

# “SPACE MEDICINE”

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The first word from the Moon







# OBJECTIVES

-DISCUSS SCOPE OF NASA MEDICAL OPERATIONS

-HIGHLIGHT UNIQUE PREVENTIVE MEDICINE ASPECTS OF SPACEFLIGHT

-NOTE CHALLENGES FOR CARE IN EXPLORATION CLASS MISSIONS

# Medical Operations Responsibility

To ensure the health, safety, and well being of the Astronaut corps during all phases of spaceflight.

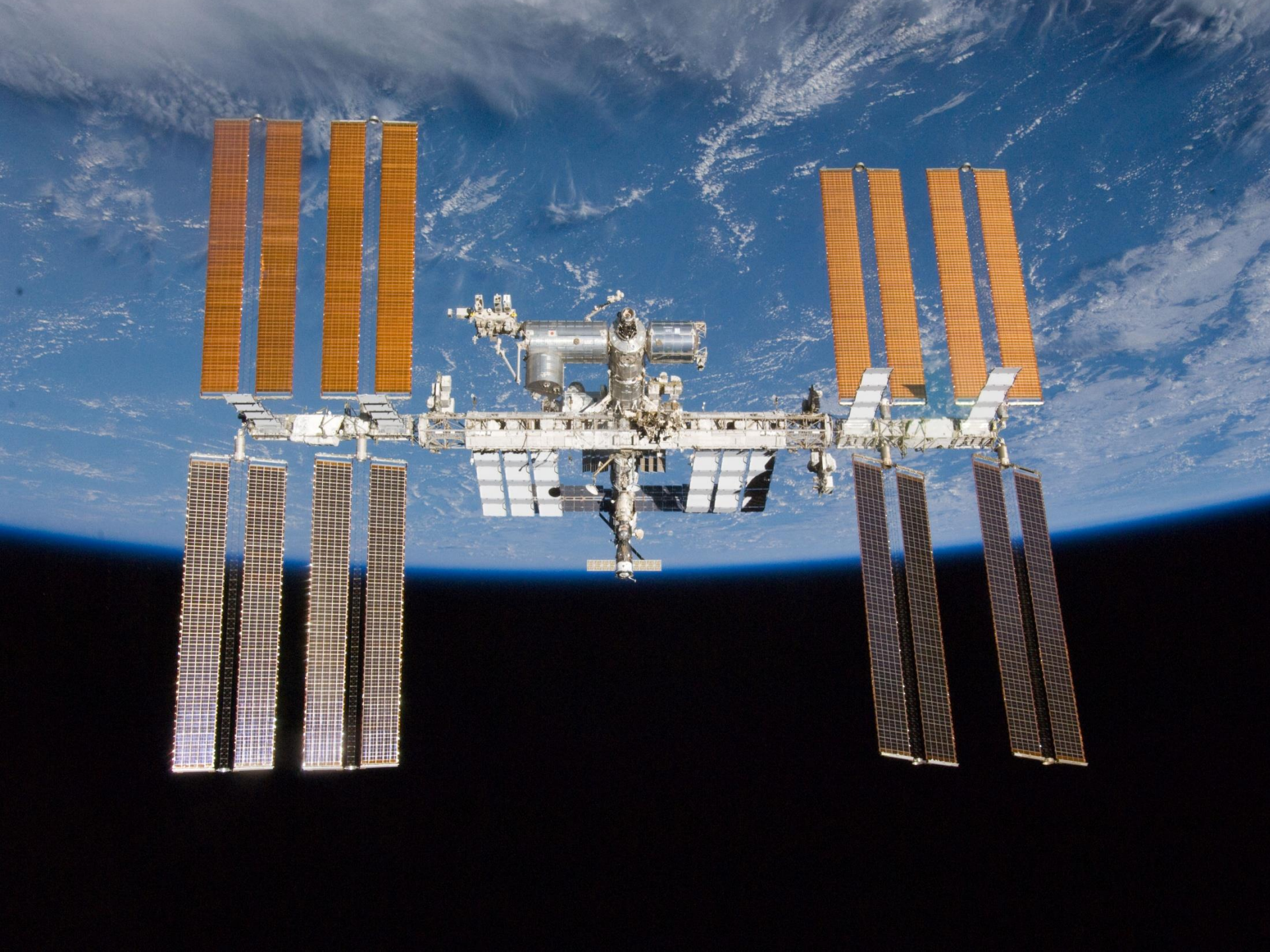






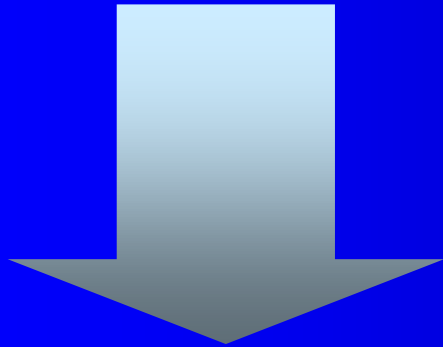
# Soyuz Landing Deployment Schematic





# Human Response to Spaceflight

Astronauts experience a spectrum of adaptations in flight and postflight



Balance disorders  
Cardiovascular deconditioning  
Decreased immune function  
Muscle atrophy  
Bone loss



- Neurovestibular
- Cardiovascular
- Bone
- Muscle
- Immunology
- Nutrition
- Behavior

# Hazards of Space Flight

- Space Environment

- Reduced Gravity
- Radiation
- Vacuum
- Debris

- Spacecraft Environment

- Isolation and confinement
- Noise and Vibration
- Closed loop environment (life support)
- Payloads and construction activities
- Waste production

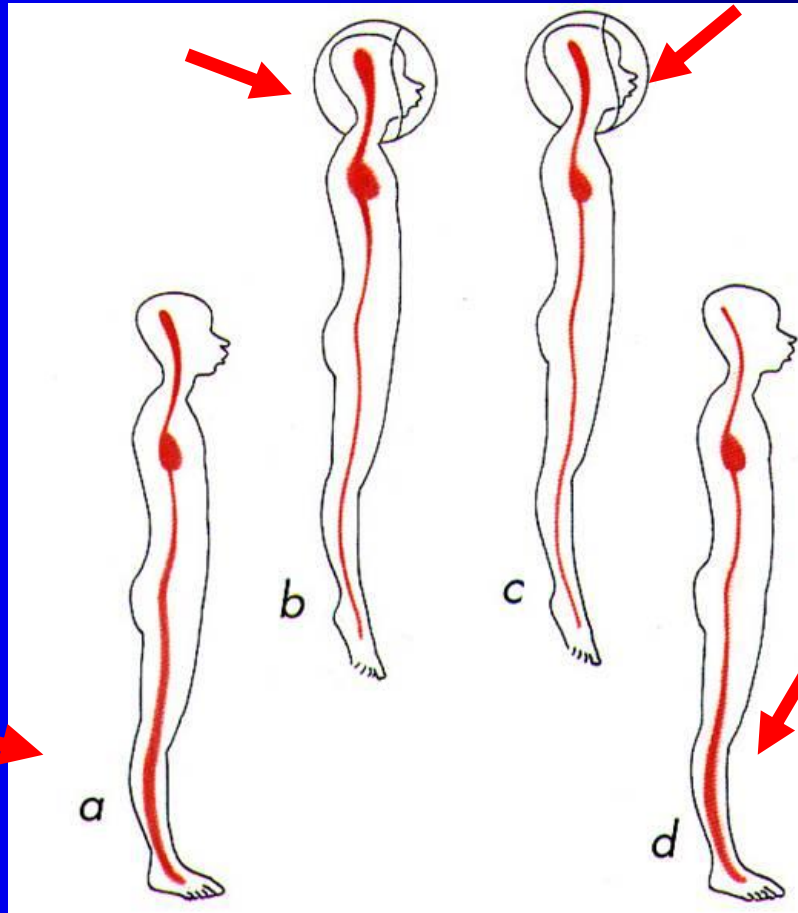
- Space Flight Mission

- Flight activity; Launch and Reentry Forces
- Remoteness and communication access
- Circadian rhythms and crew schedule changes
- Extravehicular Activity (EVA)
- Decompression Sickness

# Fluid Shifts and Blood Volume during Space Flight

*In space*, with loss of the hydrostatic gradient, some fluid quickly redistributes toward the chest and upper body; sensed as 'overload' of circulating blood volume

*In space*, the newly sensed excess blood volume is adjusted by expelling excess fluid into tissues and cells (**12% to 15% vol reduction**) and red blood cells are adjusted downward to maintain a normal concentration (**relative anemia**)

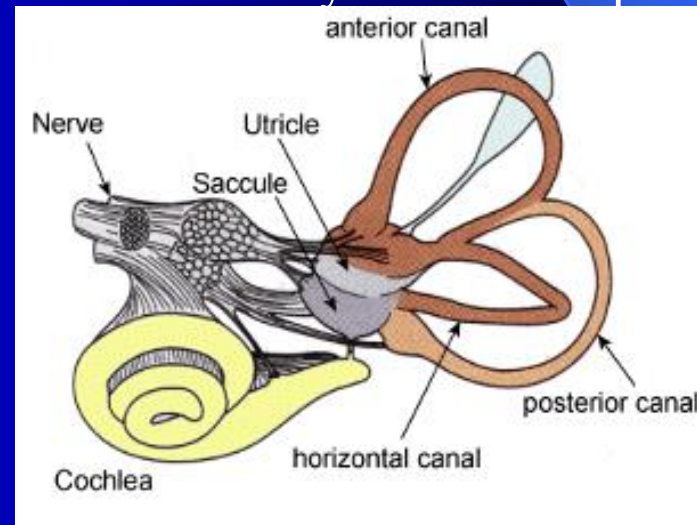


*On Earth*, gravity exerts a downward force, setting up a vertical hydrostatic gradient. When standing, some 'excess' fluid resides in vessels and tissues of the legs.

*Upon return to Earth*, gravity again pulls the fluid downward, but now there is a relative deficit in both circulating fluid and red blood cells. Tissue edema also contributes to a greater loss of volume

# Neurosensory Response

- Sense of balance, position and motion result from centrally integrated inputs from neurovestibular system (otolith organs, semicircular canals), vision, body position sensors, haptic sensors (touch)
- These inputs are immediately and radically altered in weightlessness
- Altered meaning of inputs leads to central sensory conflict – space motion sickness
- Sickness resolves in a few days
- Adaptation continues...



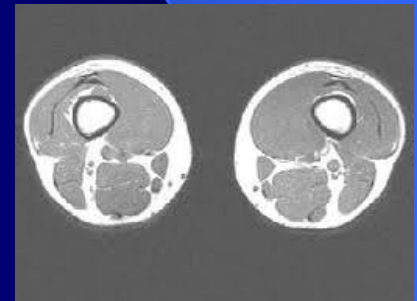
# Neurosensory Response

- Eventual adaptation to position sense and motion in three dimensions without gravitational reference
- Sense of ‘up’ or ‘down’ are what you choose to define



# Musculoskeletal System

- Bone and muscle are vital tissues that are constantly remodeled based on physical loading
- The weightless environment causes a relentless loss (atrophy) of bone and muscle tissue concentrated in the weight bearing regions
- Physical countermeasures on ISS are very good, but not a complete solution





# Bone compartments or bone types

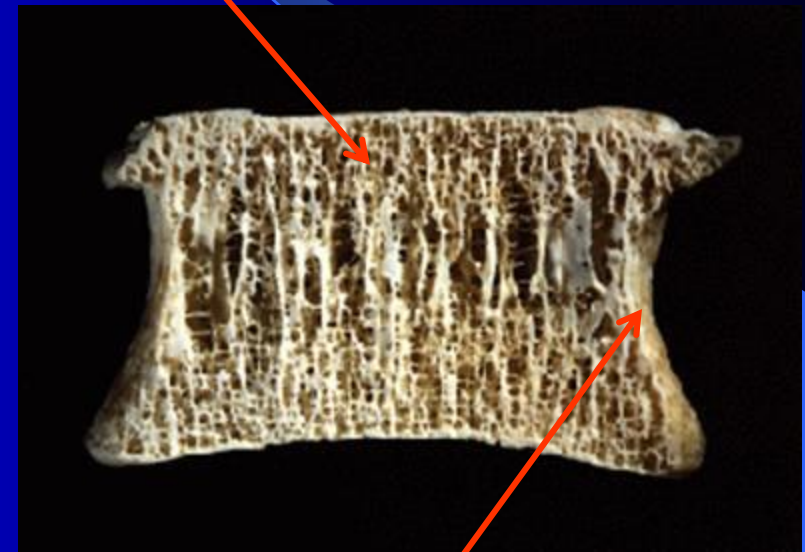
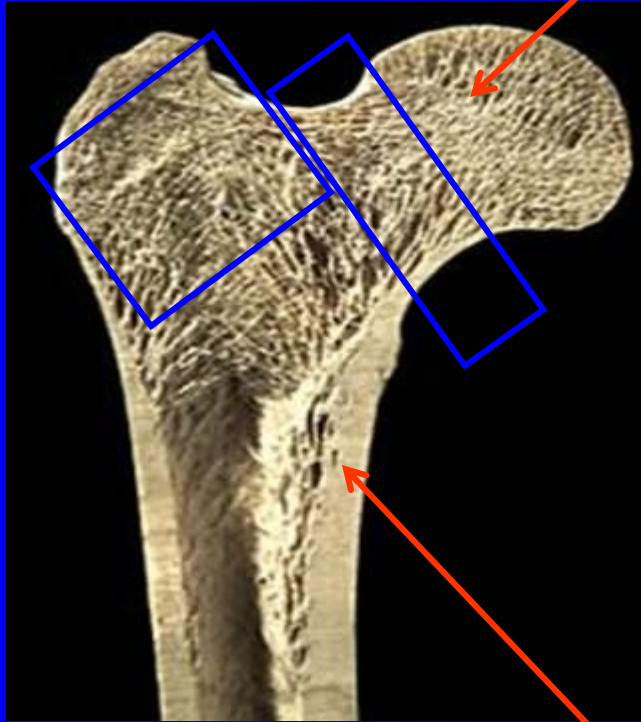
Cancellous "Spongy" Bone/Trabecular Bone

PROXIMAL FEMUR

VERTEBRAL BODY

Trochanter

Femoral  
Neck



Cortical Bone/ "Compact Bone"

An example of a spaceflight adaptation that is well described but still lacks understanding of time course, recovery, and long term risk





WESTERN KENTUCKY

89

TM

1068

ДРП



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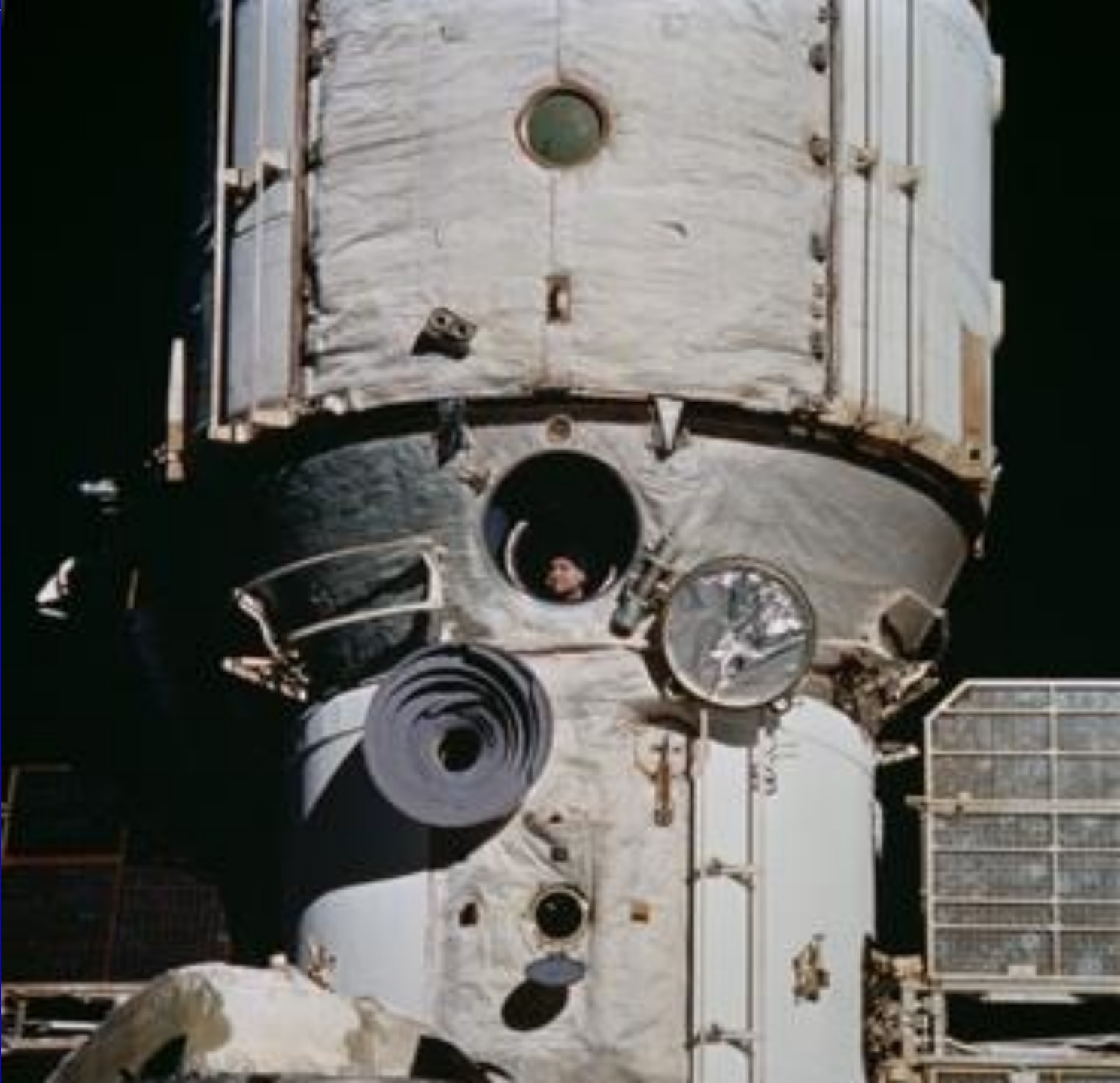


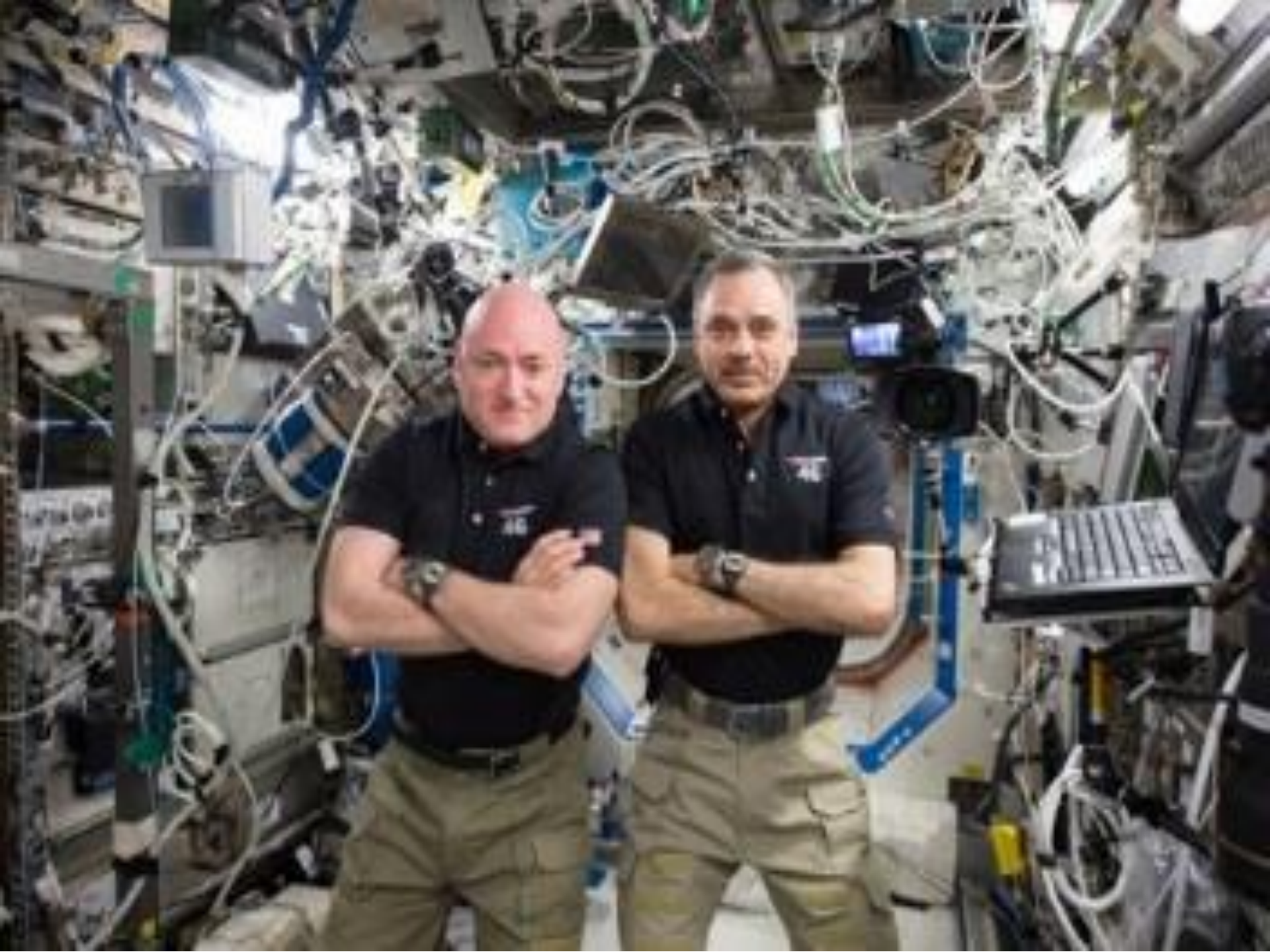
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# Behavioral/Psycho-Social

## Changes in crew mood, morale, and circadian rhythm

- **Incidence** - Affects all crewmembers to some degree
- **Symptoms** - Fatigue and irritability, performance decrements
- **Time course** - Variable
- **Causes**
  - Work load
  - Sleep habits and facilities
  - Crew personalities, “crew space”, and cultural differences
  - Temperature
  - Noise
  - Odors
  - Atmosphere
  - Diet
  - Lack of family contact
- **Treatment** - Treat causes and maximize living conditions







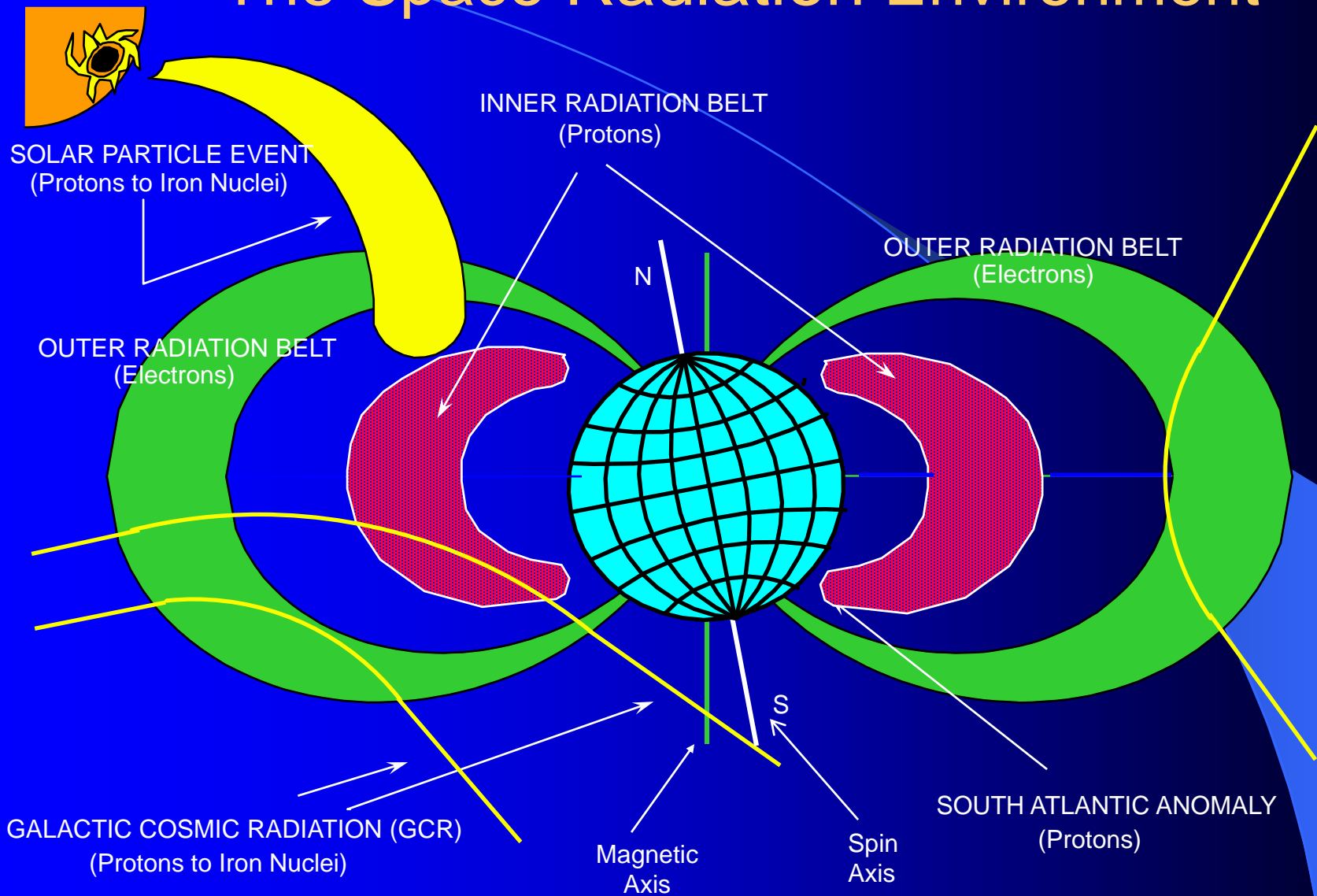


Оранжерея "СВЕТ"



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# The Space Radiation Environment



Representation of the major sources of ionizing radiation of importance to manned missions in low-Earth orbit. Note the spatial distribution of the trapped radiation belts.



# Systems & Crew Training



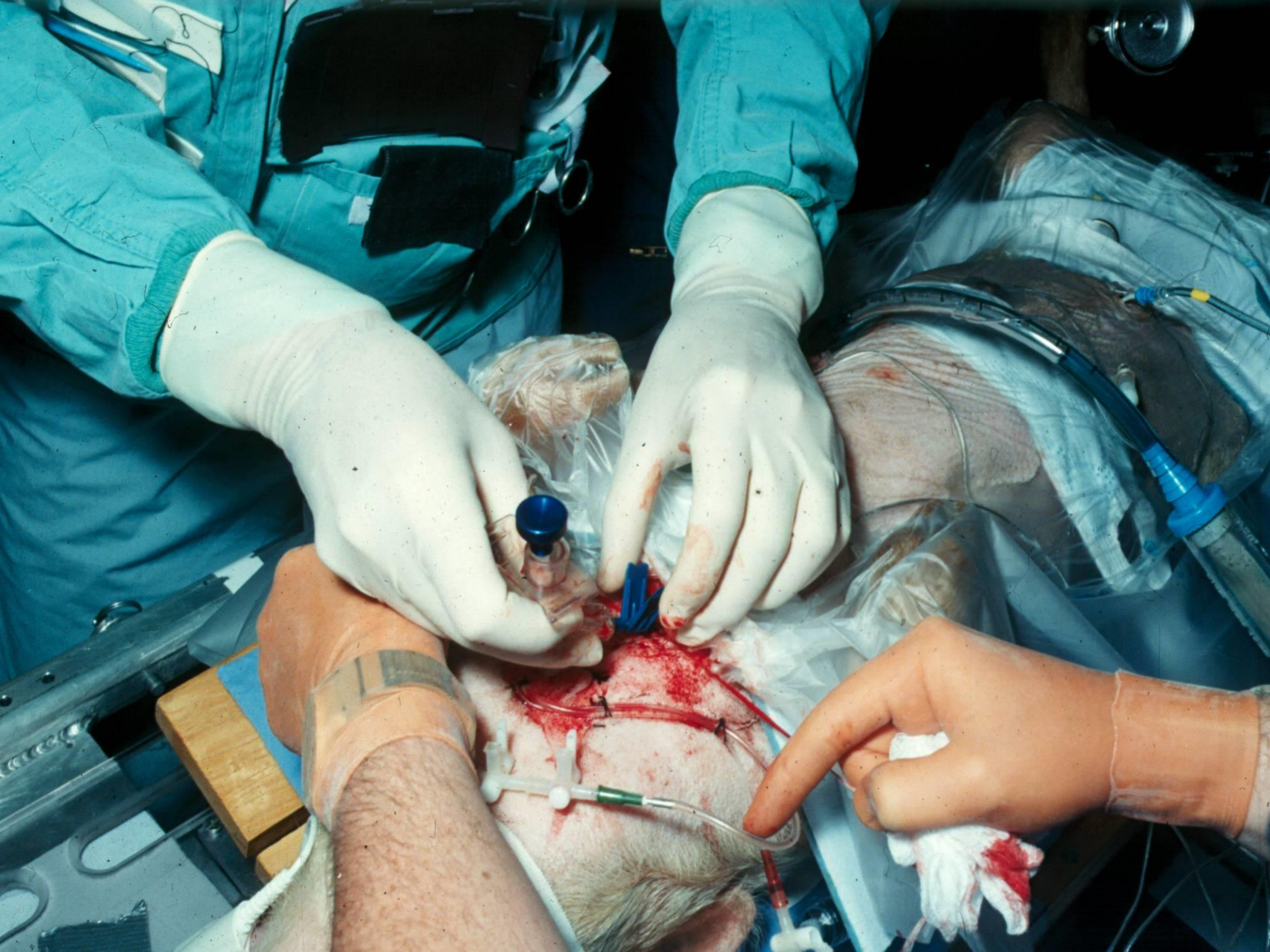
KC-135  
“Weightless Wonder,  
Vomit Comet”



*Hardware Testing and Procedure Validation*

# Developing Advanced Cardiac Life Support (ACLS) algorithms for on-orbit use and training













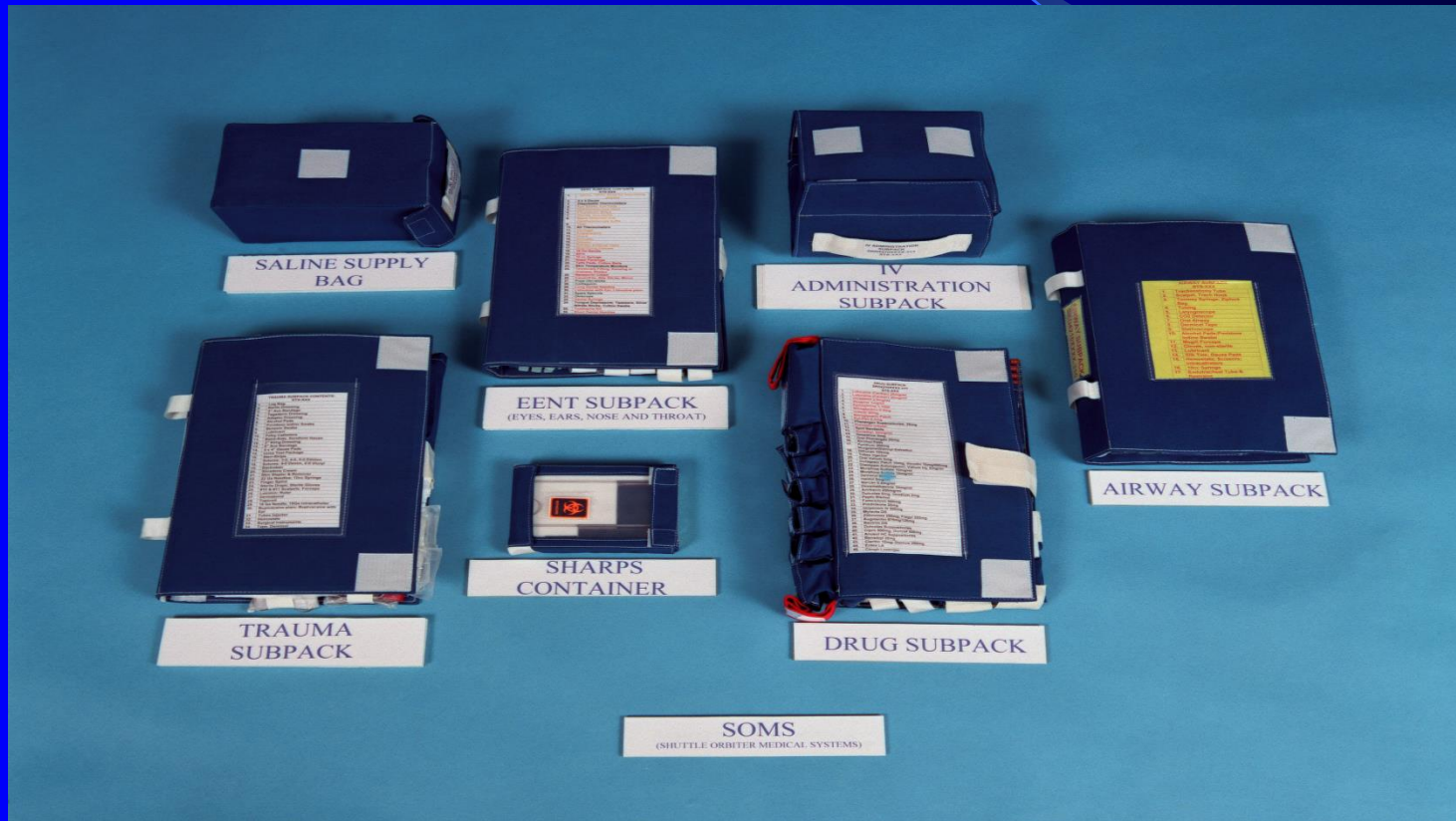


# In-flight support

- Private Medical Conferences (PMCs) weekly, 15-minute +, 1-on-1 conferences
  - More scheduled first and last weeks of mission
- Diagnosis and treatment of medical problems that develop onboard
- Analysis of fitness data
- Analysis of environmental data
- Analysis of sleep data
- Workload and work-rest assessments
- Sleep-shift analysis (visiting vehicles & EVAs)
- Family Support

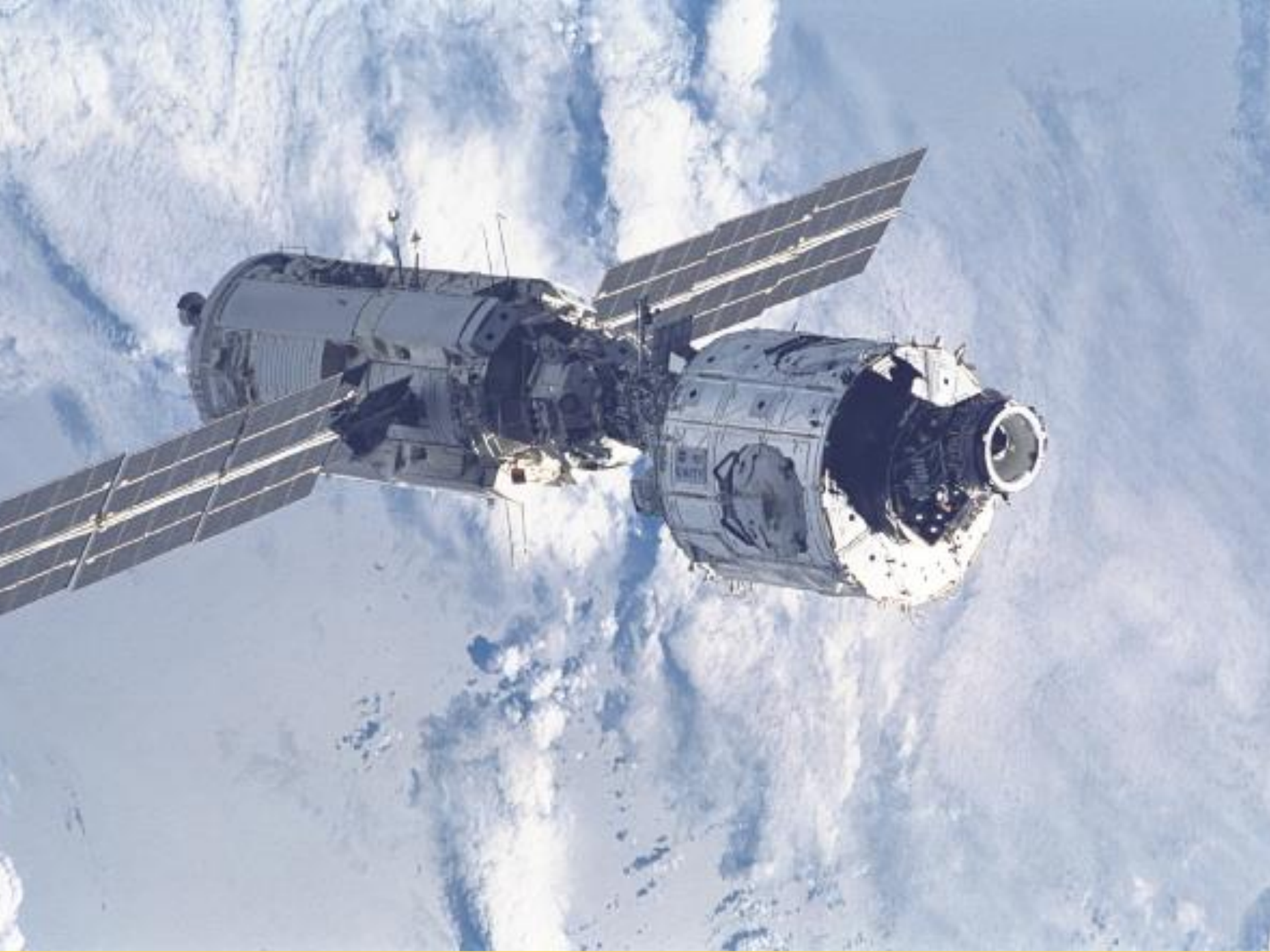
# Systems & Crew Training

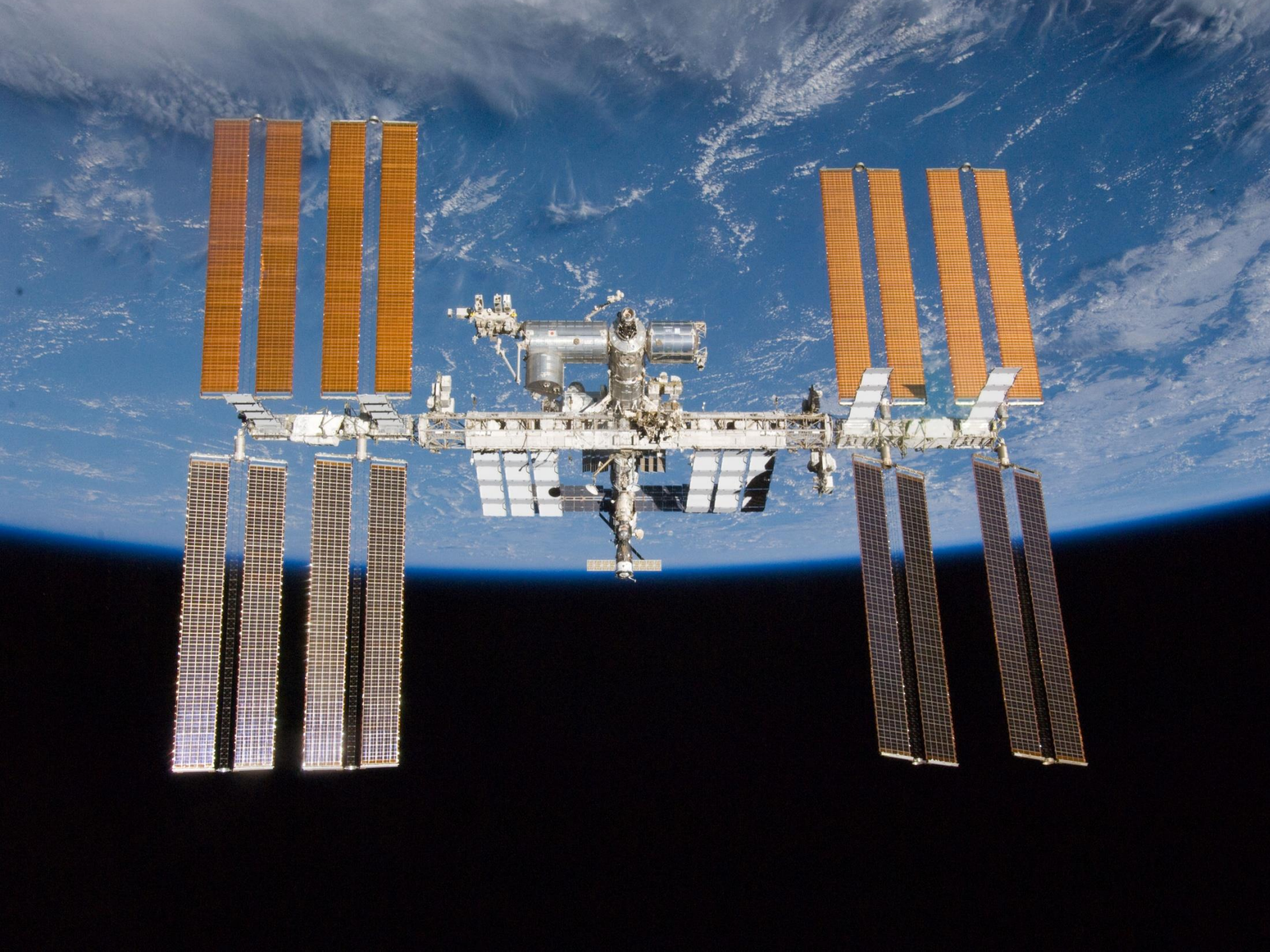
## Shuttle Orbiter Medical System (SOMS)





# DRUG SUBPACK









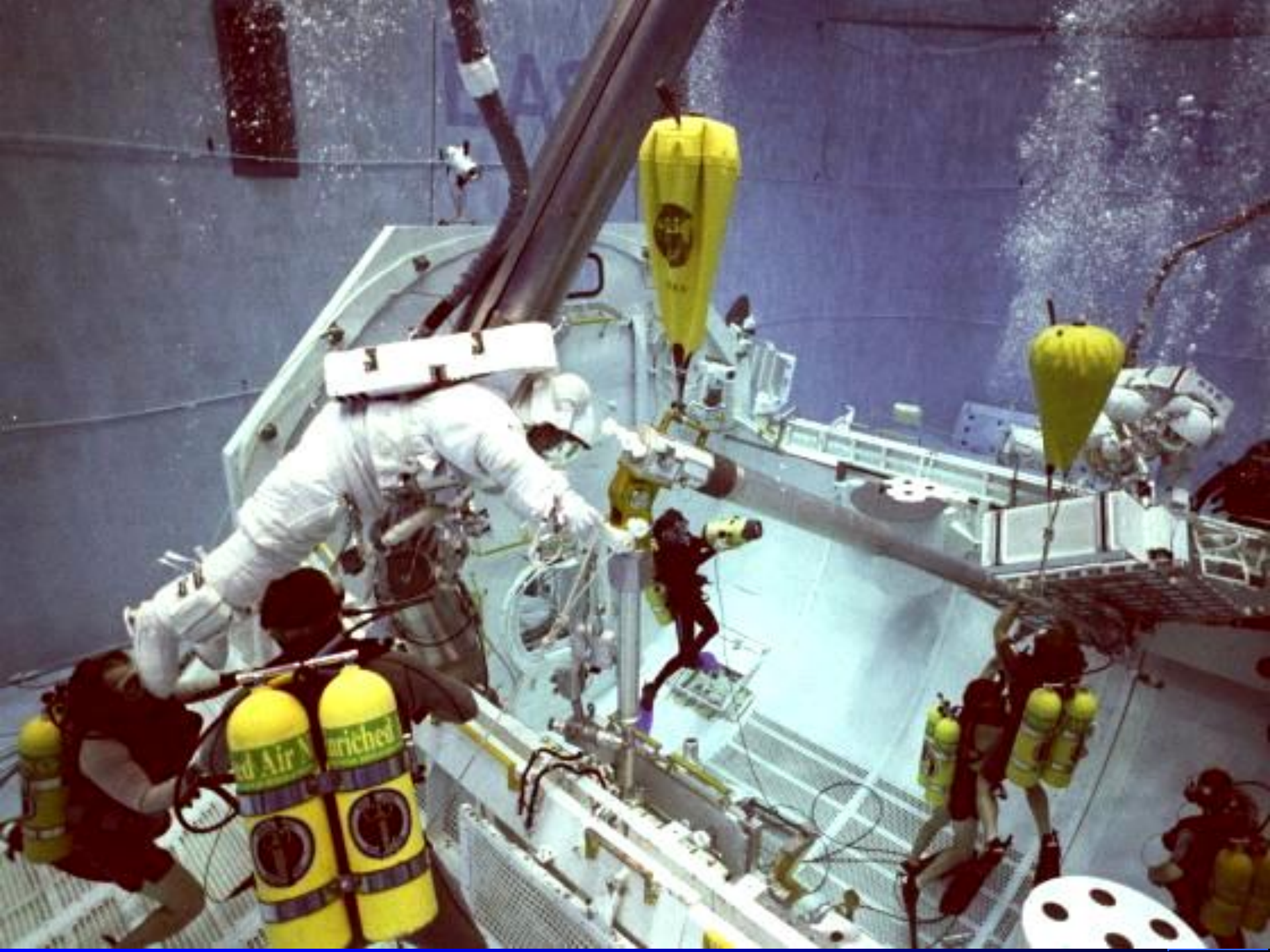


Sonny Carter Training Facility, NASA, JSC





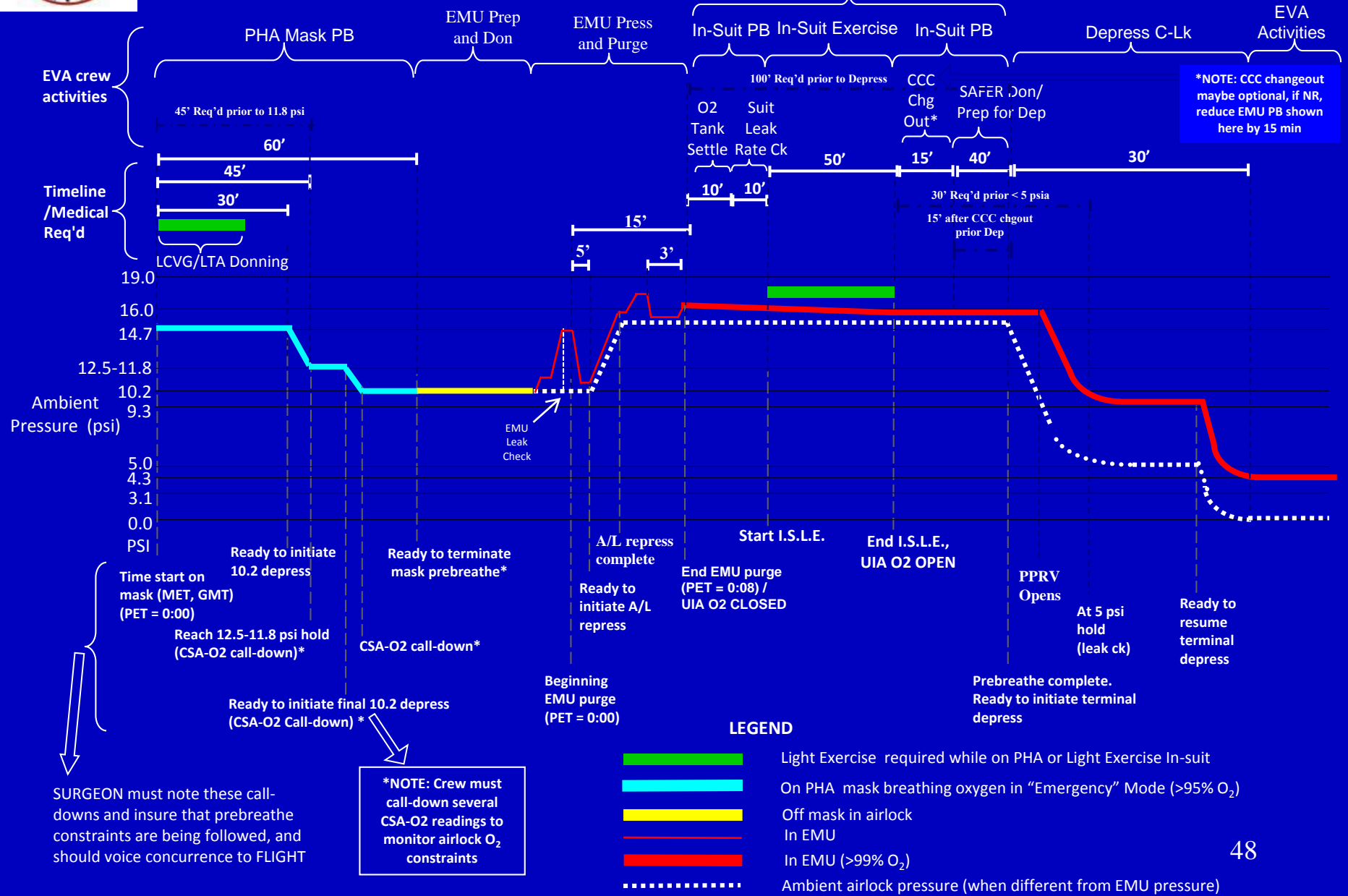






# ISLE Pressure Profile (With Data Collection)

Not to Scale

















# PREVENTION STRATEGY

## PREVENTION

Majority of microbial risk mitigation occurs before launch.

- System Design
- Materials Selection
- Engineering controls
  - HEPA air filters
  - In-line water filters
  - Surface disinfectants
  - Water biocides
- Operational controls
  - Preflight Monitoring of Environment
  - Biosafety Review of all payloads
- Extensive preflight monitoring
- In-flight countermeasures
  - Housekeeping
  - Remediation
  - In-flight Monitoring Schedule

# Real-Time Samplers

- Compound Specific Analyzer for Combustion Products (CSA-CP)

- Commercial unit
- Electrochemical sensor detection
- First alert and source finding capability
- Masking criteria after fire



- Carbon Dioxide Monitor (CDM)

- Commercial unit
- Infrared absorption used to measure localized CO<sub>2</sub> levels in air



- Multi-Gas Monitor (MGM)

- Continuous monitoring of humidity, CO<sub>2</sub>, O<sub>2</sub>, and ammonia
- Tunable laser diode sensor
- Wide dynamic range
- Stable (greatly reduced need for calibration)



- Air Quality Monitor (AQM)

- Periodic measurement of volatile organic compounds
- Gas Chromatograph-Differential Mobility Spectrometry (GC/DMS)
- Sampling and analysis time is 10-15 minutes





# US Water Recovery System



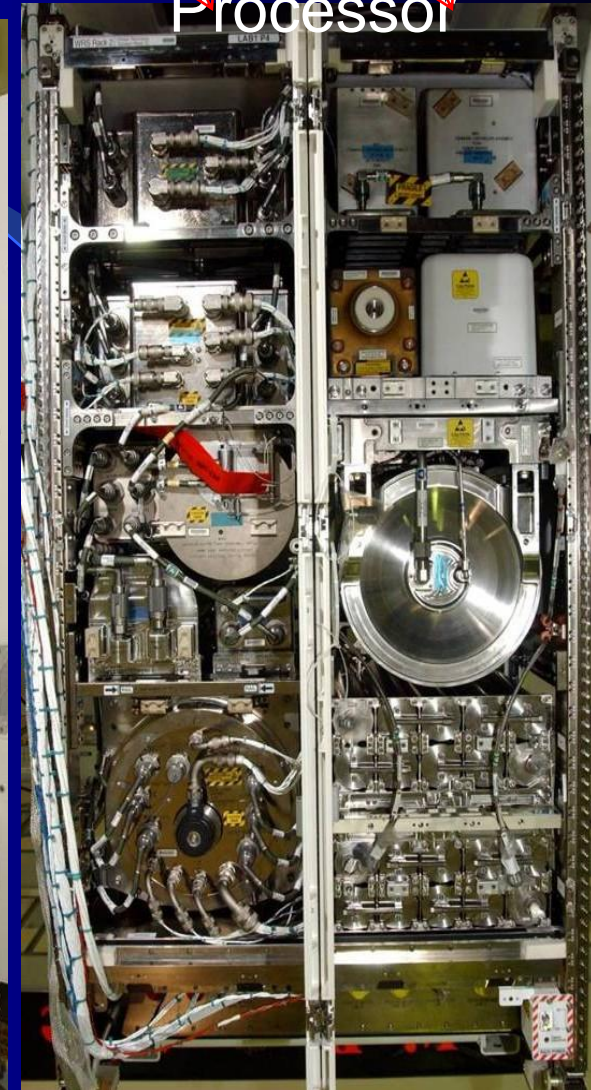
Potable Water Dispenser



Waste Hygiene Compartment



WRS 1

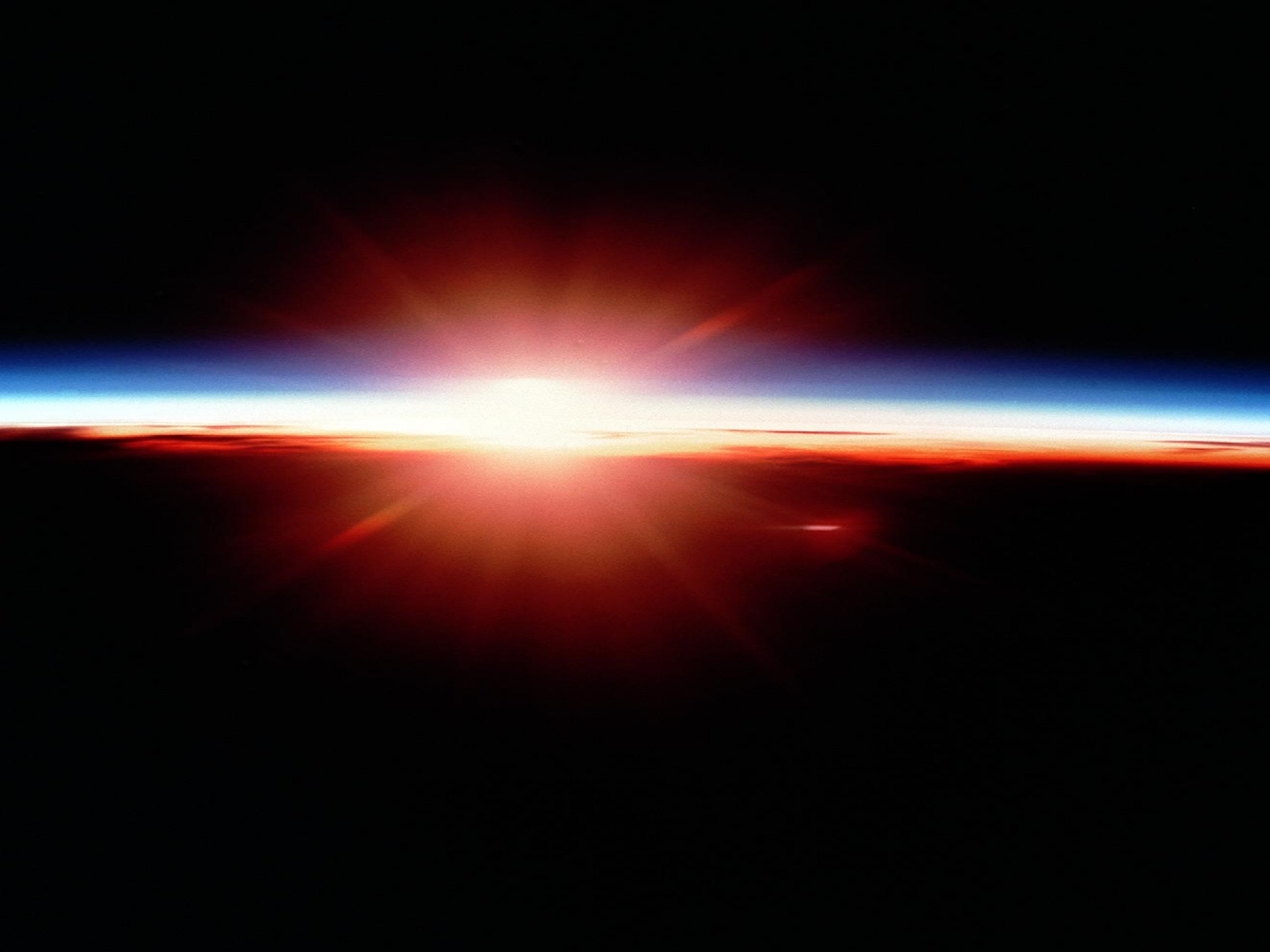


Urine Processor

WRS 2

Shuttle air filter debris







MF57E

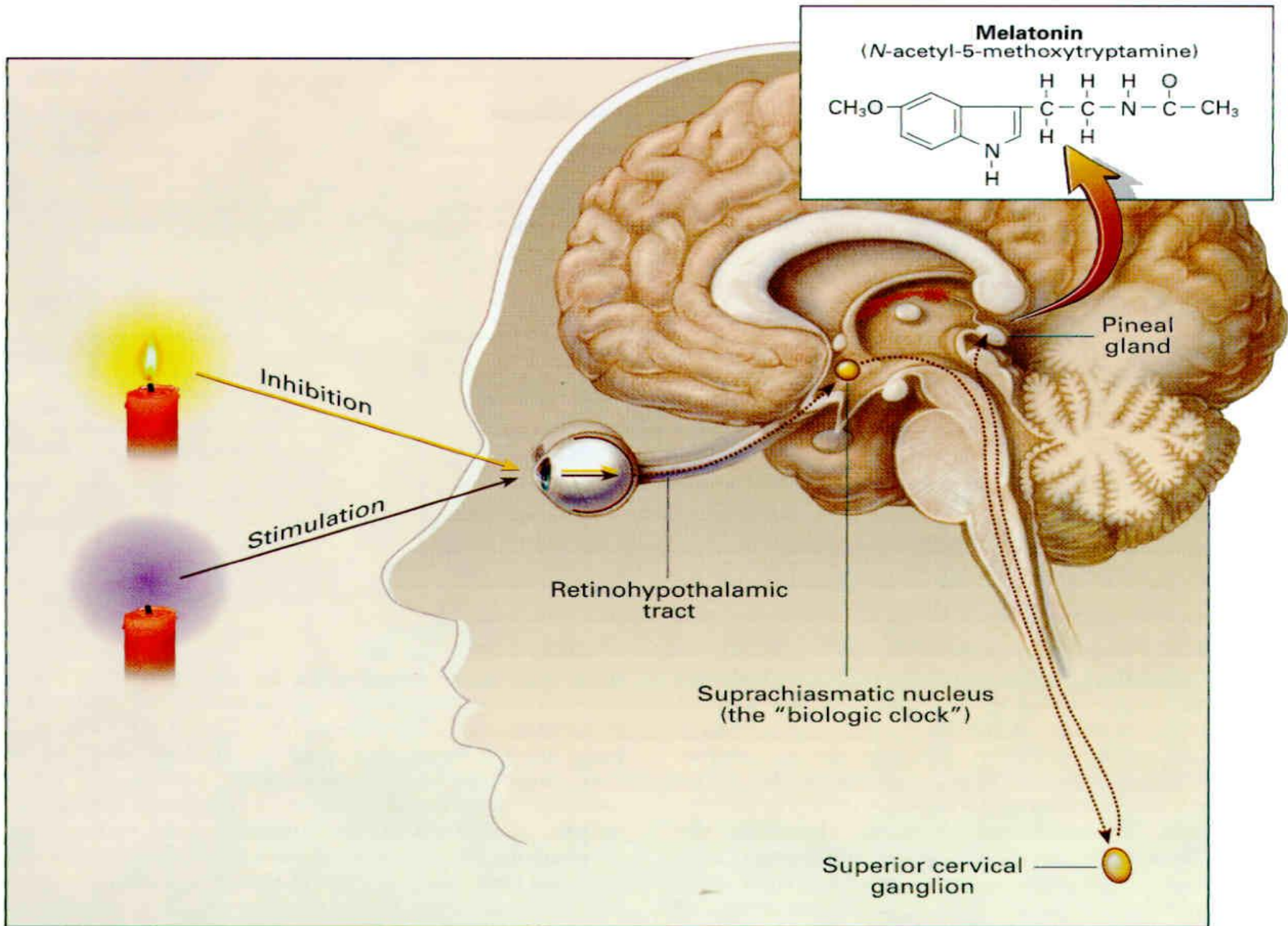
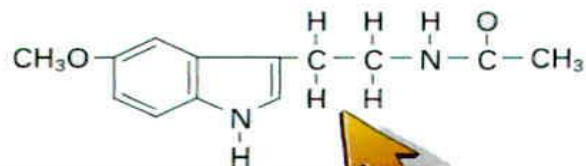
MF71E

MF57K

IFM Breathing Box  
Power/Survival  
Battery Pack



**Melatonin**  
(N-acetyl-5-methoxytryptamine)

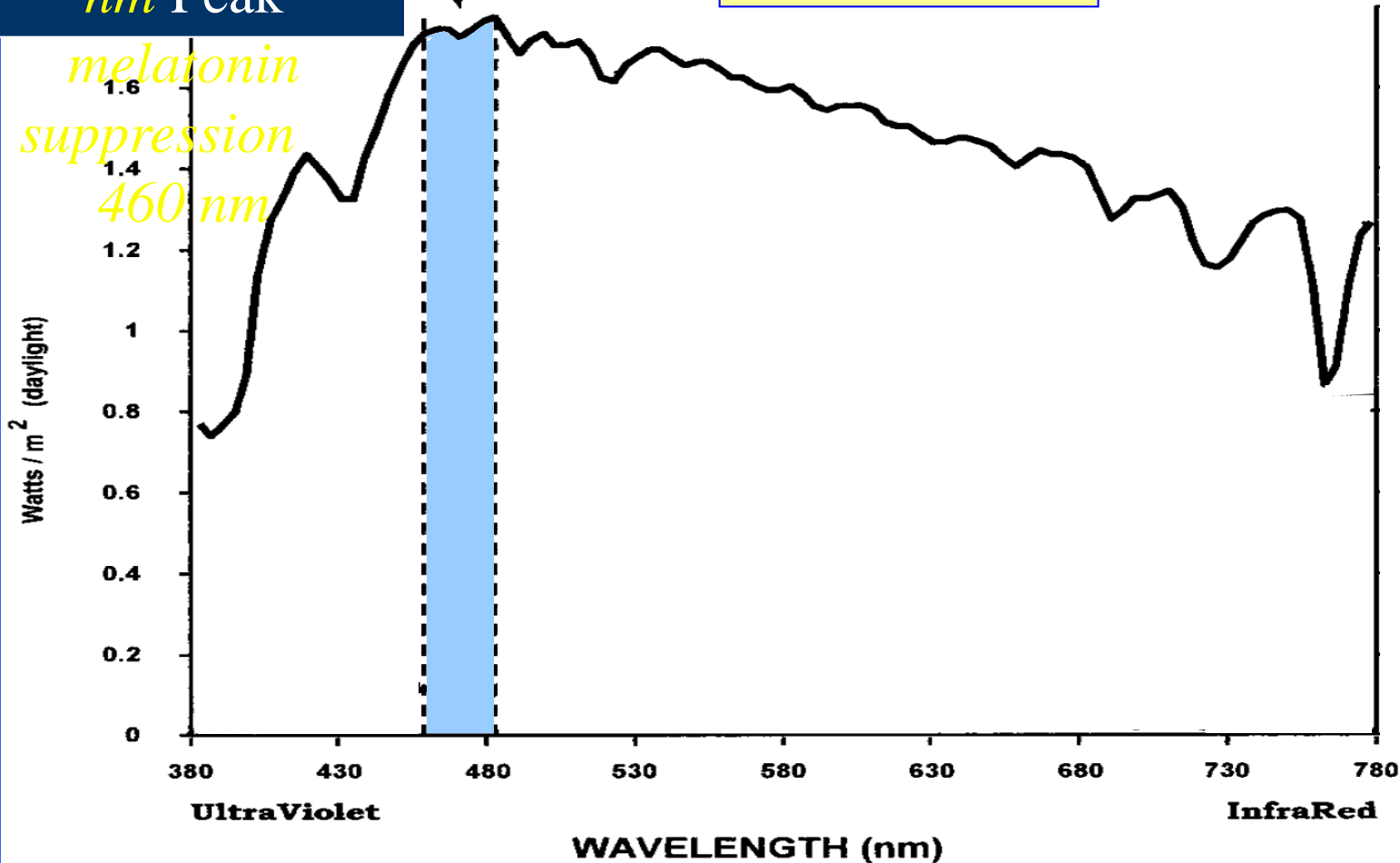


# Spectral composition of skylight is heavily blue-weighted...

Peak *melanopsin* sensitivity is 480 nm Peak

*melatonin suppression* 460 nm

— Daylight

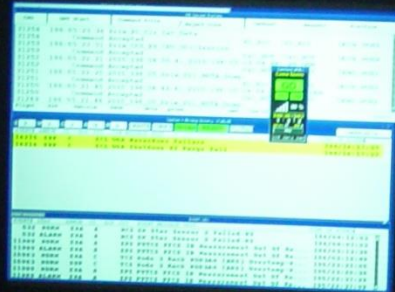




PHILIPS



With the goal of improving the alertness of flight controllers, we will determine what type of fatigue countermeasure will be the most feasible, acceptable and effective in this environment.



68 lux

147 lux

177 lux

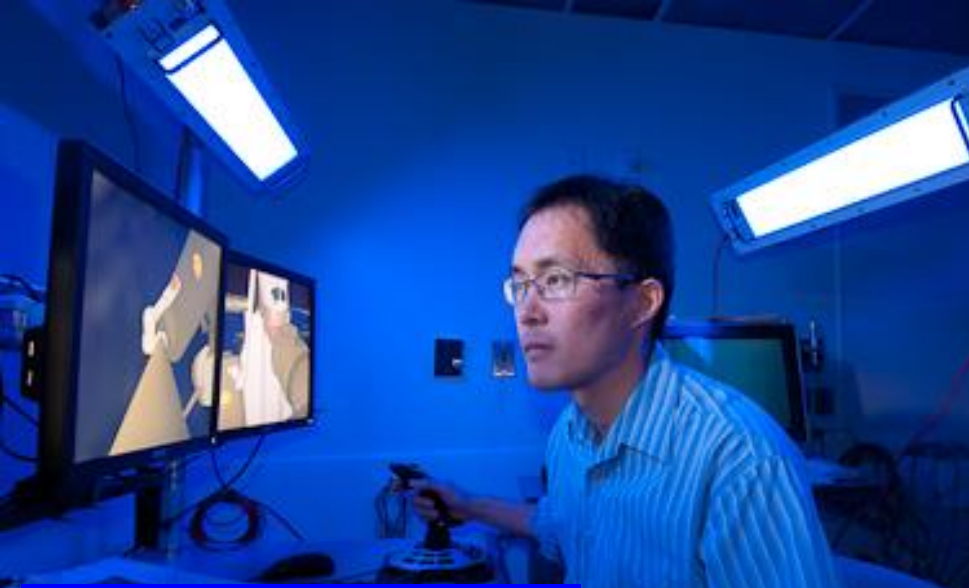
75 lux  
angle of gaze

190 lux





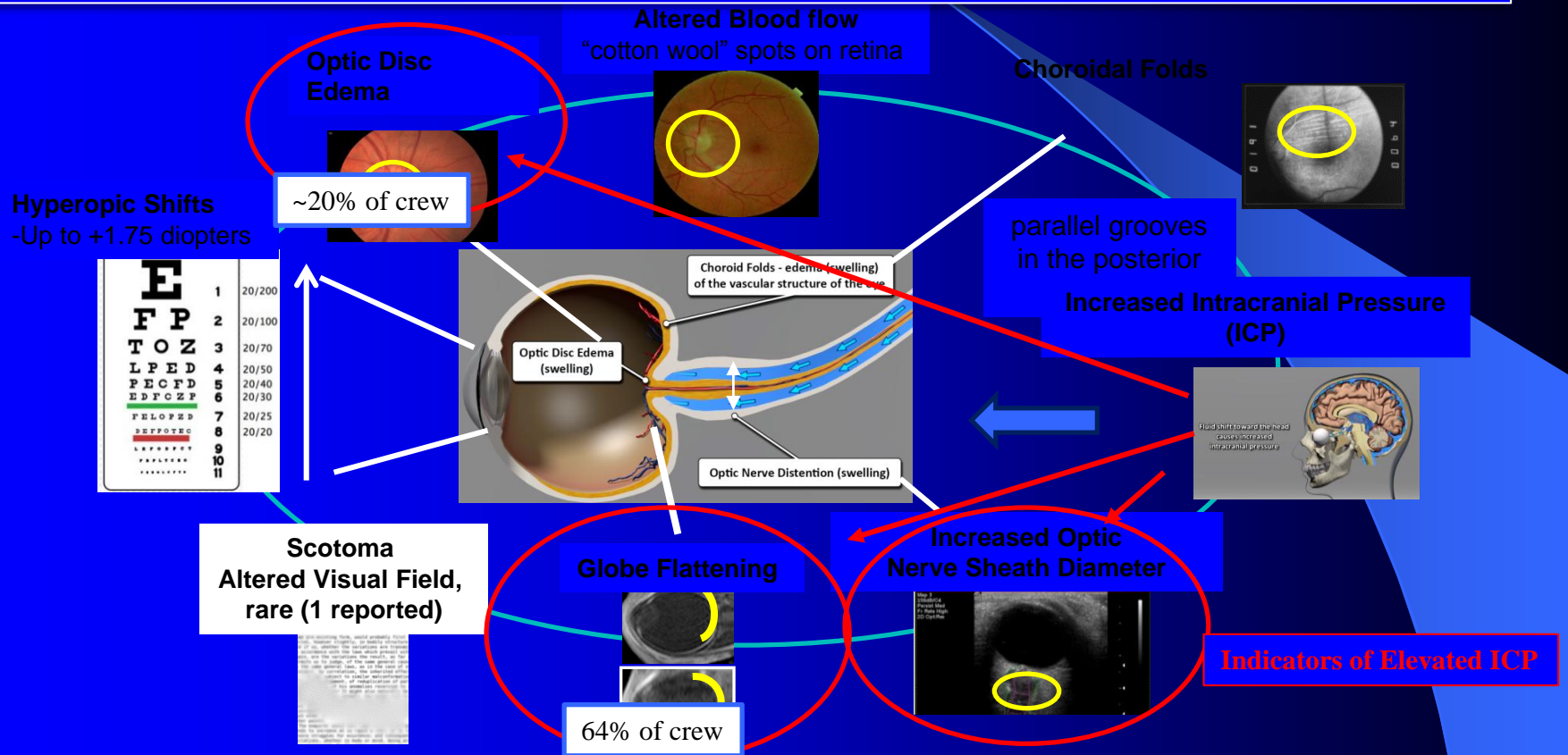
ISS018E008782



**ISS Lighting and Robotics Analog  
Center for Clinical Investigation, BWH**

# Spaceflight-Induced Idiopathic Papilledema/Vision Alteration

Some long duration crew members have various expressions of vision impairment/intracranial pressure. Both NASA's medical and research communities are pursuing options to mitigate this risk.



NASA's Medical Operations has an extensive Clinical & Occupational Surveillance Program to understand and mitigate the risk. Including development of advanced imaging diagnostics.

NASA's Human Research has numerous research protocols to investigate the phenomenon and also to develop advanced technology to non-invasively measure Intracranial Pressure (ICP) in spaceflight.



Astronaut Pettit Performs Ultrasound Eye Imaging





United States







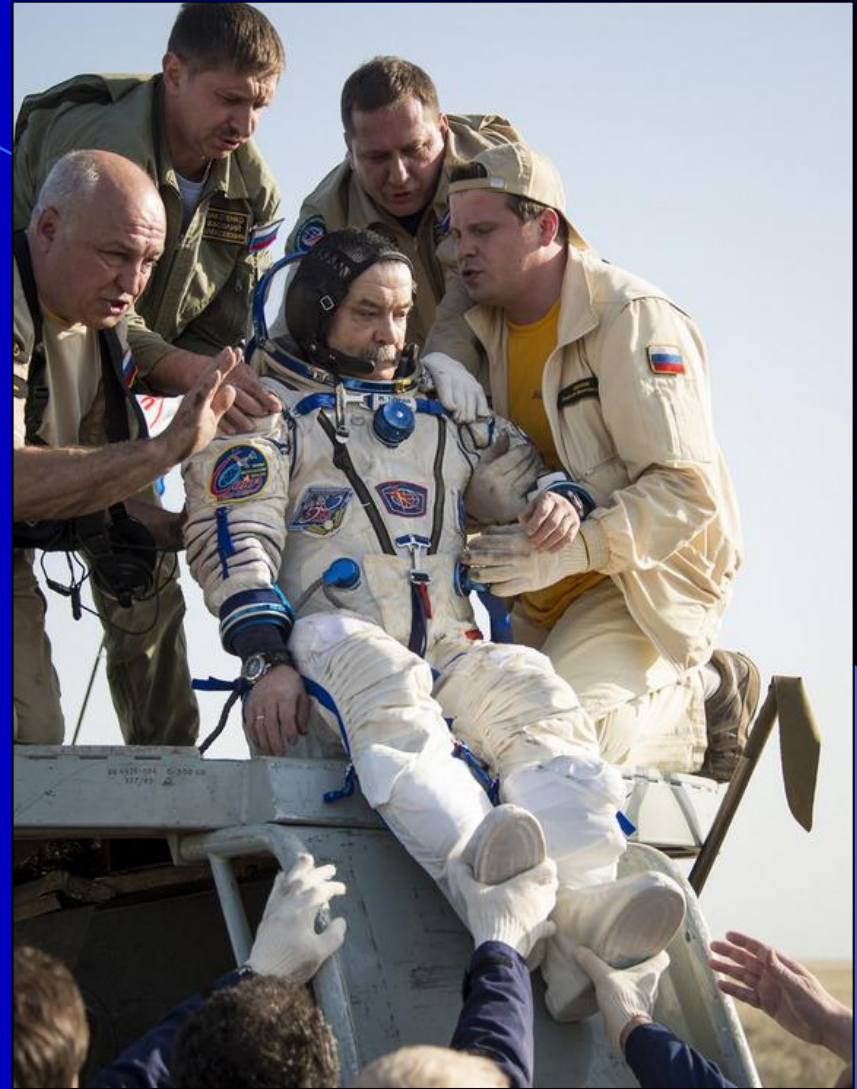




National Aeronautics  
and Space  
Administration



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and Space  
Administration





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and Space  
Administration

# Medical Tent







N992NA



NO  
WARRANTY  
REPAIRS  
PERMITTED



# NASA 992



## Capability:

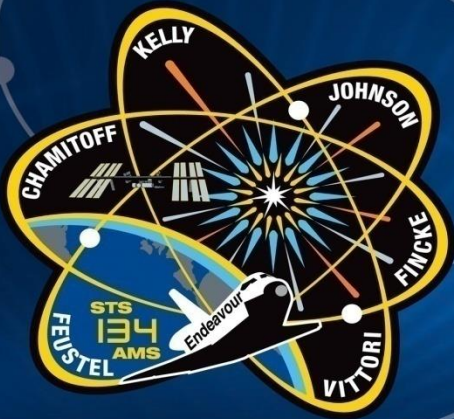
- ACLS
- Expected post flight symptoms
- Basic procedures – IV placement, Foley
- Some advanced procedures – airway
- Ultrasound
- Cooler for medical and research specimens

# Astronaut Health



- Physical training and rehabilitation







: 3:03:10

DISCOVERY

JE BEVAN

XVII XVII XVII

STS-133



