The Challenges of Developing a Food System for a Mars Mission

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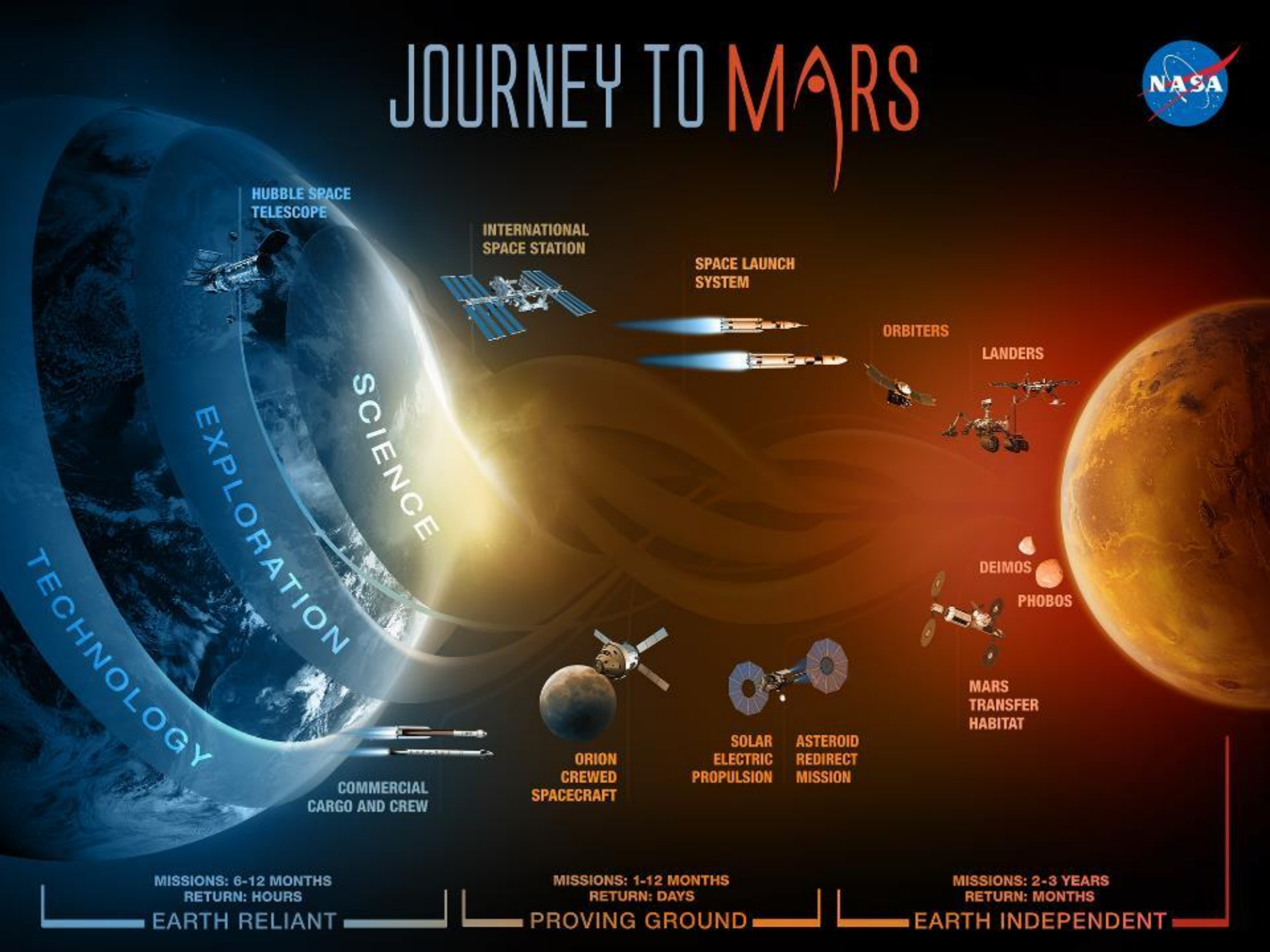
Layers at the Base of Mount Sharp (taken by Curiosity)

JOURNEY TO MARS



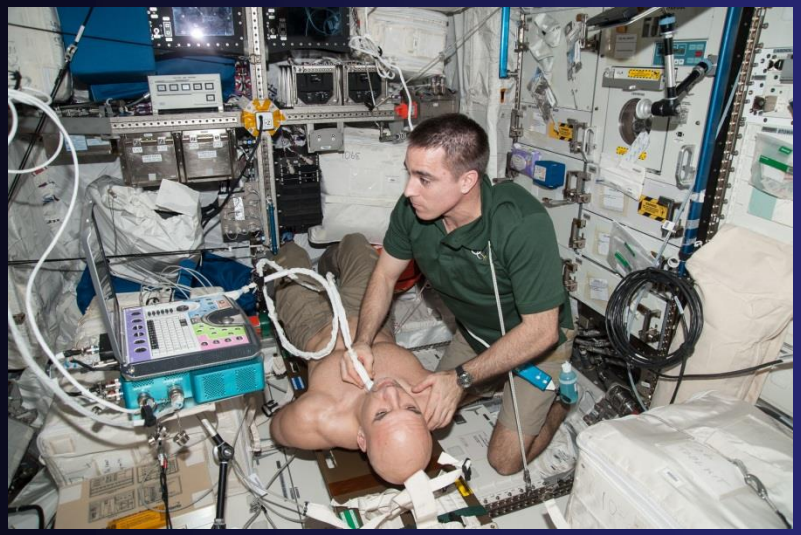
MISSIONS: 6-12 MONTHS
RETURN: HOURS
EARTH RELIANT

MISSIONS: 1-12 MONTHS
RETURN: DAYS
PROVING GROUND

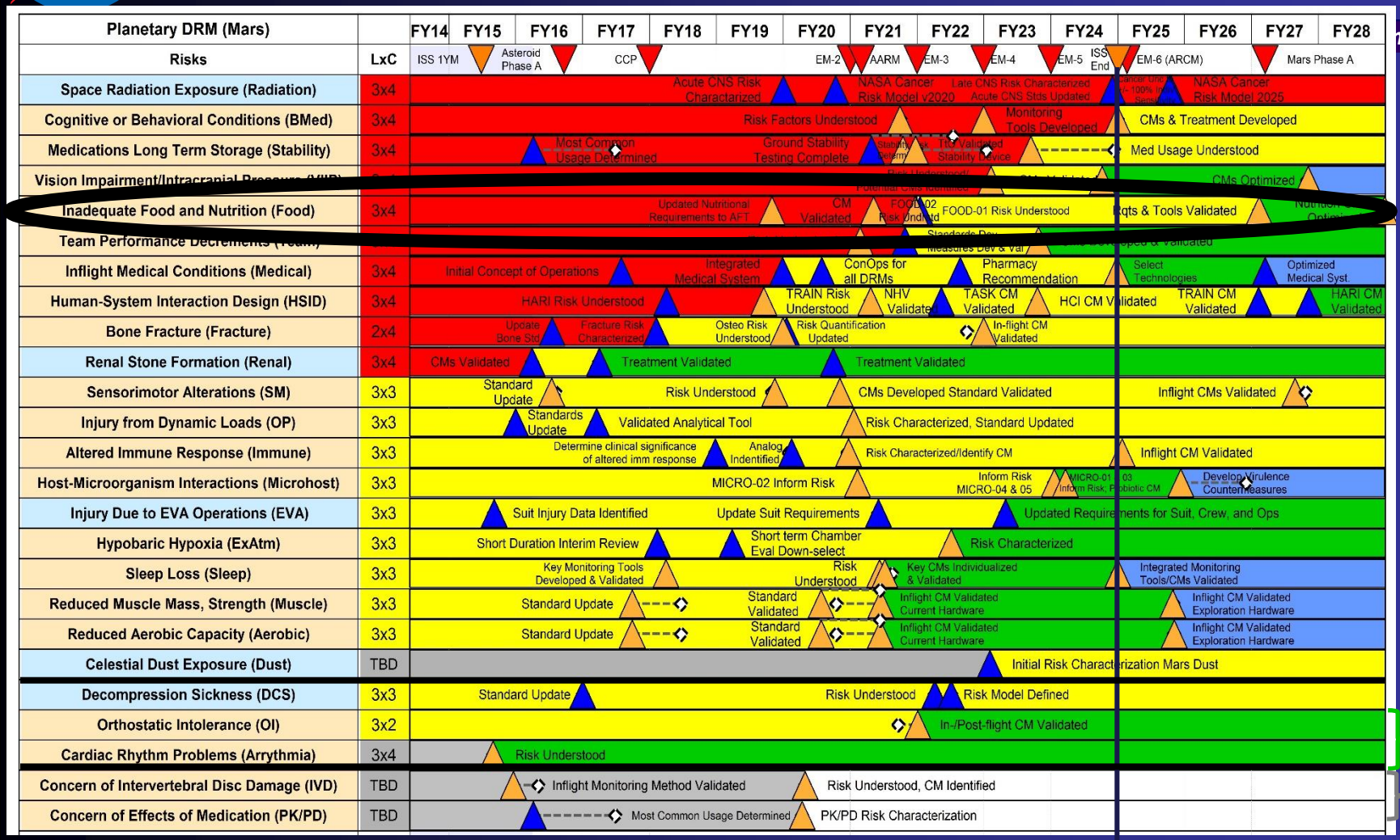
MISSIONS: 2-3 YEARS
RETURN: MONTHS
EARTH INDEPENDENT

Human Research Program

The goal of HRP is to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration.



HRP Integrated Path to Risk Reduction



Ultimate goal is to provide a food system that supports all aspects of a Mars mission

- Develop a food system that is **Safe**, **Nutritious**, **Acceptable**

and

- Efficiently balances appropriate vehicle resources such as:

volume, **mass**, **waste**, **water**, **power**, **cooling**, **air**, **crew time**

<u>Example</u>: To maintain an adequate food system may require more packaging mass which conflicts with minimization of mass.

Evolution of the Space Food System

Mercury
- Highly engineered foods (Meal in a Pill concept) – cubes, tubes

Gemini
- Highly engineered food with new introductions (Pudding, Chicken and Vegetables)

Apollo
- Thermostabilized food, spoon bowl, natural form foods

Evolution of the Space Food System

Skylab

- Freeze-dried, thermostabilized, natural form and frozen foods
- No resupply – all food stored at the time of launch

Shuttle / MIR

- Higher quality food in lighter packaging
- Assignment of 9-month shelf life on food

International Space Station

- Irradiated items (meats) through special FDA allowance.
- Aluminum film overwraps allow 12-18 month shelf life for most food.

Current Space Food System – 130 options

Natural Form Foods

Rehydratable Foods

Intermediate Moisture Foods

Beverages

Irradiated & Thermo-stabilized Foods

Not pictured: Extended shelf-life breads and fresh food (limited basis)

Food System Considerations

International Space Station:

- 6 month microgravity missions
- No refrigerators or freezers for food storage, all food processed and prepackaged
- Regularly scheduled resupply
- Eight to eleven day standard menu cycle augmented by crew preference foods

Mars Expedition Scenario:

- 32 month mission; microgravity and reduced gravity
- Possibility of refrigerators or freezers for food storage
- No resupply; food may be prepositioned to accommodate high mass and volume
- Radiation impact is unknown
- Current food system is mass constraining and will not maintain nutrition/acceptability

Prepackaged Food – 5 Year Challenge

Focus on nutritional stability, acceptability, health promotion, and mass reduction

Human Research Program

Formulation

Fortification

Food Matrix

Functional Foods

Meal Replacement

Variety

Processing

Pressure Assisted Thermal Sterilization (PATS)

Lyophilization Improvement

Microwave Sterilization

3D Printing (SBIR)

Packaging

Improve barrier

Mass reduction

In Suit Delivery System

Environment

21°C

-80°C

Atmosphere

Temperature

Radiation

Microgravity

Partial Gravity

Closed System

Variety Limitations

Psychosocial support

Physiological impacts

Psychology of Food

There are psychological benefits of the food system

- Socialization during mealtimes.
- Food quality, variety and acceptability are important. Highly acceptable food is a familiar element in an unfamiliar and hostile environment.

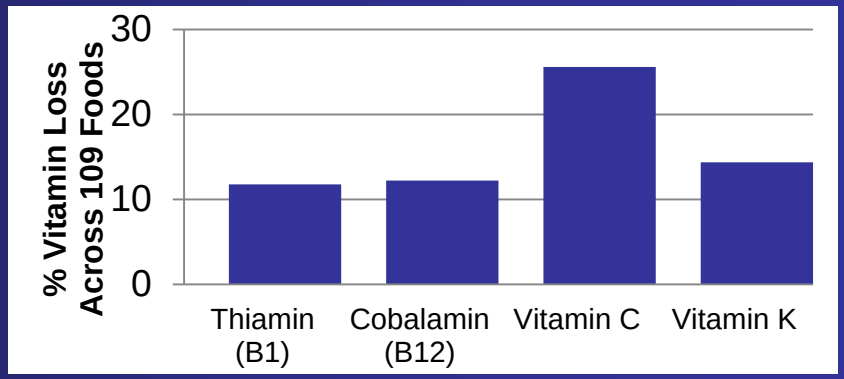
Taste Changes in Microgravity

There are anecdotal reports that food does not taste the same in space

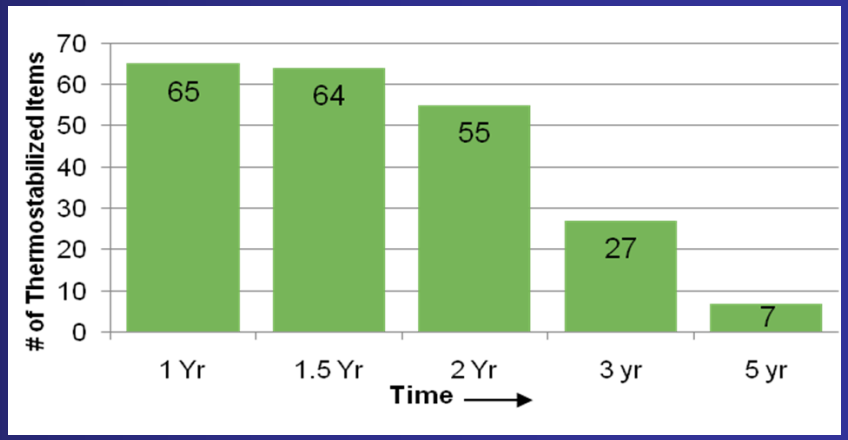
- 85 – 90% of what you taste is what you smell
- Hot air (volatiles) does not rise in microgravity
- Food is not heated to very hot temperatures
- Food is eaten out of packages with small openings
- Fluid shifts in the body result in a feeling of congestion in the nasal passages

Nutrition and Acceptability Impacts of Room Temperature Storage

- Critical micronutrients show concerning degradation in space food system after 1 year of storage.



- Only 7 out of 65 thermostabilized foods are expected to be palatable after 5 years of storage. (Catauro. JFS. 2011)



Mass Reduction Opportunities

Current mass requirement for 3000 kcal per crewmember per day is 1.83 kg. Total mass for a Mars scenario (6 crewmembers, 1095 days) is 12,023 kg.

Orion has challenged the food system to a 25% mass reduction

- Four **Meal Replacement Bars** enabling 10% reduction in mass developed through Natick (NSRDEC); acceptability testing underway in four 2016 HERA missions; stability testing through 2018
- In the event of cabin depressurization, crewmembers may be required to don pressurized suits and will require nutrition during contingency operations
  - Guidelines were determined for contingency beverages that meet macro-nutritional requirements, a minimum one-year shelf life, and compatibility with the delivery hardware. These beverages could reduce mass for nominal operations

Integrate Bioregenerative Foods

International Space Station

Supplement prepackaged with "Pick and Eat" beginning with Veggie chamber

Mars Scenario

Optimize mission specific phased implementation and balance with prepackaged foods – based on nutrition, acceptability, resources

Research gaps

Infrastructure, resource use, radiation effects, safe handling/ micro procedures, system integration, crew time usage

Potential Exploration Food Systems

Prepackaged

Less Infrastructure	Nutrient Degradation
Reduced Micro Risk	Quality Loss
Less Crew Time	High Mass and Volume
No Risk of Food Scarcity	No customization

Bioregenerative

Lower Food Stowage Mass	High Crew Time
Agri-Therapy	Microbiological Risk
Higher Nutrient Density	Infrastructure
Fresher Food	Risk of Food Scarcity
Variety / Customization	

Possible Bioregenerative Food System

Greenhouse Crops		
Lettuce	Tomato	Peas
Spinach	Strawberry	Snap Beans
Celery	Radish	Sweet Potato
Green Onion	Bell Pepper	White Potato
Carrot	Mushrooms	Dwarf Plum

Bulk Ingredients		
Rice	Peanuts / Peanut Oil	Soybeans
Dry Beans	Wheat Berries / Wheat Flour	

Food Preparation Current to Future

Food Warmer

Potable Water Dispenser

From top left: A) Pressure cooker, (B) Juicer, (C) Soymilk Maker, (D) Dehydrator, (E) Stand Mixer, (F) Pasta press, (G) Immersion blender, (H) Tofu mold, (I) Grain mill, (J) Induction burner

Thanks to current and former HRP Advanced Food Technology Team Members!

Questions?

Mars Explorers Wanted Poster
http://mars.nasa.gov/multimedia/resources/mars-posters-explorers-wanted/