Near-Term Mars Colonization

-A DevelopSpace Project-

May 4th, 2008

Earth to LEO, Earth-Mars Transit, At Mars, Emergency Return

SPACE TRANSPORTATION

1. Earth to LEO

- What are the options available in the near-term?
  - Current capabilities are for ~25 mt to LEO
  - Is it reasonable to expect ~50-100 mt in the near future?
- What are the minimum capabilities required for a Mars Colonization campaign?

2. Earth – Mars Transit

- What are the near-term technology options?
  - Chemical possible, nuclear unlikely
- What are the optimal trajectories for a colonization mission?
  - For initial delivery of infrastructure and crew
  - For re-supply missions
- Abort options, crew factors (habitat, radiation, etc)

3. At Mars

- Aero-capture
  - What are reasonable near-term capabilities?
- EDL
  - What is the best approach?
  - Capabilities?

4. Emergency Return Capabilities

- What would be the penalty for developing this capability?
- What is the best trajectory?
- Is it that beneficial?
  - What are the availability options for emergencies?

SURVIVAL INFRASTRUCTURE, SURFACE OPERATIONS, OPERATIONAL INFRASTRUCTURE

SURFACE INFRASTRUCTURE

“Survival Infrastructure”

- Habitation (Ryan)
  - Thermal, Structural, Crew Facilities, Radiation, Avionics
- Logistics (Wilfried)
  - Resupply options, ISRU capability
- Power Supply (Chase)
  - Power requirements, system robustness

Surface Operations

- What does the crew do when they are on Mars (other than survive)?
  - Maintenance and Repair (survival)
  - Infrastructure Improvements
  - “Public Relations”
  - Exploration
  - Science
- How many crew members are optimal?
- What tools & infrastructure are required?

“Operational Infrastructure”

- Maintenance and Repair
  - Spares, Repair Tools, etc.
  - What is the sparing strategy?
- Infrastructure Improvement
  - Technology Demonstrations (ISRU)
  - How can someone on Mars improve their own life?
- Exploration Tools and Equipment
  - Robotic Assistants
  - What is the goal of exploration?
- Science Tools and Equipment
  - Instruments and Payloads

- Communications
  - Surface communications (Exploration & Science), Earth-Mars communications (“Public Relations”), etc.
- EVA Infrastructure
  - Suits, Consumables, etc.
  - What is the EVA frequency & schedule?
- Mobility Options
  - Habitat Mobility, Unpressurized Rovers, Pressurized Rovers, etc.
  - How much mobility is required?

Forward Actions / Goals

- Space Transportation
  - Lit review to analyze near-term capabilities
  - Analyze optimal transportation architecture for colonization
  - Study up on aero-assist and EDL
- Surface Operations/Infrastructure
  - Further analysis each segment of “operational infrastructure” to determine trade space
    - What exactly is needed?
    - What are the possible solutions?
  - Perform lit review to determine near-term capabilities for surface operations

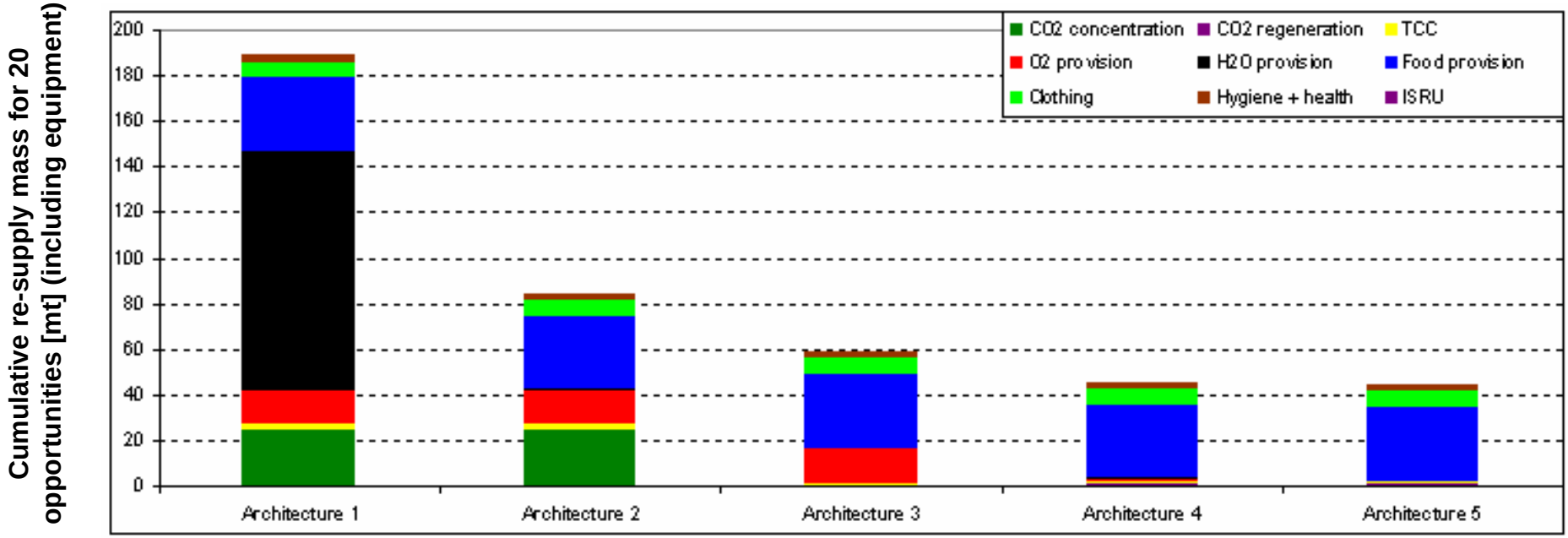
Life Support & Crew Systems Re-Supply

Re-Supply Assessment

General Study Objectives

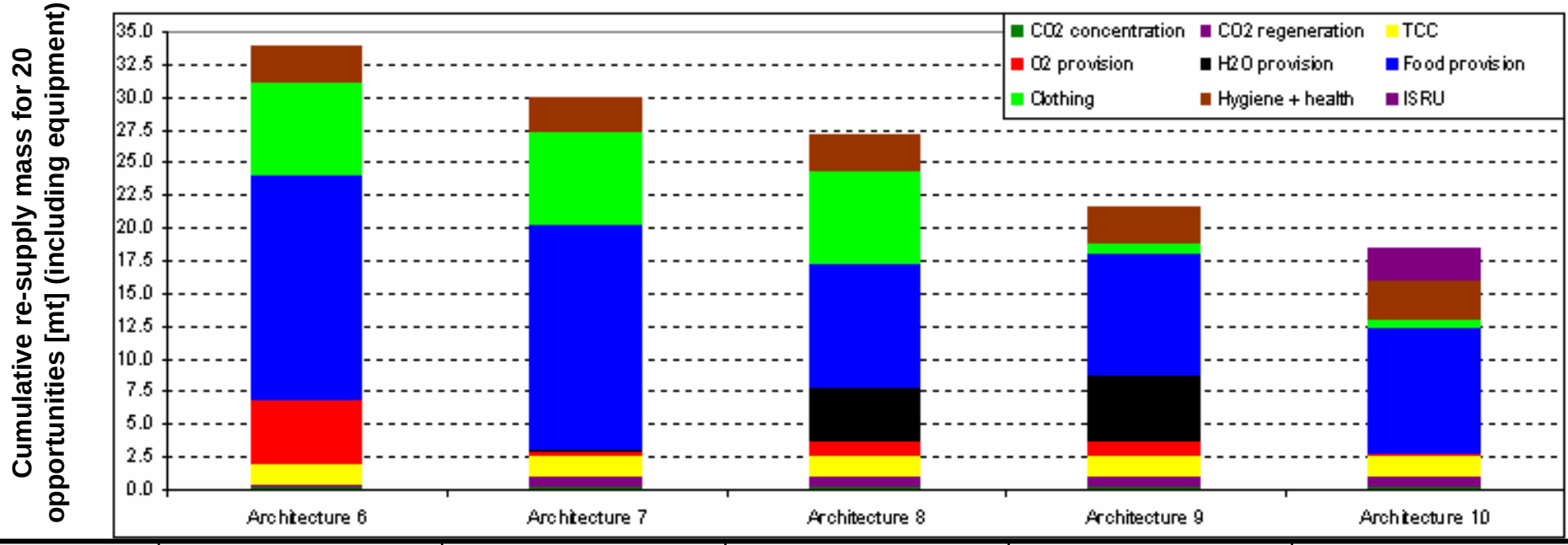
- Carry out an assessment of re-supply needs for the outpost given different technologies
  - Including high-closure life support, ISRU
- Identify key re-supply drivers and carry out in-depth analyses
- Identify interesting technologies with high payoff in re-supply mass reduction
  - Carry out initial modeling and testing of these technologies
- Formulate plan for further technology development

Preliminary Re-Supply Assessment (1)



CO2 removal	LiOH	LiOH	4BMS (zeolite)	4BMS (zeolite)	4BMS (zeolite)
Water provision	Stored	Multifiltration + VCD (90% closure)	Multifiltration + VCD (90% closure)	Multifiltration + VCD (90% closure)	Multifiltration + VCD (95% closure)
O2 provision	High-pressure storage	High-pressure storage	High-pressure storage	Electrolysis	Electrolysis
CO2 regeneration	None	None	None	Sabatier reactor	Sabatier reactor
Food	Fully hydrated, stored	Fully hydrated, stored	Fully hydrated, stored	Fully hydrated, stored	Fully hydrated, stored
Clothing	Stored	Stored	Stored	Stored	Stored
ISRU	None	None	None	None	None

Preliminary Re-Supply Assessment (2)



CO2 removal	4BMS (zeolite)	4BMS (zeolite)	4BMS (zeolite)	4BMS (zeolite)	4BMS (zeolite)
Water provision	Multifiltration + VCD (95% closure)	Multifiltration + VCD (95% closure)	Multifiltration + VCD (95% closure)	Multifiltration + VCD (95% closure)	Multifiltration + VCD (95% closure)
O2 provision	Electrolysis	Electrolysis	Electrolysis	Electrolysis	Electrolysis
CO2 regeneration	Sabatier reactor	Sabatier reactor + methane pyrolysis	Sabatier reactor + methane pyrolysis	Sabatier reactor + methane pyrolysis	Sabatier reactor + methane pyrolysis
Food	Partially hydrated, stored	Partially hydrated, stored	Completely dehydrated, stored	Completely dehydrated, stored	Completely dehydrated, stored
Clothing	Stored	Stored	Stored	Washing machine	Washing machine
ISRU	None	None	None	None	Zirconia electrolysis

Preliminary Insights

- Existing technologies allow for re-supply masses per opportunity of under 2 mt / person

- Remaining high-mass re-supply items are food and spare parts
  - These should be focus of in-depth analyses