Spacecraft Micro Robot

(formerly known as the PSA)

March 4, 2000

Principle Investigator
Yuri Gawdiak

Context

Shuttle Mission 89 Flight:

" One astronaut, Andy Thomas, will undertake several hundred research runs involving 26 different science projects in five disciplines. The projects are provided by 33 principle investigators from the U.S., Canada, Germany and the U.K."

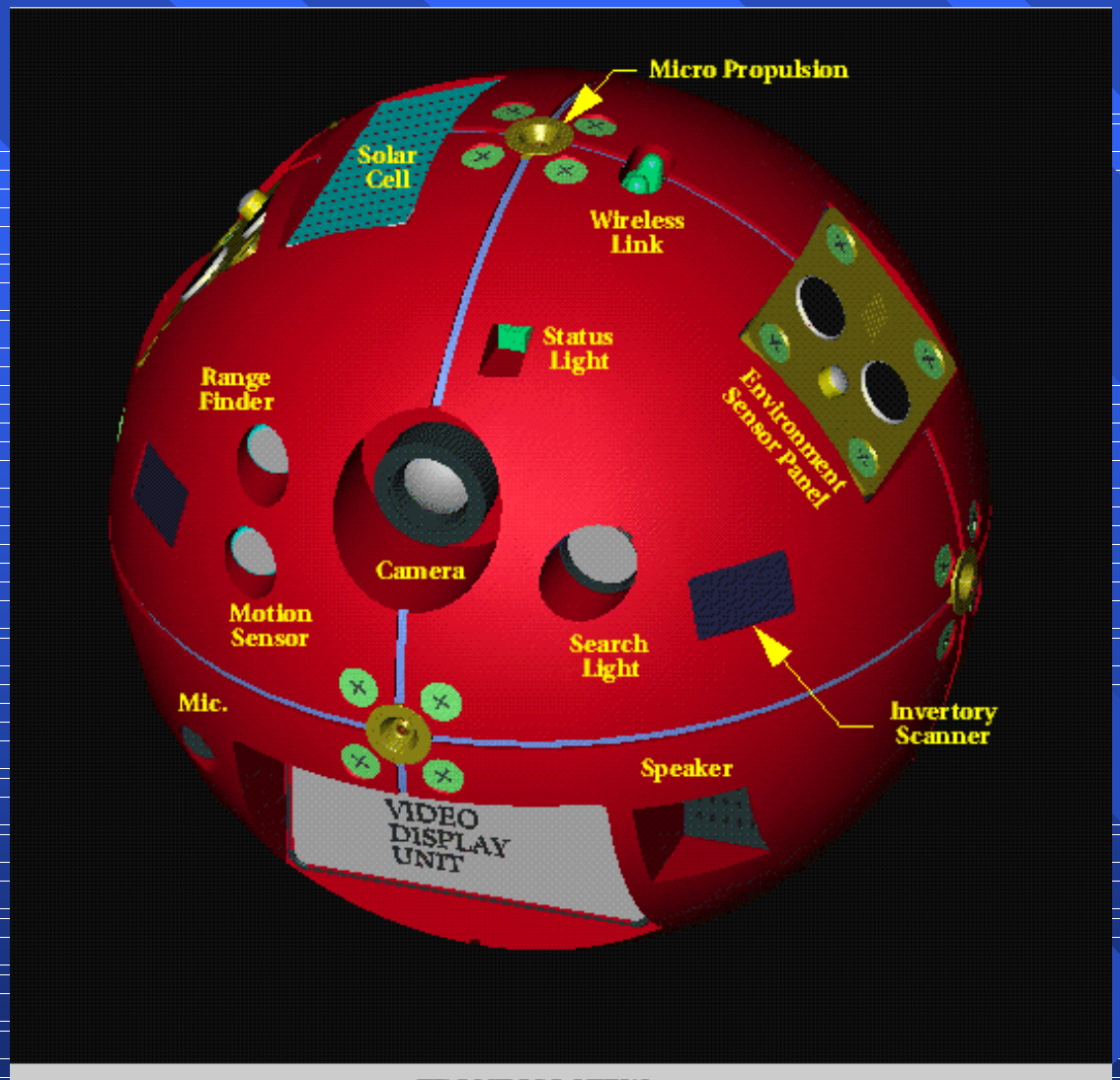
Date: July 6, 1998

International Space Station

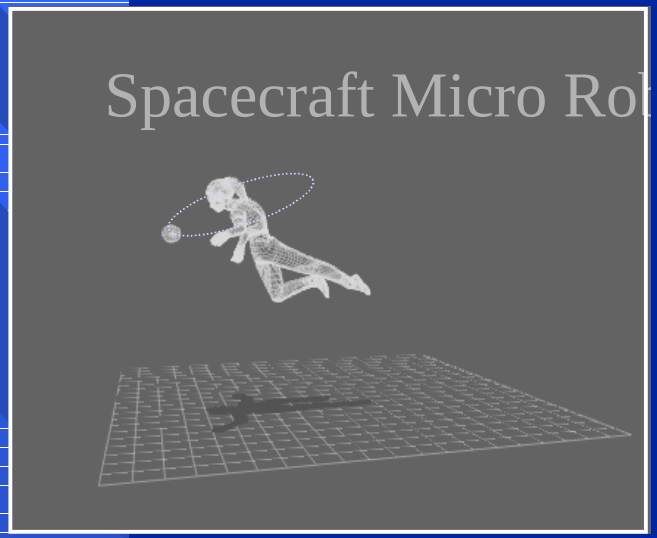
S97-10537 (June 1, 1997) --- This digital artist's concept shows the International Space Station after assembly is completed in 2003. The completed station will be powered by almost an acre of solar panels and have a mass of almost 1 million pounds. The pressurized volume of the station will be roughly equivalent to the space inside two jumbo jets. Station modules are being provided by the U.S., Russia, Europe and Japan. Canada is providing a mechanical arm and "Canada hand." In total, 16 countries are cooperating to provide a state-of-the-art complex of laboratories in the weightless environment of Earth orbit. The first piece of the station is scheduled to launch in June 1998, beginning a challenging five-year, 45-flight sequence of assembly in orbit.

Date: July 6, 1998

Spacecraft Micro Robot (SMR)



FRONT ISO VIEW



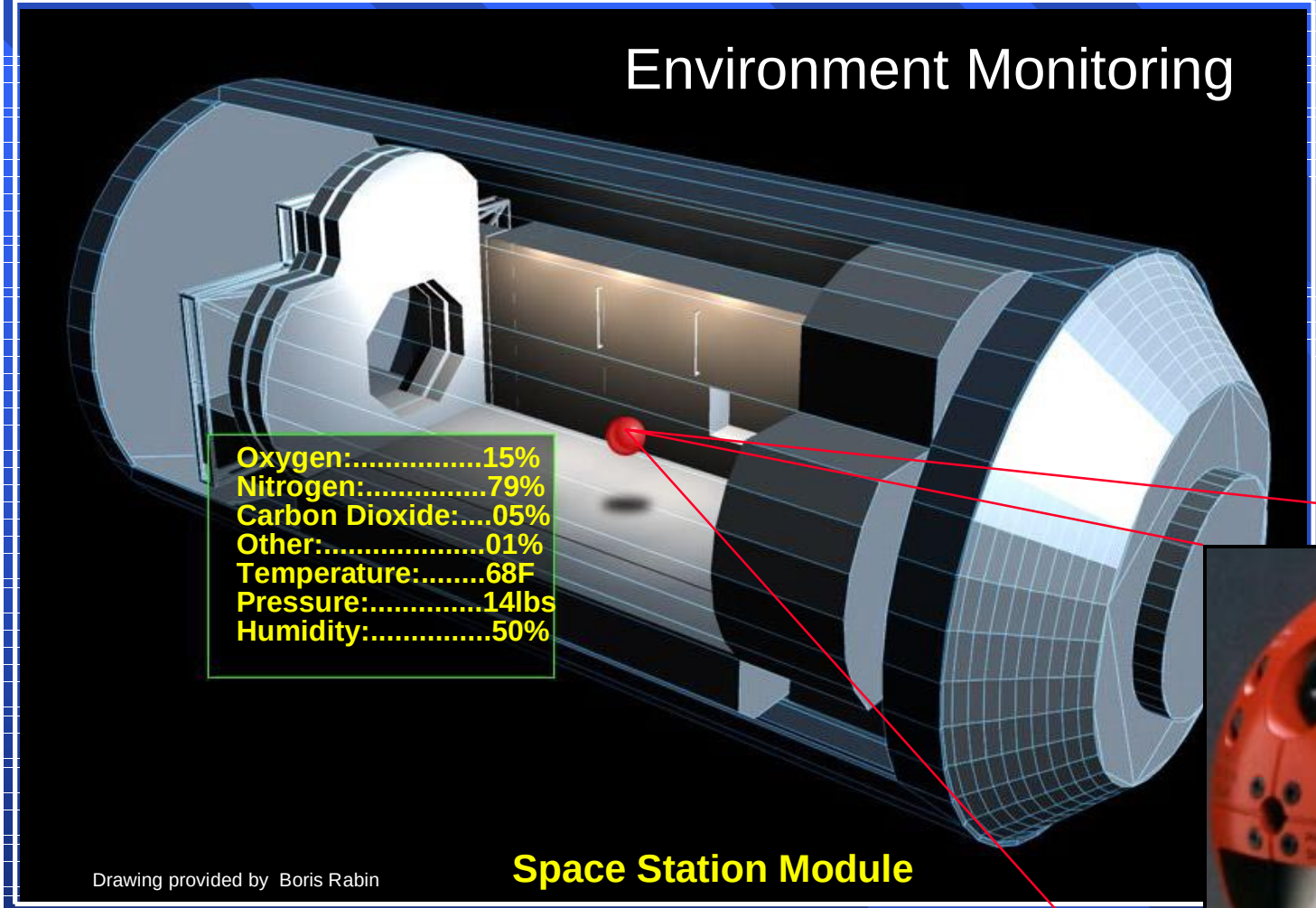
Evolutionary Capabilities

- Crew Personal Data Assistant
- Personal Video Conferencing
- Virtual Principle Investigator
- Environment & Inventory Monitoring

Revolutionary Capabilities

- Health Monitoring
- Collaborative Fault Isolation & Recovery
- Sensor Quality Control
- Integrated Payload Support

Spacecraft Micro Robot (SMR)



Drawing provided by Boris Rabin

Spacecraft Micro Robot (SMR)

- **Technical Challenges:**

Navigation & Control
Propulsion
Orientation
Identification
Mapping
Tracking

Collaborative Applications
Intelligent Personal Agents
Just-In-Time-Training
Virtual Scientist (PI-In-a-Box)
Fault Detection & Isolation
Inventory Tracking & Control

Model-Based Diagnosis & Recovery
Models
Simulations
Planning, Priority Mmgnt
Execution/Re-evaluations

SMR Hardware Architecture

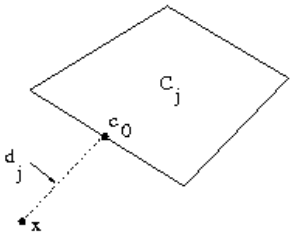
Integrated External System/Payload Interfaces

- **Technical Approach:** The SMR platform will be built with COTS components based on the Personal Advisory System technologies currently being built for Space Station
  - The platform will include onboard processing system that will support intranet applications and communications, a sensor suite, human crew I/O, and navigation and mobility components (microfans, gyro, etc.)

One G Testbed

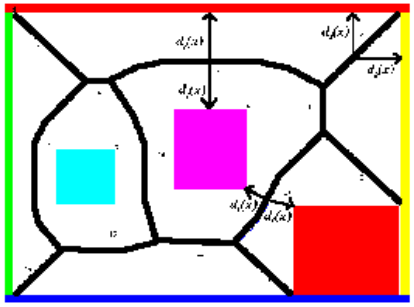
- COTS Hardware
- VxWorks OS
- Pump-driven air bearing
- Ducted Fan Propulsion
- FOG inertial meas. Unit
- Wireless ethernet
- Onboard vision processing for visual tracking and depth measurements
- Offboard processing for
  - speech recognition
  - Sequence execution & Fault diagnosis

Visibility Planning



$$d_j(x) = \min_{c \in C_j} \|x - c\|$$

(Sensors)

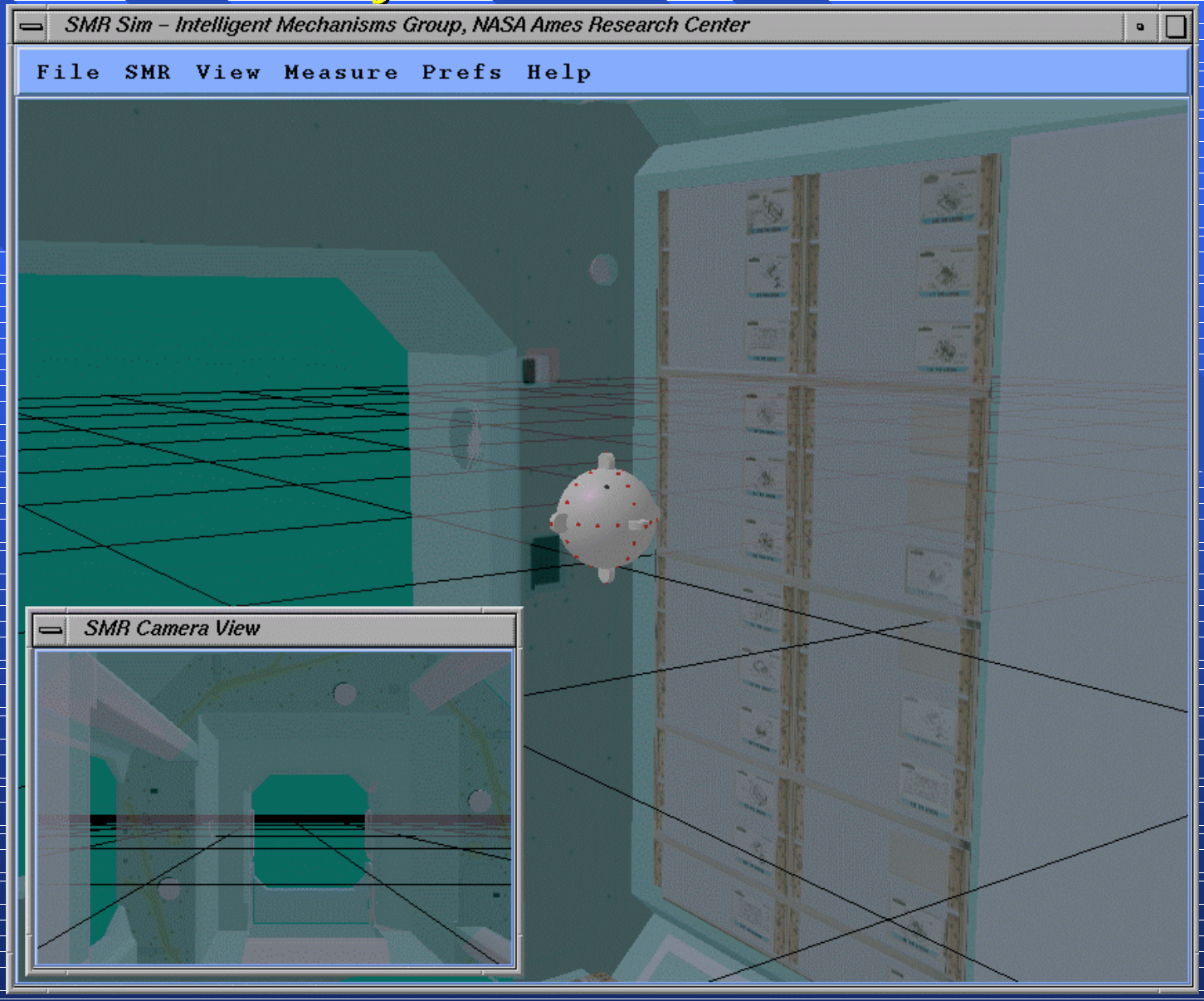


Planar double equidistance,

$$d_i(x) = d_j(x)$$

- Utilize Generalized Voronoi Graph search
- Approximate 3D world using simple geometric primitives (cubes, spheres, cylinders)
- Generate visually admissable highways
- Use SRI SVS Engine for Crew tracking

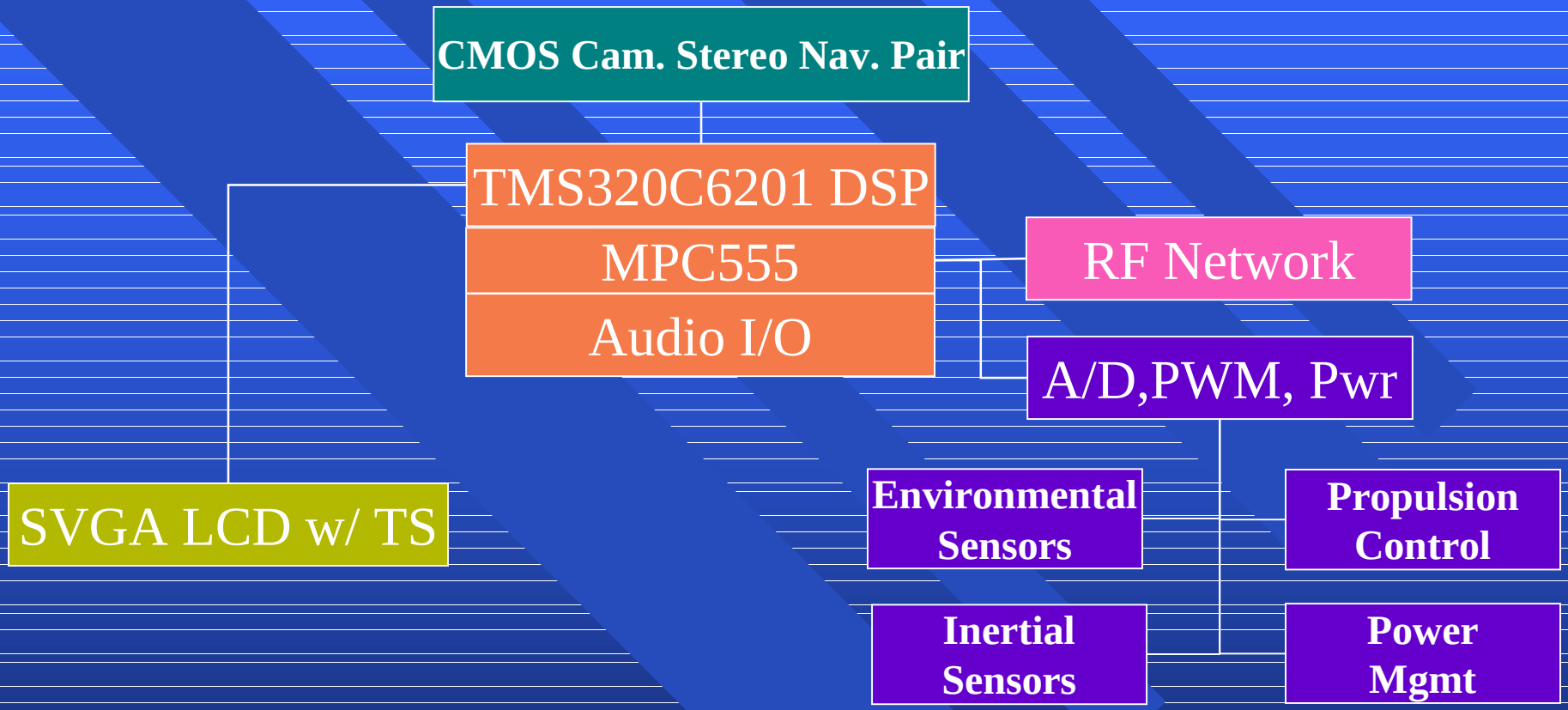
Dynamic Simulator



KC-135 µG Simulator

- Target acceleration in all axis < .01G
- Duration of 20-25 secs.
- Test coordination with JSC/Reduced Gravity Office

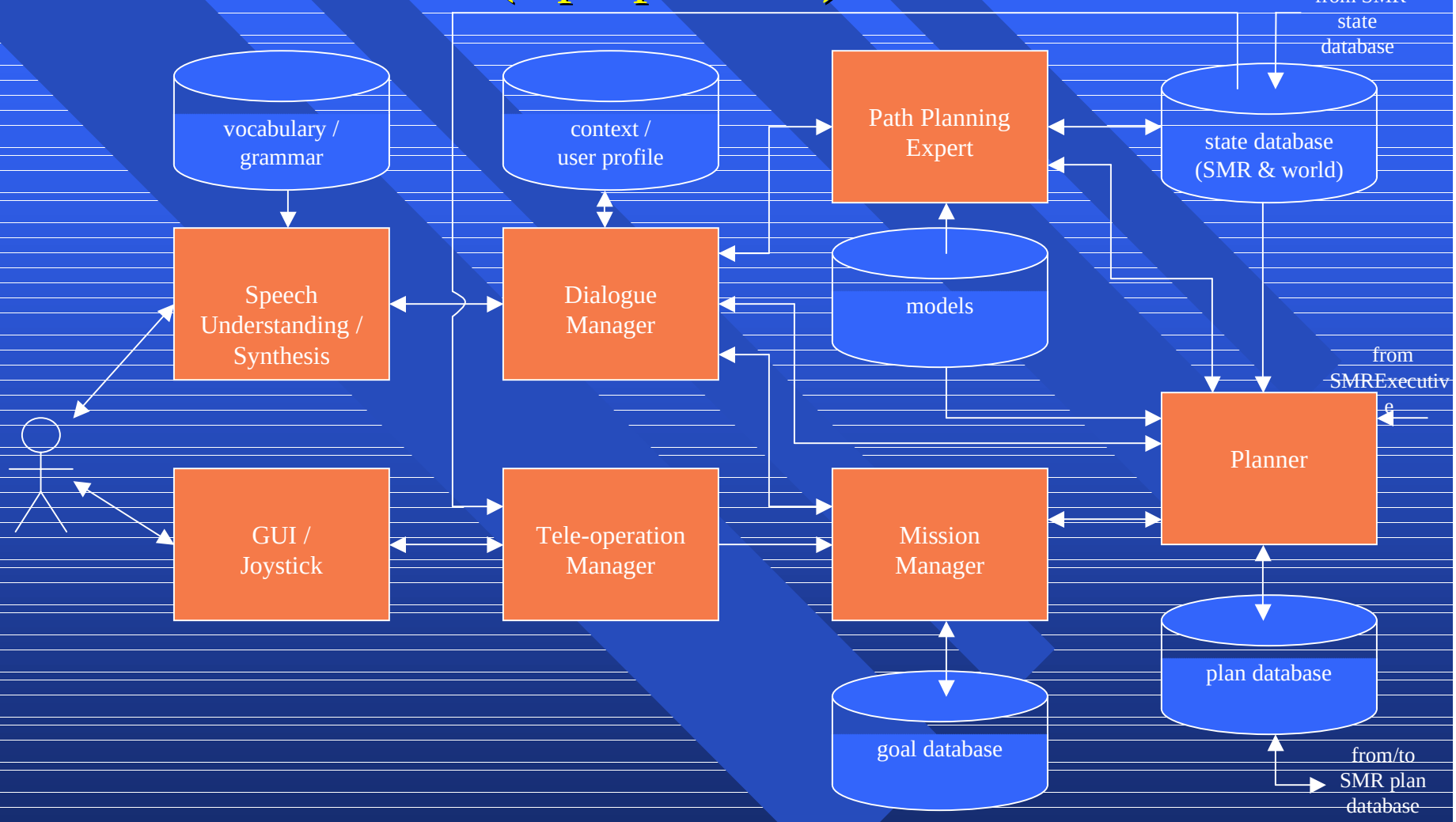
µG Hardware Testbed



- Utilized DSP for speed vision processing, embedded auto. PowerPC for control
- Recent DSP devel. may eliminate MPC555

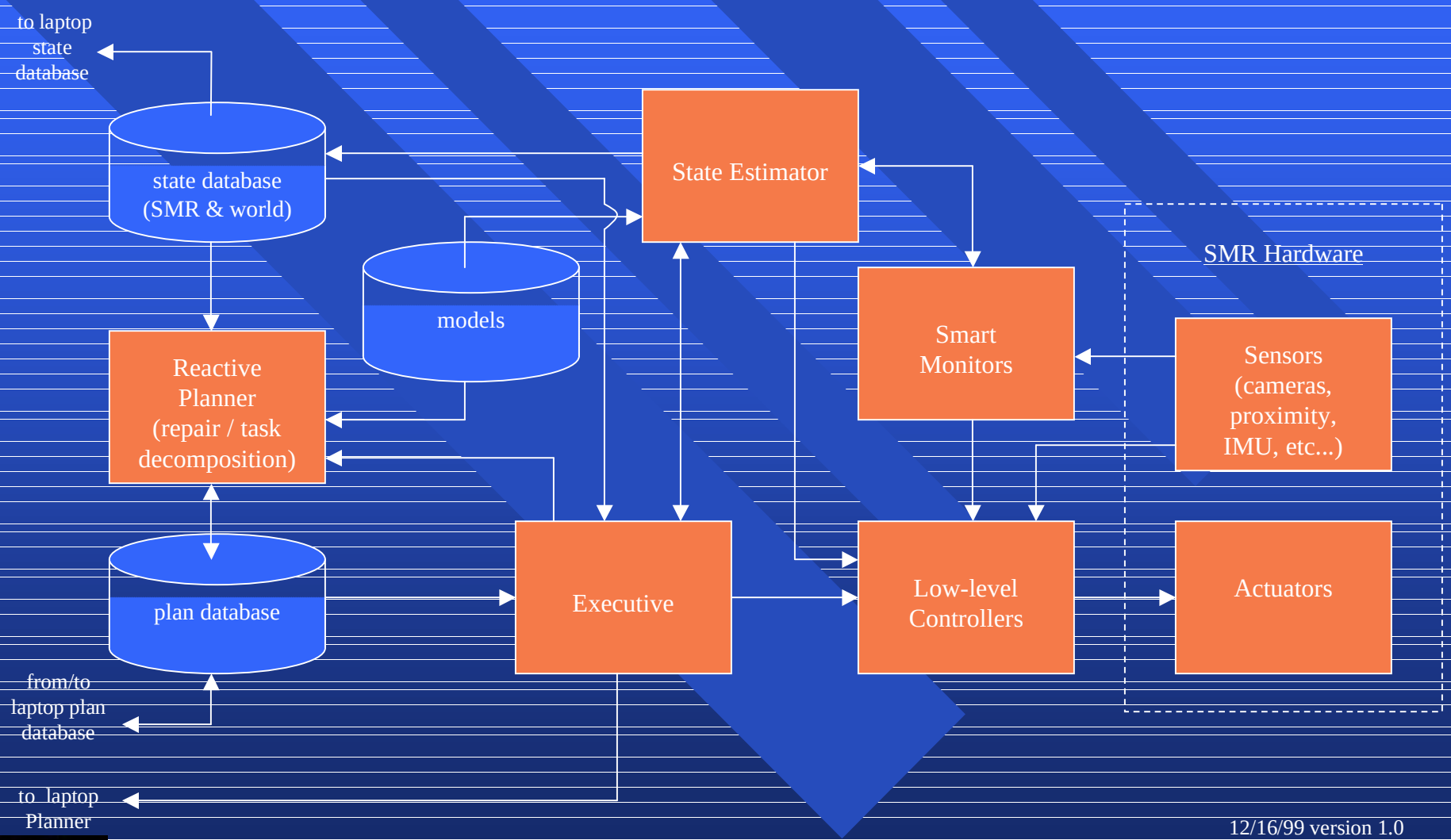
Primary High-Level Control Modules

(laptop server)



12/16/99 version 1.0

Primary Lower-Level Control Modules (SMR)



12/16/99 version 1.0

Spacecraft Micro Robot (SMR)

- **Major Milestones**
  - FY98 Concept Development (not funded by 632-30)
  - FY99
    - » Feasibility Evaluations
    - » Concept Mockup Completion
    - » Initial engineering testbed developed
    - » Model and simulation initiated for Intelligent Executive development
    - » Path planning prototype developed
    - » Initial Natural Language syntax and interface developed
    - » Detailed Design Concept completed for 175% six-axis prototype
  - FY 00 KC 135 Flight
    - » 175% sized prototype
    - » Microgravity flight demonstrations of command, control and navigation
    - » Beta intelligent executive operational