Applications for Mission Operations Using Multi-Agent Model-Based Instructional Systems with Virtual Environments

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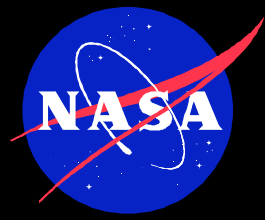
Presentation Outline

- Intelligent Tutoring Systems —using AI (problem-solving models) for instruction
- Astronauts as Students
- ICAT: The Hubble Repair Training System
- Foundations for Revitalizing ITS at NASA
  - Brahms: Workpractice modeling, Agents, and VE
  - Trends and Opportunities for Exploration Systems

Guidon: Case Method Tutor (1979)



Student: What is the CSF Glucose?

Guidon: The CSF glucose value is 5.

We have substantially completed our discussion of the type of the infection. Would you like to make a hypothesis now?

S: Yes

G: What is the type of the infection?

S: Bacterial (.9)

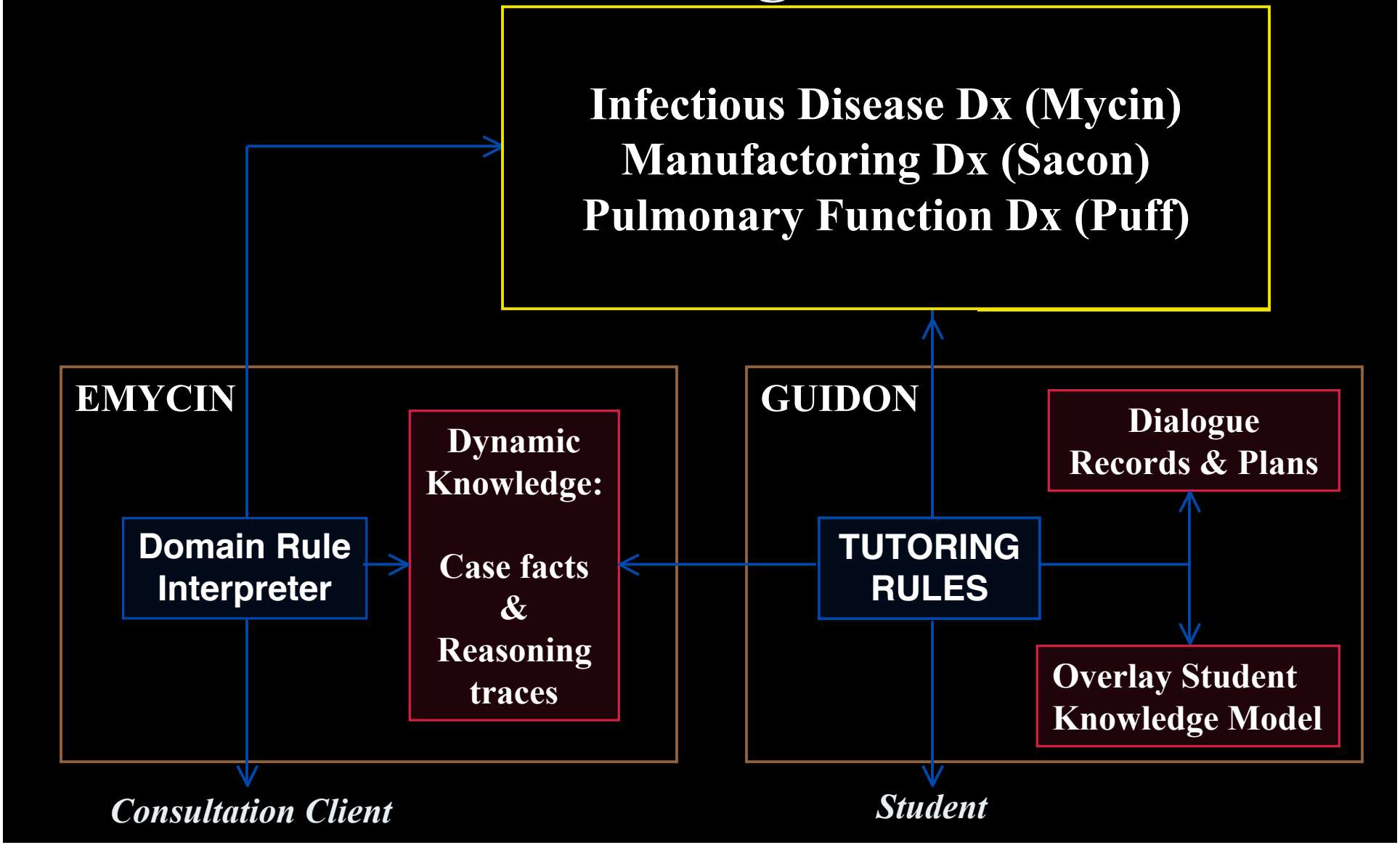
G: What facts about this case tell you that the type of the infection is bacterial (.9)?

S: CSFGLUC, PMNS, CSFPOLY, PROTEIN

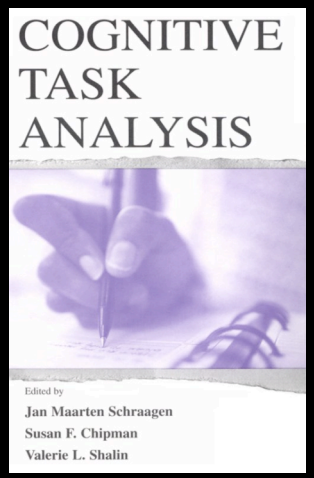
G: The percent of PMN's in the CBC is not relevant for determining the type of the infection.

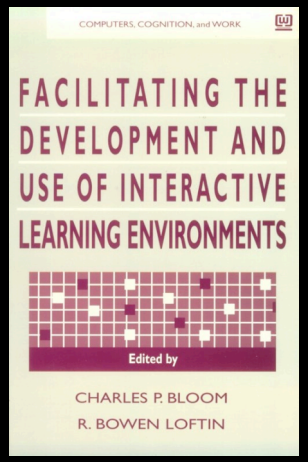
You're right about the CSF protein, the percent of PMNSs in the CSF and the CSF glucose value, however you should have mentioned the fact that the meningitis is partially treated (.95), the WBC from the CSF and the fact that the simultaneous blood glucose value is not known.

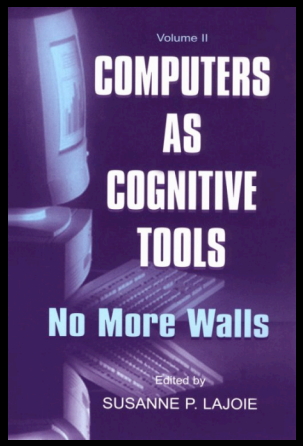
Guidon's Domain-General Design



ITS Successes (30 Years)

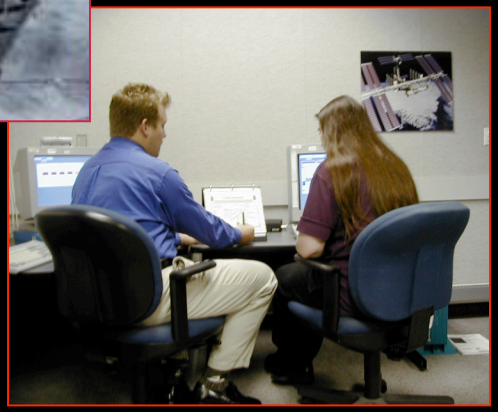






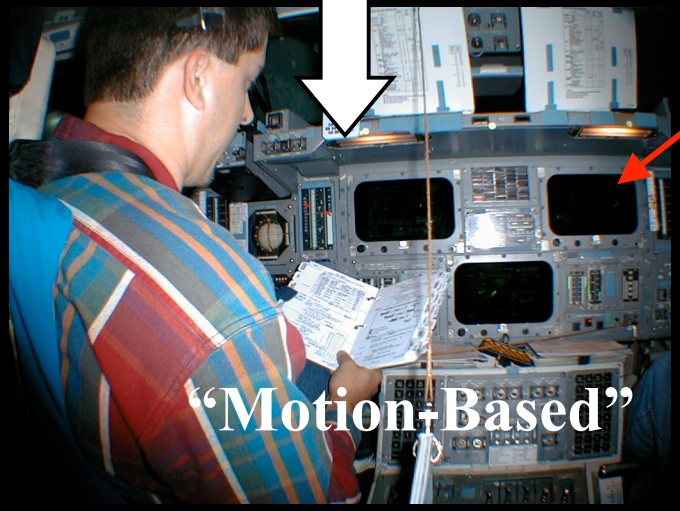
- High School Algebra
- Electro-mechanical Troubleshooting (military)
- Manufacturing Process Control
- Computer Programming
- Medical Diagnosis

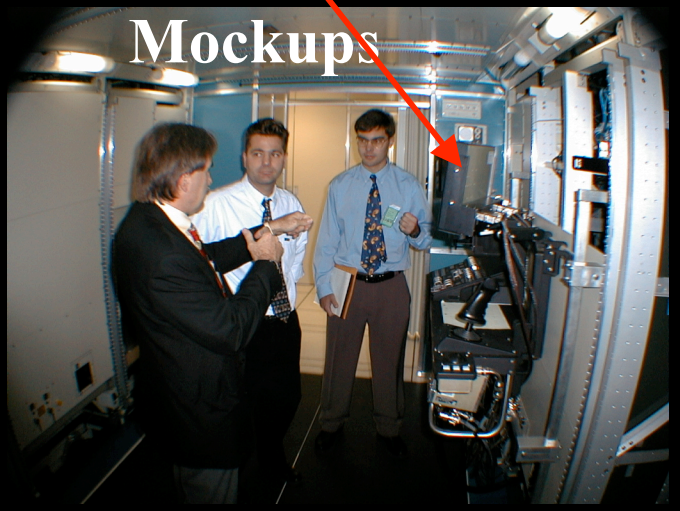
Astronauts as Students



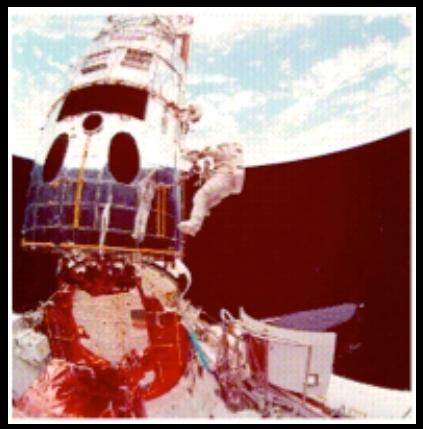
- Multiple PhDs/MD
- Insufficient time from specs to flight to formalize domain knowledge
- Highly procedural, mission critical, manipulative skills
- “Practicing understanding”
- Tasks open to alternatives
- CBT with personal tutors
- Comprehensive ground support “coach in your ear”

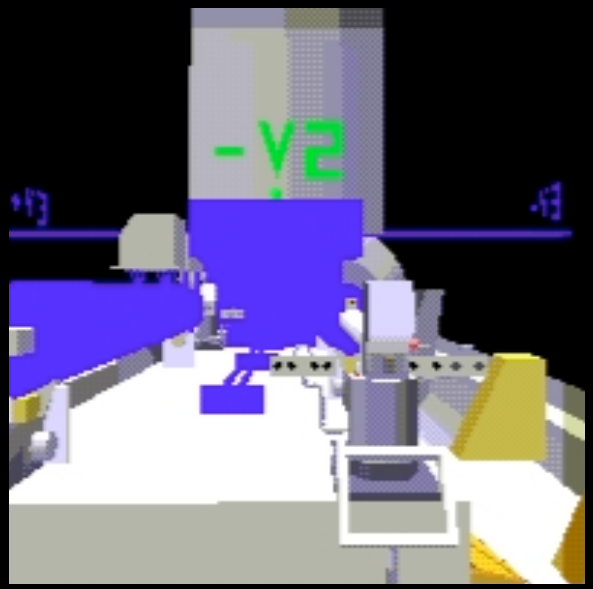
Varieties of Simulation Training





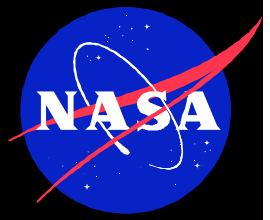
Bowen Loftin's Hubble VE





- Dec ’93 Hubble Repair Mission
- Hubble model + Shuttle payload bay
- 100 team members, 200 hrs training
- Feature id & repair constraints; six EVA scenarios (part changes)
- Procedure monitoring, intervention, & assistance

Shalin's ICAT Evaluation



- Part-Task model highly restricted
  - Flattens data–process relation (e.g., comparing alternative methods)
  - Omits contextual information (e.g., orbit #)
  - Omits interaction with other individuals/subtasks
- Increased cognitive demand
  - Undermined learning
  - Misleading evaluation of effectiveness
- Need richer work system conceptualization

S: … I would tell dynamics to make ephemeris 2 and 4 look like 1.

E: How would you do that?

S: I would tell them exactly that – to make ephemeris 2 and 4 look like 1. So, I'm going to have to do this myself.

Technology Foundations for Revitalizing ITS at NASA

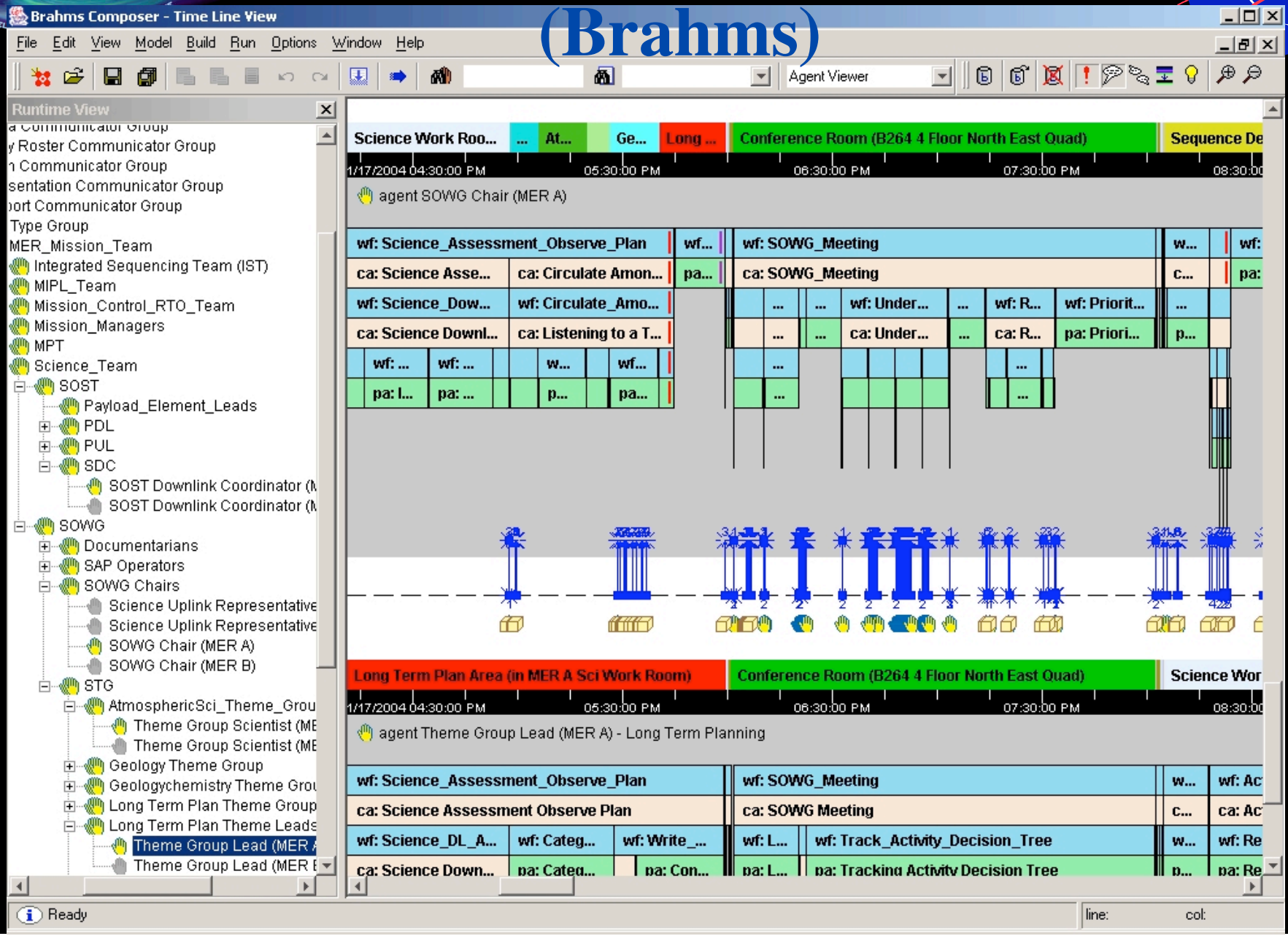
MER
Work System Study
& Simulation

BrahmsVE
Human-Robotic
Systems

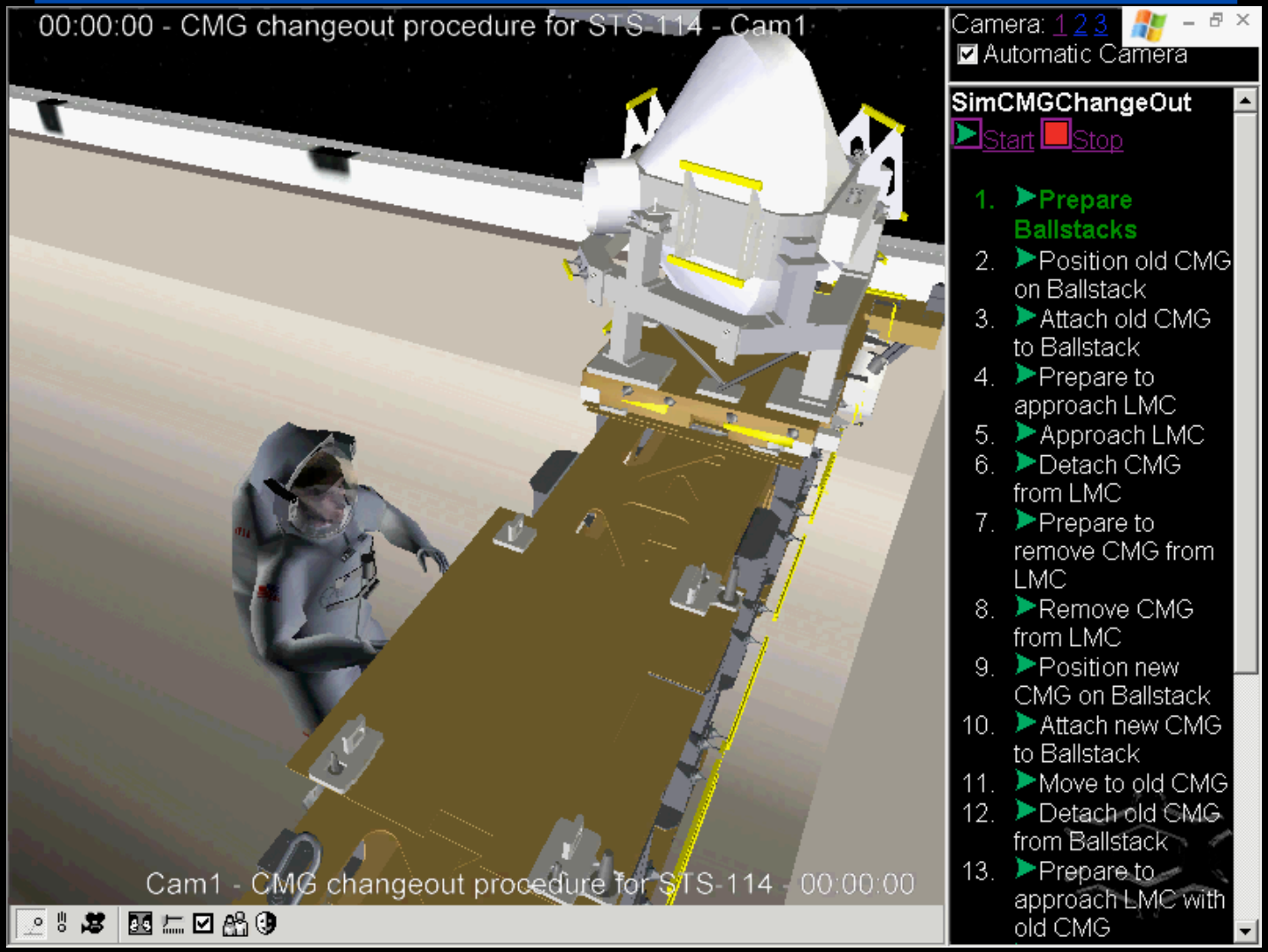
Mobile Agents

- Work practice (activity-based) simulation of mission operations and tools
- Virtual environments for design and training of human-robotic systems
- Multiagent systems using NL for life support and surface exploration

MER Operations Simulation (Brahms)



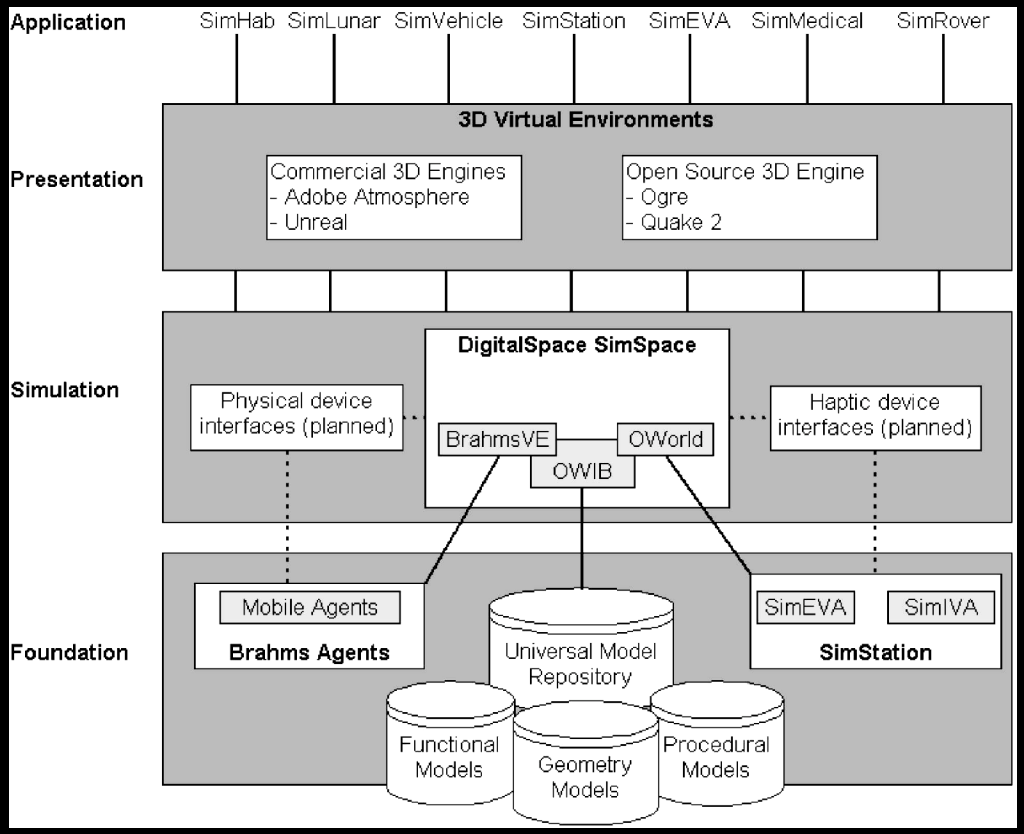
ISS Assembly Training



DigitalSpace & NASA Collaboration 2004

BrahmsVE Architecture

- **Multiagent Work Practice Simulation:** People, systems, places, activities, communications
- Coupled to animation graphics in virtual world
- **Browser-based Visualization** implemented in *Adobe Atmosphere*
- Foundation for interactive distributed training

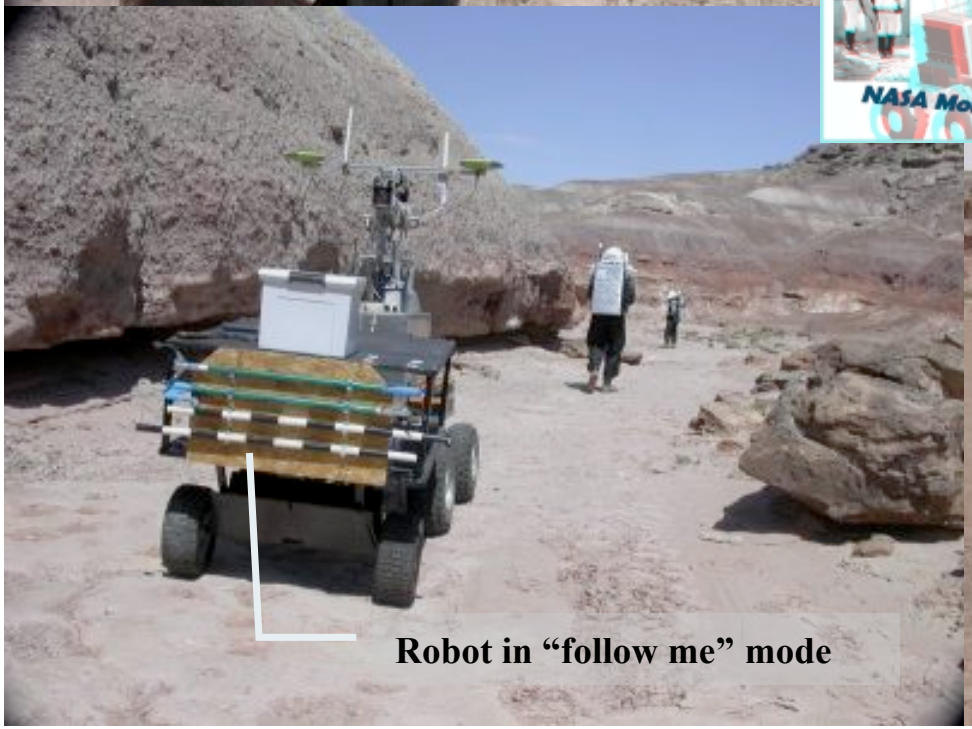


Agent system simulates behaviors;
Virtual World simulates spatial relations

MOBILE AGENTS: "Automating Capcom"

Astros can work in parallel, talking to personal agents

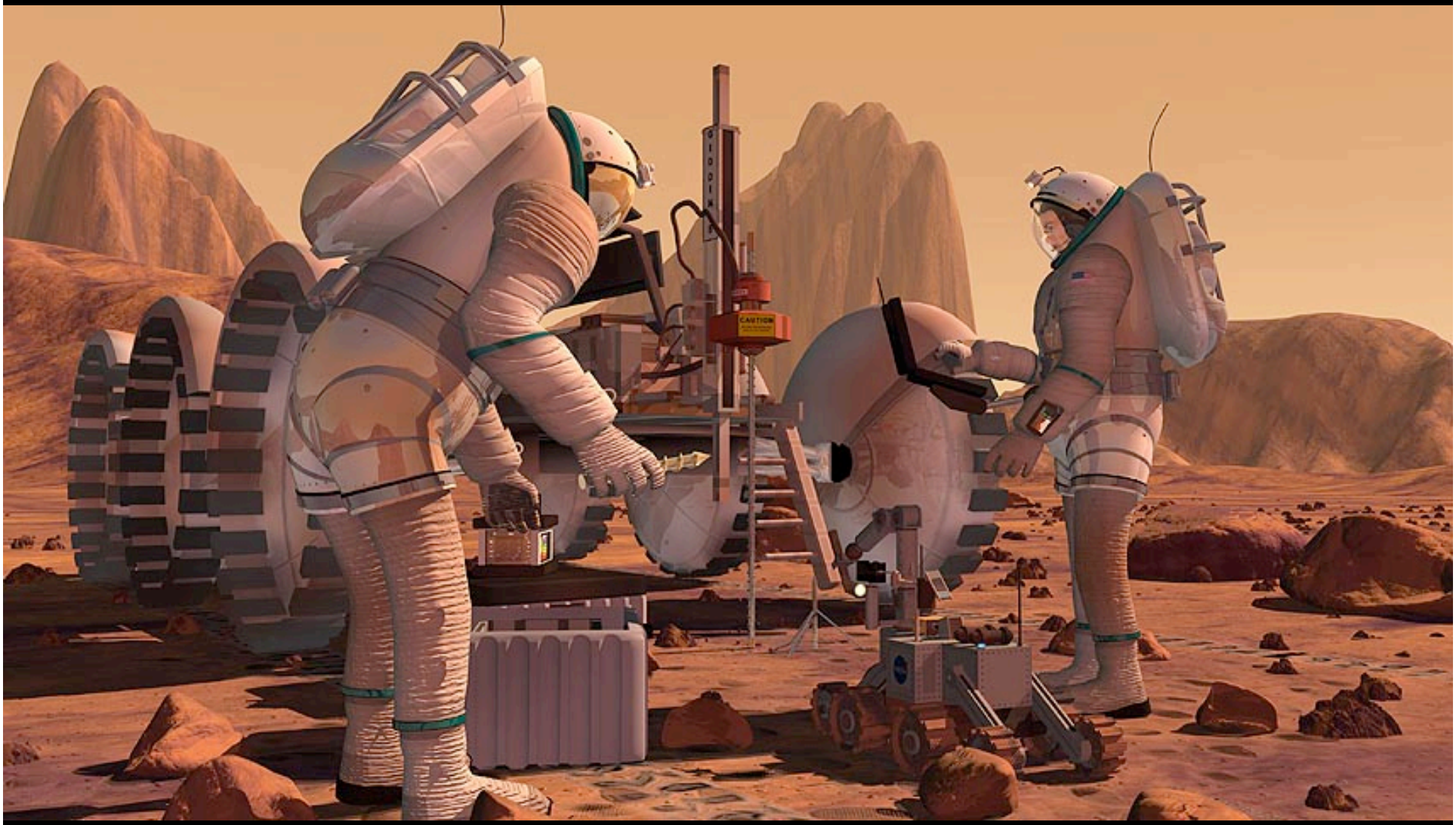
Robot on ledge tracks Astronauts & takes photos when commanded



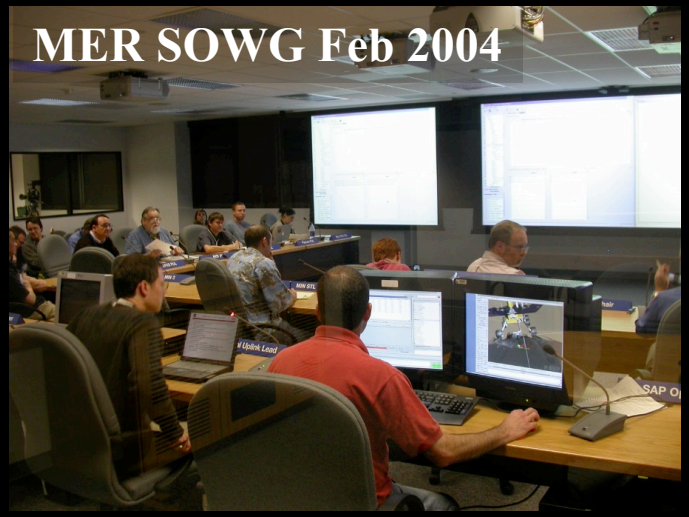
Robot in "follow me" mode

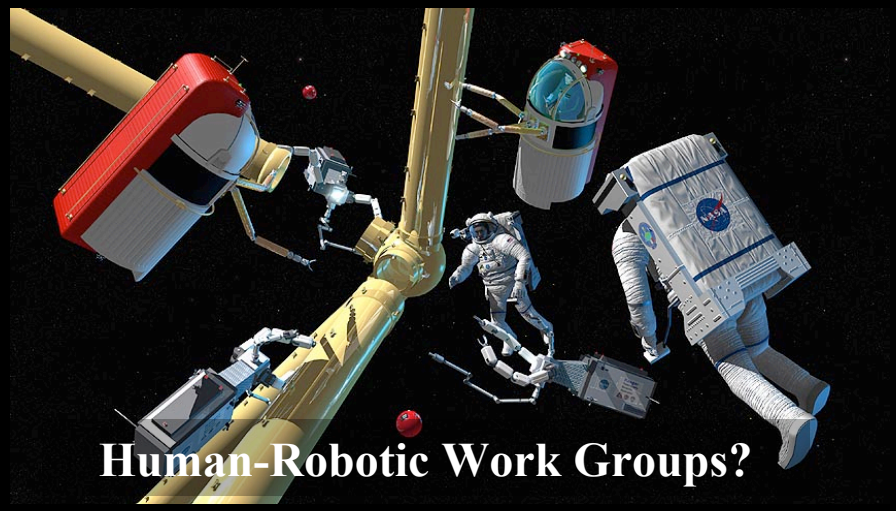
Voice annotation is recorded and transmitted to database in habitat & to RST on earth

Recommendations



A Key Point





Scientific understanding of the *differences* between present technology and people is essential for both exploiting and improving computational tools

What is Collaboration? Teamwork? Decision making?

For more information…

- *http://bill.clancey.name*
  - Simulating Activities
  - Field Science Ethnography
  - Automating CapCom
  - Roles for Agent Assistants in Field Science
  - Multiagent Modeling and Simulation in Human-robotic Mission Operations Work Systems Design (Sierhuis, et al.)
  - Agent-based Modeling of Collaboration and Work Practices Onboard the ISS (Acquisiti, et al.)
- *www.agentisolutions.com*
  - Brahms download & refs

Robotic tool (left); Scientist (right)