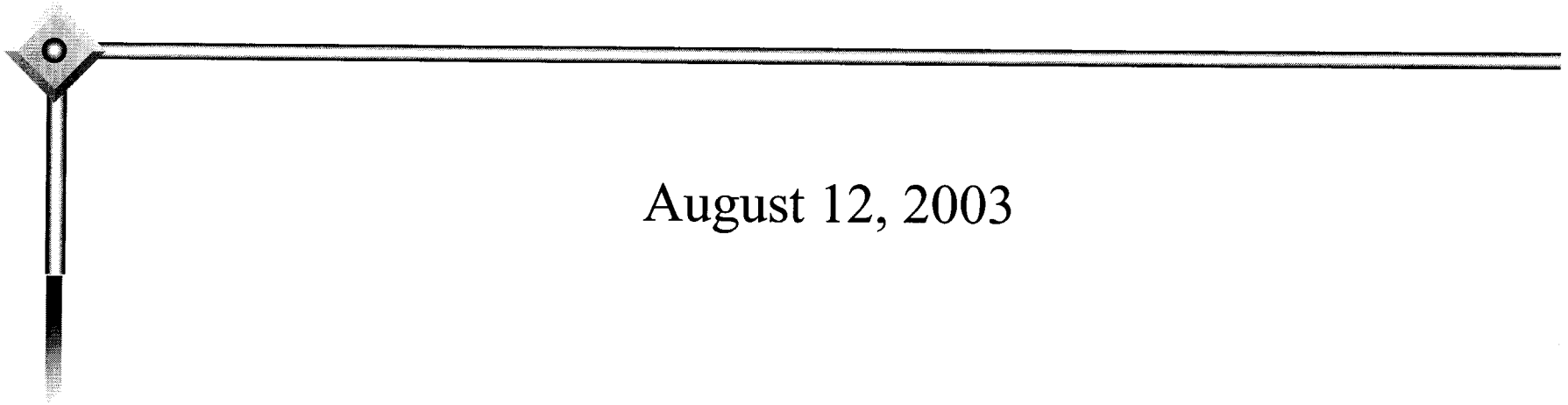
JPL / UCLA Meeting on Sensor Networks



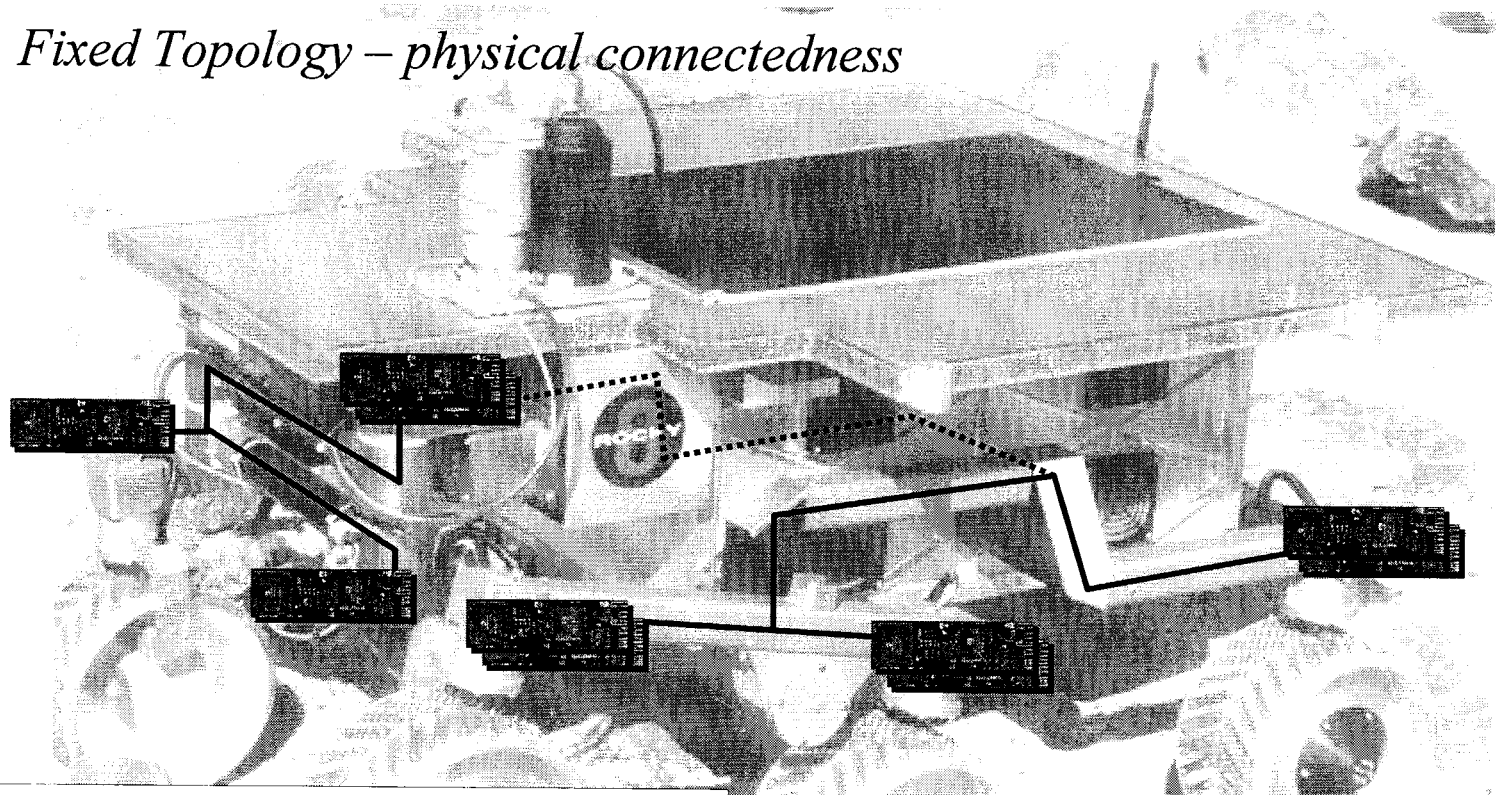
August 12, 2003

Projects Using Distributed Computing

- Fixed topology - physically connectedness
  - I2C-based control using widget boards (e.g. Rocky 8)
  - Ethernet/FireWire FPGA-based computing and control (e.g. future rovers)
- Changing topology – wireless connectedness (Axel Concept)
  - Mobile units
  - Reconfigurable robots
  - Fault detection and recovery
- CLARAty
  - Reusable robotic software on heterogeneous platforms

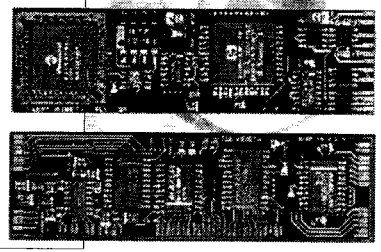
Distributed Control for Rocky 8

Fixed Topology – physical connectedness



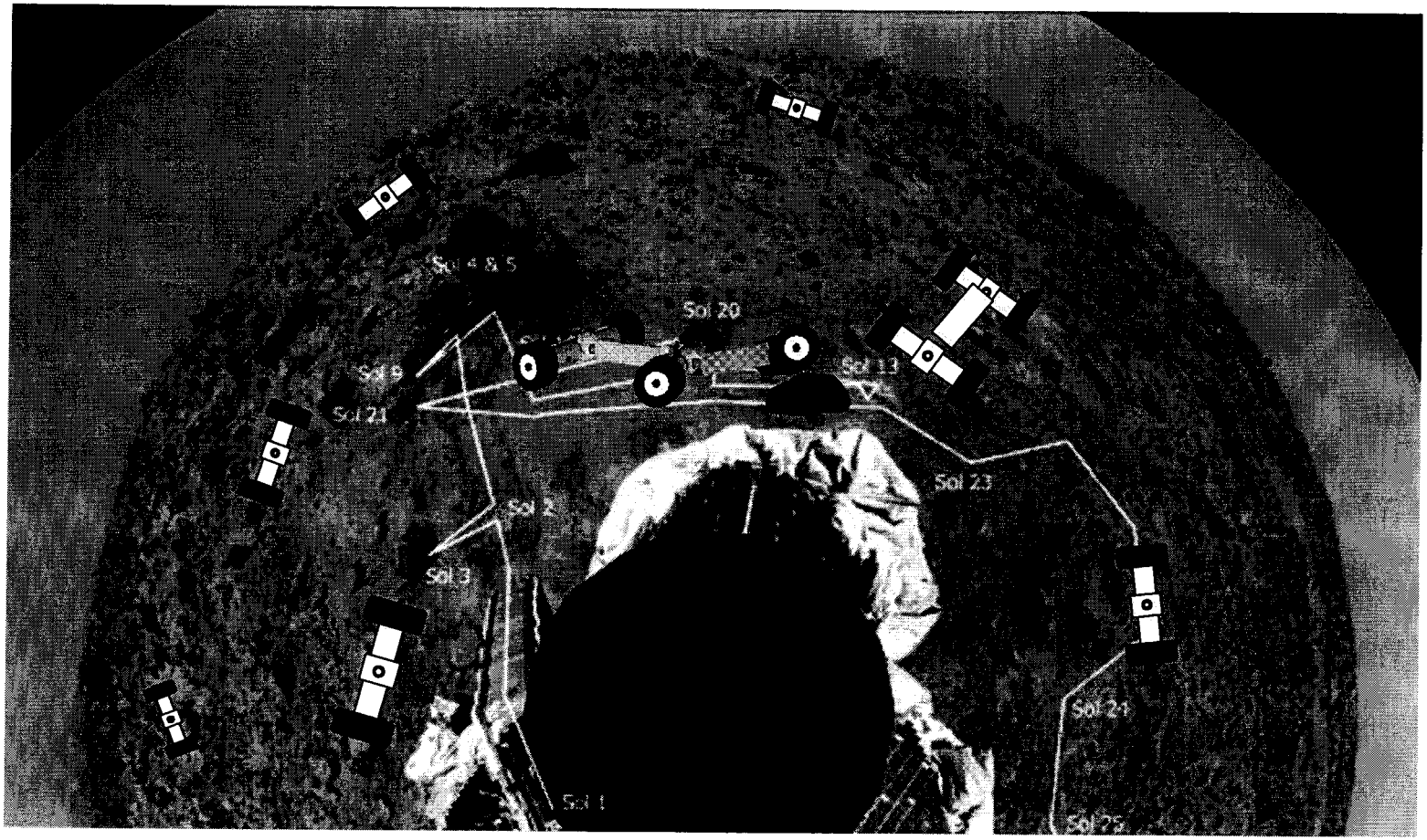
Widget Board

- 16 MHz 16xx PIC processor
- Single-axis motion controller (HCTL 1100)
- On-board analog filter
- 10 digital I/O lines
- 8 (12-bit) single-ended analog-to-digital
- 8 (8-bit) digital-to-analog conversion



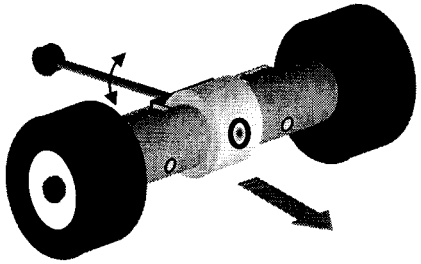
Distributed Robotic Exploration Concept

Changing Topolgy - wireless connectivity

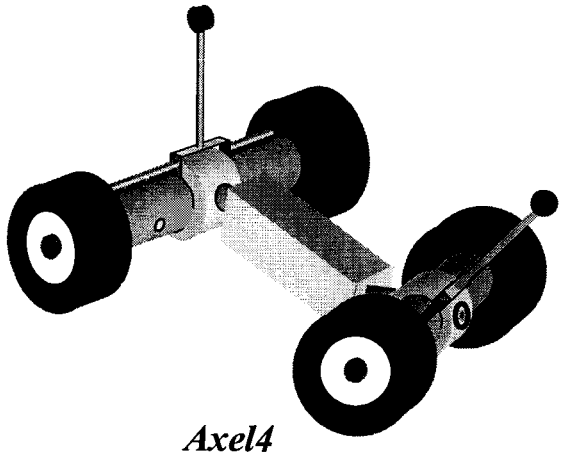


Distributed Robotic Exploration Concept

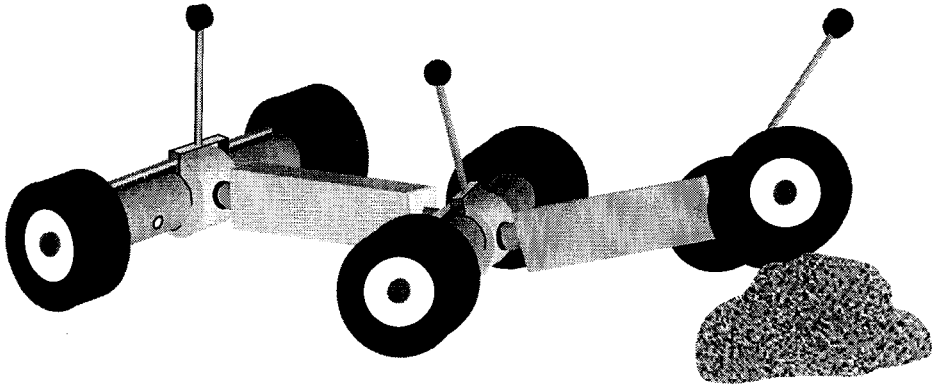
Axel Concept - Wireless Connectivity



Axel2



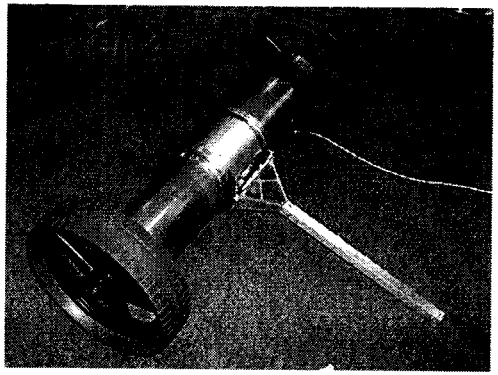
Axel4

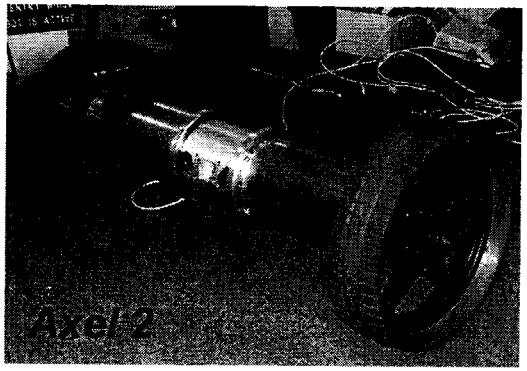


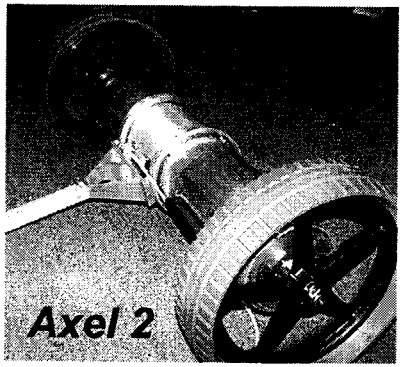
Axel6

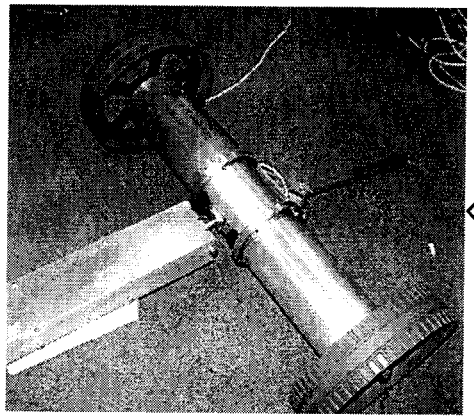
Distributed Robotic Exploration Concept

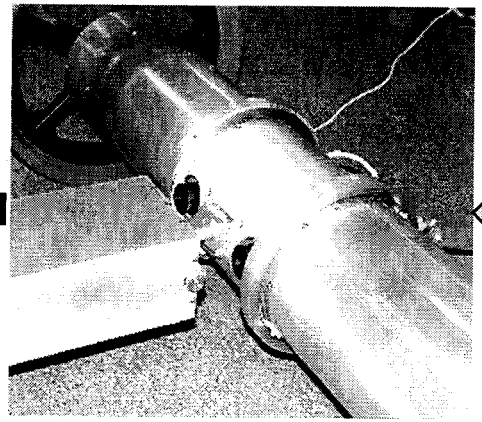
Axel Concept - Wireless Connectivity

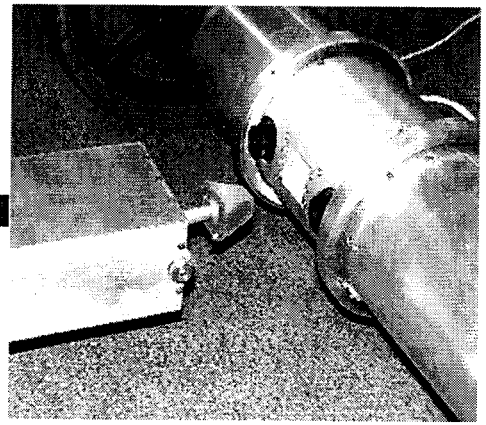








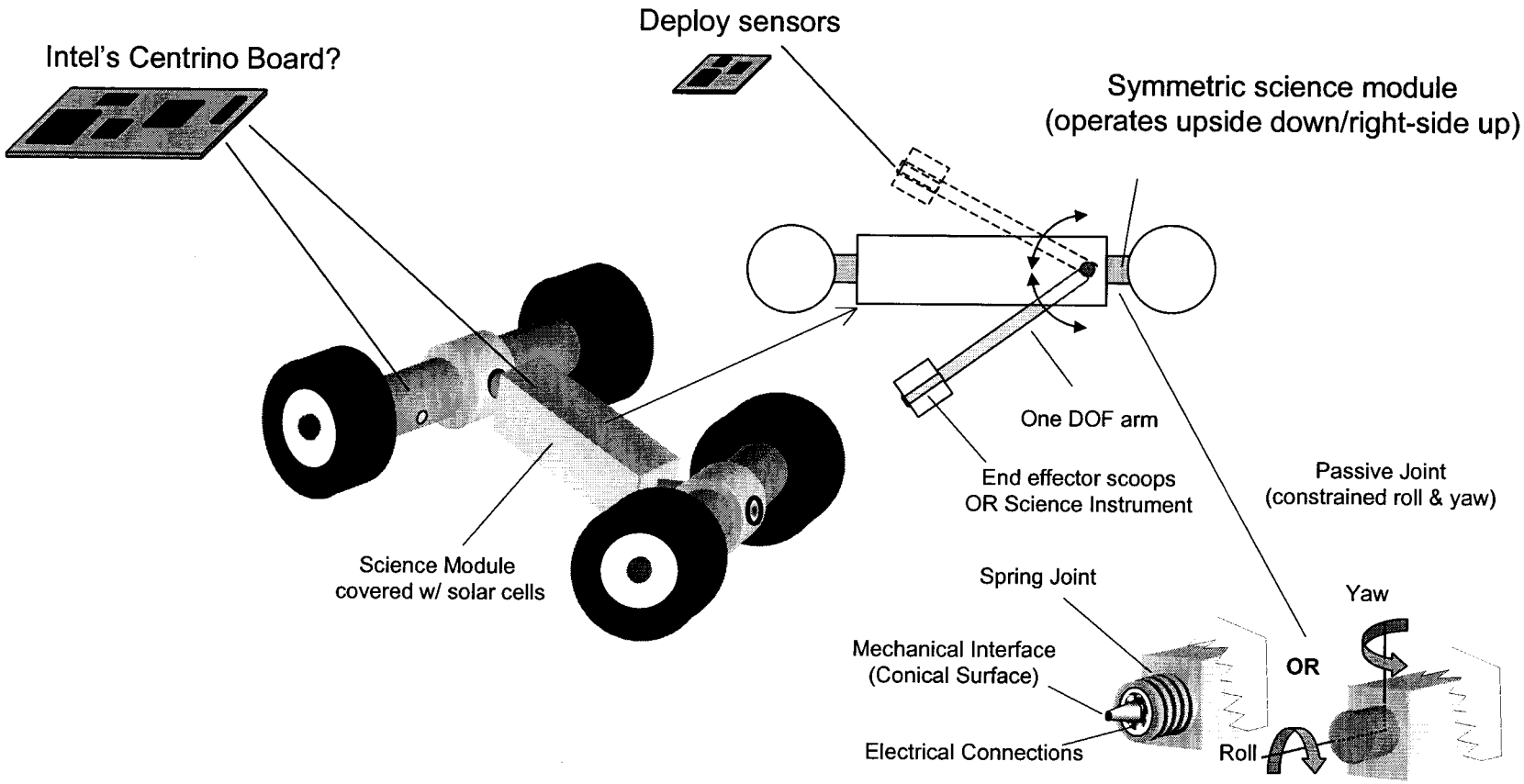




Docking

Distributed Robotic Exploration Concept

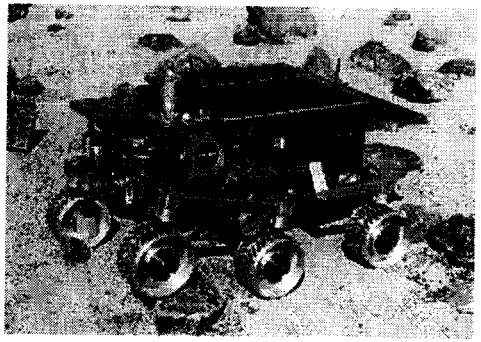
Axel Details

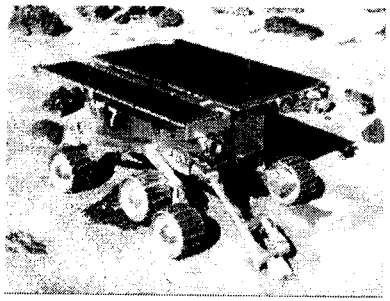


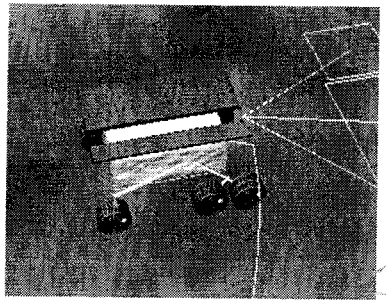
Distributed Robotic Exploration Concept

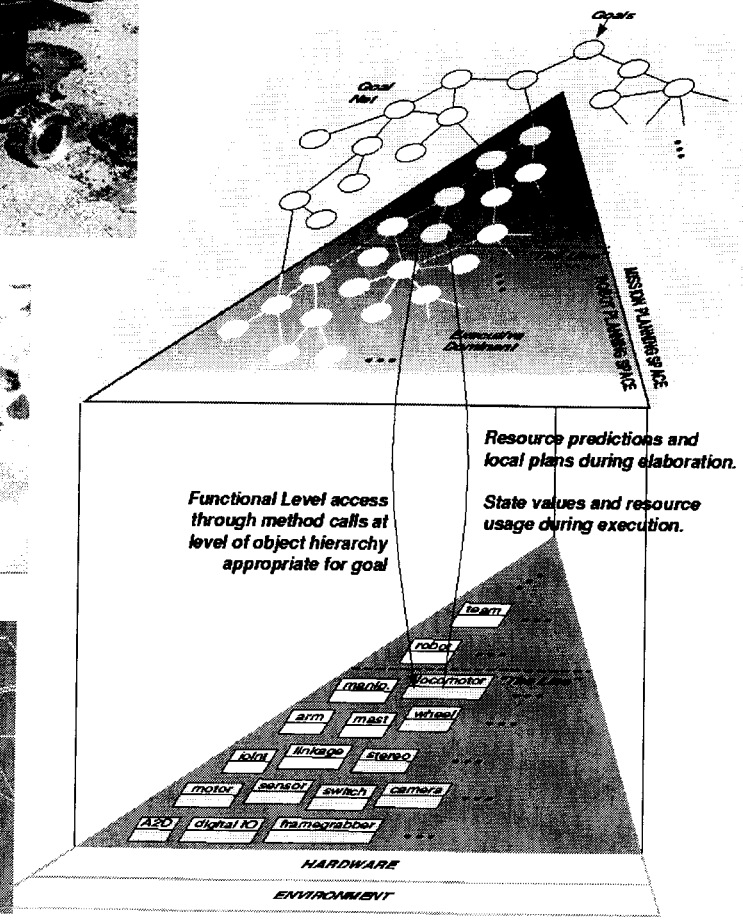
- Joint proposal on Axel submitted to Mars Exploration Program
  - JPL (organizer and previous lead)
  - University of Minnesota (lead - Prof. Nikos Papanikolopolous)
  - Intel (Jim Bulter, Myron Hattig)
  - Purdue University (lead – Prof. Ray Cipra)
  - Arkansas Tech University (Prof Murray Clark)
- Proposal includes:
  - Continuation of feasibility studies on Axel concept
  - Development of several prototypes at various universities
  - *Use Intel's Centrino boards*

CLARAty – Reusable Robotic Software

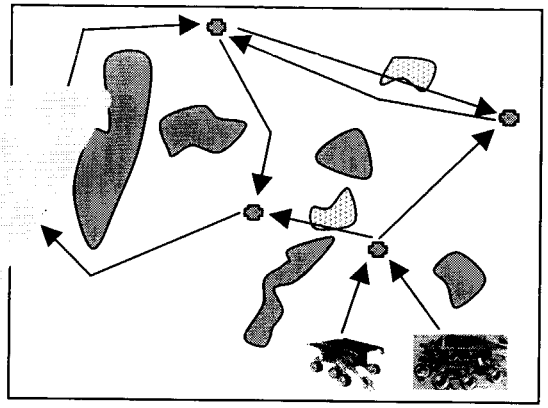




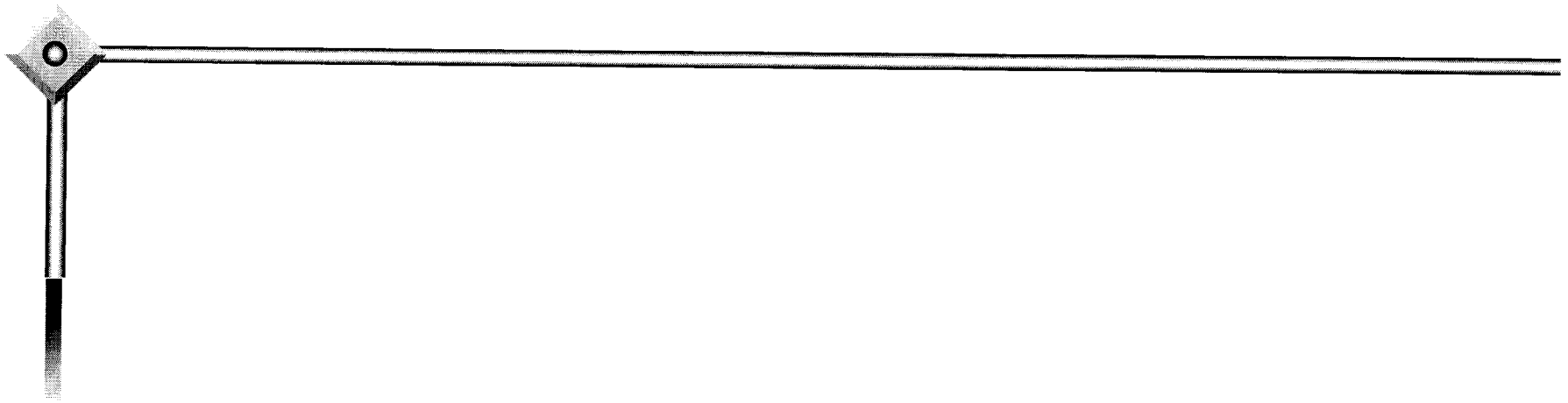




DYNAMIC REPLANNING



Backup Slides



Intel's Initiative

- Intel is leading an open source robotic initiative under the Proactive Computing program focusing on the following areas:
  - Standardization of robotic software - RETF (robotic engineering task force)
  - Distributed sensor networks using mobile robots to support them
  - Development of common computing robotic hardware
    - Low power, small footprint Stayton board – uses 400 MHz XScale processor, flash, and runs Linux
    - Phase 2 – developing next generation Centrino board/processor which adds floating point support

JPL / Intel Interaction

- Several email exchanges and telecon with Intel and JPL:
  - *Center for Integrated Space Microsystems* (L. Alkalai)
  - *Mars Technology Program* office (R. Volpe)
  - CLARAty (JPL's robotic software for research) (I. Nesnas)
- CLARAty task manager attended the second Annual Robotic Workshop at Intel held in Portland Oregon – January 2003
- CLARAty/JPL hosted Intel for ½ a day of discussions with participation of robotic managers to explore future collaborations with the Intel open source initiative
  - Intel and JPL exchanged presentations on current robotic initiatives related to common robotic hardware and software
  - Intel is participating and sponsoring universities in the DARPA Grand Challenge (JPL not participating)
- CLARAty was invited to a special session initially organized by Intel and later by USC on robotic standardizations at the IROS conference.

Possible Areas of Collaboration JPL/Intel

- CLARAty interested in working with Intel and UCLA in defining specifications for standard robotic hardware (flexible, modular, distributed) and software
  - Low power, computational capable and low-cost motion control hardware boards that can be made available to JPL, its university partners, and the extended robotic community
  - Low-power sensor hardware boards with standard hardware/software interfaces.
- CLARAty interested in standardizing and adapting its software architecture to flexible, modular, and distributed robotic hardware components
- CLARAty with additional support can provide the Intel hardware via the CLARAty testbed which will be accessible to a number of developers within its community (JPL, ARC, CMU, and U. Minnesota)