Technologies for Human Exploration

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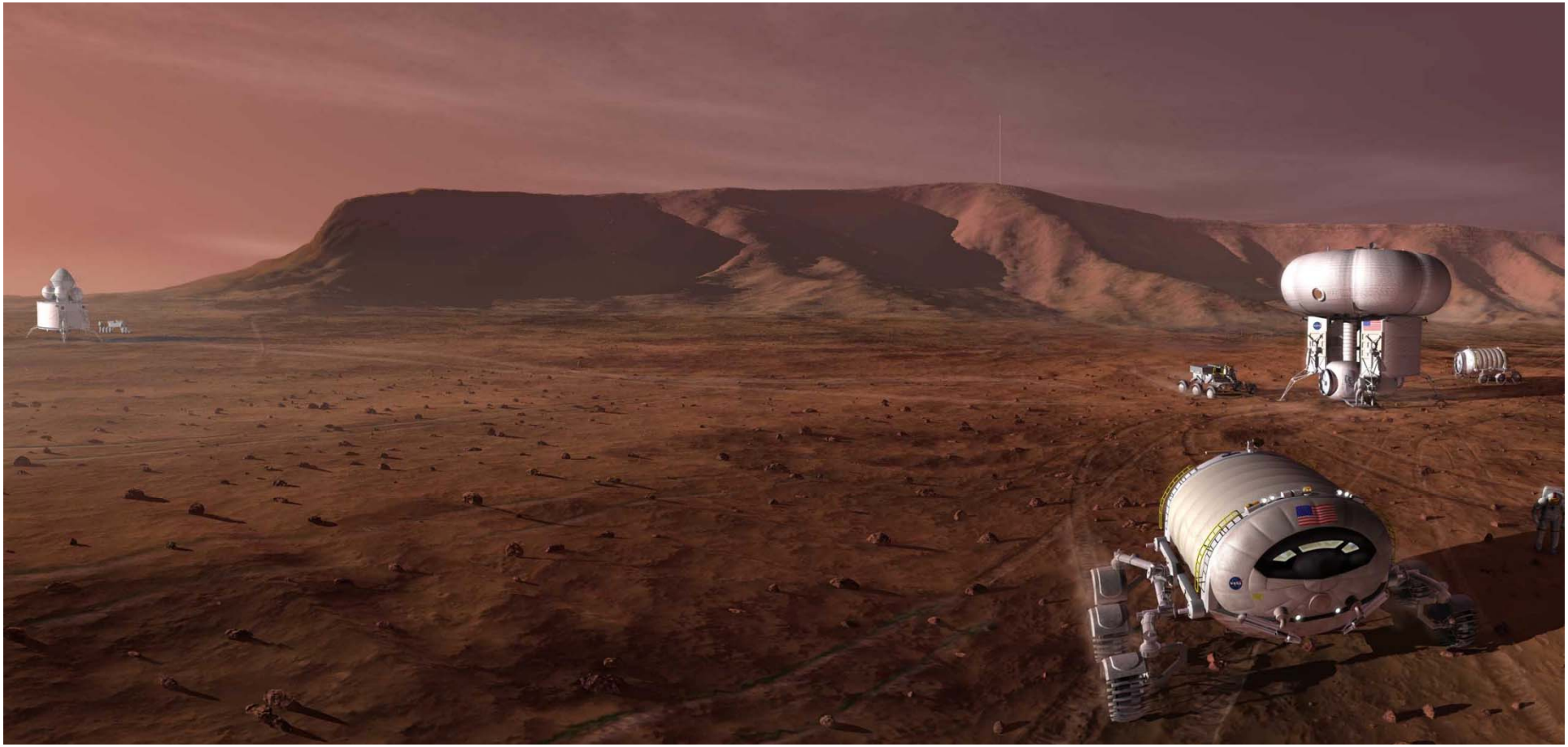

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Mars Challenges

Technology Focus for Staying Healthy

Life Support

- High reliability systems
- O_2 recovery and reducing logistics
- Water recovery loop closure
- Processing of solid waste to recover water
- Store nutritionally-adequate food for years

Space Suits

- Low mass suit and power pack
- Lower torso mobility
- Enhanced dexterity
- Compatible with Mars environment
- Increase information system capabilities
- In-situ suit repair

Microgravity Countermeasures

- Exercise equipment for muscle and cardiovascular atrophy, and bone loss
- Low-mass, rapid deploy, low-maintenance systems

Autonomous Medicine

- Advanced medical diagnosis, prognosis and treatment capabilities
- In-situ analysis of biomedical samples

Environmental Control

- In-flight analysis capabilities
- Rapid detection and mitigation of environmental hazards
- Detect contaminants introduced via surface activities
- Automated recovery
- Fire suppression

Mars Challenges

Technology Focus for Transportation

Access to Space

- Space Launch System heavy lift for large mass and volume
- Orion crew vehicle for crew delivery to and return from deep space

Chemical Propulsion

- O_2/Hydrocarbon (CH_4) propulsion for in-space, landing and ascent
- Integrated main and reaction control propulsion systems
- Ability to maintain cryogenic fluids for long durations

Advanced Propulsion

- Advanced capabilities to improve mass delivery and trip time
- Under investigation
  - Solar Electric
  - Advanced Chemical
  - Nuclear Thermal
  - Nuclear Electric

In-Situ Resource Utilization

- Production of O_2 from the atmosphere for Mars ascent
- Production of life-support consumables
- Construction of surface infrastructure from local resources

Entry, Descent, Landing & Ascent

- Hypersonic inflatable or deployable decelerators
- Supersonic retro-propulsion
- Precision landing
- Plume blast mitigation
- High-speed Earth re-entry
- Occupant protection

Mars Challenges

Technology Focus for Working in Space

Humans & Robots Working Together

- Human/machine coordination to improve productivity & reduce risk
- Robots performing routine tasks (inspection, logistics)
- Robotic Explorers (reconnoissance and risk reduction)

Autonomous Operations

- Independent, self-reliant crew can operate with up to 40 minute time delay
- Highly automated vehicle operable by minimal crew
- MCC automation (strategic/analysis role)
- Automated rendezvous & docking

In-Flight Maintenance

- Component-based design for maintainability & reliability
- Vehicle-wide diagnostics, prognostics & recovery
- In-space repair & manufacturing

Exploration Mobility

- Routine surface exploration
- Maximize time spent and distance traveled
- Minimize "time to get out the door"
- Environmental protection including dust abatement

Power Generation

- Production of high, continuous, latitude independent power for crew operations
- Mobile power systems for robust exploration