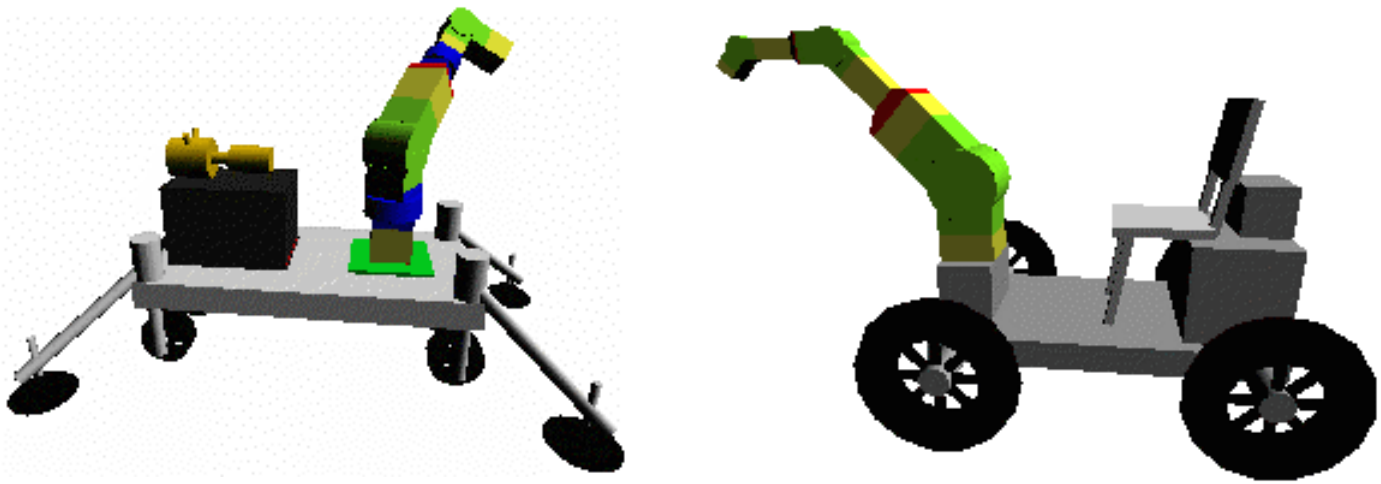
Nebraska
UNIVERSITY OF NEBRASKA-LINCOLN

A Robotic Infrastructure for Space Exploration



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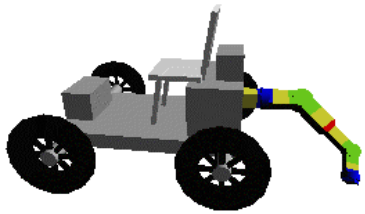
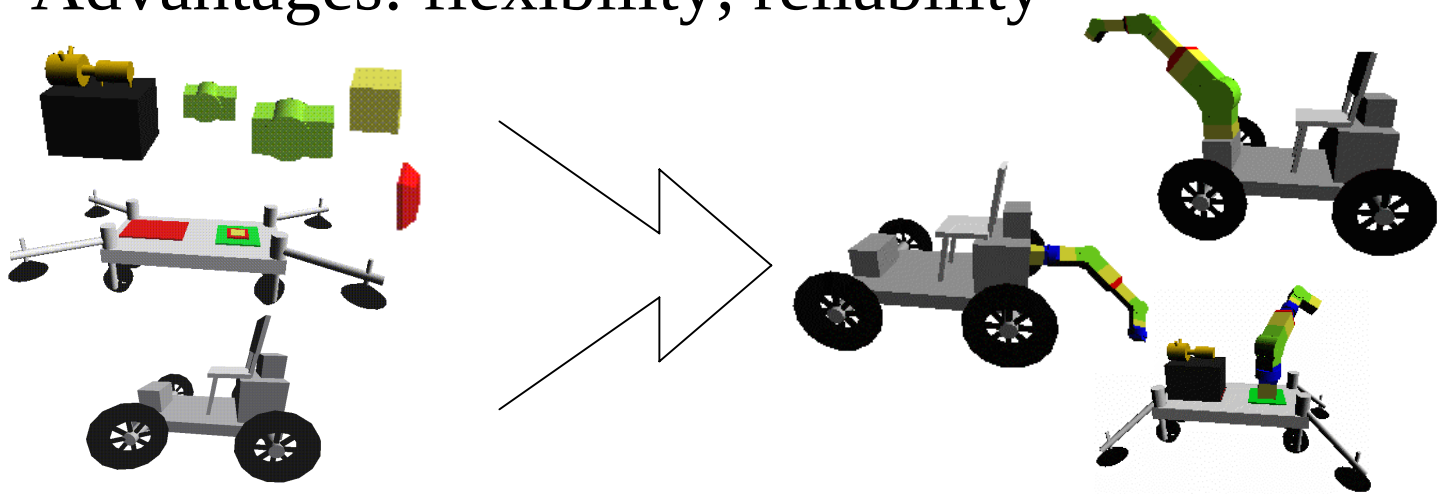
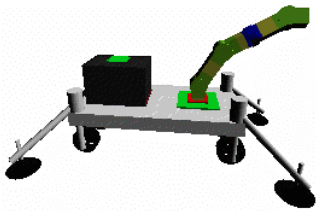


A Robotic Infrastructure

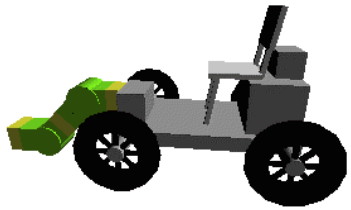
- Robotic modules that can be assembled to create a variety of robots for various tasks
  - Joints, connecting links, end-effectors, power supplies, sensors, science instruments
- Advantages: flexibility, reliability





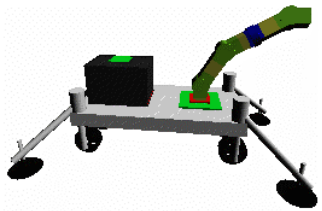
Phase 1 Objectives

- Perform many tasks with limited resources
- Demonstrate:
  - Usefulness of the approach
  - Feasibility of the approach
- Using simulation and animation



Mission Objectives

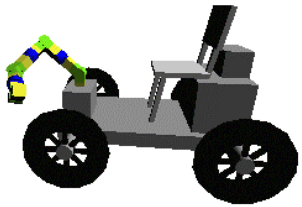
- Mission scenarios
  - “Robots will be used extensively to reduce astronaut EVA time”
- Mars
  - Human precursor mission
  - Human exploration
  - Robot colonies
- Lunar / small bodies (asteroids)



Tasks

- Deploy nuclear power supply
- Deploy science instruments
- Autonomous exploration
- Support human exploration
- Regolith manipulation

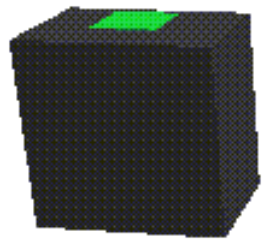
- Tele-operated – autonomous – direct operation



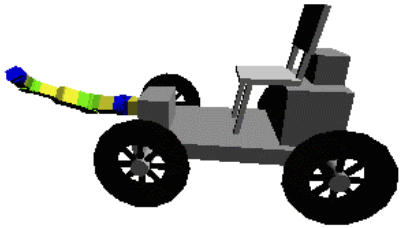
Inventory Design

- Create robots that can accomplish the most tasks using the least modules
- Inventory includes:
  - Power modules
  - Base modules
  - Joints
  - Kinematic links
  - End-effectors
  - Sensors

Power Modules

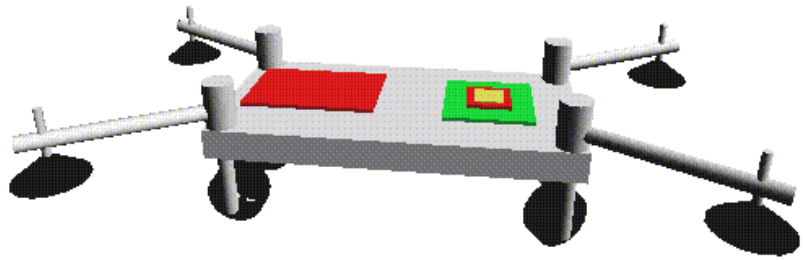


- IC engine
  - Methane/O_2
  - Electrical generator
  - High energy
- Small battery
- Large battery

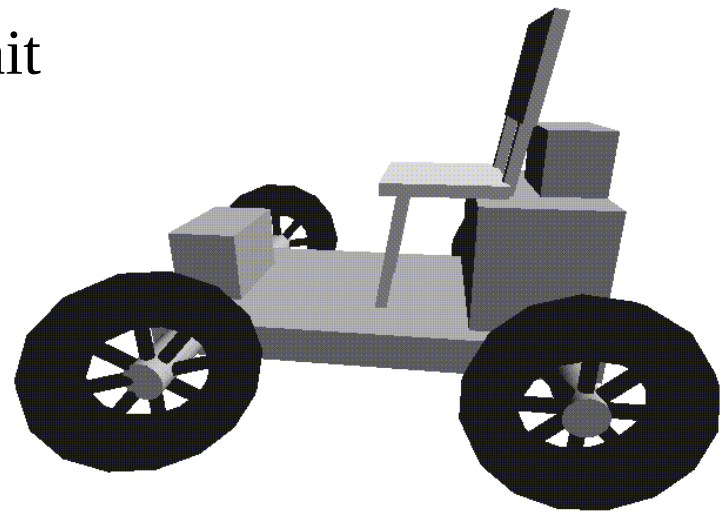


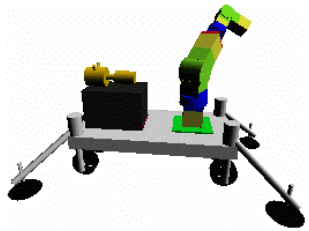
Base Modules

- Mobile platform
  - Standardized interface
    - 3 sizes (10,15,30cm)
  - Out-rigger support
  - Power supply interface

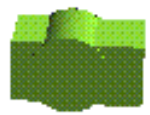
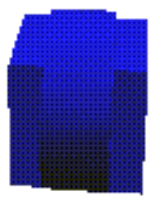
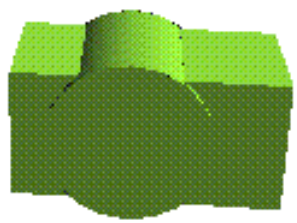


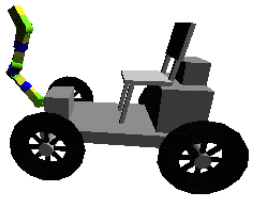
- Un-pressurized Mobility Unit
  - Front & Rear Interfaces
  - Transport 1 astronaut
  - Operate Autonomously/Tele-operated/Directly Driven





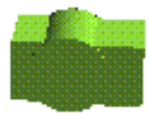
Joints

	Axial joints	Rotary joints
10 cm		
15 cm		
30 cm		

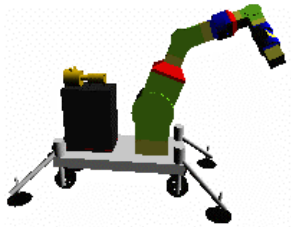


Module Specifications

15 cm (interface)



- Joint stall torque = 150 n-m
- Maximum velocity = 140 degrees/s
- Mass = 8 kg
- Joint limits = +/- 230 degrees



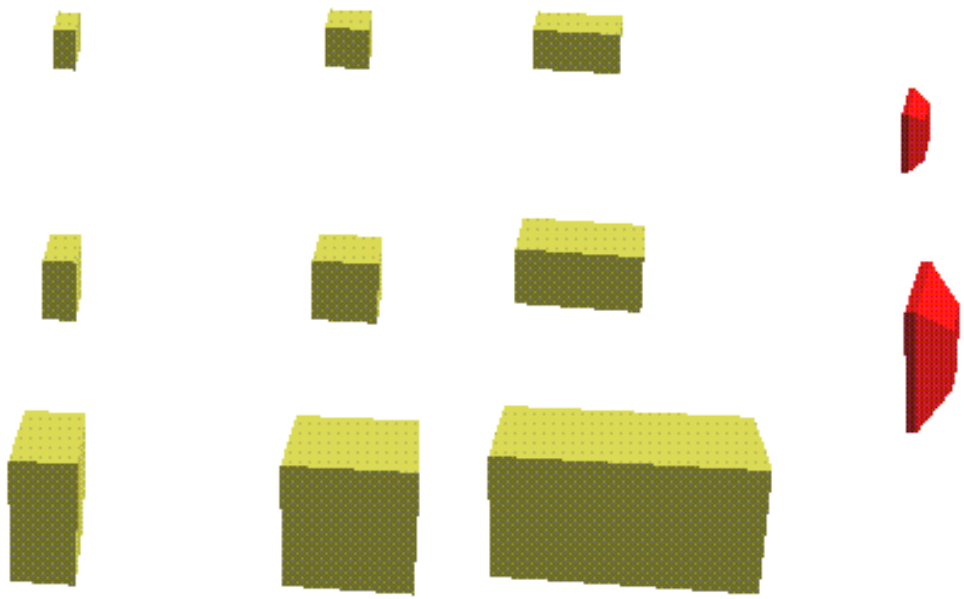
Links

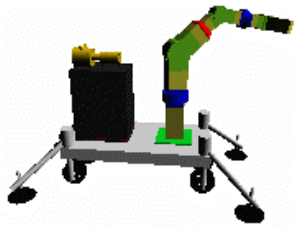
Length

10 cm

15 cm

30 cm

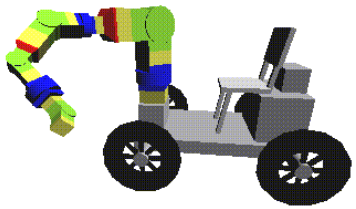




End-effectors / Sensors

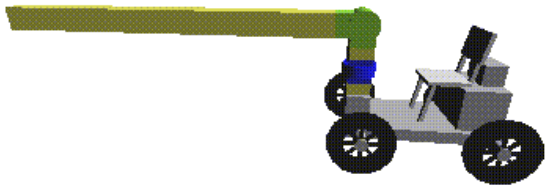
- Grippers
  - 10 cm
  - 15 cm
- Plow, blade, back hoe
- Science instruments

- Sensors for tele-, autonomous, driven operation

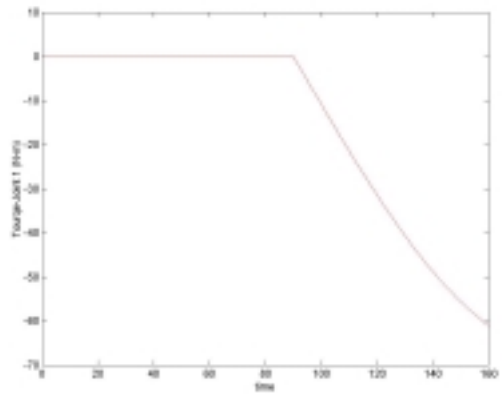


Simulation

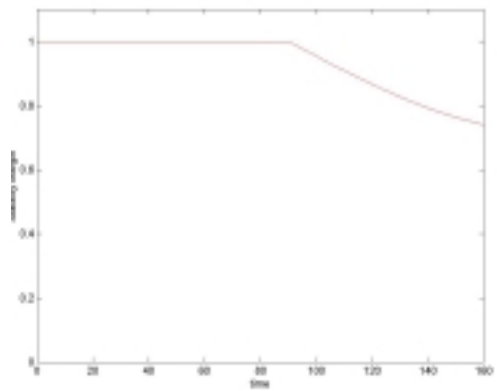
- Detailed physical simulation
- Adaptable to many assemblies
- Quasi-static approach
  - Power consumption, actuator saturation, stability, joint limits, workspace limits



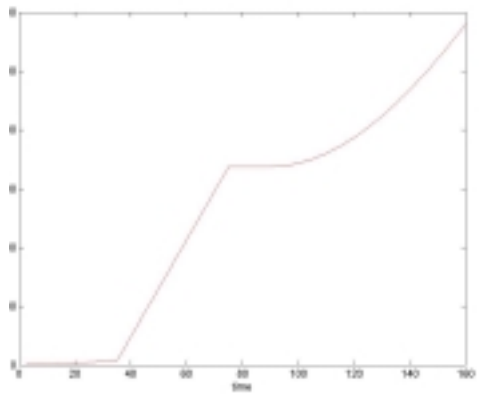
Simulation



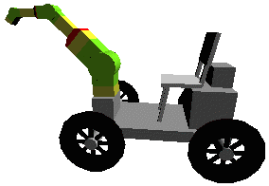
Joint 1 Torque



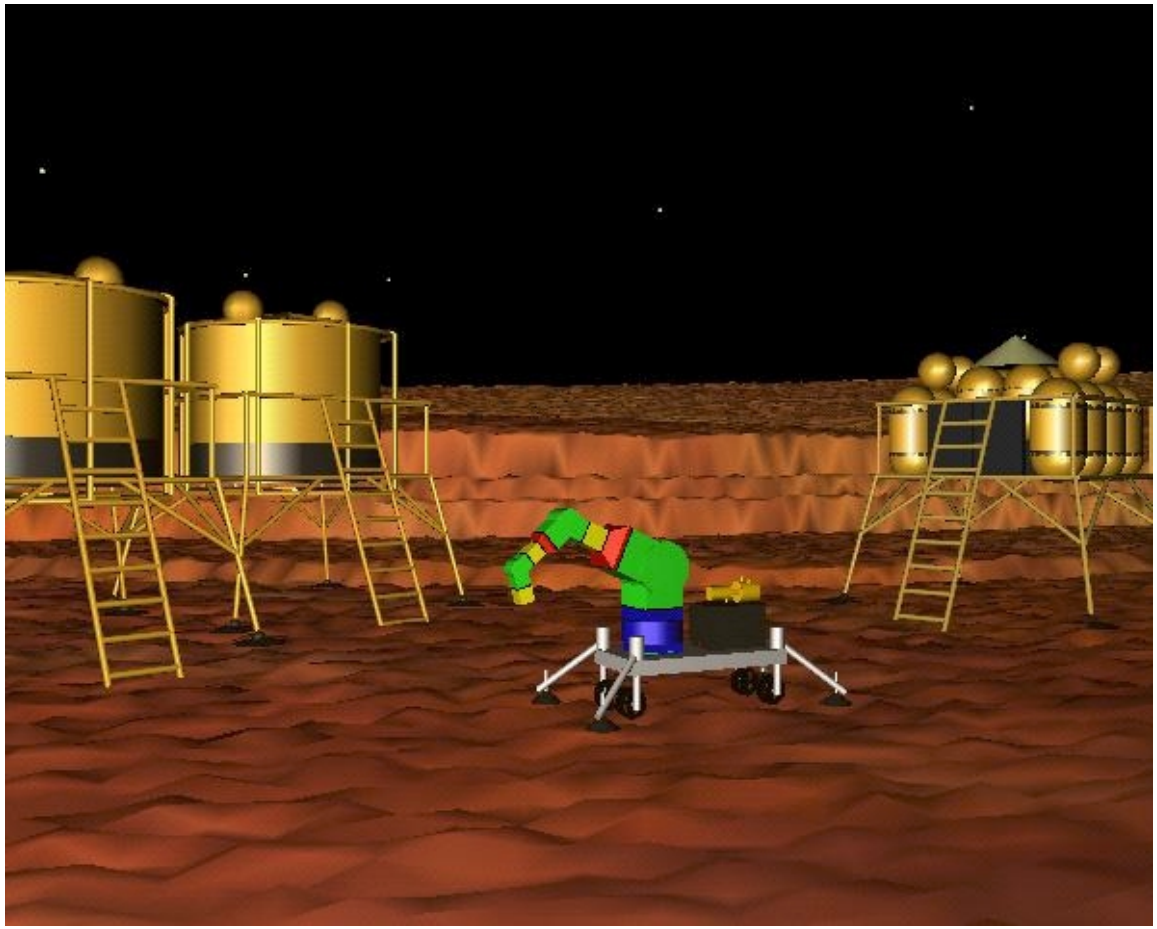
Stability Margin



Energy

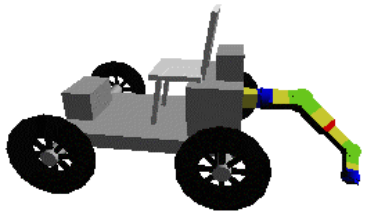


Animation



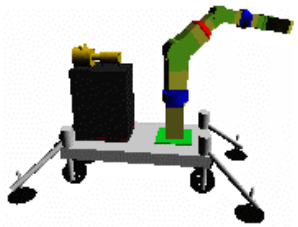
Completing Phase I

- Increase the diversity of the inventory
  - End-effectors
- Demonstrate tasks:
  - Deploy nuclear power supply
  - Various assemblies accomplishing various tasks
  - Create solar flare bunker (bury a habitat)
- Propagate results



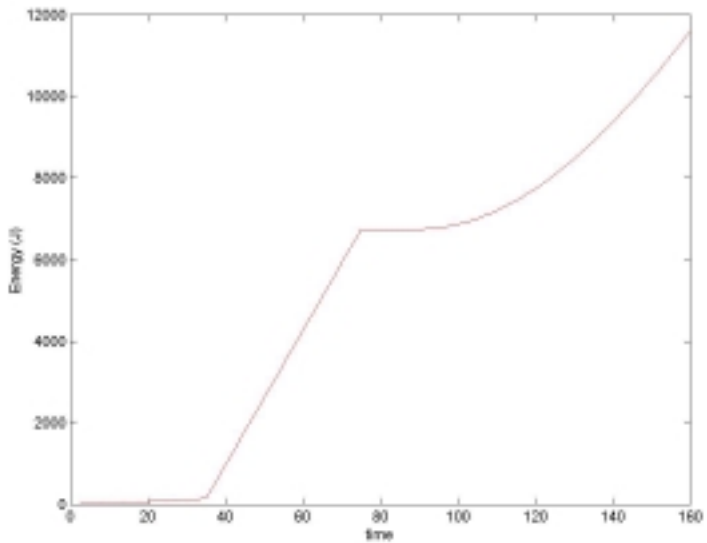
Future Work

- Demonstrate the “robot colony” approach
- Demonstrate self-assembly
- Study interface issues



Energy Consumption

- Assume actuators are dominate power consumption elements
- Quasi-static analysis



$$\bar{\tau} = \bar{J}^{T} \bar{F}$$

$$\tau_i = k_t i_{motor}$$

$$P = V i_{motor}$$

$$E = P \Delta t$$