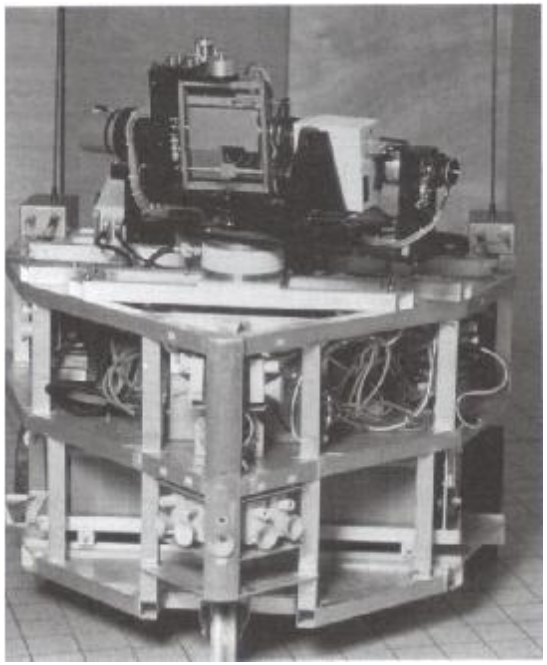
Robotics, Automation, and The Future of Transportation

Rodney Brooks
Rethink Robotics

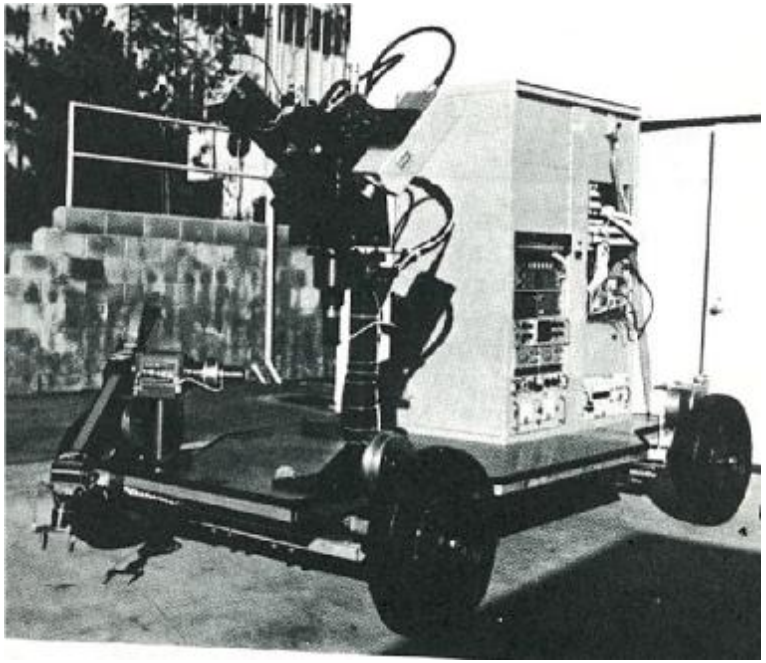
Three Stories

- SLAM **à** self driving cars
- Insect-based intelligence **à** Roomba + Packbot
- Humanoid Robots **à** Collaborative factory robots

The world's mobile robots in 1977



LAAS, Toulouse



JPL, Pasadena

SAIL, Palo Alto

Hans Moravec, Stanford AI Lab: Invent/Implement Everything

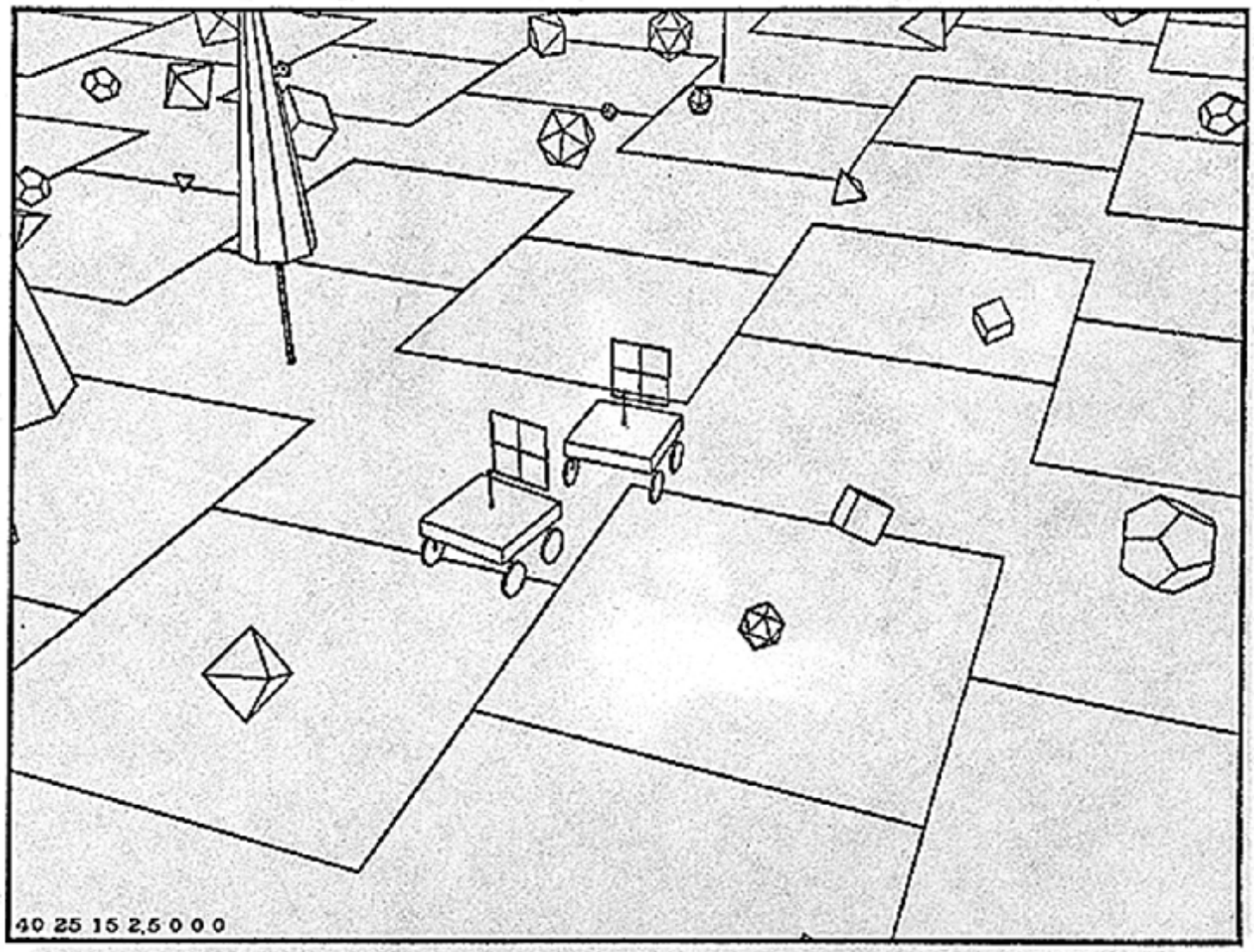
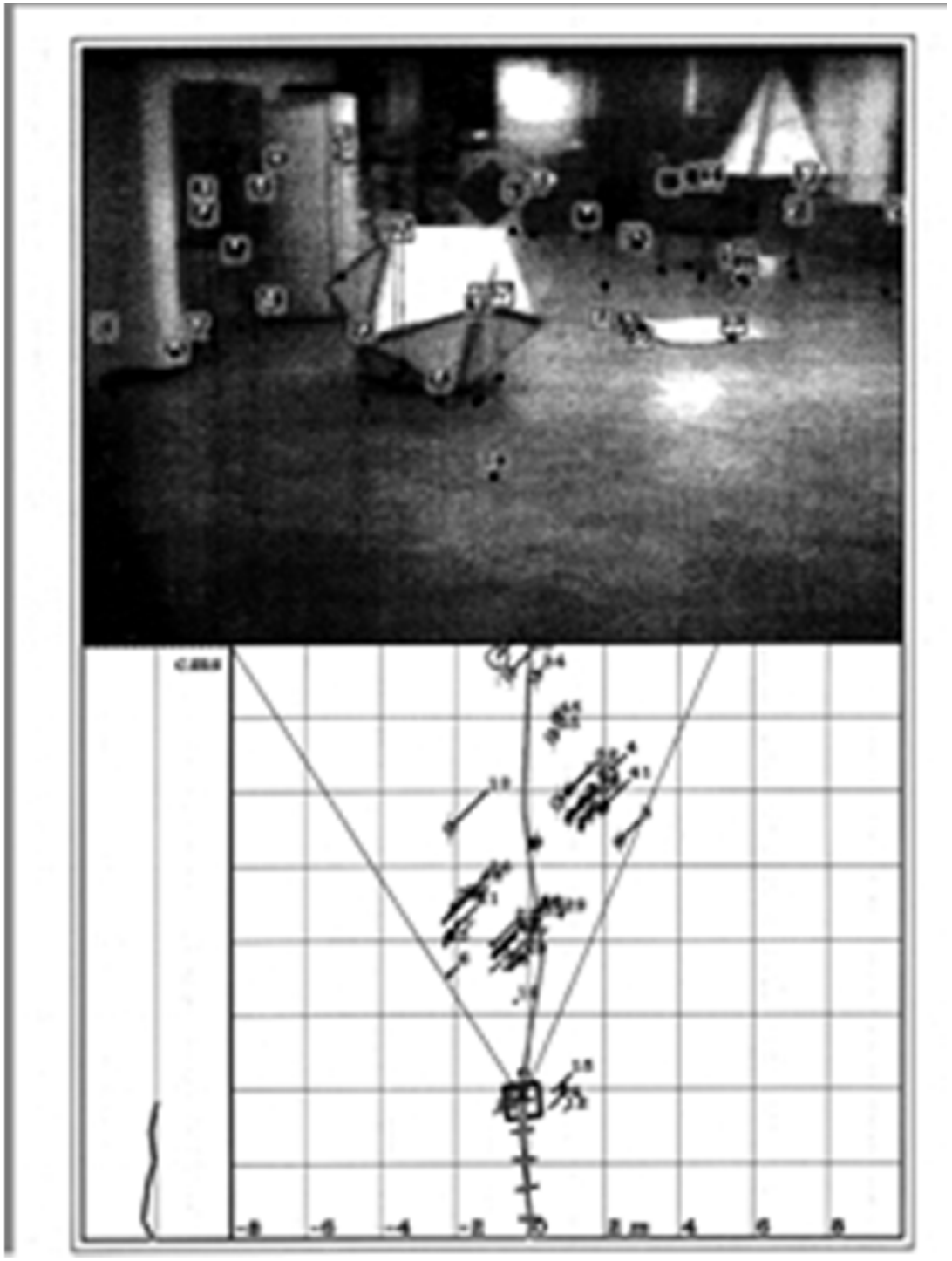
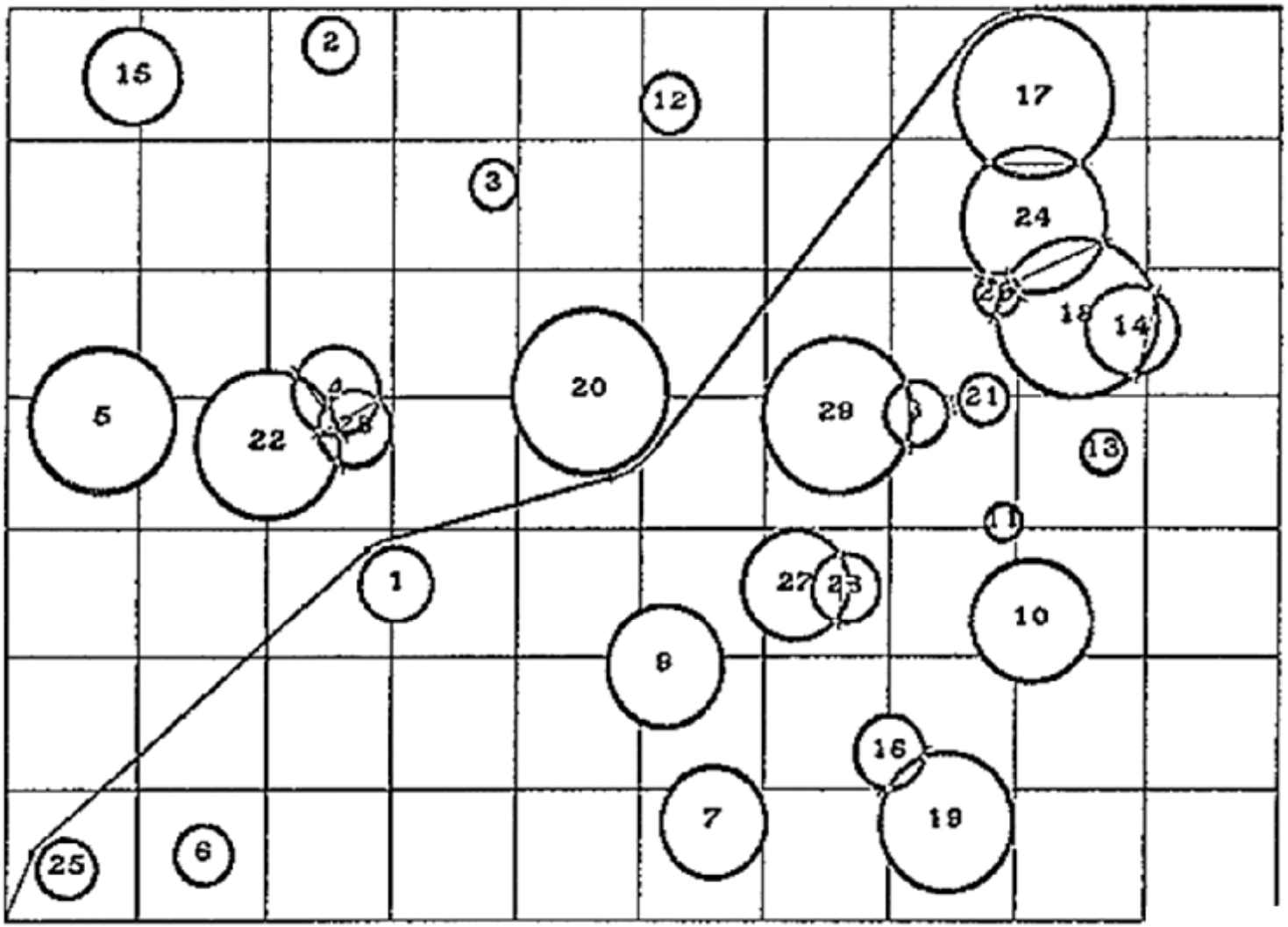


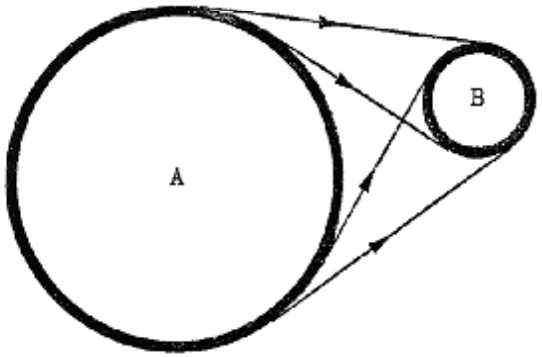
Image pyramids, stereo vision, build maps, navigate, simultaneously.

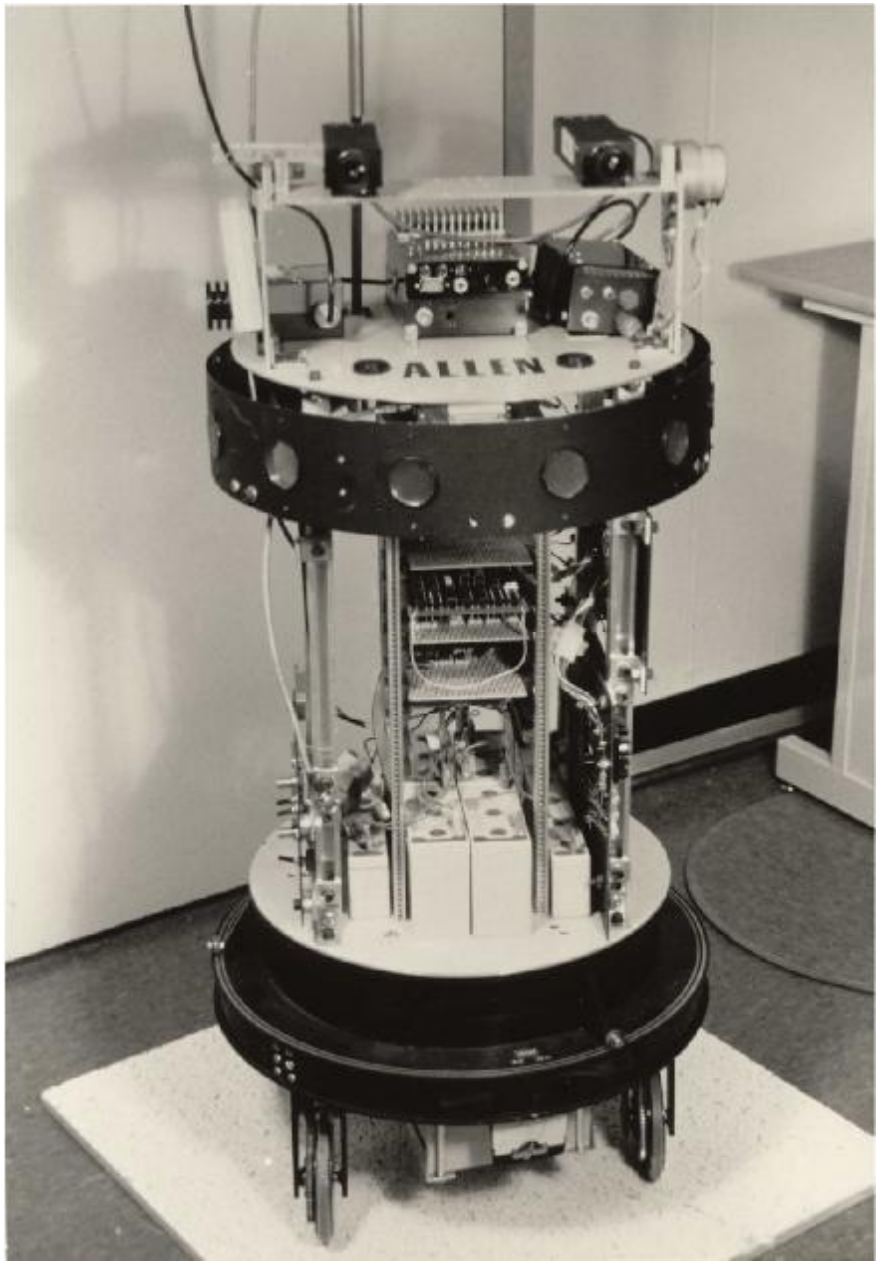
(And digital radio link, rendering images, overlay graphics, etc.)





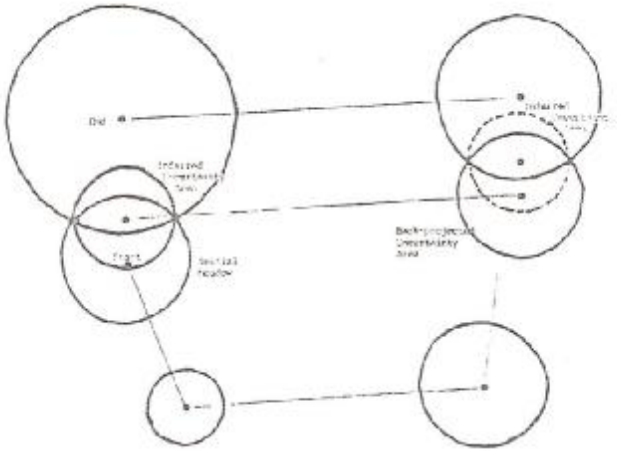
Path Planning





Rodney A. Brooks, *Visual Map Making for a Mobile Robot,* IEEE ICRA, St. Louis, MO, March 1985, pp 824—829.

Raja Chatila and Jean-Paul Laumond, *Position Referencing and Consistent World Modeling for Mobile Robots,* IEEE ICRA, St. Louis, MO, March 1985, pp 138—145.

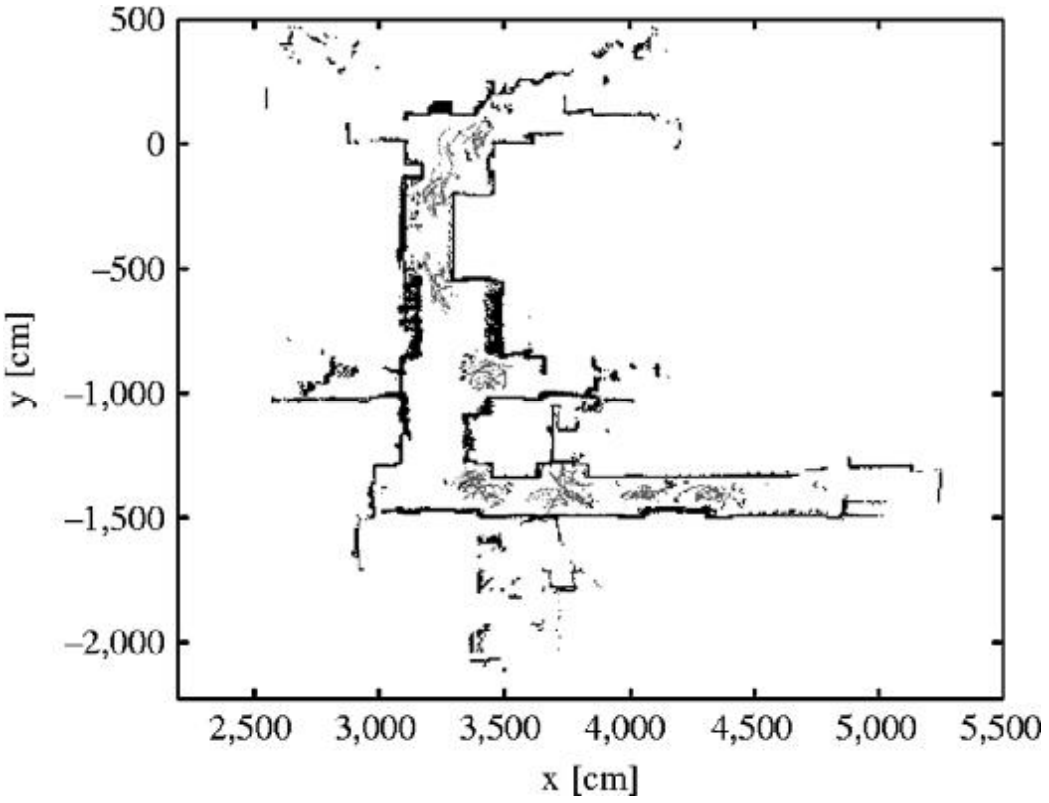



MOBILE ROBOTS


MIT


ATRV-JR
iRobot

Simultaneous Localization and Mapping (SLAM)



Hardware availability leads to crowds of researchers, leads to well defined problems & solutions.


03
Powered by
RedBull
MDV
android
MDV


79
MIT


Google
self-driving car


S MB 1091

The Evolution of SLAM/Self Driving

- Early:
  - DARPA, NASA, ONR
- Middle:
  - DARPA, NSF, NASA
- Later:
  - Private companies, other governments

How do`drivers' interface with robotic cars?

How do robotic cars interface with outside ppl?

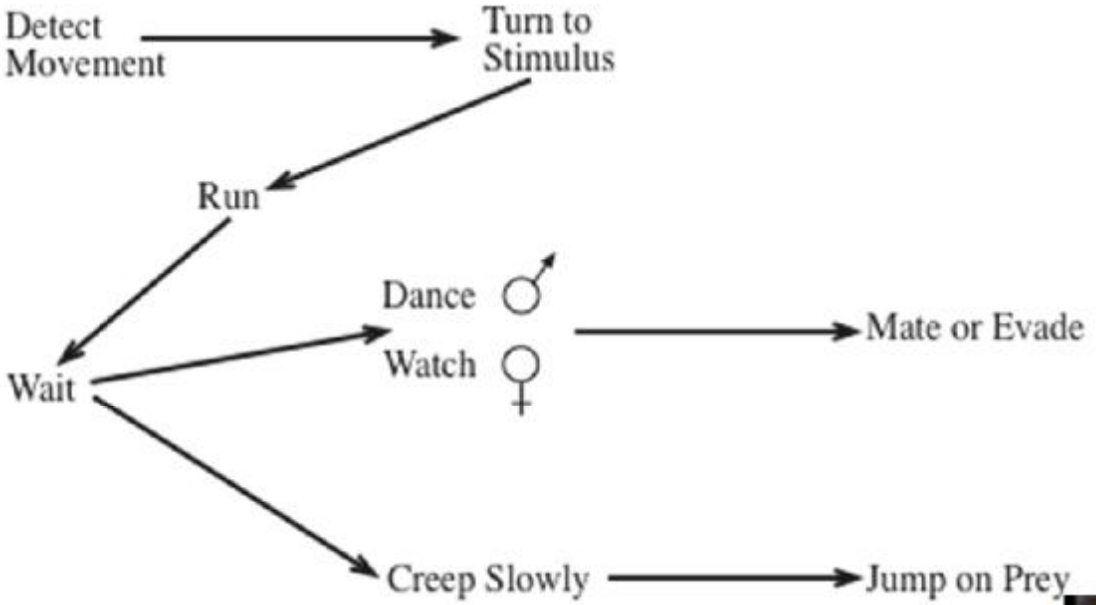
What do you do when…?

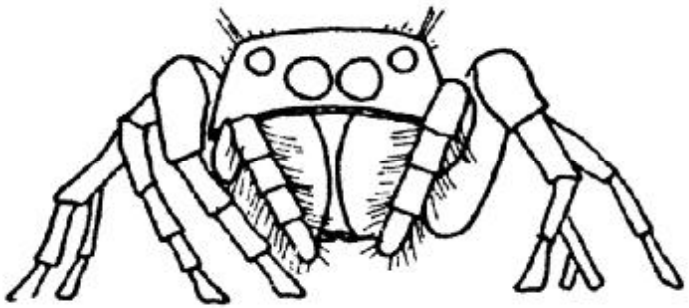
Adoption:

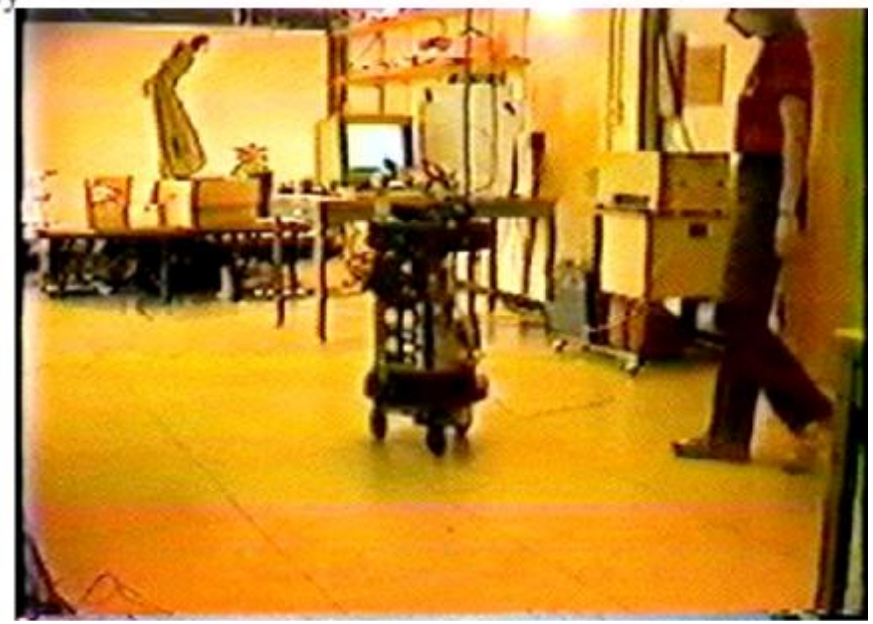
Complex interplay
of social and irrational,
with better UI

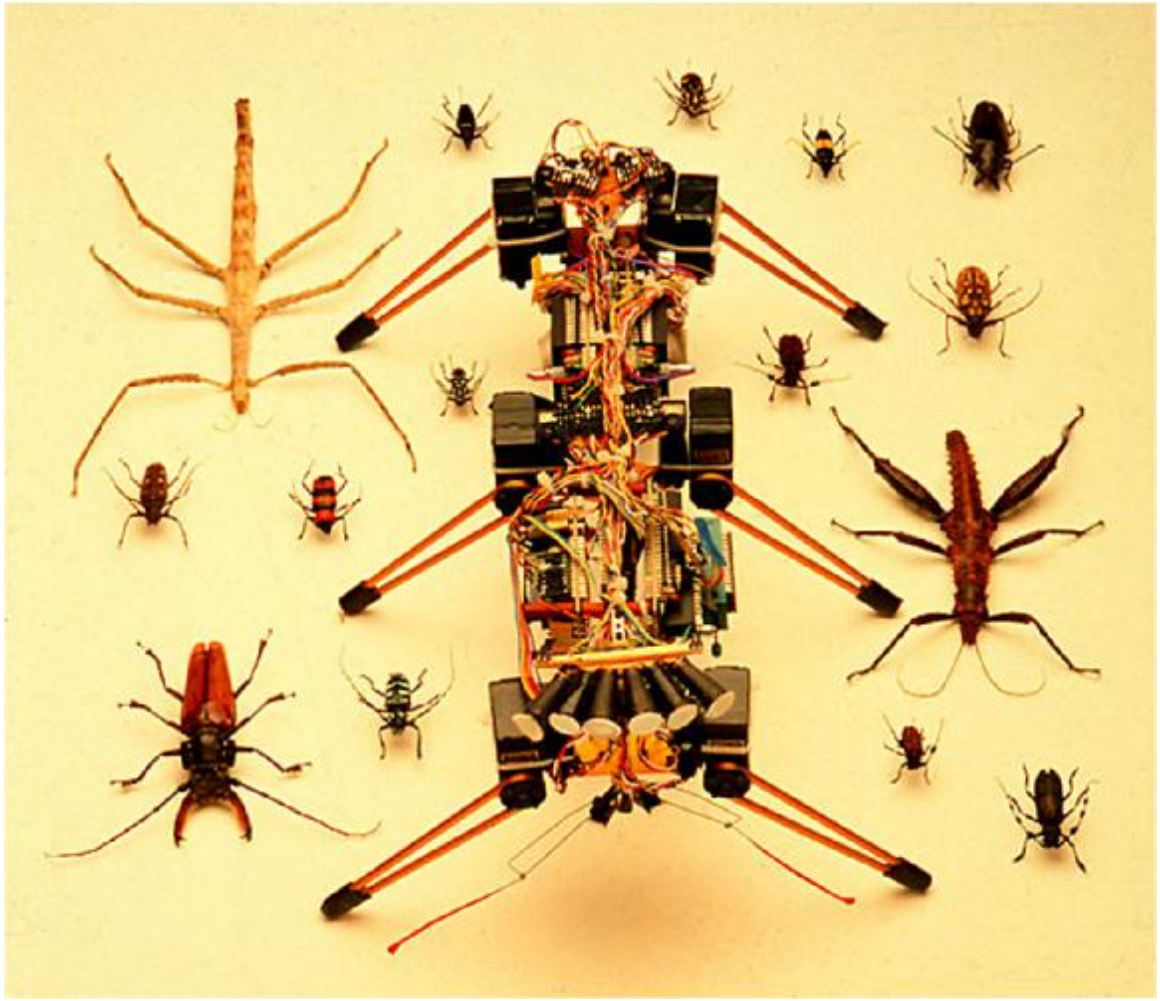
Behavior Based Robotics

Inspired by Insects, Spiders, & Birds









JBIS journal of the british interplanetary society

SMALL MISSION SYSTEMS

Vol. 42 No. 10 OCTOBER 1989

Journal of The British Interplanetary Society, Vol. 42, pp 478-485, 1989

FAST, CHEAP AND OUT OF CONTROL: A ROBOT INVASION OF THE SOLAR SYSTEM

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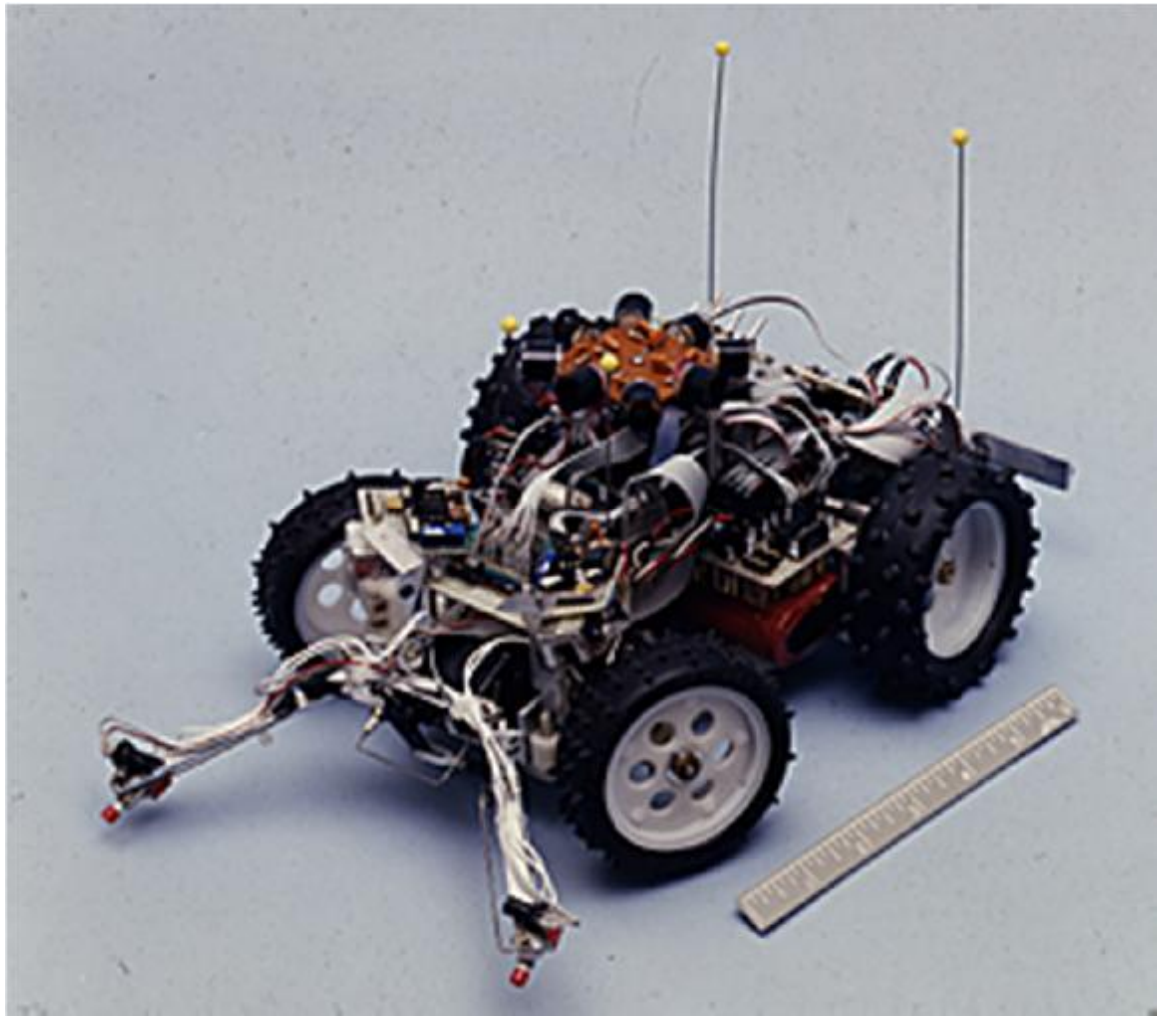
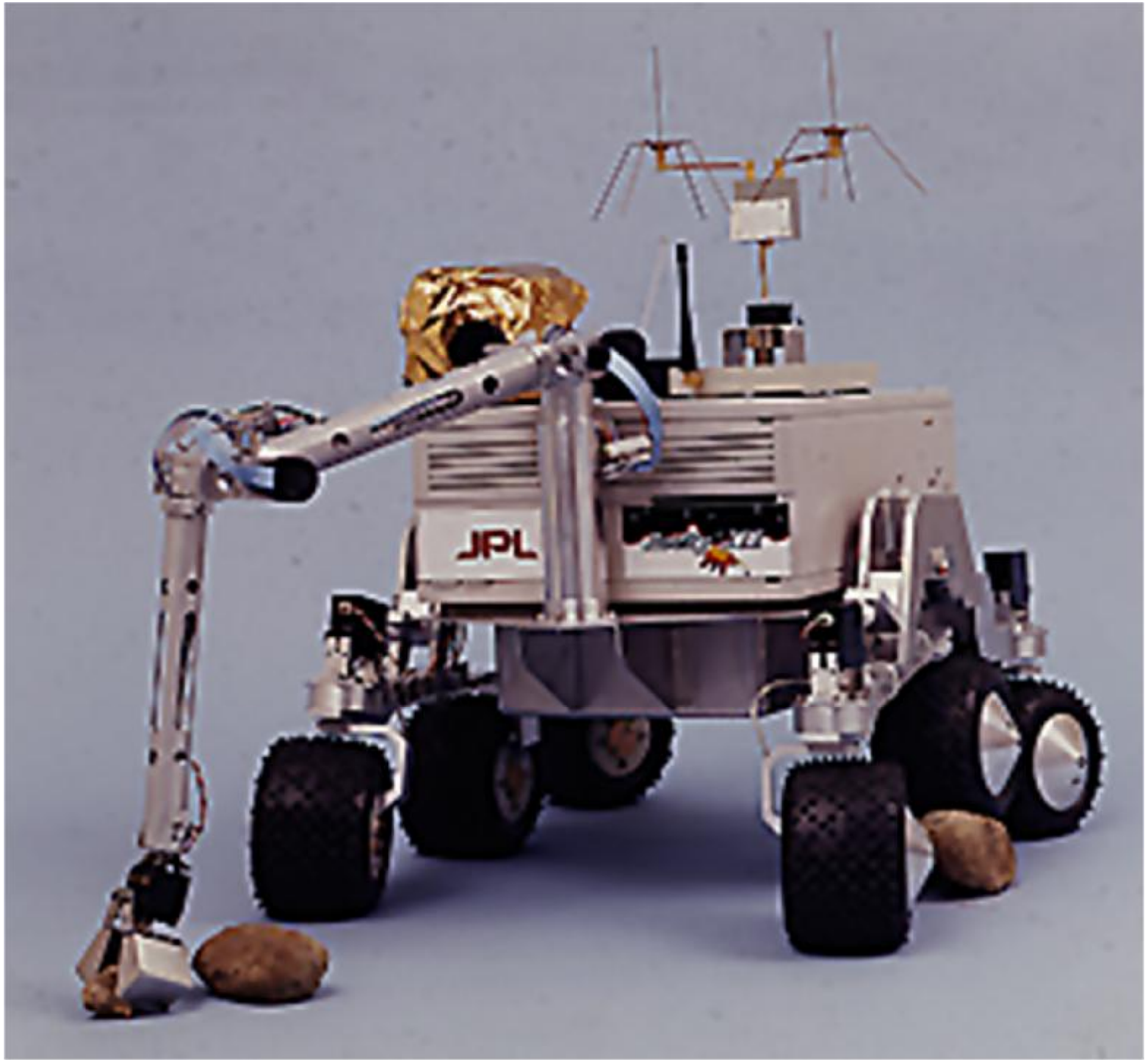
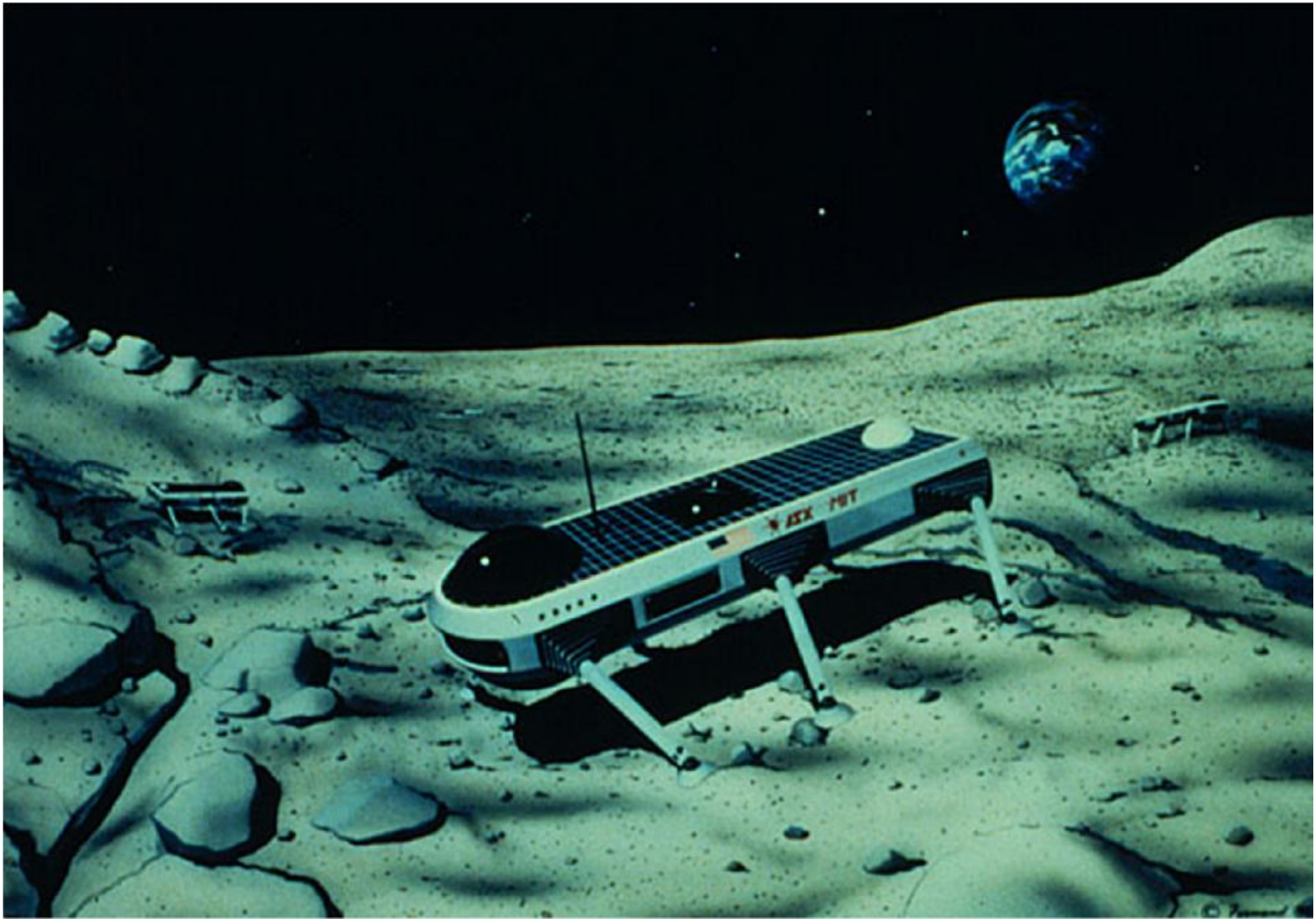
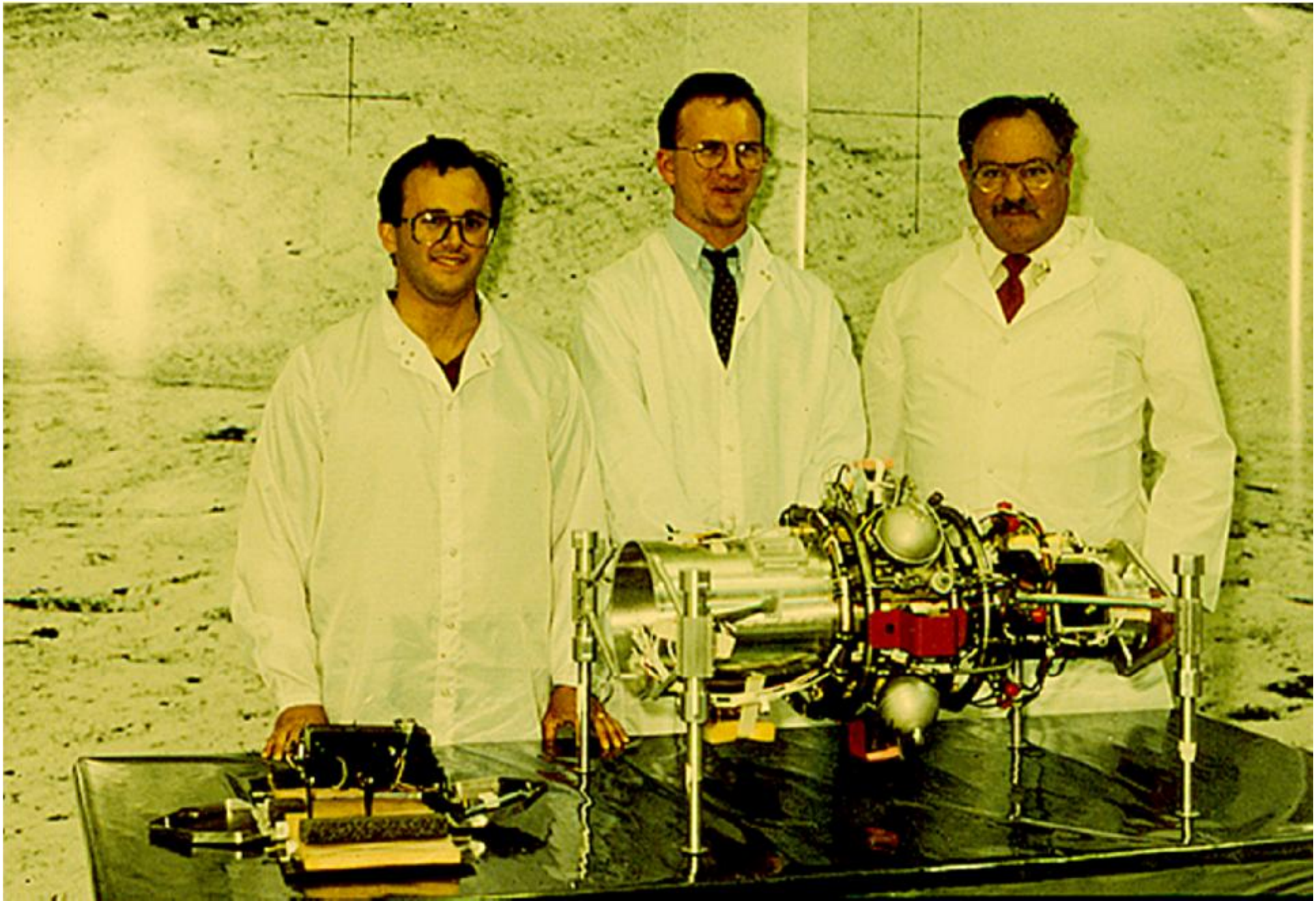
MIT Artificial Intelligence Lab, Cambridge, MA, USA.*

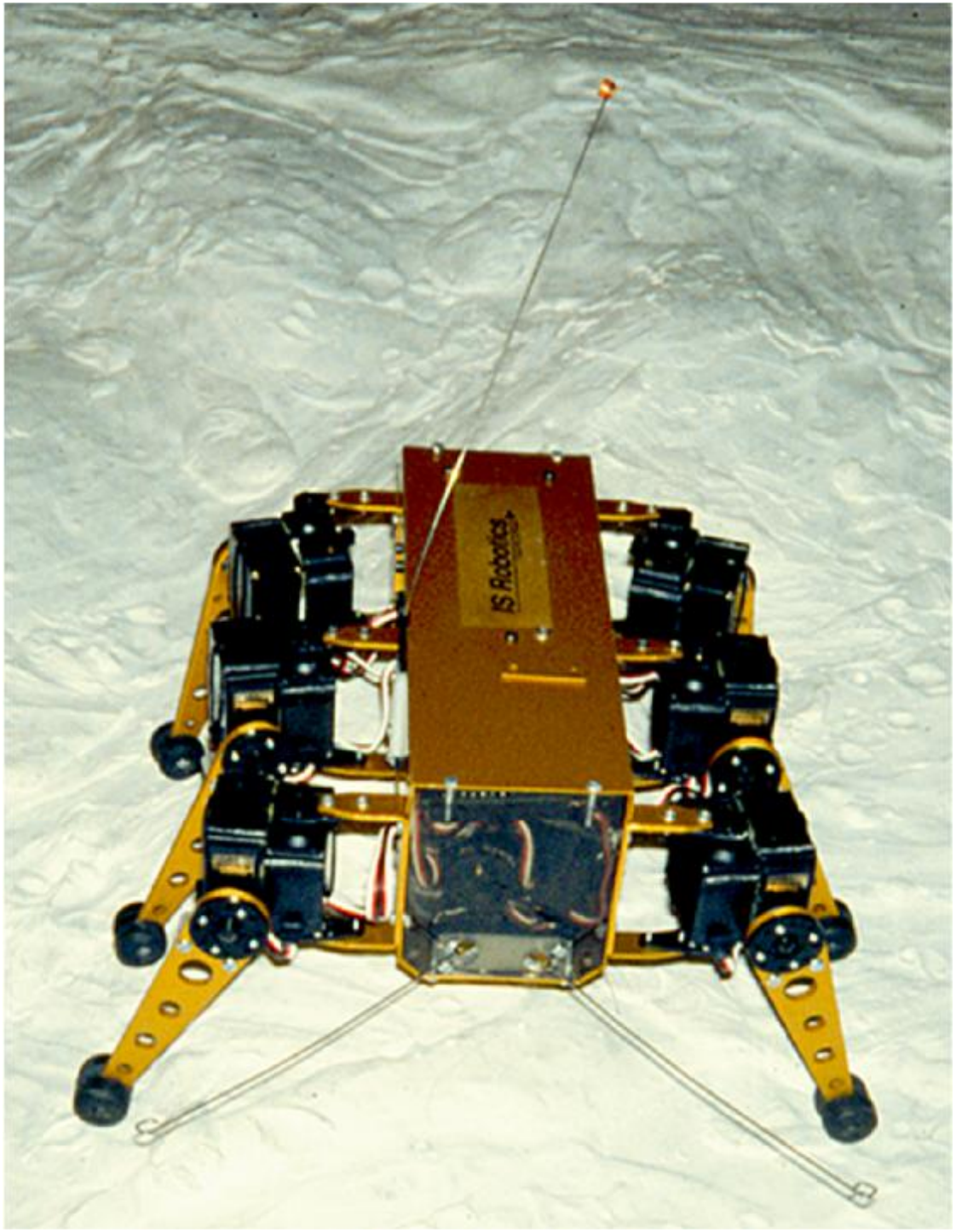


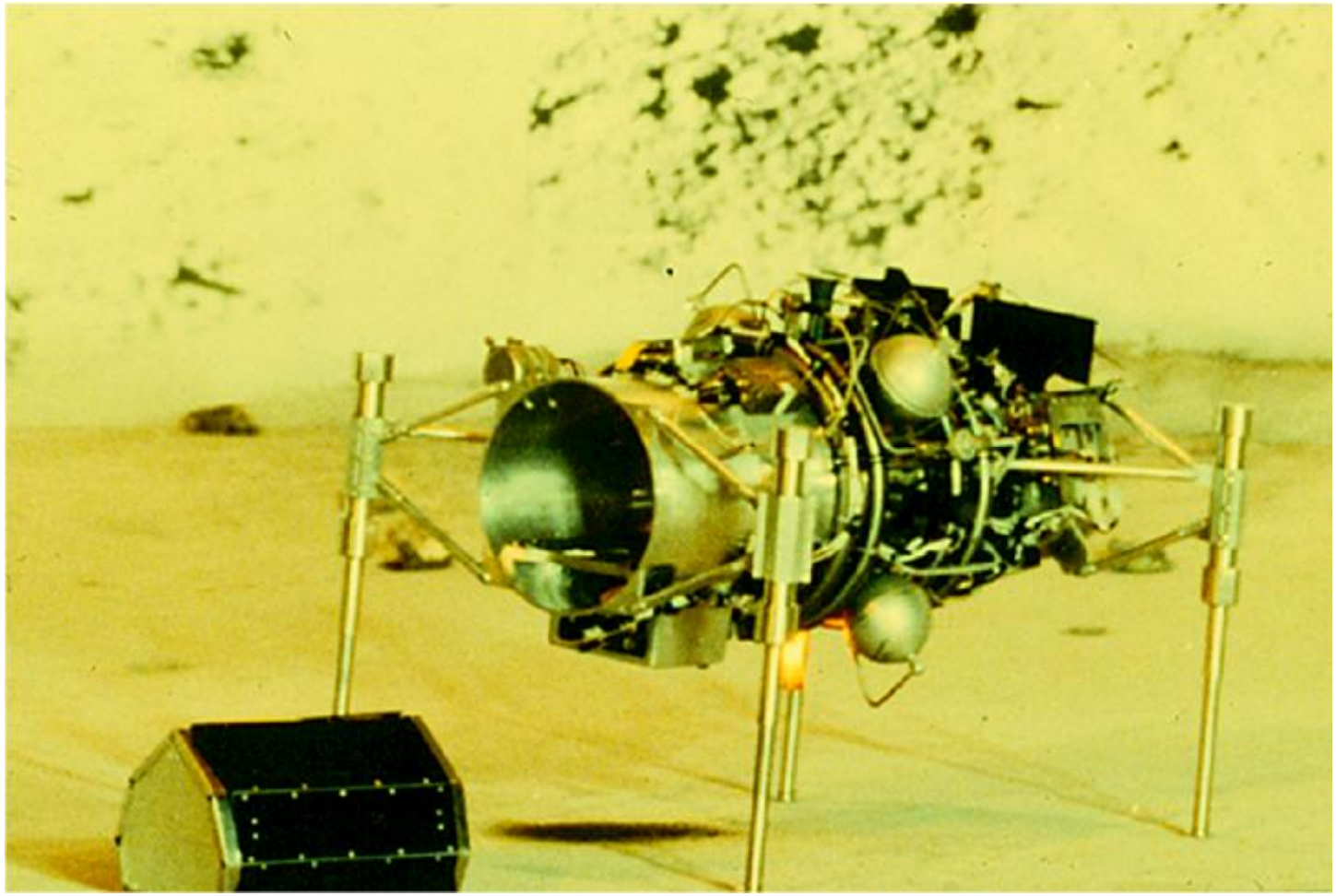

JPL



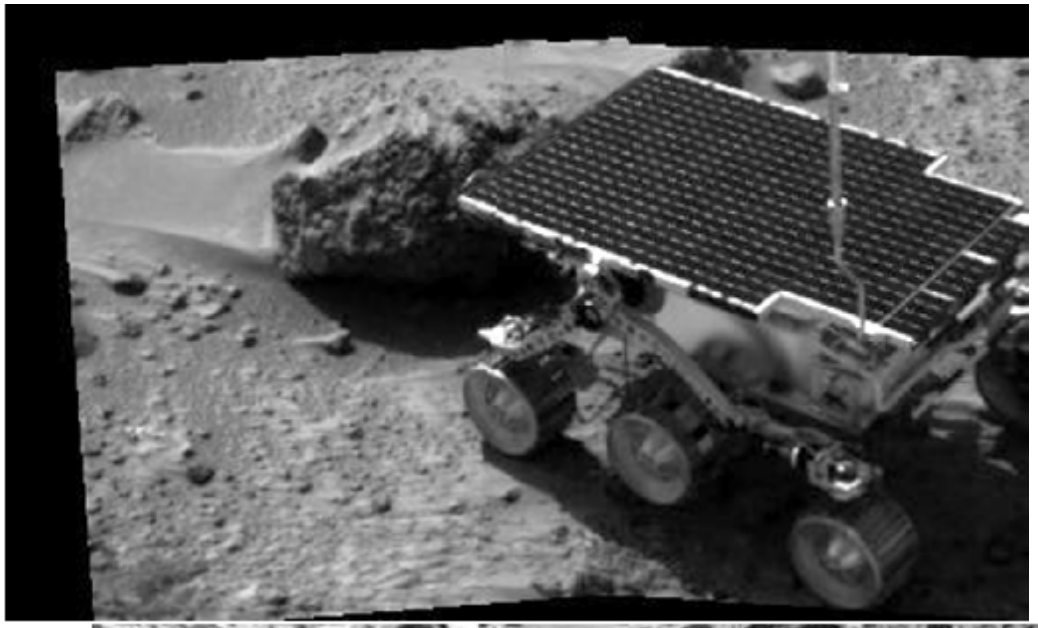





IS Robotics

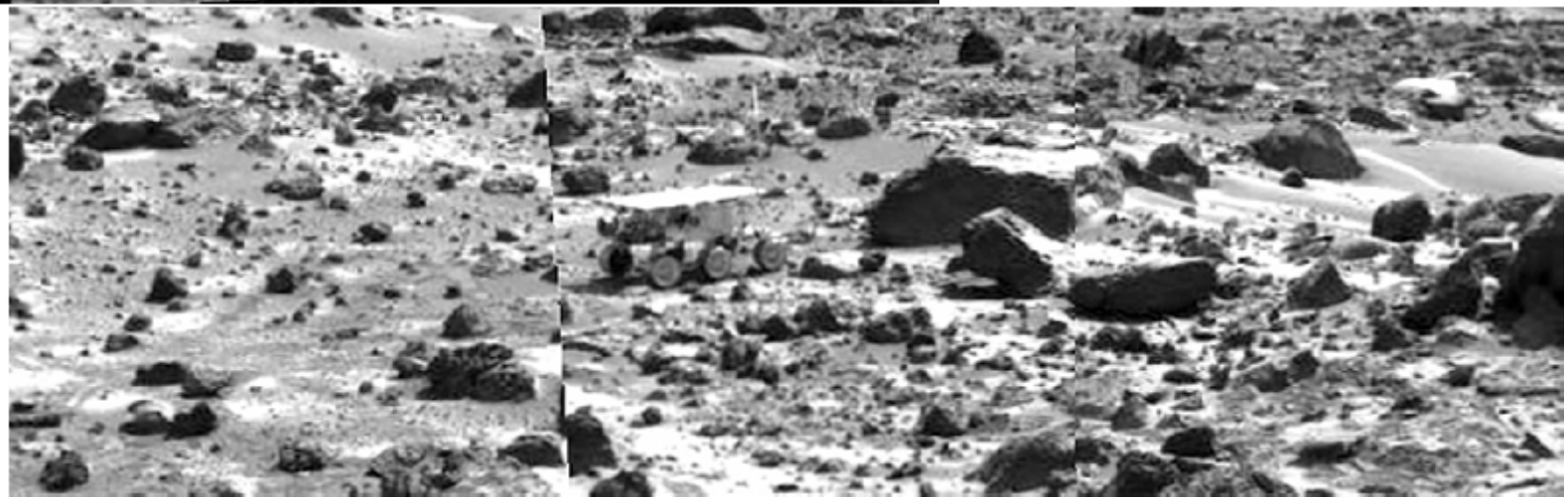


NASA/JPL Mars Rover: Landed July 4, 1997

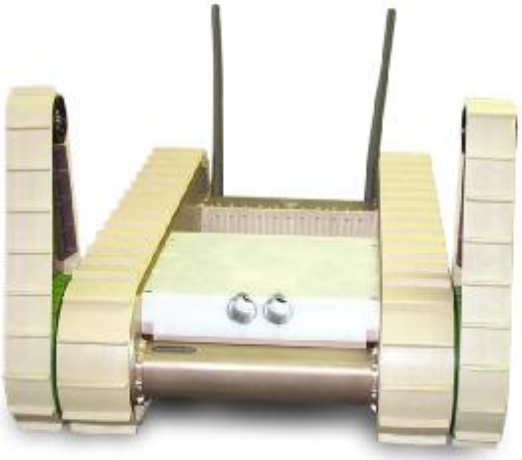


- **First 28 sols was under teleop control**
- **Sol 29 was put under behavior control**
- **Mission ended when lander failed.**

Sol 72




NEXGEN
FLOOR CARE SYSTEMS
NEXGEN

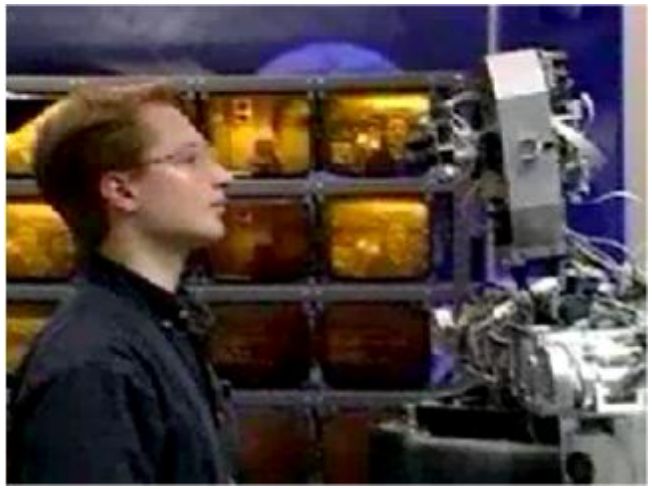


Roomba, Packbot, iRobot 2002

PACKBOTS

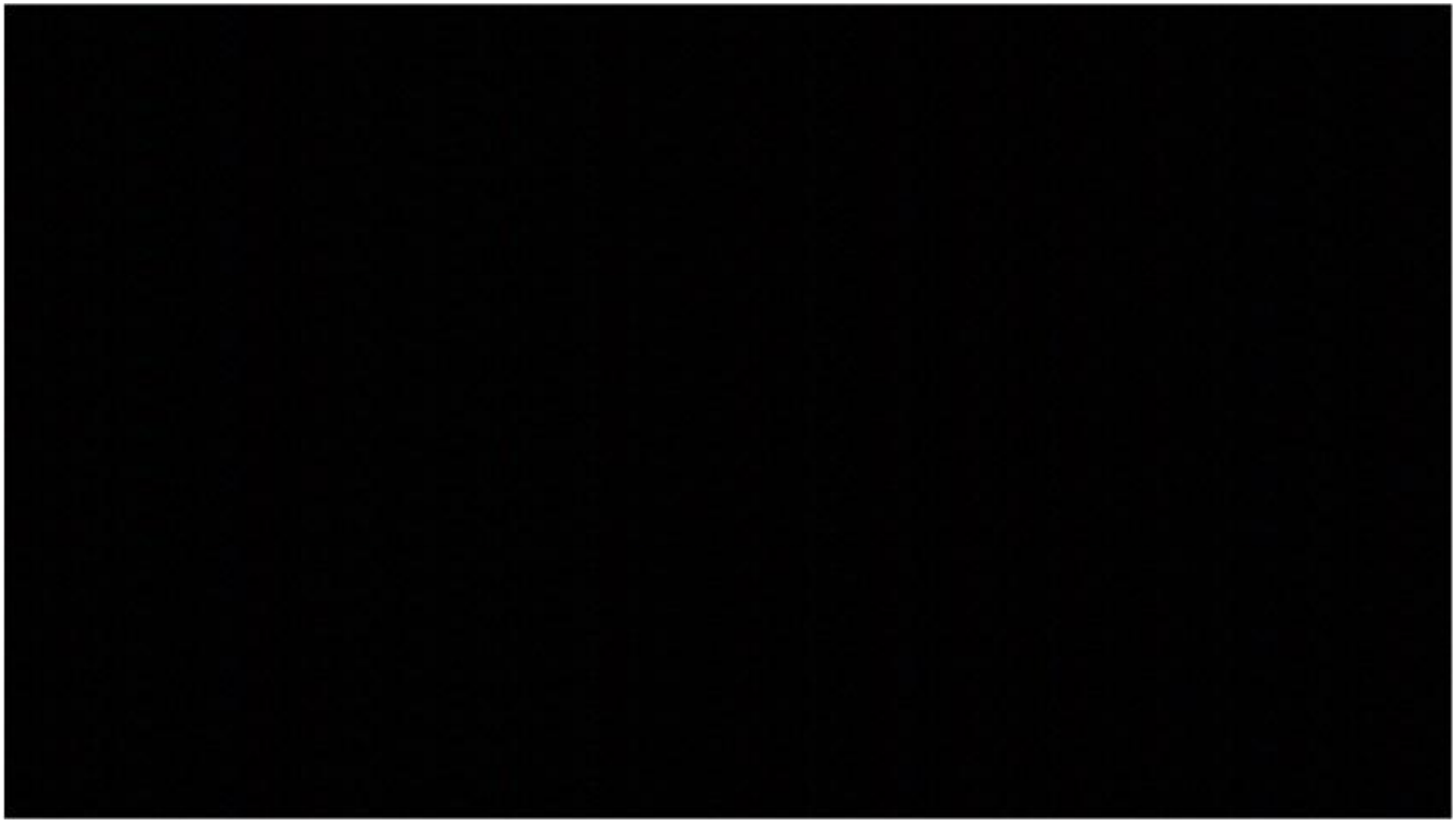
Behavior-Based Robotics

- Early:
  - DARPA, NASA, ONR
- Middle:
  - DARPA, BMDO, NASA, MITI (Japan),
- Later:
  - DARPA, Private companies
- Full deployment
  - DARPA, Rapid Equipping Force, VC



Crank

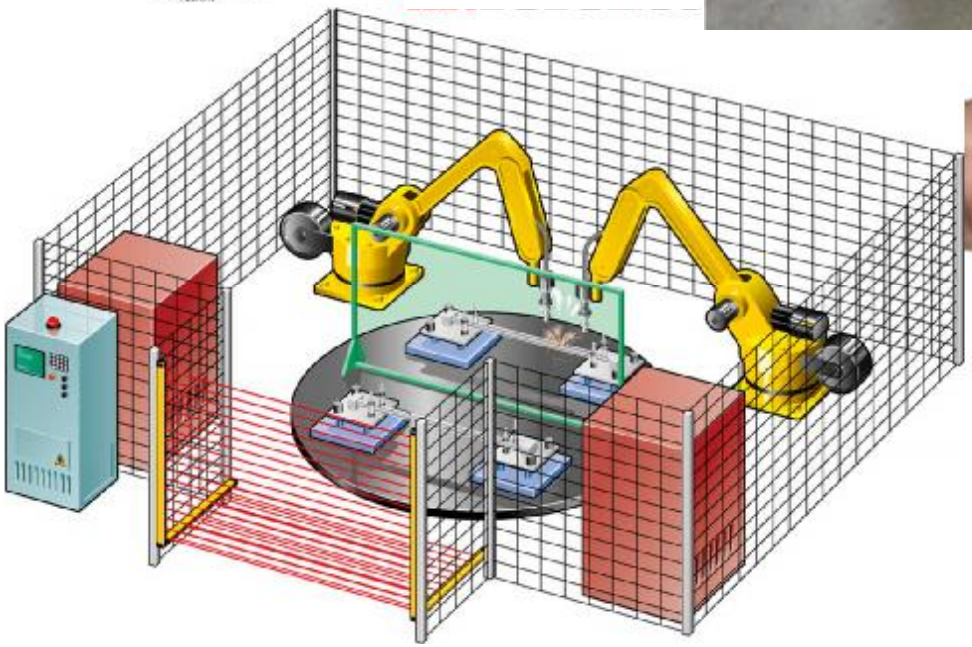
- 1 arm - 4 active dof



When A Robot Hits A Person It Can Kill


Enable/Disable Switch
Turn pendant on/off
Emergency Stop
Rear buttons and features:
- USB Port
- Deadman switch
PREV
Go to previous page on screen
NEXT
Advance to next screen shown
Selection Keys
Select options viewed on screen above
MAIN TEACH FUNCTION KEYS
Main buttons for programming
FCTN
Displays additional function menus
CURSOR/ARROW KEYS
Moves the cursor
SHIFT
DISP
Toggles between screen displays
GROUP
Toggles between motion groups
STEP
Switches between step and cycle execution
HOLD
RESET
Clears the alarm
FORWARD
Executes the next statement in a program
BACK SPACE
Deletes letter or number before cursor
BACKWARD
Executes the previous statement in a program
ITEM
Selects a line item by number
JOG KEYS
NUMBER KEYS
COORD
Selects the coordinate system or other group
JOG SPEED KEYS
Adjusts the speed of the robot
DIAG/HELP
Diagnostics/Help button. Pull up operator manuals
BACK UP
Returns to main screen
POSN
Displays position screen
- Relative
- Absolute
- Distance To Go
- Machine
I/O
Displays I/O screen
STATUS
Displays current position screen
MAIN FCTN
Displays function menu
EQUIP
Toggles between tool functions and robot functions


ABB




COGNEX
COGNEX
COGNEX


5K

Humanoid Robots

- Early:
  - DARPA, NASA
- Middle:
  - DARPA, NASA
- Later – for manufacturing:
  - VC