Extravehicular Activity (EVA)

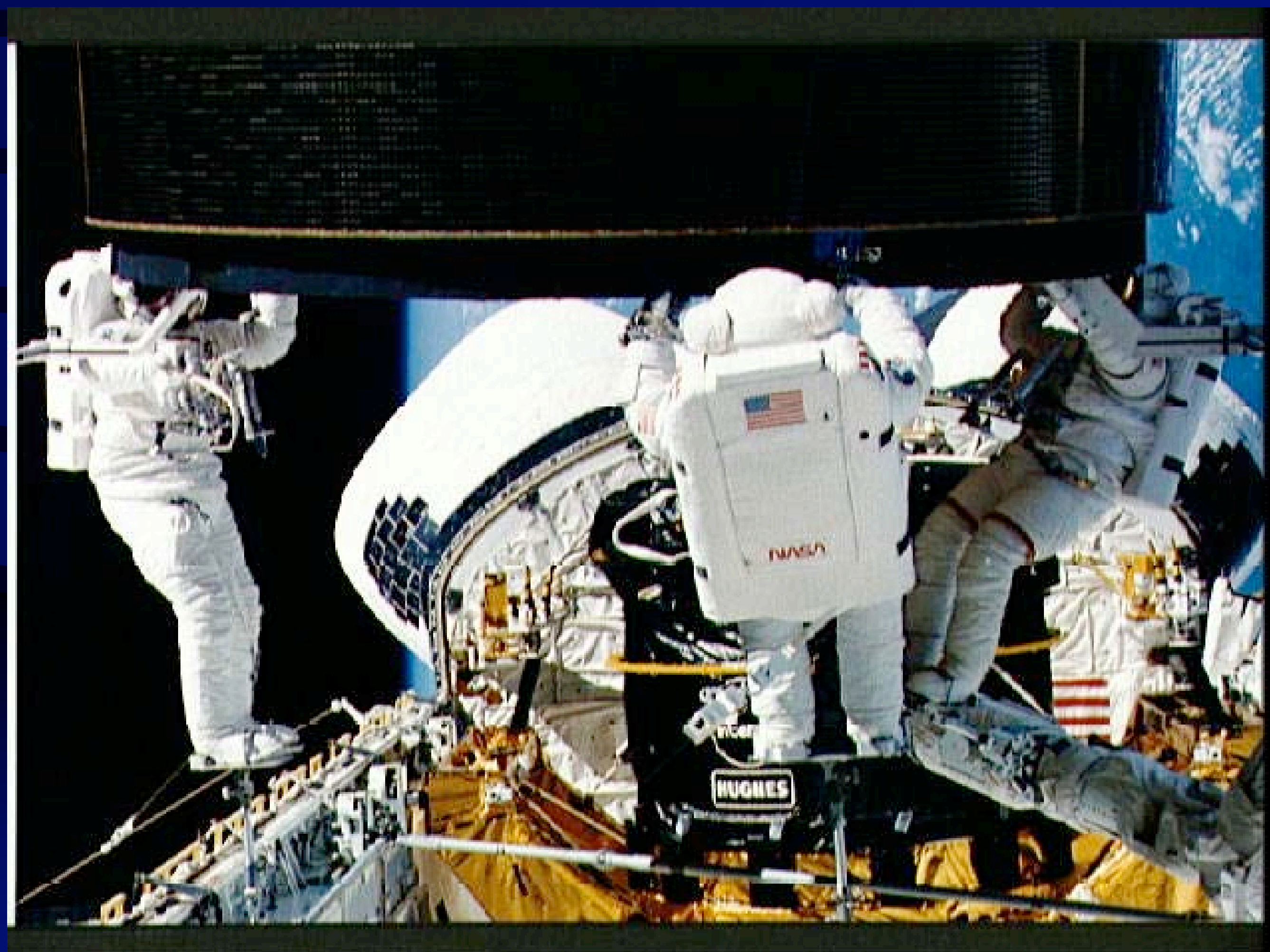
Professor Dava J. Newman

Overview

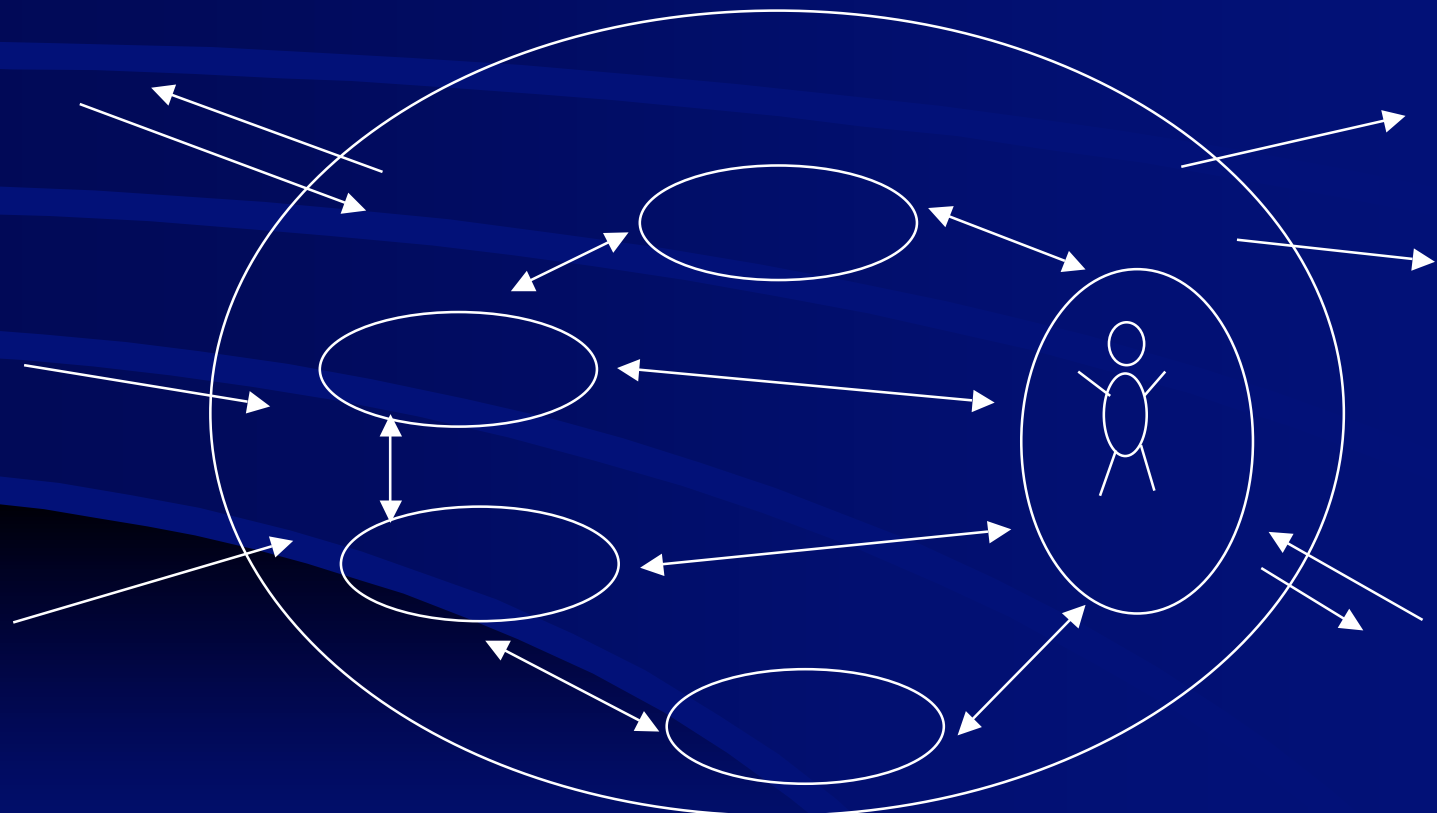
- **History**
- **Life Support Systems (LSS)**
- **Spacesuits**

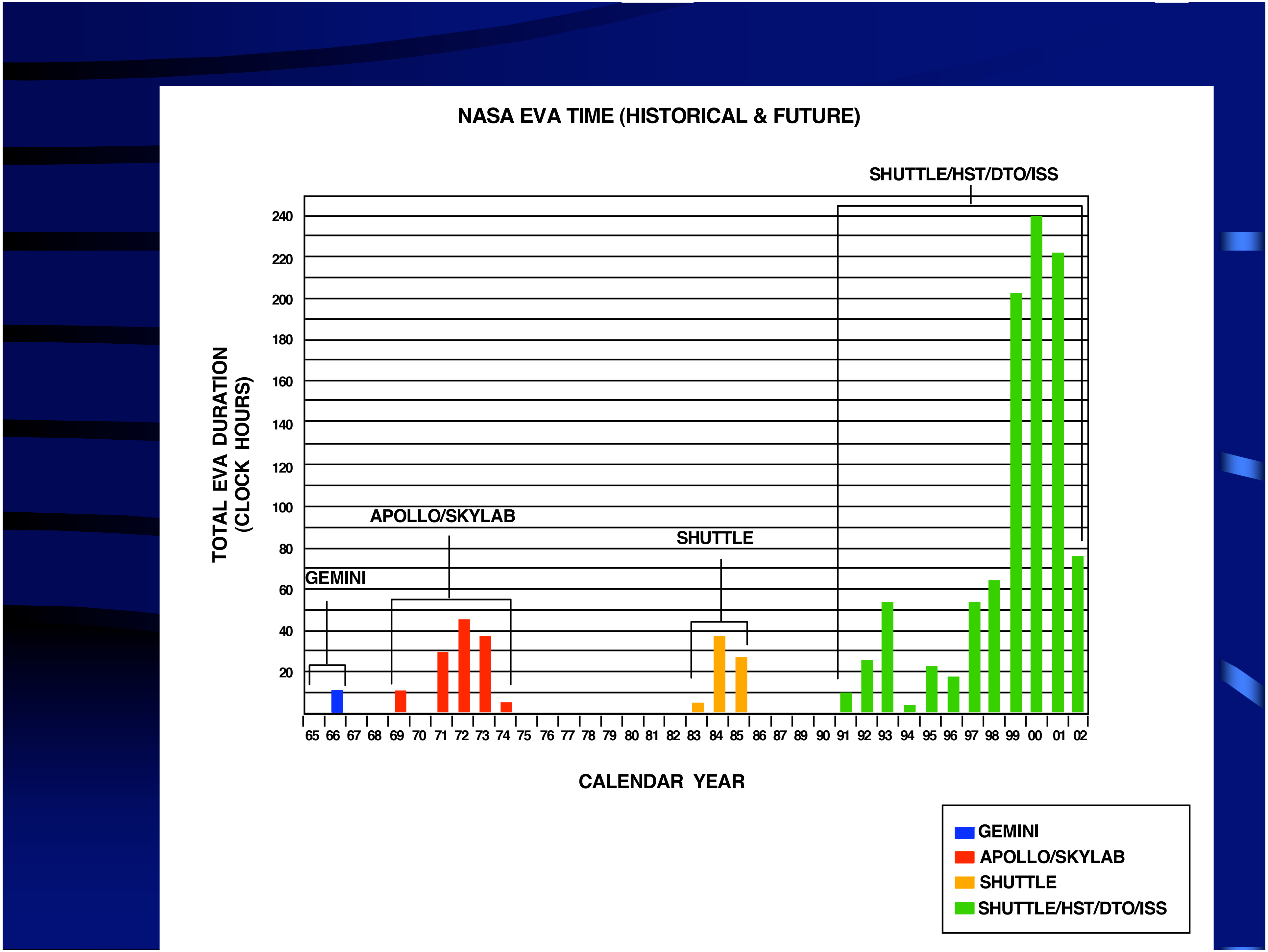
Gravity?

A (Mis)Capture?



Intelsat VI




NASA EVA TIME (HISTORICAL & FUTURE)
SHUTTLE/HST/DTO/ISS
APOLLO/SKYLAB
SHUTTLE
GEMINI
TOTAL EVA DURATION (CLOCK HOURS)
240
220
200
180
160
140
120
100
80
60
40
20
65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 89 90 91 92 93 94 95 96 97 98 99 00 01 02
CALENDAR YEAR
GEMINI
APOLLO/SKYLAB
SHUTTLE
SHUTTLE/HST/DTO/ISS

Spacesuit Atmosphere

- **Physiological Limits**

- **Engineering Constraints (operational)**

Pressure

- **Partial Pressure of Oxygen, PO_2**
  - **Inadaquate PO_2 in lungs - Hypoxia**
  - **Oxygen Toxicity**

Medical Problems - Pressure Changes

- **Compression**
- **Decompression**

Pressure (continued)

Decompression Sickness (DCS) "The Bends"

Examples : Diver ascends quickly or EVA astronaut dons a spacesuit (decompressed)

- **Symptoms**
  - **Limb joint pain** — **Skin rash (easily treated)**
  - **Cardiovascular** — **CNS (life threatening)**
- **Explosive DCS (loss of pressurization of spacesuit)**
  - **Air arterial embolism**
- **Avoiding DCS**
  - **Eliminate excessive absorbed nitrogen**
  - **Variable Factors**

Establishing Safe Limits - Low Pressures

Why?

Risk of DCS - R factor

- **Ratio of initial absorbed tissue N_2 pressure / final ambient pressure**
  (based on slow 360 minute half-time tissue denitrogenation)
- **Shuttle R = 1.65, Space Station Freedom R = 1.4**
- **Protocol : • 4 hour prebreathe of oxygen**
  • 12 hrs. at 70.3 kPa (10.2 psi)
  40 minutes in suit breathing pure oxygen

Oxygen Requirements for EVA LSS

- **PO_2 dictates**

Sea Level - guideline to Artificial Environments
PO_2 = 21.06 kPa (3.06 psia)

(Water vapor in the upper respiratory tract tends to decrease the alveolar PO_2)

- **Dalton's Law**

Total pressure of a gas mixture is equal to the sum of the partial pressures of all the individual gases.

- **Artificial Environments**

Radiation Protection

- Essential to consider EVA crew member protection
  - Most damaging radiation in LEO - SAA
  - Inner Van Allen magnetically trapped proton belt dips down to lower altitudes.
- Orbital inclination of 28.5 degrees, 500 km altitude
  6 orbits pass through SAA
  9 orbits that miss SAA
- Scheduling
- Additional Factors
  - Galactic Cosmic Radiation
  - Solar Flares

EVA Requirements

- **Spacesuit**
  - pressure vessel around astronaut
  - protection from environmental hazards
  - human performance (i.e., mobility, comfort, workload)
  - gloves
- **Portable Life Support System (PLSS)**
  - oxygen supply and pressure control
  - carbon dioxide and trace contaminant removal
  - humidity control
  - thermal control
  - power, communications, and data display
- **Differences between PLSS and Habitat Life Support System**
  - short duration
  - small volume
  - close coupling with metabolic rate
  - food and water supplies

Space Shuttle Extravehicular Mobility Unit (EMU)

- Provides environmental protection, mobility, life support, and communications for EVA in LEO.
- 29.7 kPa, 100% Oxygen, multiple fabric layers, hard upper torso
- Modular Sizing System
- Operational Capabilities
  - Total EVA duration 7 hrs.
  - 15 min. egress, 6 hr. useful EVA, 15 min. ingress, 30 min. reserve
  - Average metabolic rate not to exceed 400 kcal/hr (1600 btu/hr) in any hour not to exceed 250 kcal/hr for the EVA duration
  - Peak metabolic rate not to exceed 500 kcal/hr
  - Minimum metabolic rate not less than 100 kcal/hr for 30 minutes

Russian EVA Spacesuit

- **Orlan-DMA model, derivative of the semi-rigid Salyut-Soyuz suit**
- **40.6 kPa (27.6 kPa), 70 kg, fabric layers limbs, metal upper torso**
- **Advantages (G. Severin)**
  - **Rear hatch entry**
  - **Minimal overall dimensions of suit torso in pressurized state**
  - **Ease of rapid donning/doffing**
  - **Handling capabilities, improved life support line connections**
  - **One-size-fits-all, Single spacesuit for crewmembers of different sizes**
  - **Easy replacement of consumables**
  - **Easy maintainability due to ease of access to units**
- **Future research (G. Severin)**
  - **Improve suit mobility**
  - **Regenerative systems**
  - **Improve operating life**
  - **Microprocessors to control and monitor spacesuit systems**

Three Suits

To Mars

Thanks, that's all folks!