Overview of Space Health Threats and Technology Drivers

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Significant Challenges of Deep Space Missions

Human Space Exploration beyond Low Earth Orbit presents significant challenges to human health and performance

1. Loss of Van Allen Belt Radiation Protection
2. Communication delays (no real time support)
3. Training and proficiency issues
4. No resupply unless pre-positioned stores
5. Limited or no abort options for critical events

Human Spaceflight Experience

As of March 2017

Total spaceflight time: 136.4 crew-years

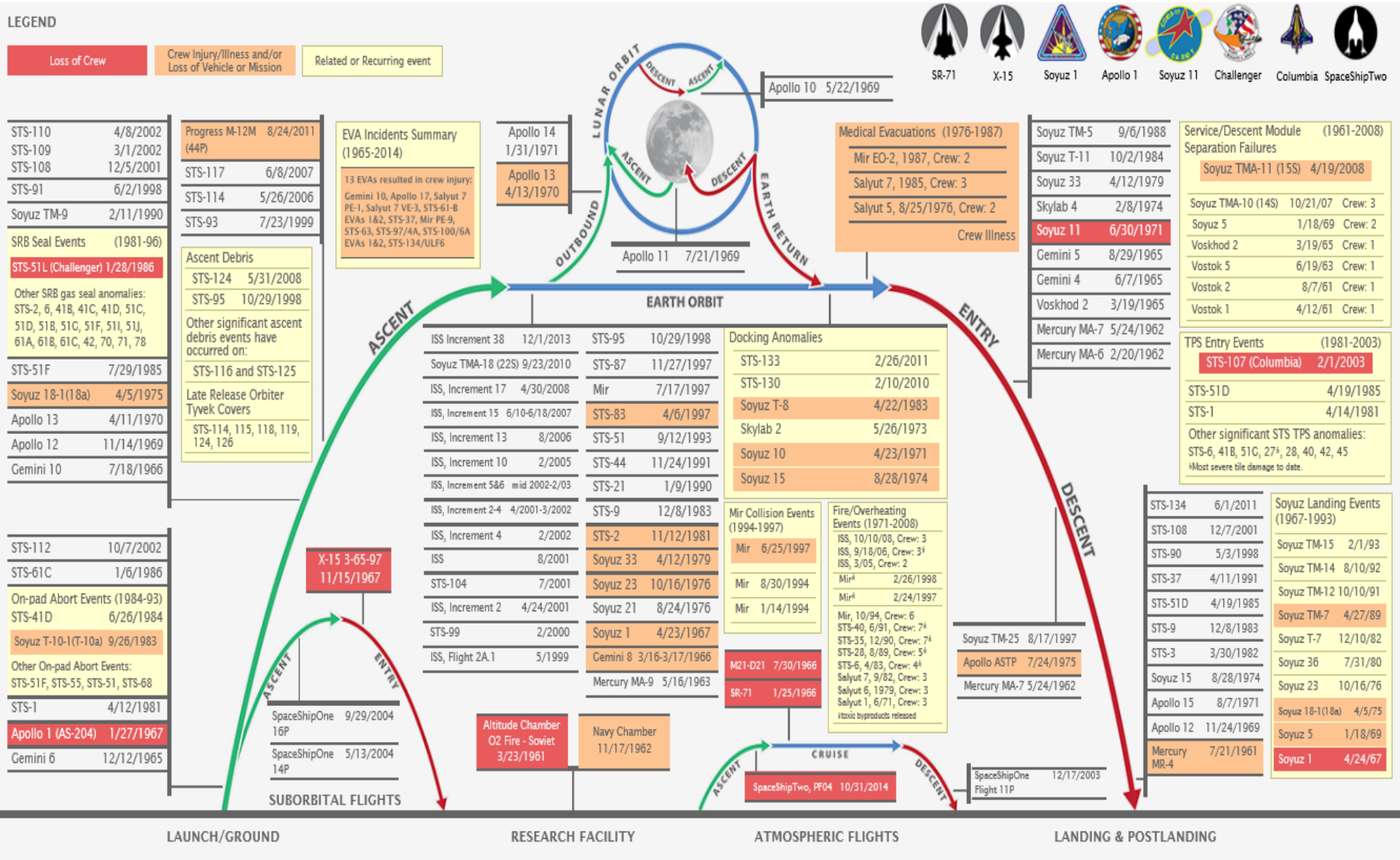
Persons who have flown in orbit: 552 (60 women)

Crew with Cumulative spaceflight in Low Earth Orbit

- Over 800 days - 3
- Over 700 days - 5
- Over 600 days - 7
- Over 500 days - 19 (2 US)
- Over 400 days - 22 (2 US)
- Over 365 days - 35 (6 US)

Crew with single mission duration over 1 year - 4

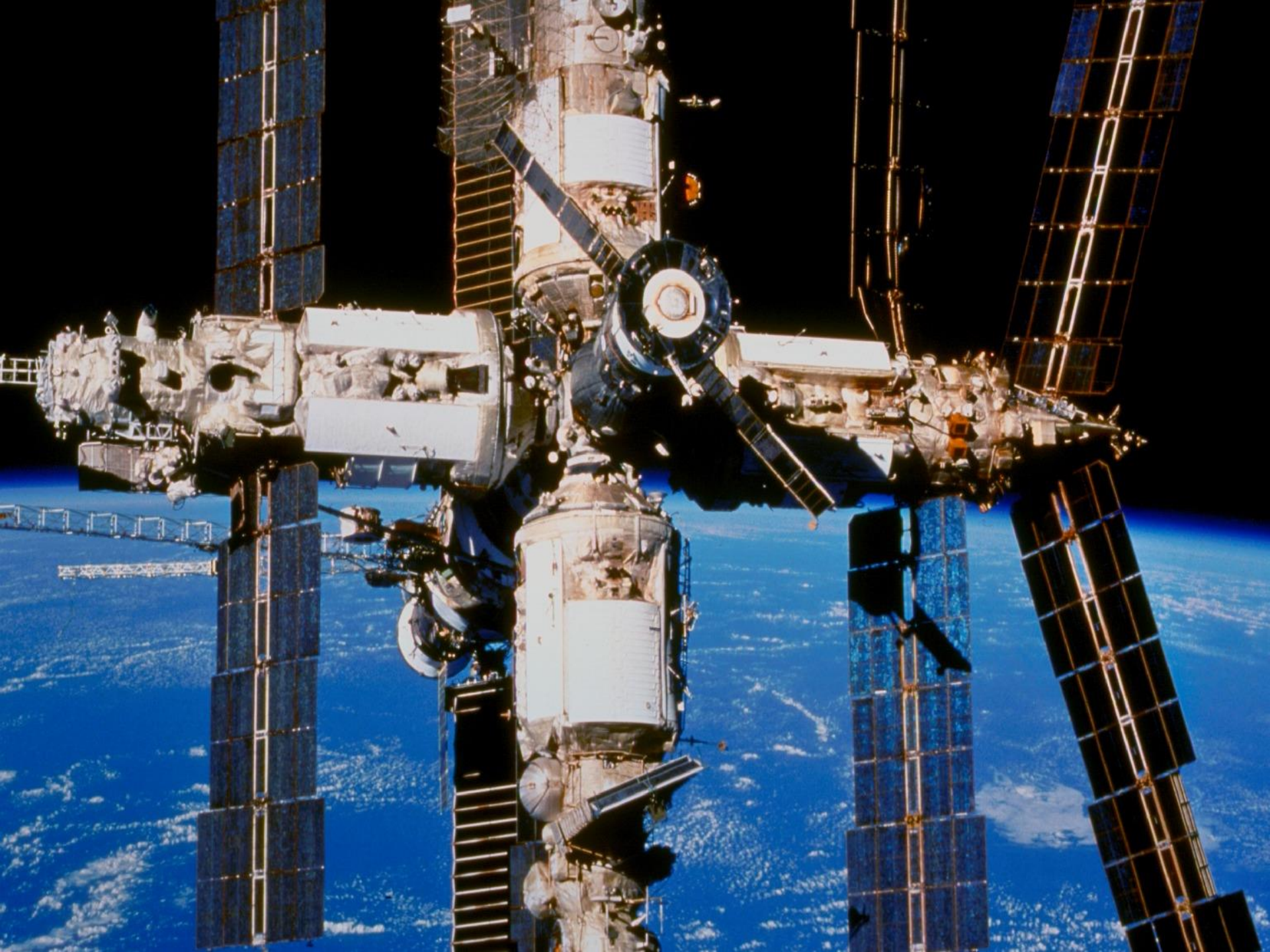
Significant Incidents and Close Calls in Human Spaceflight



http://spaceflight.nasa.gov/outreach/SignificantIncidents/index.html

Significant Events in Human Spaceflight

- Space Fatalities
  - Russian – 4 crew (2 Soyuz)
  - US – 15 crew (X-15, 2 Space Shuttles)
- Mission Terminations/ Evacuations from Space
  - Russian - 3 missions terminated and 3 near terminations
- Spacecraft Combustion Events
  - 6 Salyut/ Mir, 4 Shuttle, 3 ISS
- Medical Events in Space
  - Cardiac, Genitourinary, Neurologic, Behavioral
- Performance Events in Space
  - Crew Coordination Errors during Robotics, EVA, Rendezvous & Docking, Reentry/ Landing



Spacecraft Environmental Events


HISTORY.COM

Spacecraft Environmental Events

Combustion Events (6 Salyut/ Mir, 4 Shuttle, 3 ISS)

Toxic Atmosphere (crew symptomatic)

- Carbon monoxide (Mir) 600 ppm measured
- Ethylene glycol (Mir) 75 ppm measured
- Carbon Dioxide (Salyut, Apollo 13, STS 96)
- Nitrogen Tetroxide (Apollo/ Soyuz Test Project)

Water Contaminants

- Formaldehyde (Mir)
- Cadmium (ISS)

Spaceflight Related Performance Events

Impaired cognitive performance - described as "Space Stupids, Space Fog, Space Dementia, Mental Viscosity, Neurasthenia"

Crew Coordination Errors
- Rendezvous and Docking Collision
- Robotic Arm Collision

Missed Checklist Items

Lost tools on Spacewalks

esa
COLUMBUS

Significant Incidents during Extravehicular Activity (1965-2011)

13 EVAs resulted in crew injury

13 EVAs terminated early due to crew injury or systems issues

EVA Cut Glove – 6

40 EVAs resulted in Inadvertent Releases


Psychological Environment

In-Flight Behavioral Events

Acute Behavioral Change

STS 51B (1985) payload specialist **despondent when experiment failed**, crew concerned about **potential for dangerous behavior**

Acute Grief Reaction

Mir 18 Dezhurov's **mother died, withdrew** from crew for 1 week

Depression, Homicidal and Suicidal Thoughts

Salyut 7 - Valentine Lebedev 1988 211 day mission developed sour disposition from crew conflict, **contemplated killing his crew mate**

NASA Mir 3 – Blaha had fits of anger, insomnia and withdrawal, exacerbated by an excess workload. "He was hurting," Linenger recalls. "He was, in essence, **depressed**."

NASA Mir 5 – After the Progress collision with Mir, Lazutkin **contemplates suicide**

Crew-crew **interpersonal conflicts**

Soyuz 21 (1976), Soyuz T14 (1985), Soyuz TM 2 (1987)

personality incompatibility

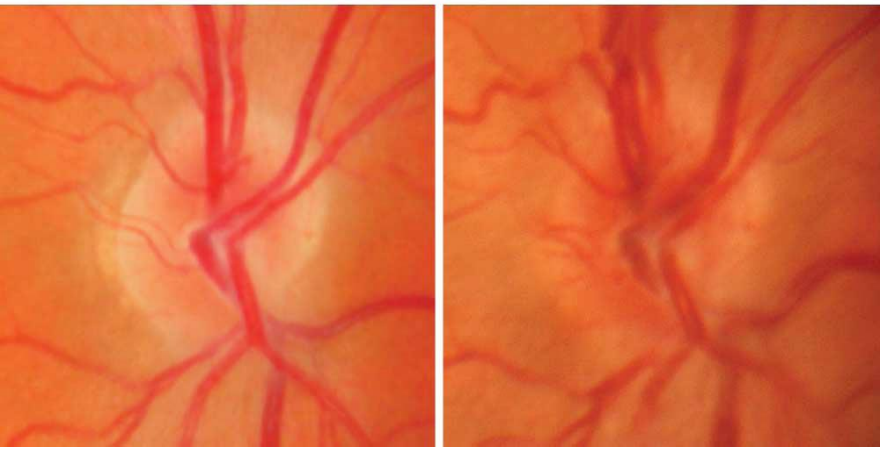
Crew- mission control team conflicts

Skylab 4 (Carr, Pogue, Gibson), NASA Mir 4 (Linenger)

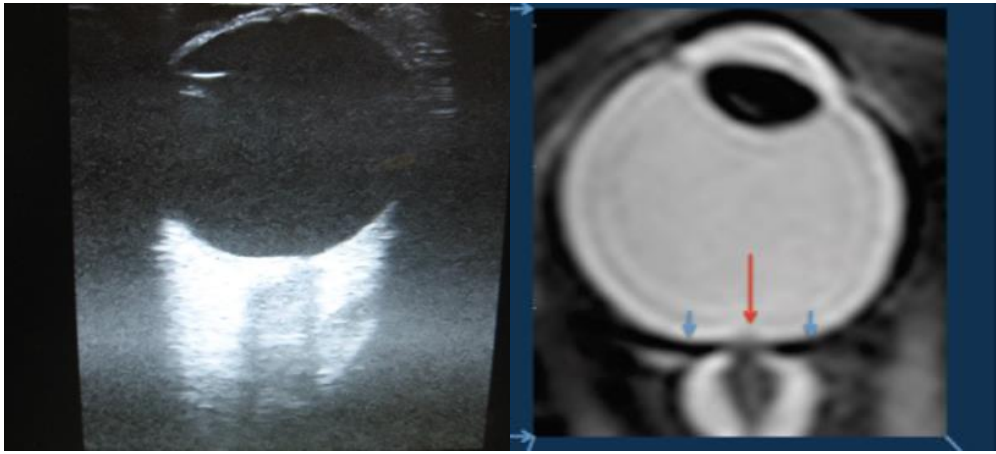
Excessive workload and disrupted sleep rest cycle

Ocular and Intracranial Findings in Astronauts after Long Duration Space Flight

1. **Optic Disc Edema**

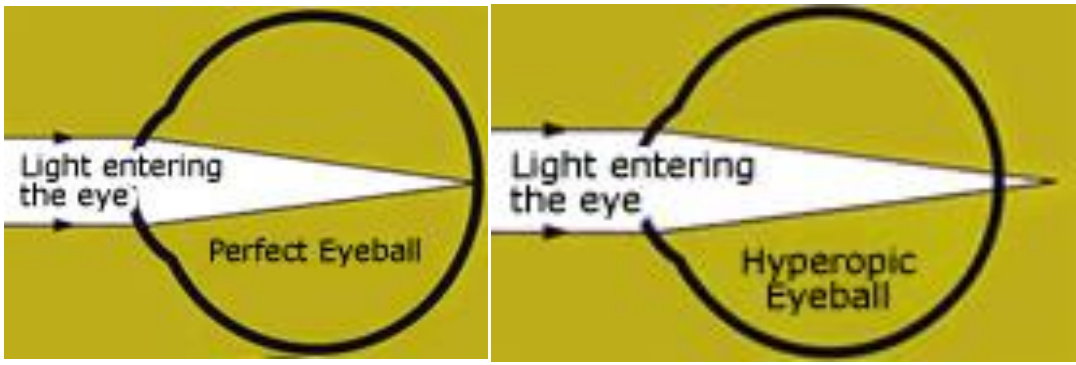


2. **Globe Flattening**



3. **Choroidal Folds**

4. **Hyperopic Shifts**

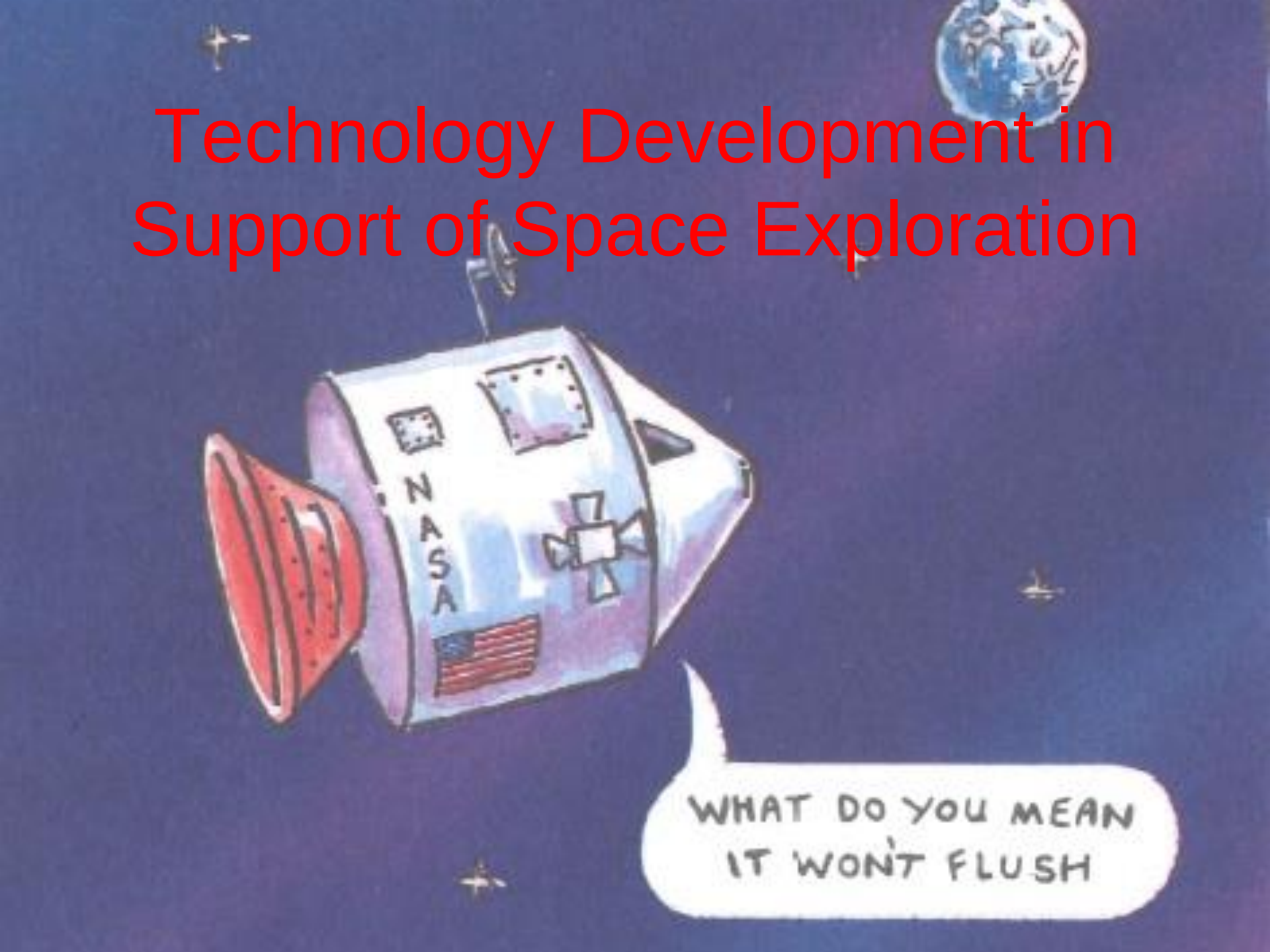


Update on Microgravity Associated Ocular Intracranial Syndrome (AKA Visual Impairment Intracranial Pressure)

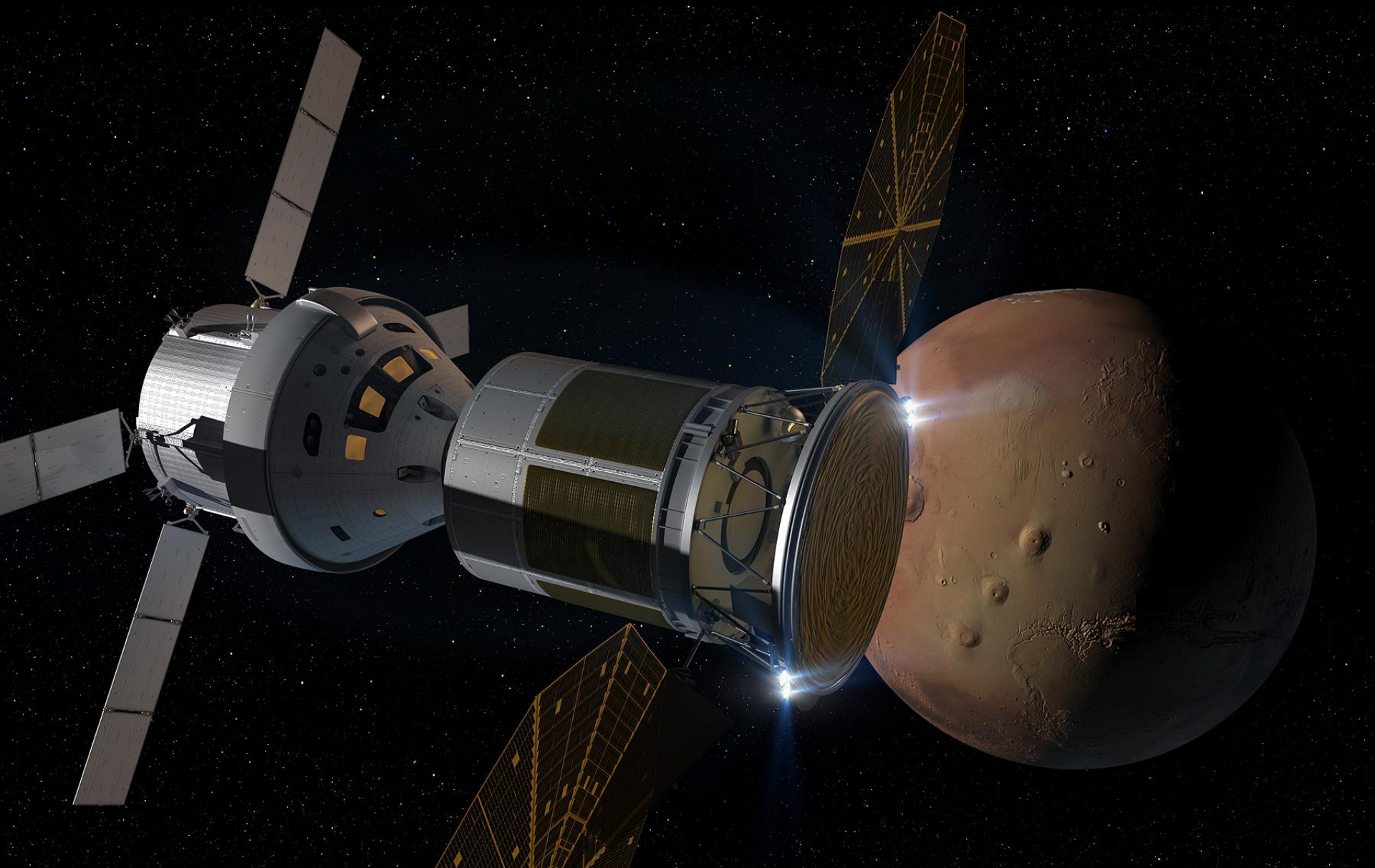
Summary of ISS Expeditions 1-48

Clinical Condition	Cases	Astronauts Evaluated
Ocular Disc Edema (Grade 1 or greater)	10	64
Globe Flattening (MRI)	12	47
Choroidal Folds (OCT)	11	47
Cotton Wool Spots	7	64
Refractive Error >0.5 Diopter	9	47
Total astronauts	**24**	**64**

Technology Development in Support of Space Exploration



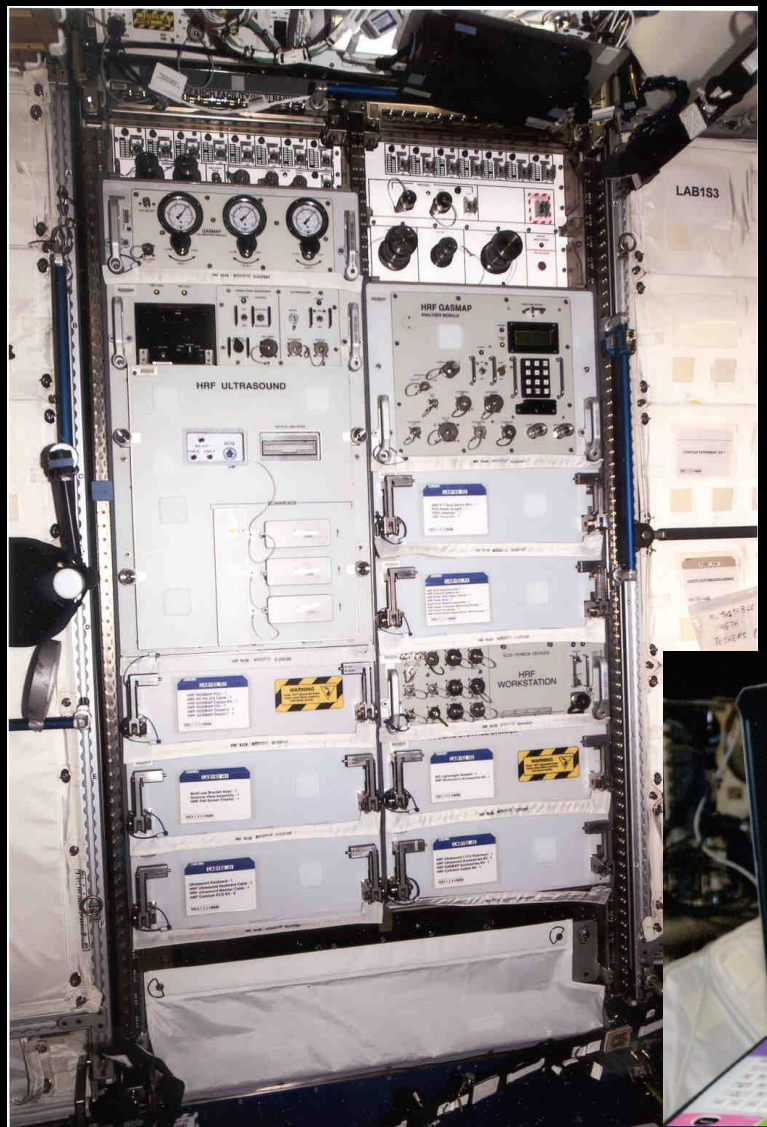
Key Drivers for Human Spaceflight Systems



Desirable Characteristics For Human Spaceflight Systems

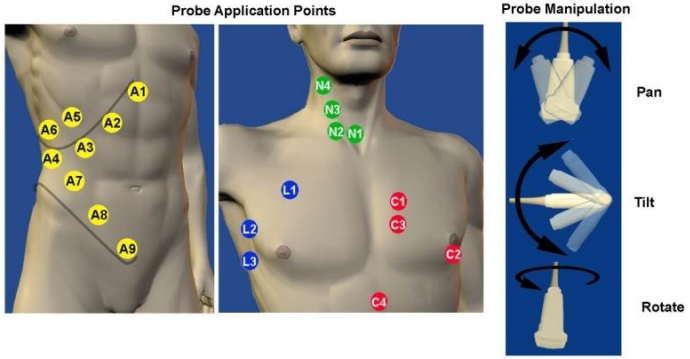
Low Mass
Low Power
Minimal Size
Reliable
Autonomous/ semi-autonomous operation
Intuitive human interaction
Minimal Training
Minimal consumables, recyclable consumables
Module replaceable
Non-invasive application
Low toxicity, flammability, electromagnetic signature

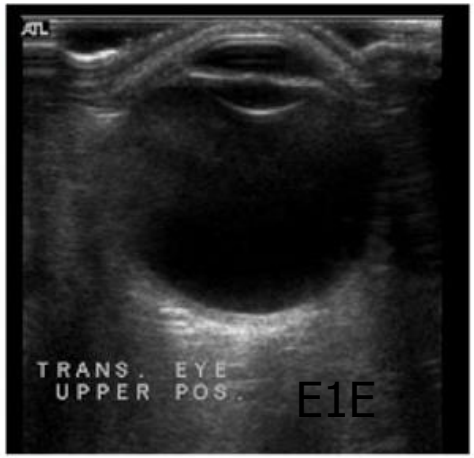
Evolution of Ultrasound Systems

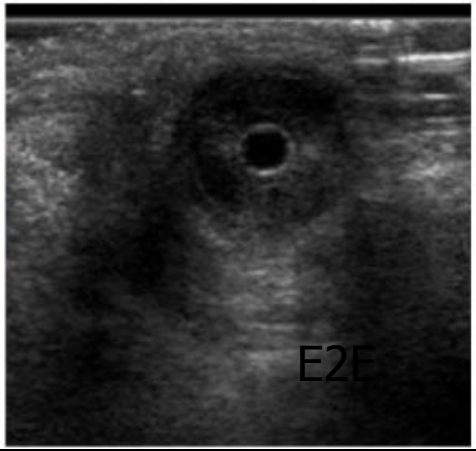


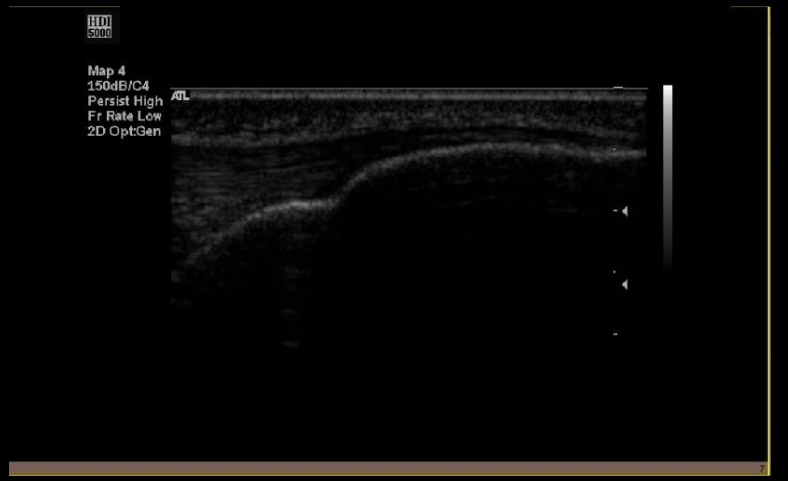
Just in Time Ultrasound Protocol

Cue Card and Reference Images

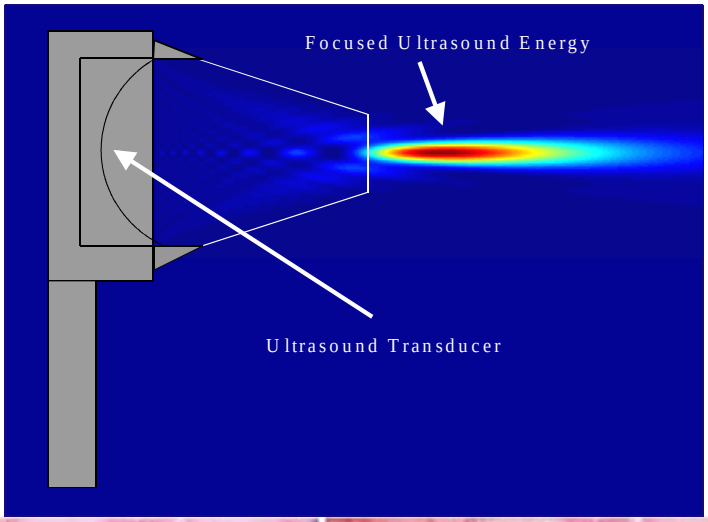


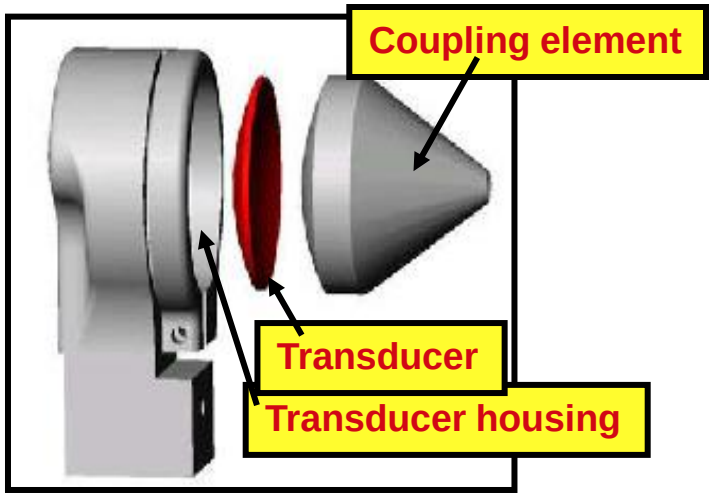


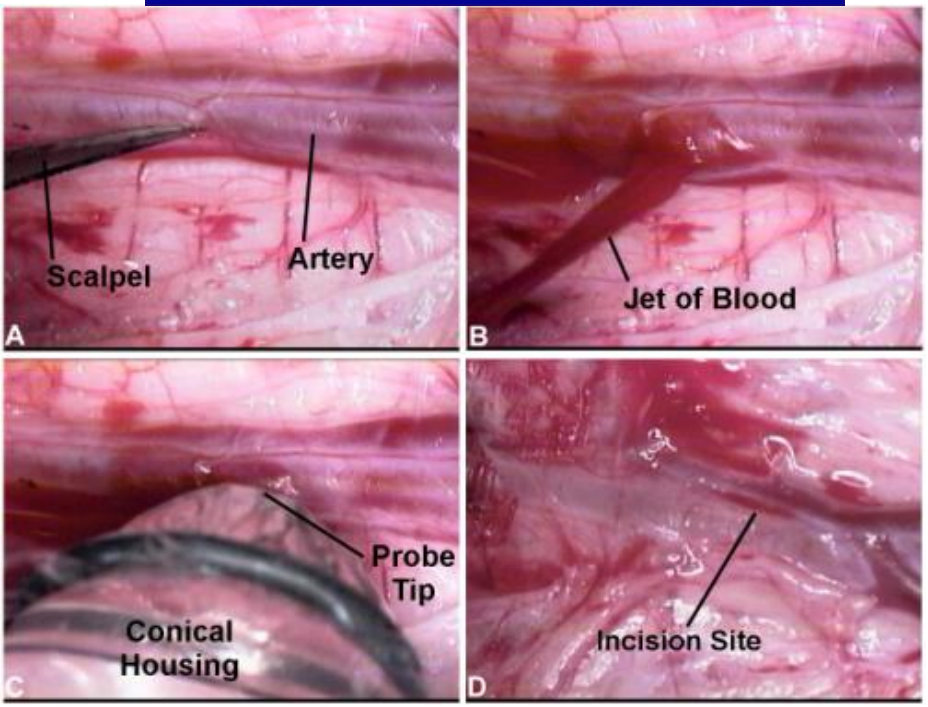




HIFU Hemostasis without Occlusion of Punctured and Lacerated Vessels





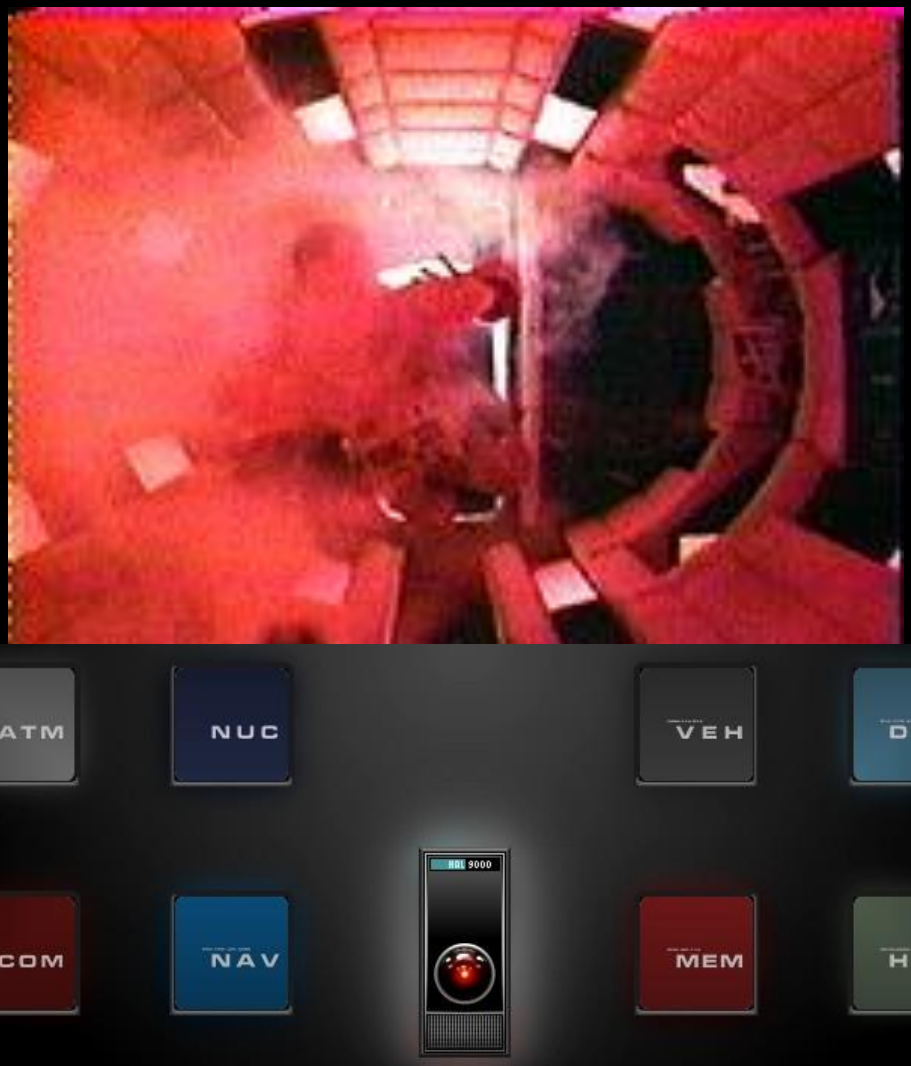


Metal cone;
water cooled

NASA recently sent a machine to
the International Space Station.

It converts URINE into DRINKING WATER.

HAL 9000
“I’m sorry Dave, I’m afraid I can’t do that”



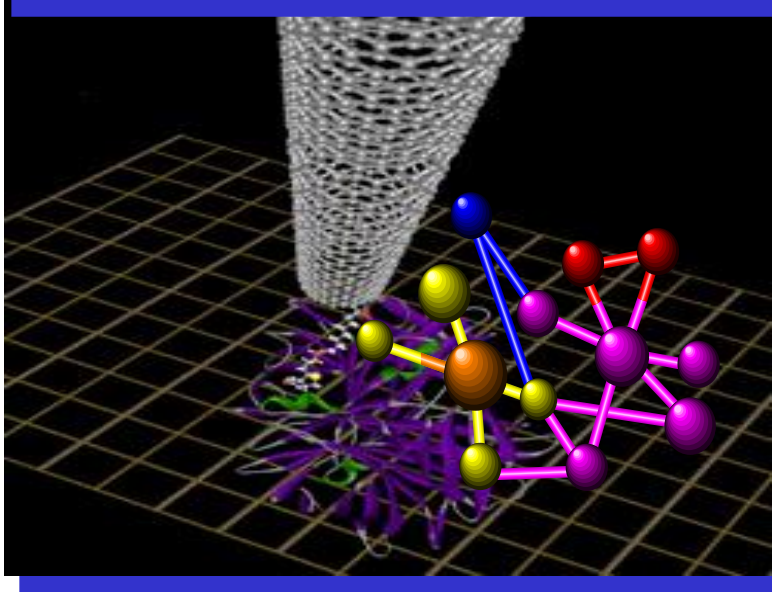
Future Space Health Care Systems

Wearable physiologic monitoring particularly for high risk activities

Minimally/ non-invasive diagnostic systems capable of evaluating broad range of disease states

Health care system capable of therapeutic intervention for a wide range of illnesses and injuries

Precision Medicine Program to individualize therapeutic and preventive measures based on knowledge of specific environmental and genetic risk factors



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