Muscles/Forces and Reactions
  - Translations or relocation via handrails
    - Primary movement with fingers, hands, arms, and shoulders
    - Secondary with toes, feet, legs, stomach, and back
  - Station keeping
    - Primary with toes, feet (top), legs (shin), stomach, back
    - Secondary with fingers, hands, arms, and shoulders

Ergonomics and Human Factors for Space flight

- Repetitive and/or continuous use of muscles, tendons, joints, and bones can cause crew injuries or disorders
  - Cumulative Trauma Disorders (CTDs)
  - Repetitive Strain Injuries (RSIs)
  - Musculoskeletal Disorders (MSDs)
- The medical history of ISS crew members is not identified in this report; however, the possible injuries that the ISS crew members could suffer from operational R&MA
  - Back Pain
  - Shin Splints
  - Stress Fracture
  - Tendinosis or Tendinitis – Achilles, Patellar
  - Compartment Syndrome

Ergonomics and Human Factors for Space flight

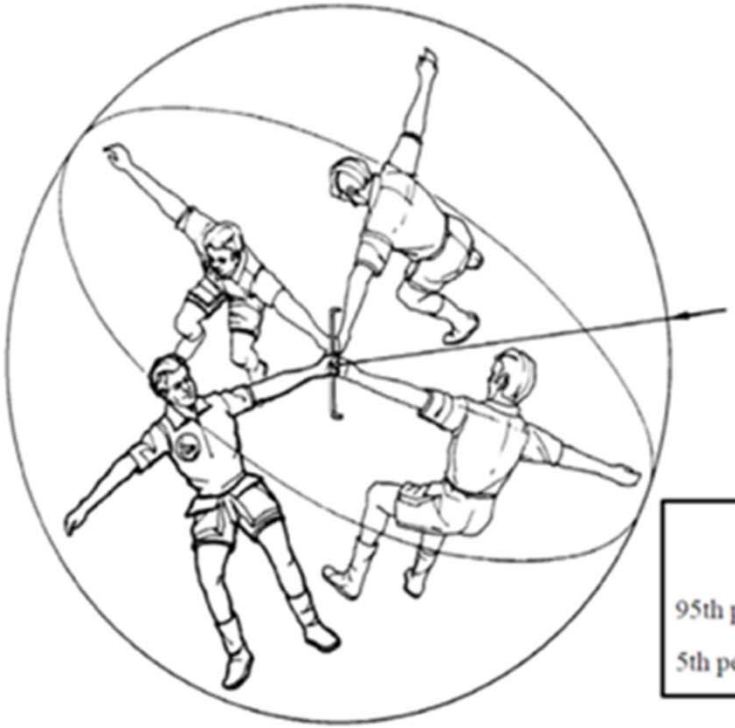
- Crew comments from debriefs related to ergonomics
  - "a lot of times you are reacting ….with the top of your feet beneath the handrail ….. just the act of typing for a length of time with your feet constantly having to pull you back in"
  - "typing on a laptop …. They found it to be a bit troublesome because you are reacting that force, not with your mass sitting in a chair, but with your feet and the small muscles in the front of your shins"
  - "You spend an hour or two holding yourself in place with the little muscles on the front of your shins and it hurts."

Ergonomics and Human Factors for Space flight

- Crew comments from debriefs related to hardware
  - "The crew wanted to have a foot restraint ….with foam wrapped on it, and they could do this with the CTB dividers"
  - "The crewmember attached a bungee at the end of the handrail that their feet were under, had the bungee around their hips, wrapped their legs around each side and was locked in and typing."
  - "the WHC foot restraint, all the mechanisms come loose eventually and pop off with the way it clamps on the handrail"
  - "crewmember disliked the banisters and questioned if it was because they didn't understand the intent of them"

Ergonomics and Human Factors for Space flight

- Human Factors consideration on the design boundary for reach

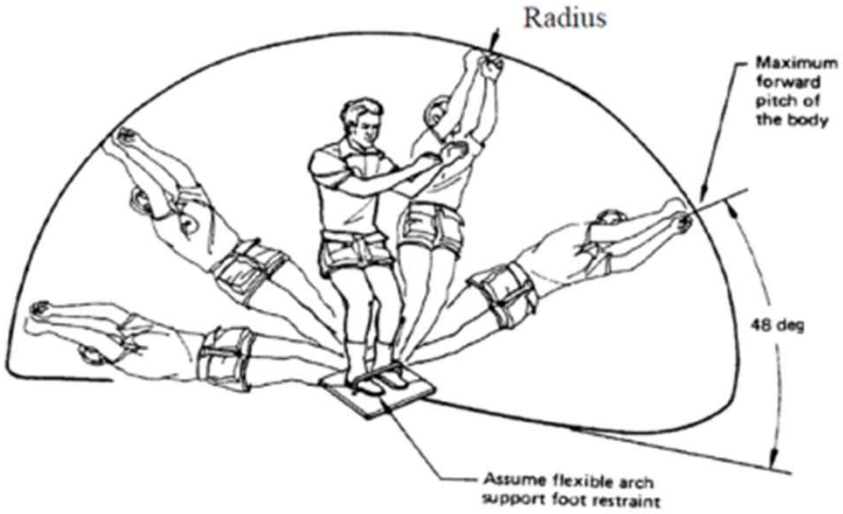


Type of Task	Adjustment
Finger tip operation	+7.0 cm (2.8 in.)
Full hand grasp	−5.5 cm (2.2 in.)

	Radius of fingertip reach boundary
95th percentile male	195 cm (77 in.)
5th percentile female	150 cm (63 in.)

Ergonomics and Human Factors for Space flight

- Human Factors consideration on the design boundary fwd/aft



	Radius of reach fingertip boundary in X–Z plane	
	Flexible arch support foot restraint	Fixed "flat" foot restraint
95th percentile male	222 cm (87 in.)	212 cm (83 in.)
5th percentile female	188 cm (74 in.)	172 cm (68 in.)

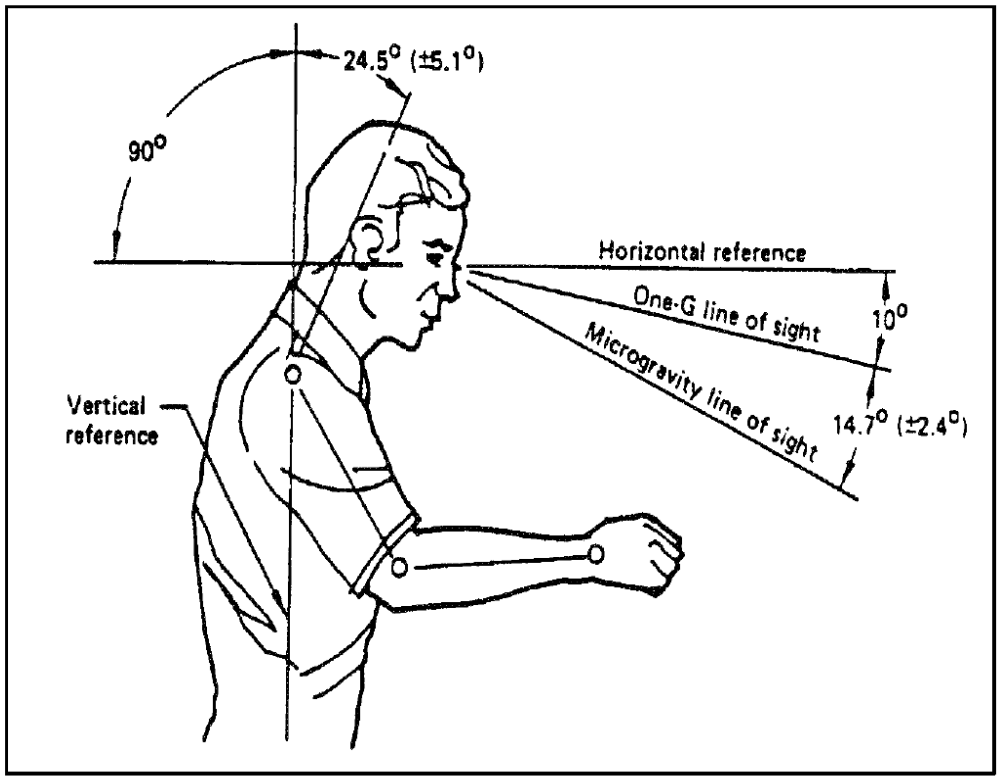
Ergonomics and Human Factors for Space flight

- Human Factors consideration on the design boundary side-side

Dimensions of fingertip reach boundary in Y–Z plane			
	Angle (degrees)	Y–axis dimension	Z–axis dimension
95th percentile male	90	0	222cm
	75	80 cm (31 in.)	193 cm (76 in.)
	60	110 cm (43 in.)	160 cm (63 in.)
5th percentile female	90	0	188 cm (74 in.)
	75	28 cm (11 in.)	175 cm (69 in.)
	60	80 cm (31 in.)	140 cm (55 in.)

Ergonomics and Human Factors for Space flight

- Human Factors consideration on the design boundary line of sight



Suggested Improvements

- Provide adequate R&MA and Training to improve Operational environment and realize the return on investments
  - New Hardware
  - Modified existing hardware
  - Physical Training Plans

Suggested Improvements

- New hardware for consideration
  - Harness with adjustable hydraulic dampener or simply elastic straps that is easy to use
  - Foot rails with adequate padding that stay secured and not loosen with continued use
  - Padding for current Handrails

Suggested Improvements

- Modified hardware for consideration
  - Harness with retractable tether or bungee straps
  - CTB dividers for added padding on current Handrails

Suggested Improvements

- Physical Training Plans
  - Primary objective is to increase flexibility and muscle strength focusing on the toes, up foot motion, and shin area (dorsiflexion angles)
  - Secondary objective is to focus on legs, hips, back, stomach, arms shoulders, hands
  - Maintain a good respiratory rate and eat healthy

Recommendations

- What is the cost, will it solve the issues, and will the crew use it?
  - New Hardware (Harness, Foot rail, Padding)
    - Foot rail provides the best benefit with minimal cost and easy to use
  - Modified Hardware (Harness, Padding)
    - Padding for hand rails easy to implement and use; however, needs crew time
  - Physical training
    - Add angle dorsiflexion to crew physical training plan

Questions?

References

- International Space Station Flight Crew Integration Standard (NASA–STD–3000/T) SSP 50005 Revision E; 30 June 2006; National Aeronautics and Space Administration
- Occupational Safety & Health Administration (OSHA), Analysis Tools; On line at http://www.osha.gov/SLTC/ergonomics/analysis_tools.html
- Price per crew hour; Correspondence with ISS Vehicle Chief Engineer via NASA e-mail
- Crew Debrief Questions Database; NASA Habitability and Human Factors Division
- ISS Downlink Imagery Collection; On line http://images.jsc.nasa.gov/
- Physical training plan; Correspondence with Crew Trainer via phone call