Human Factors and Life Support in Apollo

Engineering Apollo
16.395/ESD.30/STS.471
Prof. Laurence R. Young
1958 NACA Space Technology

Study Chaired by Guy Stever of MIT
Human Factors and Training Group chaired by Randy Lovelace, MD
15 Technical Areas

Wiesner and Abelson wanted NASA out of the science

Need for a basic biomedical research program
1958 HF and Life Science Issues

1. Program administration
2. Acceleration
3. Hi-intensity space radiation
4. Cosmic radiation
5. Nuclear propulsion
6. Ionization effects
7. Human info processing/comm.
1958 HF and Life Science Issues (cont)

8. Displays
9. Closed-cycle living
10. Balloon simulators
12. Space capsules
13. Crew selection and training
14. Research Centers
15. Launch sites
Major Life Science Issues

Astronaut Selection
Medical Requirements
   Skill Set

Life Support Systems
   Accelerations
   Atmosphere
Early Biomedical Concerns

Heart Failure
Pneumonia
Muscle cramps
Balance
Sleep
Bone loss

Eating/drinking
Disorientation
Manual control
Vision
Hearing
Separation
Acceleration Tolerance

Transverse (Eyeballs In)
Fitted couches
Decreased tolerance
Animals in Space First?

Science Community wanted Animals
Chimps trained for flight
Enos had ectopic heart beats
Ham successful in Mercury suborbital flight
X-15 program seemed to qualify man for flights
**Biosatellite** 3 flights with chimps 1963-67
Office for Biotechnology & Human Research

Man-machine integration
Advanced life support
(AG and closed systems)
In-flight animal studies
Bioinstrumentation
In-Flight Medical Monitoring

No knowledge of o-g tolerance
A source of friction with crews
Originally only:
  Body temp. (rectal, then oral)
  Respiration rates (thermistor then impedance pneumograph)
  Blood pressure, later, ECG

Reliance on voice and interrogation
Pilots vs. Flight Docs

Pilots feel invincible
Flight surgeons are conservative and are considered a threat
Scientific community wants more studies
See Charles Berry quote, p. 149 of Engle and Lott
Astronaut Duties

Backup of the automatics systems
Scientific observer
Engineering observer
Test pilot
Crew Training

Space familiarization
High performance aircraft
Exposure to stresses
Simulation
Flight Crew Training

Selection
Physical health
Mental health
Test Pilot Experience
Training
Coordination of Manned Program

NACA WG on Human Factors
Chaired by Guy Stever (MIT)
Report by Randy Lovelace
Air Force Lead (X-15 and beyond)
Dyna-Soar
Mercury Biomedicine

Life Science Advisory Committee, 1959
Randy Lovelace, Chair
Stan White, MD
Bob Voas, PhD
Only involved in selection
14 day Gemini key to Apollo Biomedicine

Acceleration
(Henry-Gauer)
Pneumatic cuffs
Bungee exerciser
Weightlessness
Radiation
Capsule environment

Waste management
Isolation
Sleep
Man-machine
Food and water
RBC loss found
Life Science in Apollo

Microgravity Effects
Radiation Protection
Planetary Protection
Other science
## Oxygen vs Air

<table>
<thead>
<tr>
<th>Oxygen Advantages</th>
<th>Oxygen disadvantages</th>
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<tbody>
<tr>
<td>Lower pressure</td>
<td>Long term hyperoxia</td>
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<tr>
<td>Lighter structure</td>
<td>Fire hazard</td>
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<tr>
<td>Avoids hypoxia</td>
<td>Science impact</td>
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- Avoids hypoxia
- Avoids bends
- Simpler engineering

- Long term hyperoxia
- Fire hazard
- Science impact
- Toxic oxidation products
Carbon Dioxide

Potentially lethal if not regulated
Simple LiOH Cannisters
Need for monitoring
Later – molecular sieve and other chemical reactions
US and Soviet Spacecraft

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Graph of atmosphere compositions of various U.S. and Soviet spacecraft, and image of the Apollo-Soyuz joint mission.
Pre-Selection Testing

Only active duty military test pilots tested
IQ and engineering and math aptitude
Medical evaluation
Centrifuge
Hypo-baric chamber
Thermal chamber
Parabolic flight
ORIGINAL SEVEN

Selected for:
Intelligence
Physical Stamina
Health
Science/Engineering
Light Weight
Not too tall (71 in.)
Below 35 (later 39) yrs
Pilot Performance

Disorientation
Isolation
Illness
Recency
Space Suits

Designs based on high altitude pressure suits
Backup to cabin pressurization
EVA mobility
Pure oxygen PLSS, 3.7 psi
Evaporative cooling, later liquid cooling
Excessive heat production