Preparation for Human Flight to Mars:
An Integration of Occupational and Aerospace Medicine

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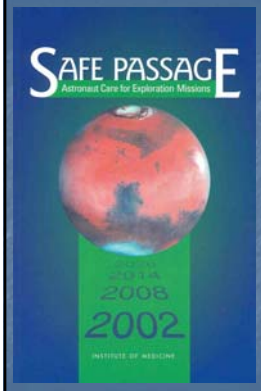

- The general charge to the Committee on Creating a Vision for Space Medicine During Travel Beyond Earth Orbit was to develop a vision for space medicine for long-duration space travel.

Publication date: 2001

SAFE PASSAGE

Executive Summary

To support safe human exploration of space, NASA should pursue a two component strategy:

(1) A comprehensive health care system for astronauts to capture all relevant epidemiological data.
(2) Pursue a long term, focused health care research strategy to capture all necessary data on health risks and their amelioration.

An occupational health model should apply in the first case.

President Bush;
January 14, 2004

"Today I Announce a new plan to explore space and extend a human presence across our solar system. We will begin the effort quickly, using existing programs and personnel. We'll make steady progress, one mission, one voyage, one landing at a time.

...to return to the moon by 2020, as the launching point for missions beyond."

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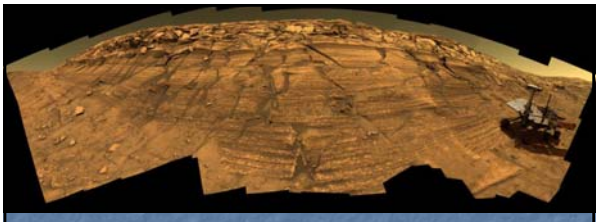

Michael Griffin, administrator of the US space agency stated on September 25, 2007 at the International Aeronautical Congress that:

"We have a long term plan to put a man on mars by 2037."

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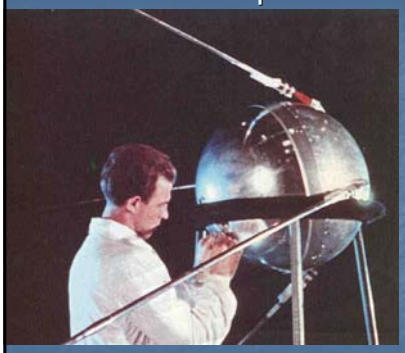
September 2009
Panel: Return to Moon is No-Go!

- An additional $3,000,000,000 per year, a mismatch between resources and rhetoric. NASA is unable to get beyond low-earth orbit without more $$$! Other options are to be considered. - *Seth Borenstein (AP)*

Sputnik



- October 4,1957
- 23 inch sphere
- 184 pounds

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W4RRV

"Ham" Radio Operator – listens to Sputnik I

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Project Mercury 1958 - 1963

First US Manned Flight May 5, 1961

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Project Gemini 1962 - 1966

Space walk, extended weightlessness, docking

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Project Apollo 1960 - 1972

1st manned flight to moon December 1968

Final lunar flight December 1972

Twelve men walked on the moon.

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Skylab Missions

May 14th 1973
Mission duration:
28,59,84 days

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Challenger
January 18, 1986
Seven fatalities

Columbia
February 1, 2003
Seven fatalities

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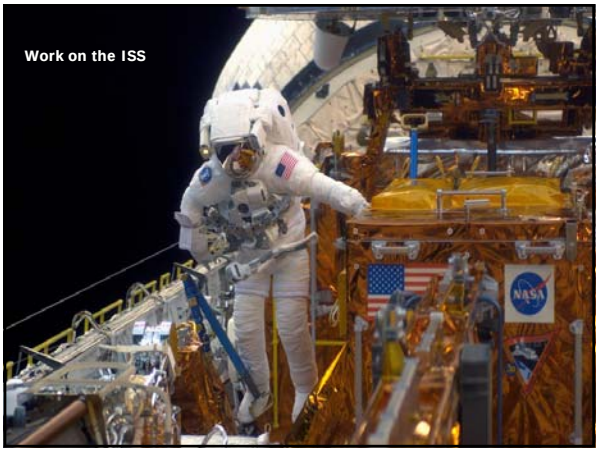

Human Physiological Change Resulting from Extended Travel in Space

- Musculosketical System:
  - Loss of bone mineral density
  - Loss of skeletal muscle
- Cardiovascular System:
  - Orthostatic hypotension
  - Loss of hydrostatic pressure
- Pulmonary System:
  - Changes in circulation and gas exchange
- Alimentary System:
  - Ileus
  - Decrease absorption or malabsorption

Human Physiological Change Resulting from Extended Travel in Space (Cont'ed)

- Nervous System:
  - Ataxia
  - Motion sickness
  - Disturbed fine motor functions
  - Altered circadian rhythm
- Reproductive Systems:
  - Effect of radiation on gametes
- Urinary System:
  - Renal Calculi
- Hematological & Immunological system:
  - Anemia
  - Potential immunologic depression

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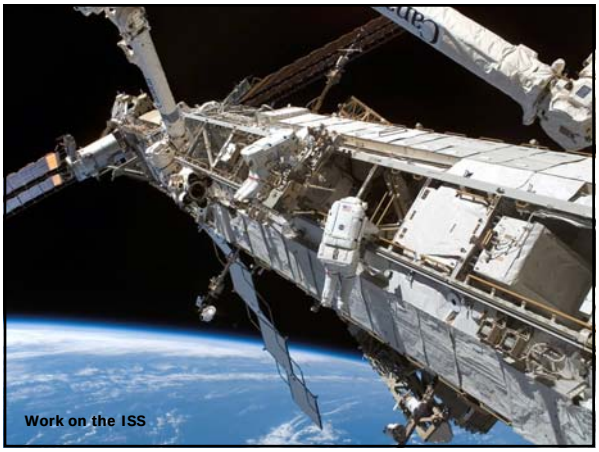

Work on the ISS

Human Space Flight Experience

- 220 Astronauts current in the corp
- 460 Astronauts/Cosmonauts have flown
- 775 Individual space flights
- Over 128 STS missions up to 17 days
- Longest duration in space: Female: 188 Male: 400 days
- 12 men have walked on the lunar surface
- Aborts: Russia 3 – USA 1
- Deaths: US has lost 17 crew in mission related accidents

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Medical Events on Space Shuttle Flights (STS) 1-89 1981 - 1998

Medical Event	Number	Percent
SAS (motion sickness)	788	42
Nervous & sense organs	318	17
Digestive system	163	8.7
Injuries	141	7.6
MS System	132	7.1
Respiratory System	83	4.4
Behavioral	34	1.8
Infectious disease	26	1.4

Medical Events (Cont'ed)

Medical Event	Number	Percent
GU System	23	1.2
Circulatory Sys.	6	0.3
Endocrine, etc.	2	0.1

> Over 128 space shuttle flights by Sept. 2009

In Summary, puffy, constipated and tall.

Effects of Spaceflight on Infectious disease

- Changes in microbial virulence. Immune system may be compromised. Salmonella typ. virulence is increased. Pathogenic Organisms have been cultured with recycled air and water with risk of increased events.

Effects of Spaceflight on Infectious disease (Cont'ed)

- Latent Herpes Virus Evidence
  - EBV, CMV, VZV reaction occurred
  - EBV, VZV both shed in saliva and urine in ¼ astronauts

Observations from SAFE PASSAGE

- Space is the most extreme environment that humans have ever entered and beyond orbit is both quantitatively and qualitatively different.

- For the past 40 years NASA has missed critical opportunities to collect & analyze clinical data.

-Health data is considered private, and has resulted in under reporting of relevant information.

Observations from SAFE PASSAGE

- Participation in clinical research has been considered voluntary.
- Astronauts are a highly privileged group with rare and valuable opportunity who have a responsibility to contribute to the safety and health of others.
- Astronauts must be considered a unique population of research participants (lab rats).

Observations from SAFE PASSAGE

- Physician (Flight surgeon) plays multiple roles: coach, clinician, researcher, and fellow Astronaut.
- Make the collection of individual medical data an expected part of participation in all space missions.
- "NASA should develop and use an occupational health model for collection and analysis of Astronaut health data."
- Crew likely to be multicultural, international & both sexes.

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Long Duration Space Flight

- Astronauts will live and work for longer periods of time. The longer in that environment, the more it resembles a workplace.
- Issues of health and safety are more likely to arise.
- In the occupational health context, medical confidentiality becomes less important.
- The occupational health model will need to transcend astronaut personal concerns.
- The occupational health model will become the primary driver of medical services.

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Important health issues

- Radiation
- Loss of bone mineral density
- Cardiovascular effects
- Behavioral adaptation

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Health Care Strategy

Preflight

- Expected incident of health conditions
- Institute preventive measures
- Match health condition with medical management

In Flight

- Level of skill on board
- Necessary diagnostic technologies
- Necessary treatment technologies
- Measures to stabilize
- Disposition plan in case of death

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Health Care Strategy (Cont'ed)

Post flight

- Long-term care
- Medical surveillance
- Strategy review

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Purposes of Occupational Health Surveillance

- Incidence & Prevalence of disease and injury.
- Identify individual causes of disease and injury.
- Find and evaluate others who may be at risk.
- Discover new associations between agent and disease.

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The Moon by 2020 ?

New crew system
Logistic lift system
Establish a habitat
Research laboratory
Expendables generator
Dependable Bus lift

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The Moon by 2020 ?

Orion Moon Transportation Capsule

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Constellation System

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The Moon by 2020 ?

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The Moon by 2020 ?

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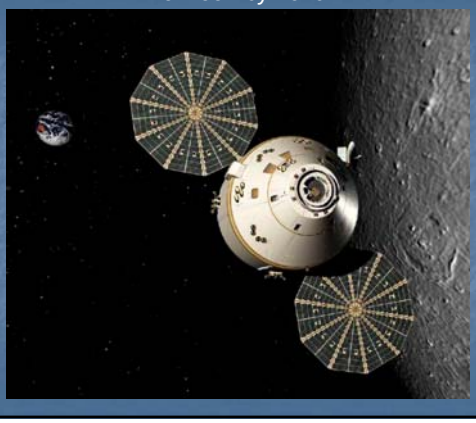
The Moon by 2020 ?



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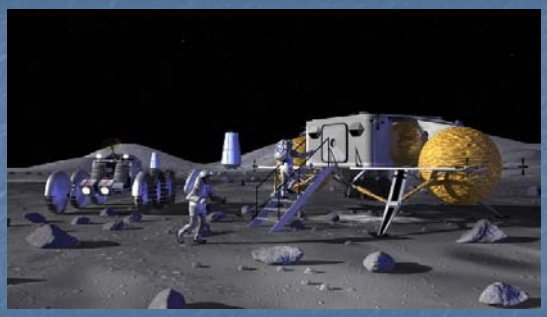
The Moon by 2020 ?



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? To Mars By 2040 ?

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Human Expedition to Mars Risk Areas

NASA - Critical Path Roadmap

- Advanced life support
- Environmental health
- Human performance
- Bone loss
- Cardiovascular alternations
- Muscle alternations and atrophy's
- Immunology interaction and hematology
- Neurovestibular adaptation
- Space medicine
- Food and Nutrition

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Space Radiation Risk

- Long term exposure to Solar particle events and galactic cosmic radiation
- Cancer, Neurologic effects, Reproductive alterations.

- Short term high-energy, charged particles (HZE) – Death.
- Estimates of events are based on large uncertainties.

Countermeasures:

- Operational shielding
- Screening (genetic predisposition)
- Prevention
- Intervention

Food for long duration Space flight

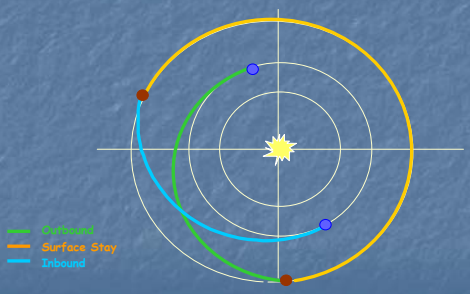
Something more than a takeout or picnic basket

- Food packages have been tested for: taste, texture, digestibility, residual and ease of preparation.
- Main courses, desserts and drinks: 1200 kcal and 550 kcal.
- 29 selections include: main courses, rice, soups, beverages, protein bars, chocolate, fruits and chewing gum.

Food for long duration Space flight (Cont'ed)

- Main Courses of: beef, pork, chicken, fish, bean curd, mushroom, cabbage.
- Sampling satisfaction rates of 86% - 100%

? To Mars By 2040 ?



Transfer to Mars and return

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? To Mars By 2040 ?

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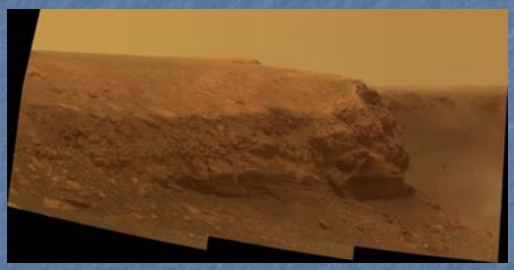
? To Mars By 2040 ?



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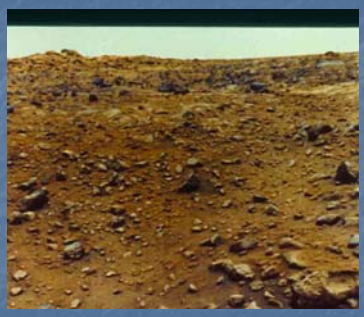
? To Mars By 2040 ?



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? To Mars By 2040 ?

First photograph of Earth and the moon taken from Mars.

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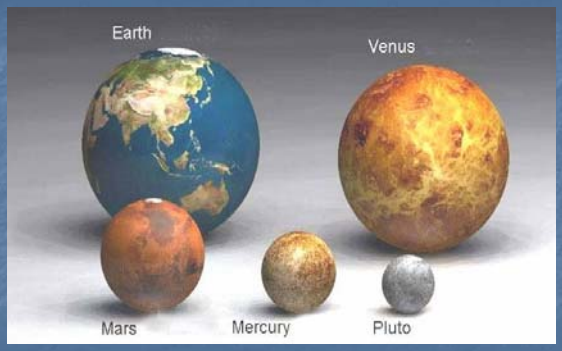
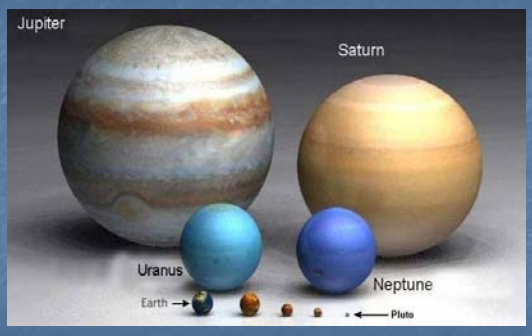
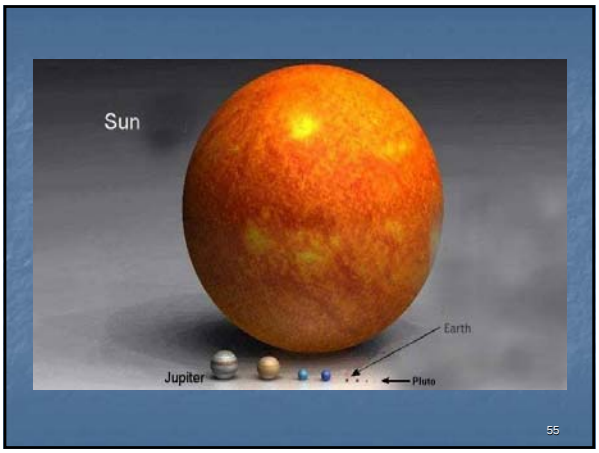
? To Mars By 2040 ?

High resolution photograph taken from Mars orbit.






Sun
Earth
Jupiter
Pluto
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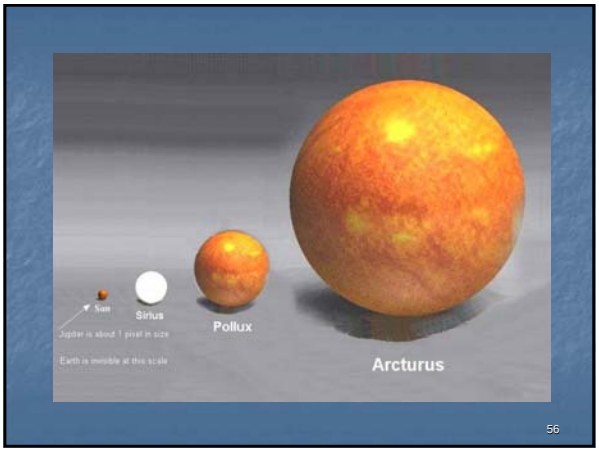
Sun
Sirius
Pollux
Jupiter is about 1 pixel in size
Earth is invisible at this scale
Arcturus
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