Opportunities for Model-Based Learning Systems in the Human Exploration of Space

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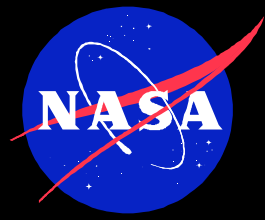
Outline



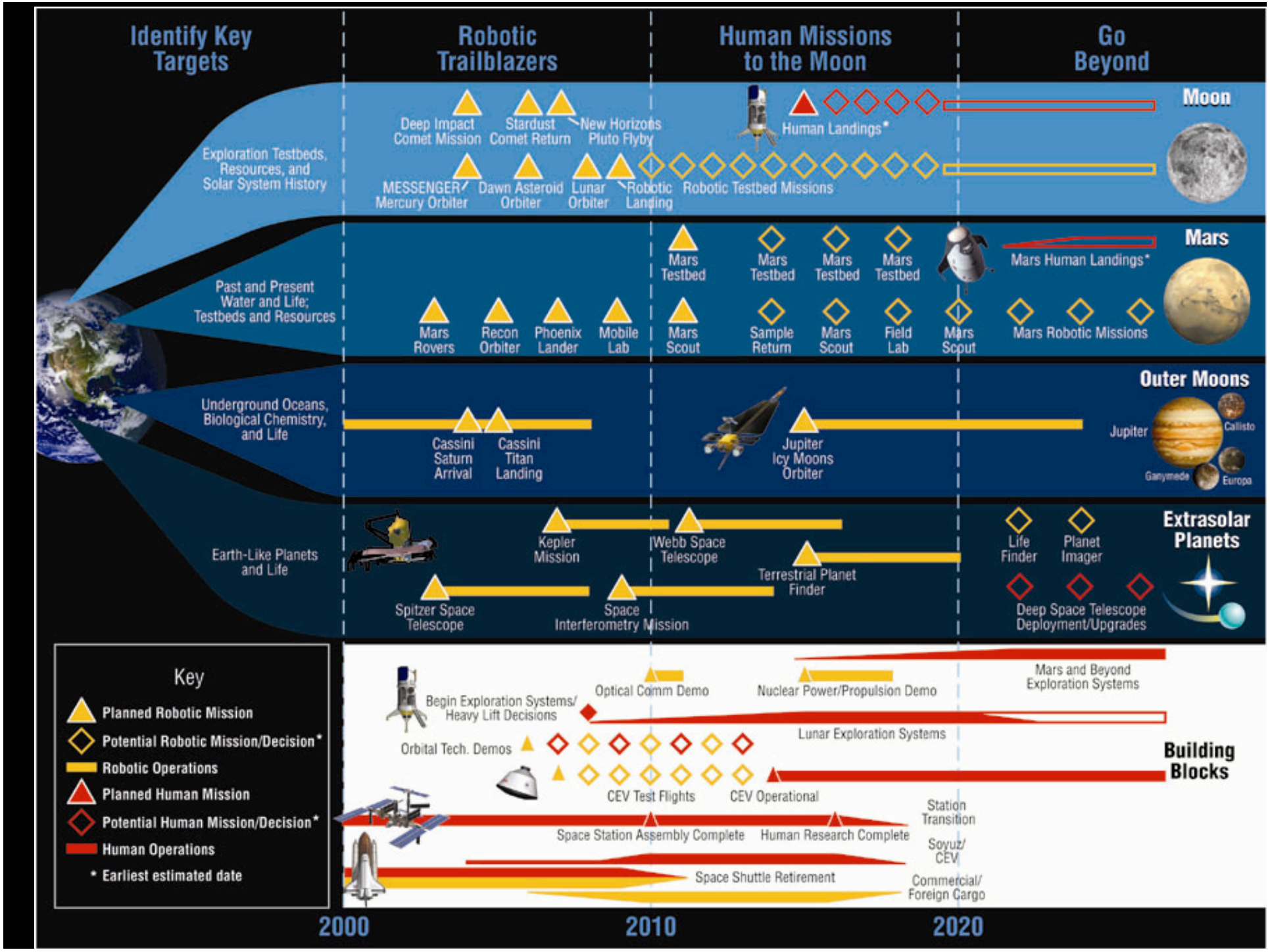
This presentation relates the various themes of ITS to new plans for the human-robot exploration of space

- NASA's Exploration Vision
- Astronauts as Students
  - The Hubble Repair Training System
- Foundations for Revitalizing ITS at NASA
  - BrahmsVE & Mobile Agents
  - Future Trends and Opportunities


The NASA Vision
To improve life here,
To extend life to there,
To find life beyond.
The NASA Mission
To understand and protect our home planet
To explore the universe and search for life
To inspire the next generation of explorers
...as only NASA can

New Space Exploration Vision

- *Implement* sustained & affordable human/robotic program to explore the solar system and beyond
- *Extend* human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations
- *Develop* the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration
- *Promote* international and commercial participation in exploration to further U.S. scientific, security, and economic interests.


Identify Key Targets
Robotic Trailblazers
Human Missions to the Moon
Go Beyond
Moon
Exploration Testbeds, Resources, and Solar System History
Deep Impact Comet Mission
Stardust Comet Return
New Horizons Pluto Flyby
Human Landings*
MESSENGER Mercury Orbiter
Dawn Asteroid Orbiter
Lunar Orbiter
Robotic Landing
Robotic Testbed Missions
Mars
Past and Present Water and Life; Testbeds and Resources
Mars Testbed
Mars Human Landings*
Mars Rovers
Recon Orbiter
Phoenix Lander
Mobile Lab
Mars Scout
Sample Return
Field Lab
Mars Robotic Missions
Outer Moons
Underground Oceans, Biological Chemistry, and Life
Cassini Saturn Arrival
Cassini Titan Landing
Jupiter Icy Moons Orbiter
Jupiter
Callisto
Ganymede
Europa
Extrasolar Planets
Earth-Like Planets and Life
Kepler Mission
Webb Space Telescope
Terrestrial Planet Finder
Life Finder
Planet Imager
Spitzer Space Telescope
Space Interferometry Mission
Deep Space Telescope Deployment/Upgrades
Key
Planned Robotic Mission
Potential Robotic Mission/Decision*
Robotic Operations
Planned Human Mission
Potential Human Mission/Decision*
Human Operations
* Earliest estimated date
Begin Exploration Systems/ Heavy Lift Decisions
Optical Comm Demo
Nuclear Power/Propulsion Demo
Mars and Beyond Exploration Systems
Lunar Exploration Systems
Orbital Tech. Demos
Building Blocks
CEV Test Flights
CEV Operational
Station Transition
Space Station Assembly Complete
Human Research Complete
Soyuz/ CEV
Space Shuttle Retirement
Commercial/ Foreign Cargo
2000
2010
2020

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
- Comprehensive ground support “coach in your ear”

Astronaut Basic Training

- Pilot & SCUBA Certification
- Manuals
- Classes: basic science and technology: mathematics, geology meteorology, guidance and navigation, oceanography, orbital dynamics, astronomy, physics, and materials processing
- CBT Orbiter Systems
- Single Systems Trainer
- Part-Task Trainers
- Shuttle Mission Simulators
- Neutral Buoyancy Lab
- Shuttle Training Aircraft

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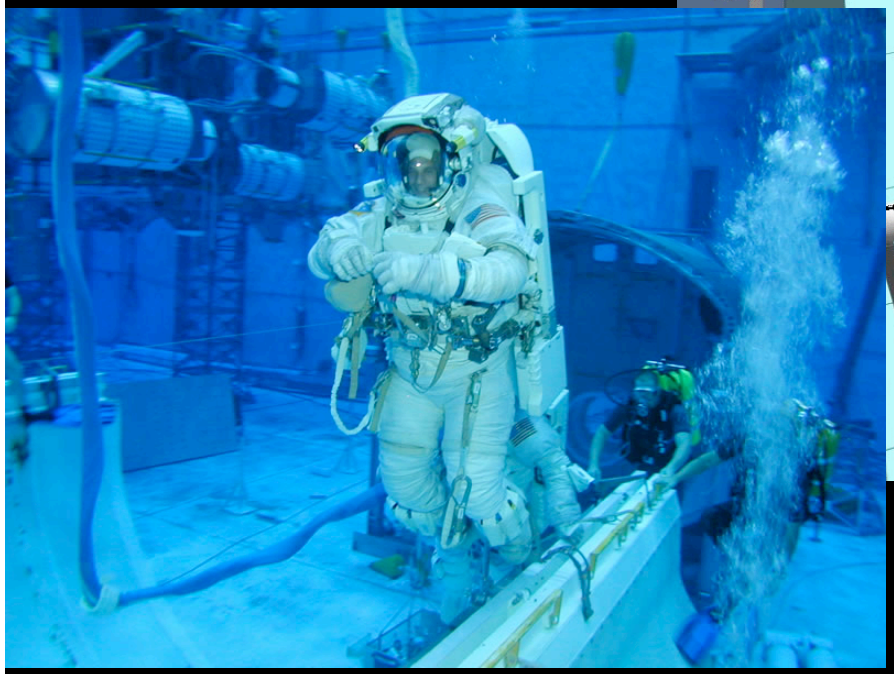
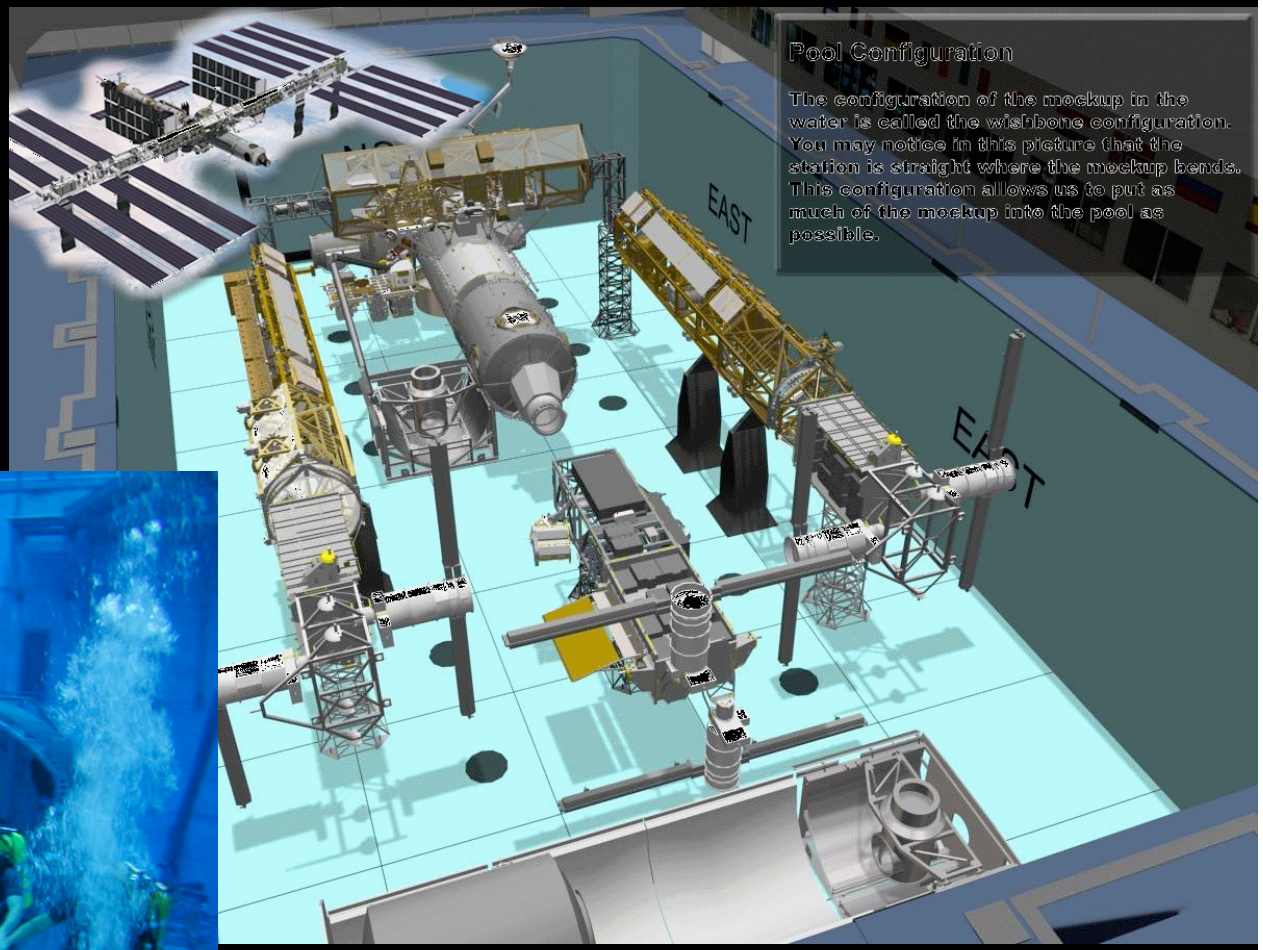
Neutral Buoyancy Lab

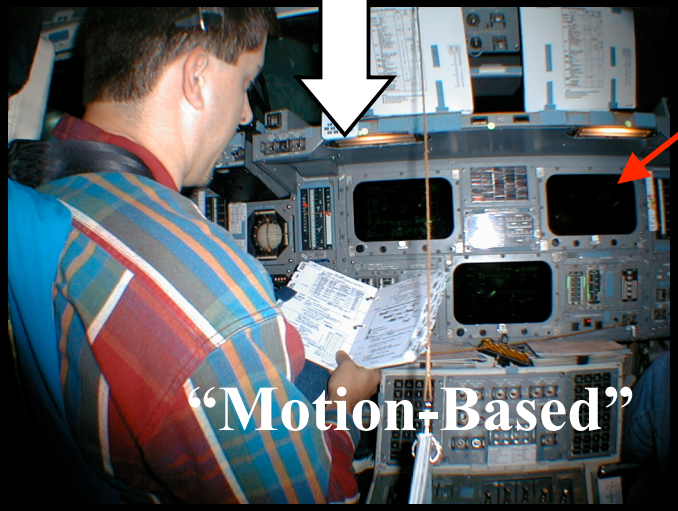
NASA

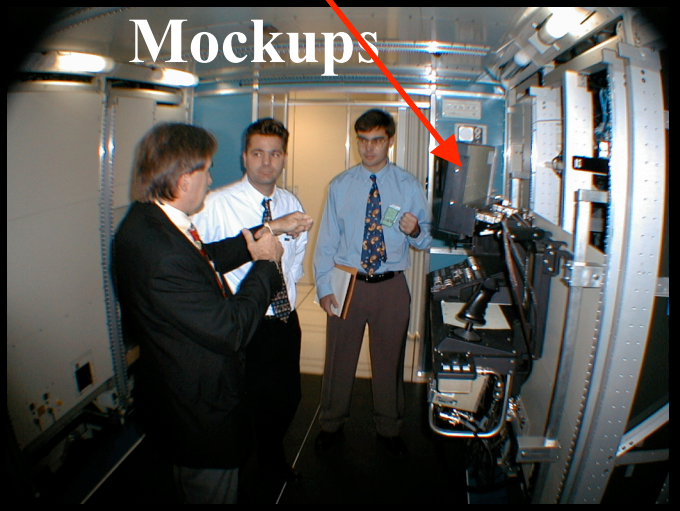
Training simulation of weightless EVA operations





Varieties of Simulation





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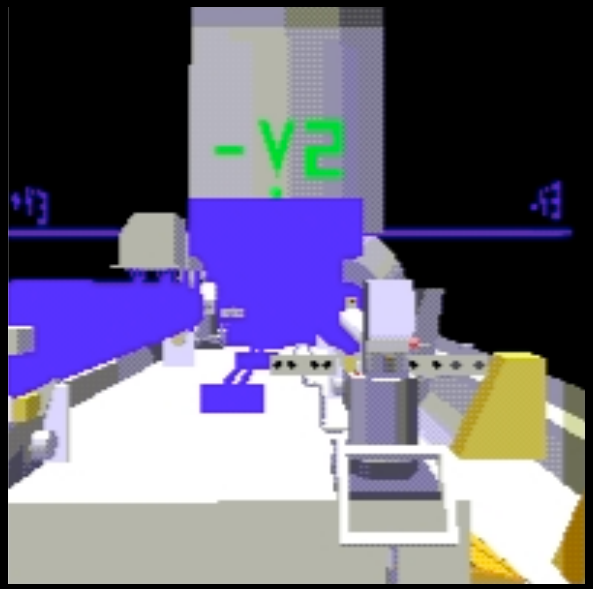
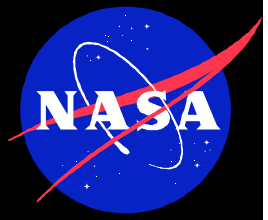
Bowen Loftin's Hubble VE



- 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.

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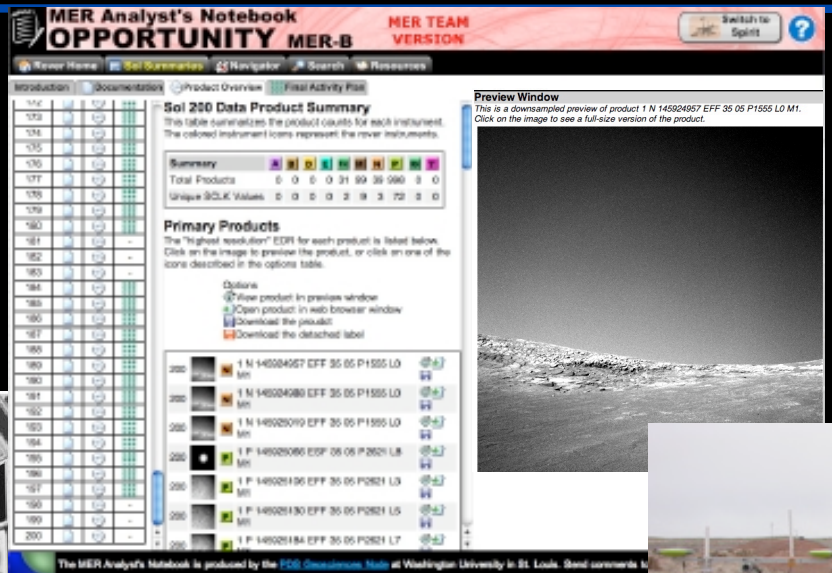
Technology Foundations for Revitalizing ITS at NASA

NASA

MER
Work System Design
& Evaluation



Mobile Agents

BrahmsVE
Human-Robotic
Systems

- Web-based systems for representing and sharing scientific discoveries
- Virtual environments for design and training of human-robotic systems
- Multiagent systems using NL for life support and surface exploration

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ISS Assembly Training

DigitalSpace & NASA Collaboration 2004

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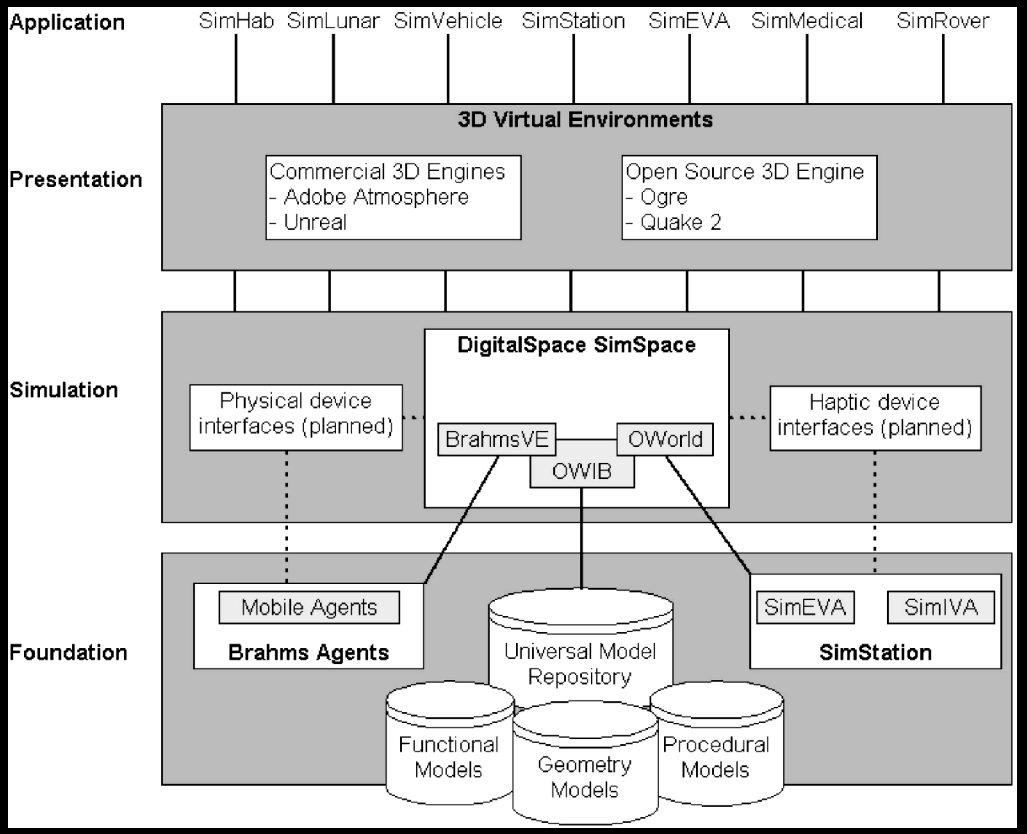
BrahmsVE Architecture

- **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

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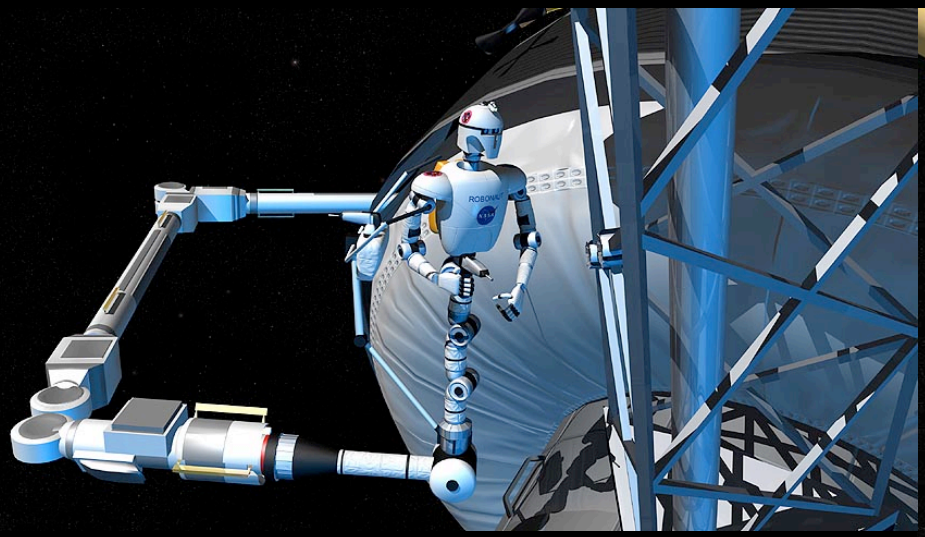
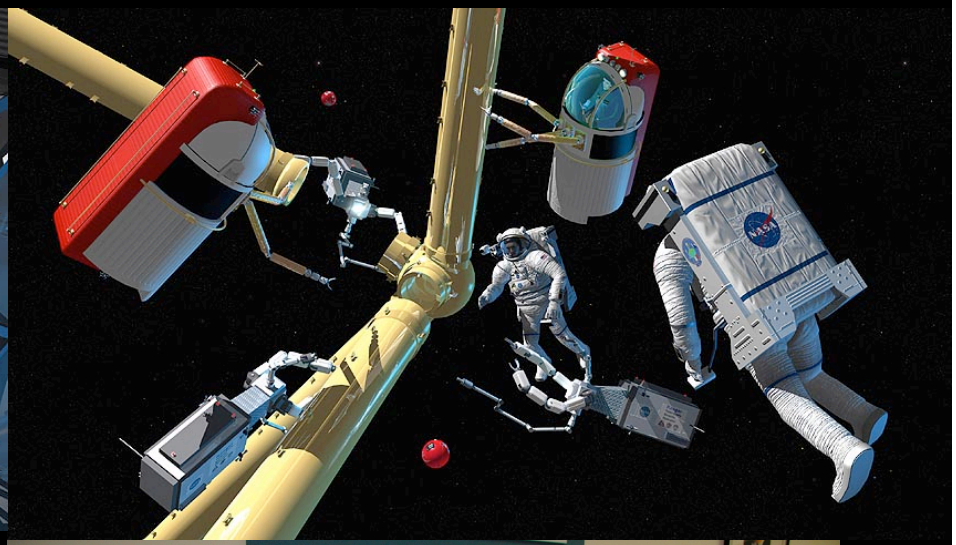
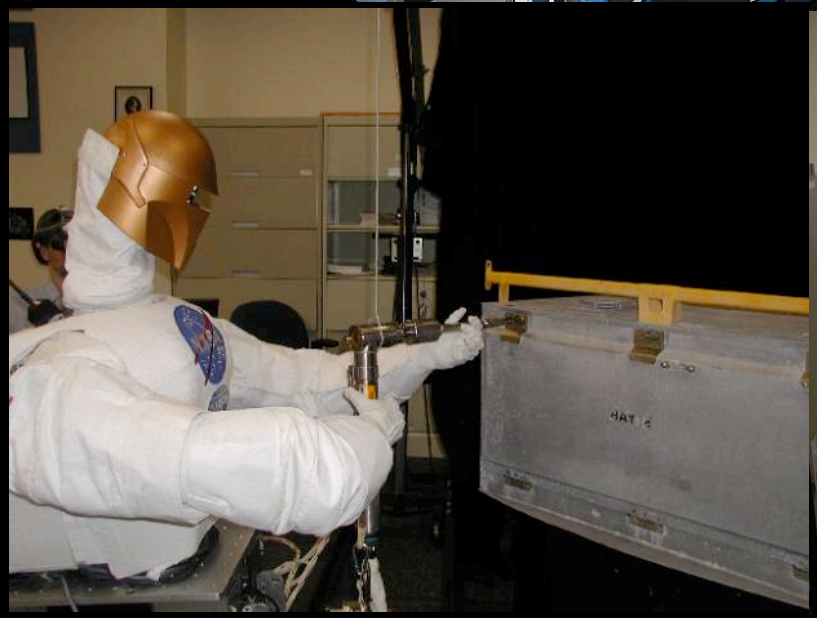
Robonaut: From Teleop to Teams







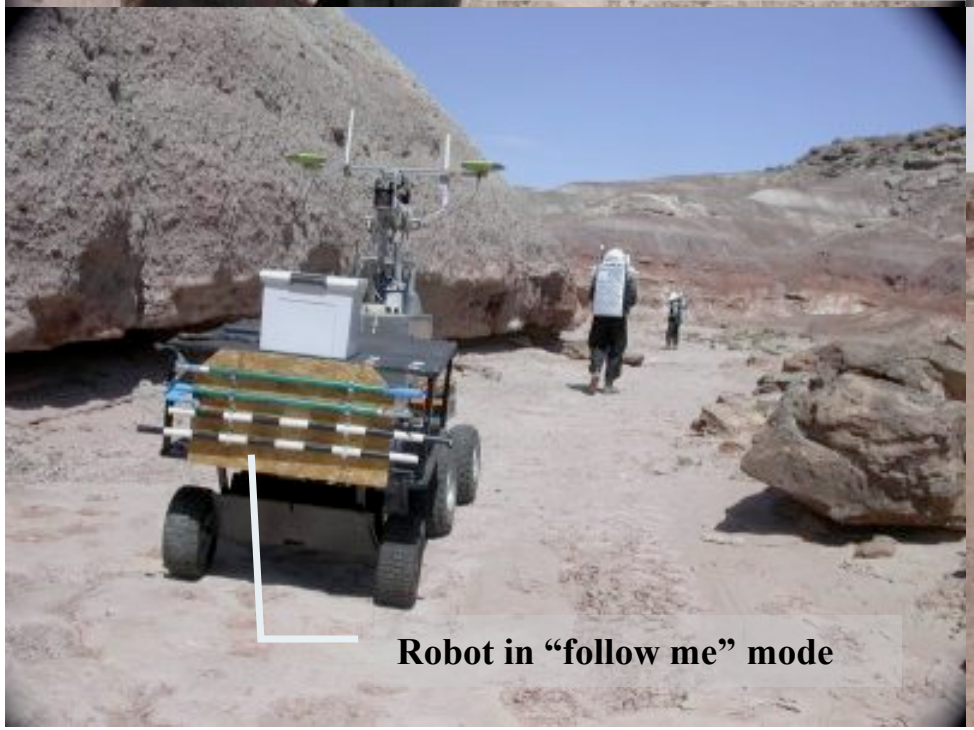
Mobile Agents
Utah Field Test 2004

Geologists in Lith Canyon with EVA Robotic Assistant

- 50 Participants; 17 days; 3 NASA centers & 2 universities
- Two diverse scenarios
- ERA (work cart,video monitor, pancam, relay) integrated with astronaut operations
- Crew collaboration with well-organized RST
- Contextual voice commanding
- EVA data stored automatically in shared database (RST email)
- Change batteries & continue; restart agents

Astros can work fully in parallel, talking to personal agents

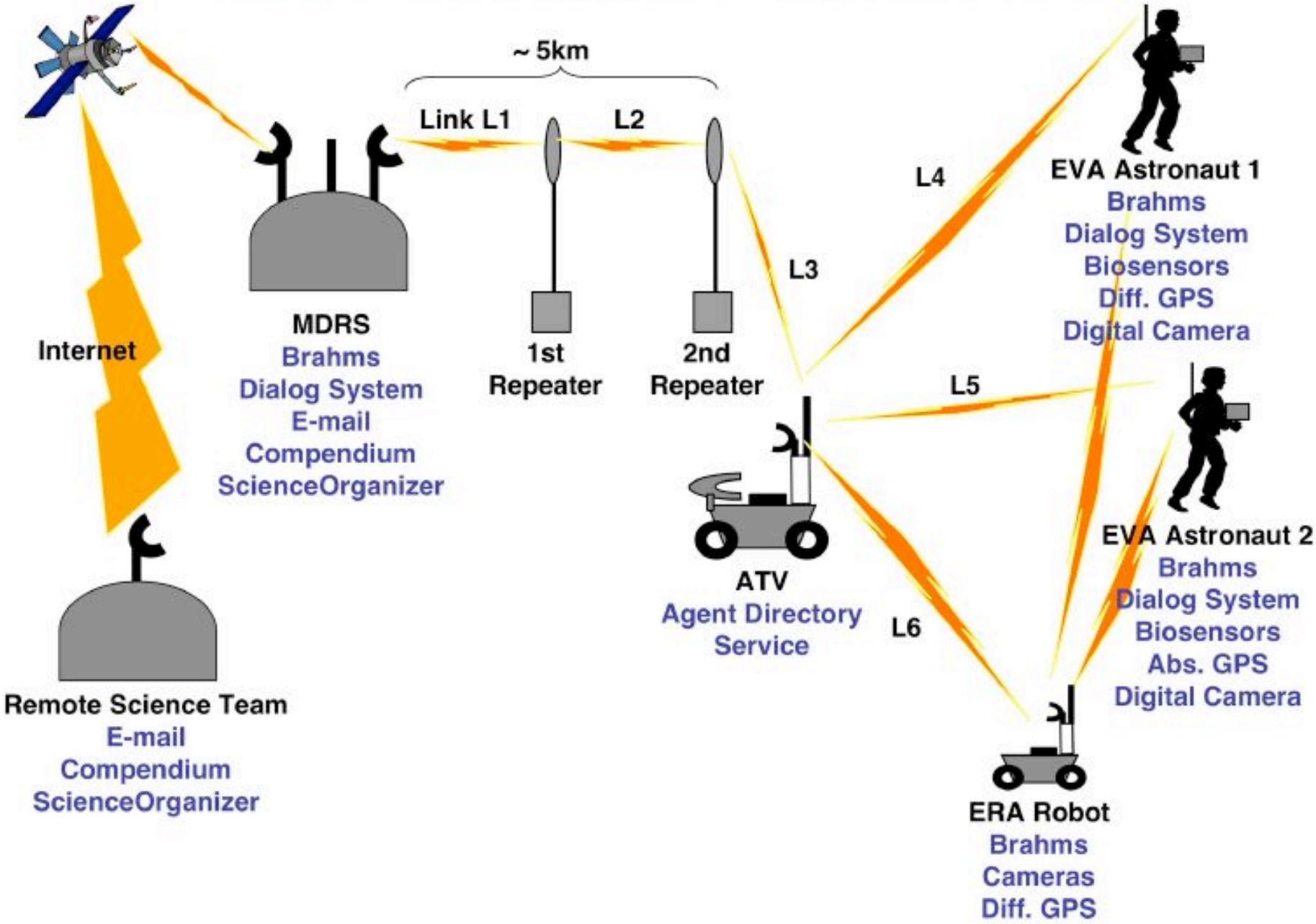
Robot on ledge tracks
Astronauts & takes photos when commanded



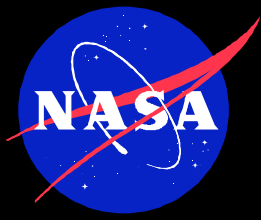
Robot in “follow me” mode

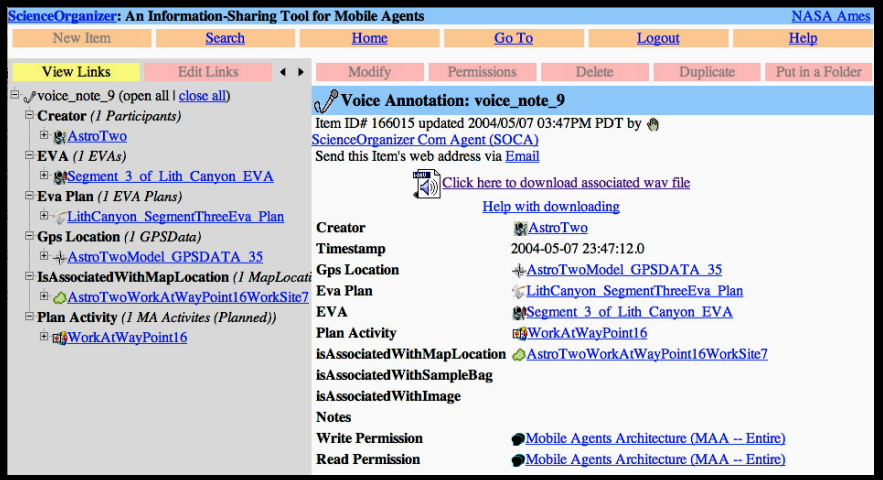
Voice annotation is recorded and transmitted to database in habitat & to RST on earth

Mobile Agents at MDRS



From Mars to Desktop





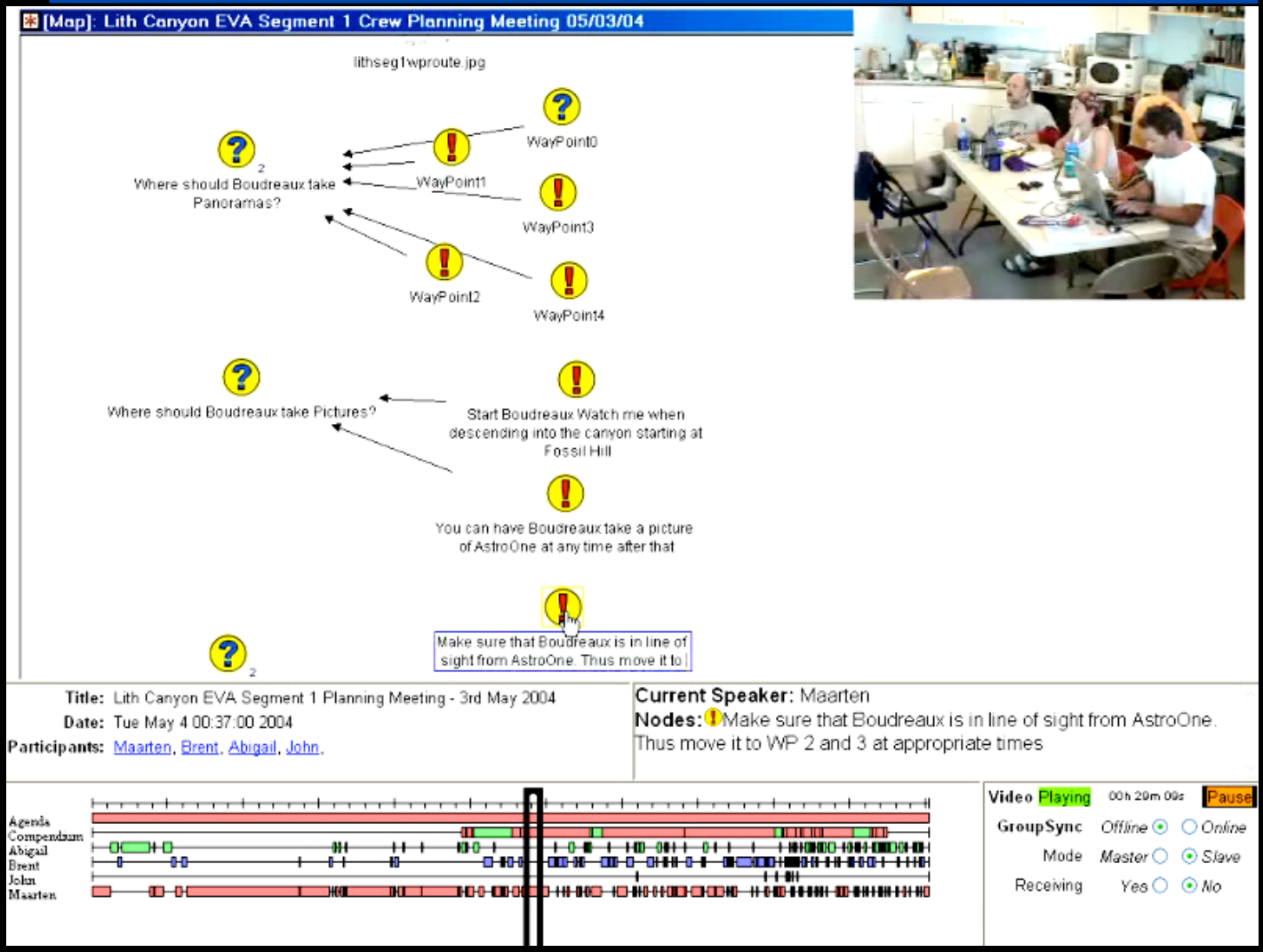
From: capcom@agentisolutions.com
Subject: MDRS New VoiceAnnotation: voice_note_9
Date: May 7, 2004 3:47:36 PM PDT
To: mdrs_rst@agentisolutions.com

New VoiceAnnotation: voice_note_9
EVA Plan: LithCanyon_SegmentThreeEVA_Plan
Activity: WorkAtWayPoint16
Creator: AstroTwo
TimeStamp: 05/07/2004 23:47:12
File Name: voice_note_2004-4-7_23-46-28.wav

Latitude: 3827.3077 NORTH Longitude: 11047.4074 WEST Northing: 4256335.2693082085 Easting: 518312.1563357575 Zone: 12S

ScienceOrganizer Link :
https://marst.arc.nasa.gov/org/166015

EVA Collaborative Planning



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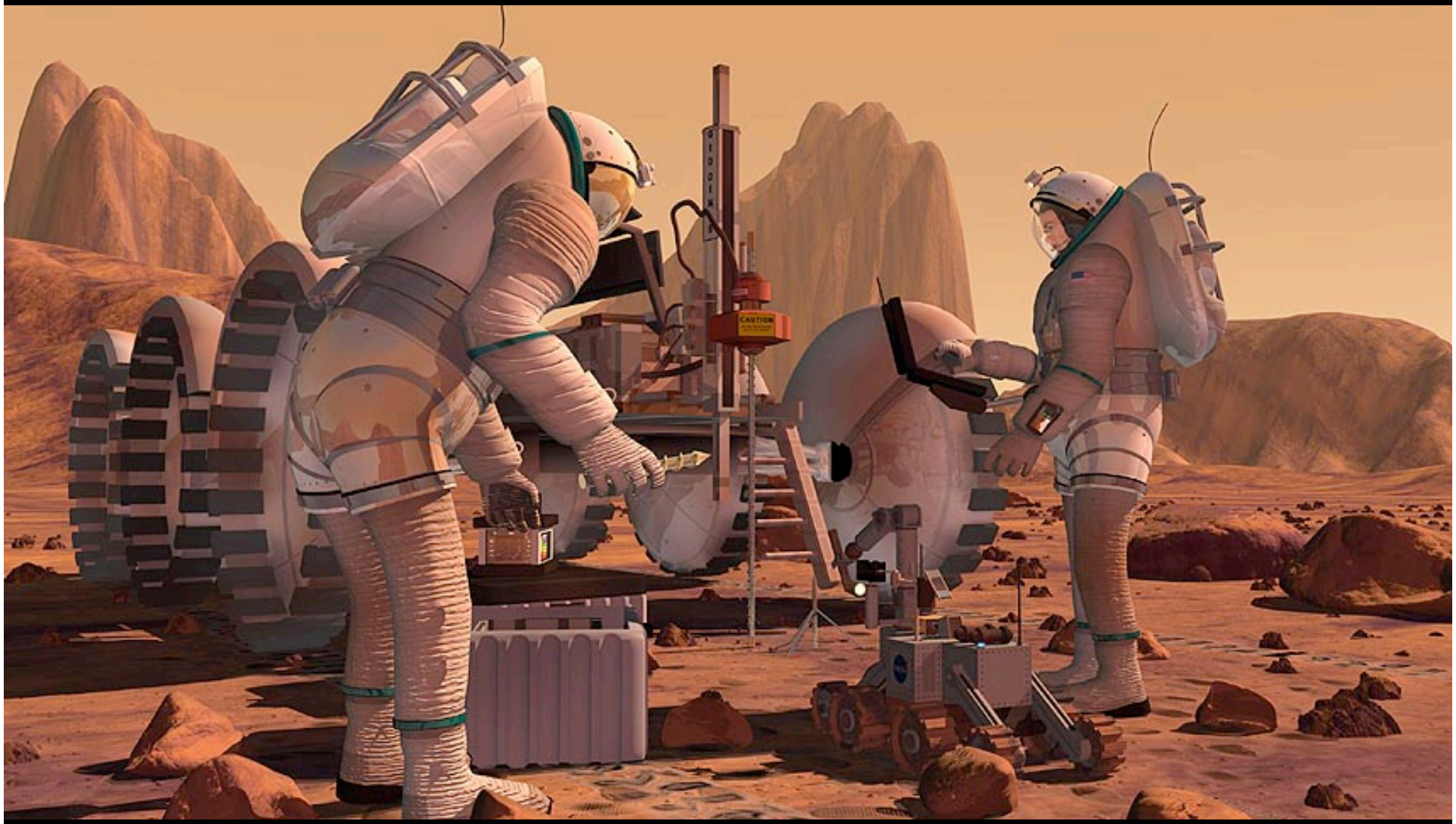
Future Opportunities



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Key Points

Best opportunity: Job performance aids ("intelligent agents") that scaffold less experienced operators/astronauts & adjust to developing practices

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For more information…

- *http://bill.clancey.name*
  - Simulating Activities
  - Field Science Ethnography
  - Automating CapCom
  - Roles for Agent Assistants in Field Science
  - Mobile Agents (Flairs)
- *http://www.marssociety.org/MDRS/fs03*
  - "Mission Info"
  - Daily reports
  - Photographs
- *www.agentisolutions.com*

Devon Island, FMARS 2001