Hazards and Countermeasures on Extended Space Missions

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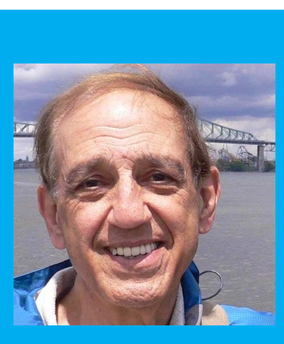
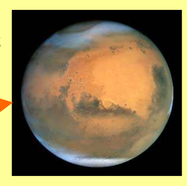


1. OBJECTIVE:

Human exploration on extended space missions beyond the Van Allen Belts to nearby asteroids or to planet Mars



DRAWBACKS

Galactic radiation effects over long periods that may lead to latent cancer

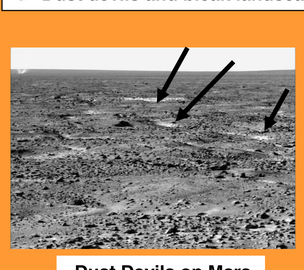
Space mission time has become synonymous with radiation dose

2. WHAT TO EXPECT ON MARS

- Extreme cold: Mean surface temperature -63 □C; Minimum polar winter temperature -140 □C; Maximum equatorial temperature +20 □C
- Rarified atmosphere 0.6 kPa (0.087 psi) predominantly : Carbon Dioxide 95.32%; Nitrogen 2.70%; Argon 1.6%; Oxygen 1.3%
- Radiation:

Mars	Earth
~ 220 μSv/day	8.22 μSv/d world average
80.30 mSv/y	3 mSv/y
~ 26.8 times more radiation than on Earth	

- Dust devils and bleak landscape



Dust Devils on Mars

The Ubehebe Crater in Death Valley, USA

Victoria Crater on Mars Explored by Opportunity

3. What Are The Hazards?

- Levels of Radiation
- Debilitating Microgravity
- Bacterial Growth
- Fluid Redistribution; Cardiovascular Effects; Loss of Red Blood Cells; Muscular Atrophy; Bone Loss Damage; Immune System Damage to T-Cells
- Psychological
- Inconveniencing Effects: Sweating in beads; Nausea and vomiting; Anorexia; Headaches; Asthenia

4. POSSIBLE COUNTERMEASURES

In Combination

5. Radiation: Reduce effects by

Having a clear understanding of galactic radiation and its biological effects Particularly HZE

6. Radiation: Reduce effects by

A new Paradigm for Dose Limits:

- Use Incidence rates from exposed cohorts(BEIR) not Mortality Rate Transport (NCRP 132)
- Adjust for never smokers
- Cancer mortality 3% of Risk of Exposure Induced Death (REID)
- Consider Lifetime Cancer Risk to model the uncertainties
- Consider age, gender, shielding, plus other countermeasures to define dose limits
- Consider risk for each tissue organ, not single weighting factor for all organs

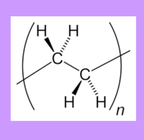
7. Radiation: Reduce effects by

Enhancing the Immune System with

- Retinoids: related with Vitamin A with antioxidant properties
- Bowman-Birk Inhibitor Concentrate: a chemo prevention drug
- Selenium: makes selenoproteins which are antioxidant enzymes
- Selenomethionine: an amino acid containing selenium

8. Radiation: Reduce effects by

- Better shielding that produce minimal secondary radiation
- Materials rich in hydrogen, e.g. polyethylene
- Using RXF1 new composite material
- Use Liquid Hydrogen as a shield (is depleted on route)
- On board water as a shield (can be depleted on route)

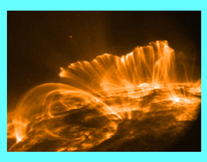


9. Radiation: Reduce effects by

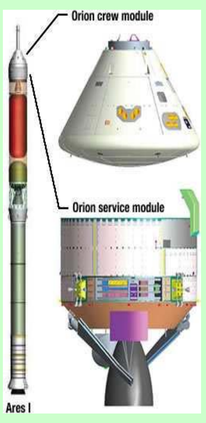
Nutrition for Bone Loss:	1000 mgm per day Calcium Exceeds 3500 mgm per day Sodium …. of concern Vitamin D
Muscle Atrophy:	Bowman-Birk Inhibitor Concentrate
Blood Plasma Decrease:	10 mgm iron intakes per day

10. Radiation: Reduce effects by

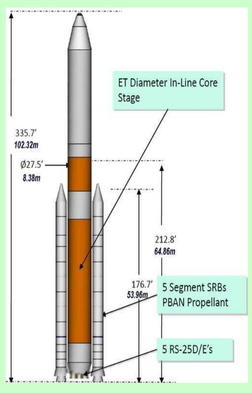
Timing the mission to avoid the solar flares to reduce impact of solar particle events



11. Radiation: Reduce effects by Faster Propulsion

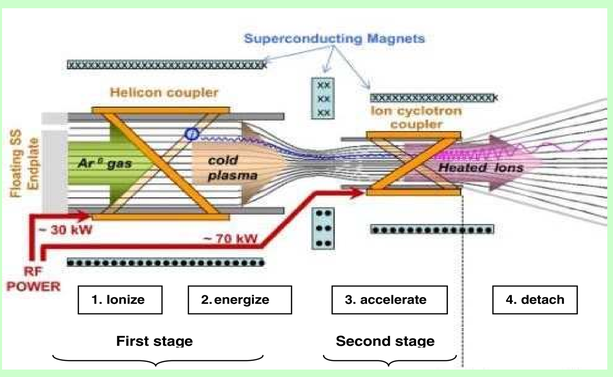


Orion Spacecraft (Under Test) with Ares I Launcher
Replaces the retired Shuttles
Carries a crew of 4
Scheduled to International Space Station by 2015
Can travel for 6 months
Solar Array Power up to 6 kW



Space Launch System Rocket
Lift capability 130 tons
Approx. 20 x Saturn V (Moon Rocket)
Scheduled for 2017
Cost est. $18 billion

Futuristic – Ion Engine



Schematic of Ad Astra's VASIMIR VX-200 Ion Engine
Currently at 200 kW Power but may be extrapolated to 10-20 MW Power to reach Mars in 39 days [optimistic]

12. Microgravity

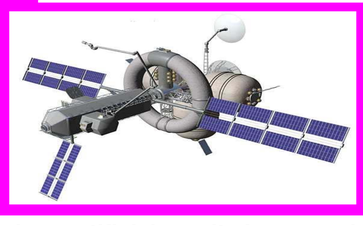
Effect	Countermeasure
Physiological: * Disorientation * Loco-motor and postural disturbances * Head-trunk coordination	A program of clinical tests to assess the crew recovery rate is part of NASA program
Debilitating Effects: * Fluid redistribution and loss. * Lower blood pressure causing fainting.	* Ingesting isotonic solutions * Apply suction to legs and abdominal region
Muscular Atrophy: * Weight bearing muscles degenerate	* Low intensity exercise 2 h per 24 h. Muscles expend less than 30 % power
Bone Loss: * Bones resorb at 1.5% per month at the hip, femur and vertebrae	* Short periods of high intensity exercise
Hematologic: * Red blood cells decrease by 15% after 3 months in spaceflight	* On board blood analyzer is used. Phenomena is reversible
Immune System: * The T-Cells become damaged	* Being researched
Effects on Medical Procedures: * Bacterial cell membranes become thicker reducing the effectiveness of antibiotics	* Being researched

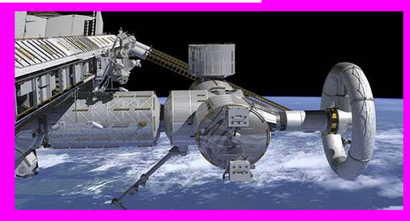
13. The Psychological Effects

- Conduct crew compatibility tests as in Canadian high Arctic
- Provide conflict resolution
- Provide amenities
- Provide counseling
- Audio-visual communication with family members

On Devon Island Northern Canada

FUTURISTIC PROTECTION FROM MICROGRAVITY





Introduce artificial gravity in spaceships

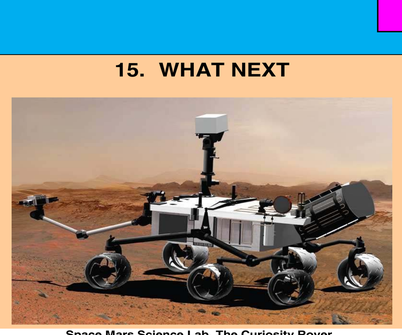
Conceptual Designs of NAUTILUS Spacecraft

14- Conclusions

- A clear understanding of galactic radiation and its biological effects by:
  - customizing each mission to the group of space travelers
  - enhancing the immune system via nutrition and/or drugs
  - revised paradigm for ascertaining dose limits
- Better shielding materials with high Hydrogen content
- Reduce or eliminate Microgravity effects via:
  - Nutrition to counteract bone loss
  - Initiating resistance exercises to reduce muscle atrophy
  - Preventing the prolific bacterial growth
- Reduce or eliminate Microgravity effects via:
  - Nutrition to counteract bone loss
  - Initiating resistance exercises to reduce muscle atrophy
  - Preventing the prolific bacterial growth
- Faster propulsion rocketry/systems to reduce travel time

  Travel time ≡ radiation dose
- Psychological: reduction of the stressors viz.
  - Isolation, lack of contact with family and kin
  - Lack of privacy
  - Selection of psychologically compatible crew culturally and diversity
  - Give the crew space … space … space, and

15. WHAT NEXT



Space Mars Science Lab, The Curiosity Rover
Launched 26 November 2011 – To Arrive Mars 6 June 2012 approx.

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Diagram and data on VASIMR ion plasma engine

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