

NASA
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

Infectious Disease Dx (Mycin)
Manufacturing Dx (Sacon)
Pulmonary Function Dx (Puff)

EMYCIN

Domain Rule
Interpreter

Dynamic
Knowledge:

Case facts
&
Reasoning
traces

GUIDON

Dialogue
Records & Plans

TUTORING
RULES

Overlay Student
Knowledge Model

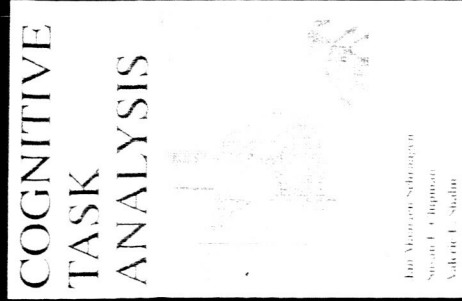
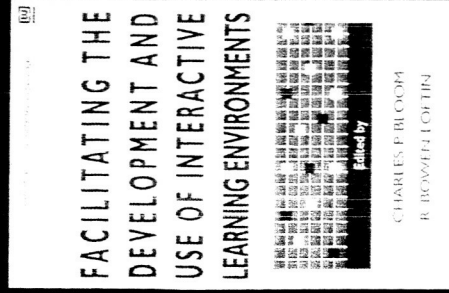
Consultation Client

Student

ITS Successes (30 Years)



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



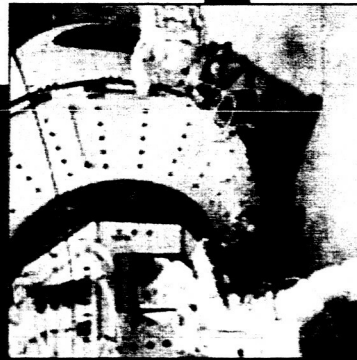
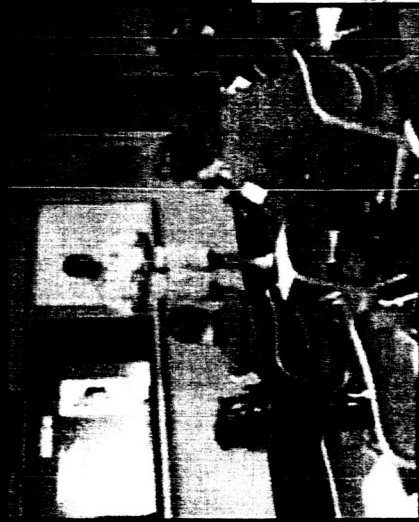
TRAINING FOR TOMORROW

INTELLIGENT | ADAPTIVE | COLLABORATIVE

Astronauts as Students

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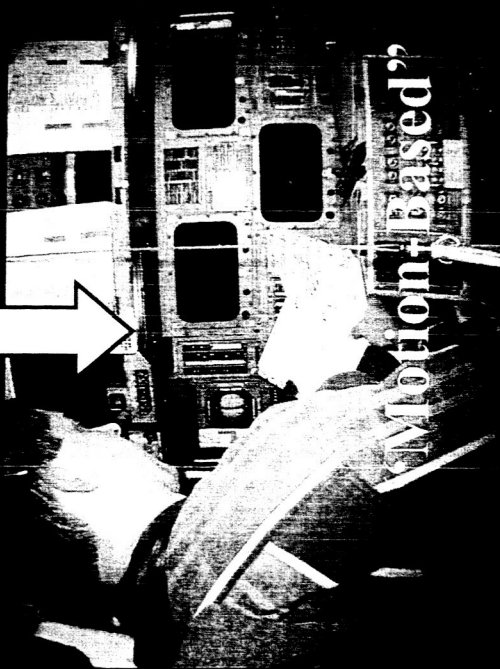
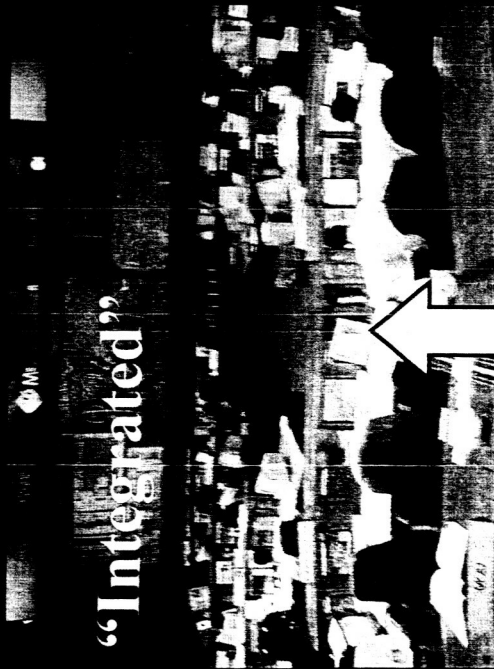
- Multiple PhDs/MD
- Insufficient time from specs to flight to formalize domain knowledge
- Highly procedural, mission critical, manipulative skills
- “Practicing understanding”
- Tasks open to alternatives
- CBT with personal tutors
- Comprehensive ground support “coach in your ear”



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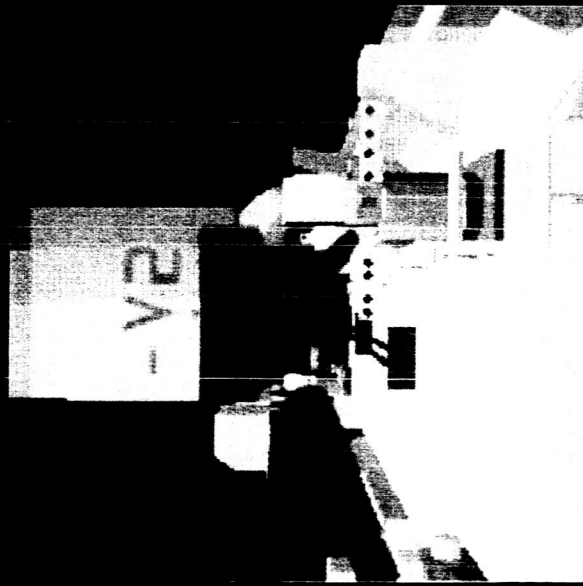
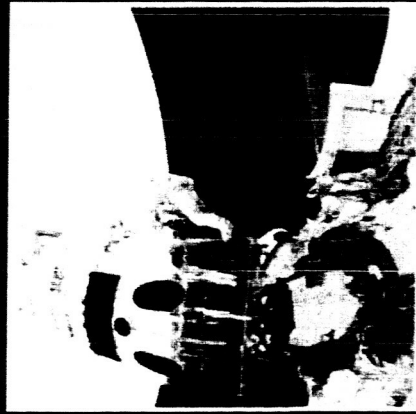
Varieties of Simulation Training

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Bowen Loftin's Hubble VE NASA

- 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

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*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 Composer - Time Line View

File Edit View Model Build Run Options Window Help



Agent Viewer



- Communicator Group
- Communicator Group
- Communicator Group
- Communicator Group

Type Group

- MER_Mission_Team
- Integrated Sequencing Team (IST)
- MPL_Team
- Mission_Control_RTO_Team
- Mission_Managers
- MPT
- Science_Team
- SOST
- Payload_Element_Leads
- PDL
- PUL
- SDC
- SOST Downlink Coordinator (A)
- SOST Downlink Coordinator (B)
- SOWG
- Documentarians
- SAP Operators
- SOWG Chairs
- Science Uplink Representative
- Science Uplink Representative
- SOWG Chair (MER A)
- SOWG Chair (MER B)
- STG
- AtmosphericSci_Theme_Group
- Theme Group Scientist (ME)
- Theme Group Scientist (ME)
- Geology Theme Group
- Geology Theme Group
- Long Term Plan Theme Group
- Long Term Plan Theme Group
- Long Term Plan Theme Group
- Long Term Plan Theme Group
- Theme Group Lead (MER)
- Theme Group Lead (MER)

Science Work Room

10/17/2004 04:30:00 PM

Ge...

05:30:00 PM

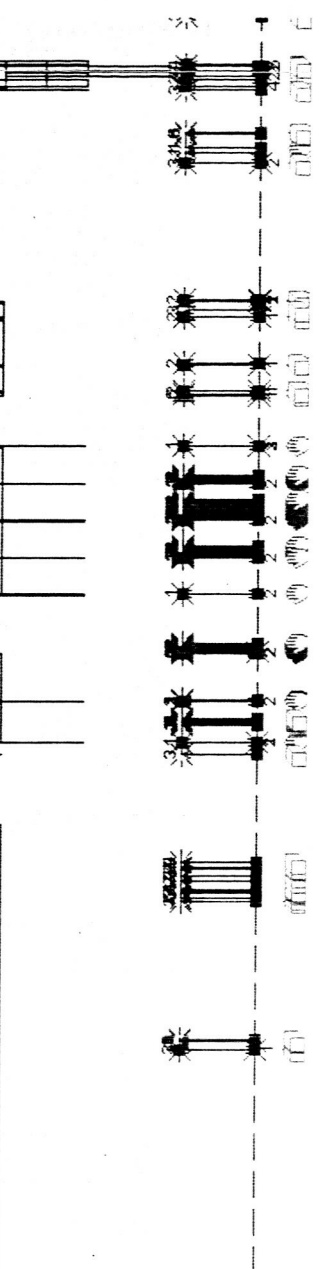
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Sequence De

08:30:00

agent SOWG Chair (MER A)

wf: Science_Assessment_Observe_Plan	wf...	wf: SOWG_Meeting	wf...	wf:
ca: Science Asse...	ca: Circulate Amon...	ca: SOWG_Meeting	c...	pa:
wf: Science_Dow...	wf: Circulate_Amo...	wf: Under...	wf: R...	wf: Priorit...
ca: Science Downl...	ca: Listening to a T...	ca: Under...	ca: R...	pa: Priorit...
wf: ...	wf: ...	...	...	...
pa: l...	pa: ...	...	...	...



Science Wor

10/17/2004 04:30:00 PM

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07:30:00 PM

Sequence Wor

08:30:00

agent Theme Group Lead (MER A) - Long Term Planning

wf: Science_Assessment_Observe_Plan	wf: SOWG_Meeting	wf...	wf: Ac
ca: Science Assessment Observe Plan	ca: SOWG Meeting	c...	ca: Ac
wf: Science_DL_A...	wf: Cateq...	wf: L...	wf: Track_Activity_Decision_Tree
ca: Science Downl...	ca: Cateq...	pa: L...	pa: Tracking_Activity_Decision_Tree

Ready

line:

col:

ISS Assembly Training



00:00:00 - CMG changeout procedure for STS-114 - Cam 1

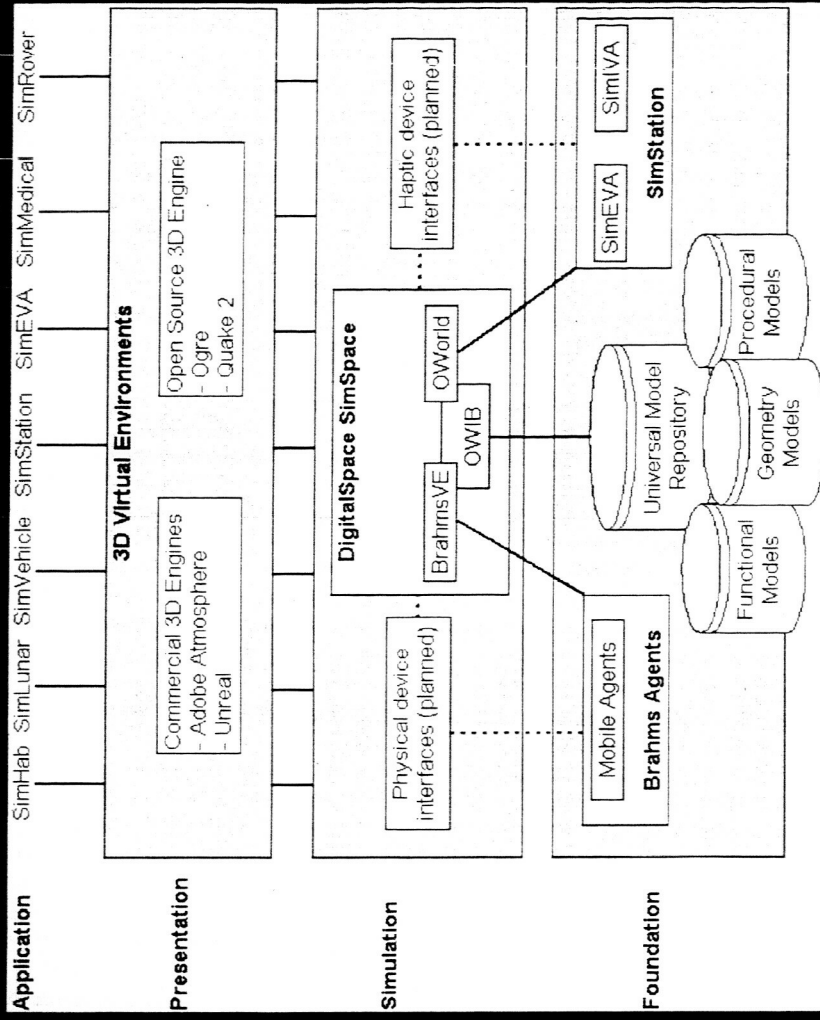
Camera
Automatic Camera

SimCMGChangeOut

2. Position old CMG on Ballstack
3. Attach old CMG to Ballstack
4. Prepare to approach LMC
5. Approach LMC
6. Detach CMG from LMC
7. Prepare to remove CMG from LMC
8. Remove CMG from LMC
9. Position new CMG on Ballstack
10. Attach new CMG to Ballstack
11. Move to old CMG
12. Detach old CMG from Ballstack
13. Prepare to approach LMC with old CMG

Cam 1 - CMG changeout procedure for STS-114

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"

Astro can work in parallel, talking to personal agents

Robot on ledge tracks Astronauts & takes photos when commanded

Mars Desert Research Station
Bratins
RIALIST
LKA
MEX
NREN
SciOrg

NASA Mobile Agents

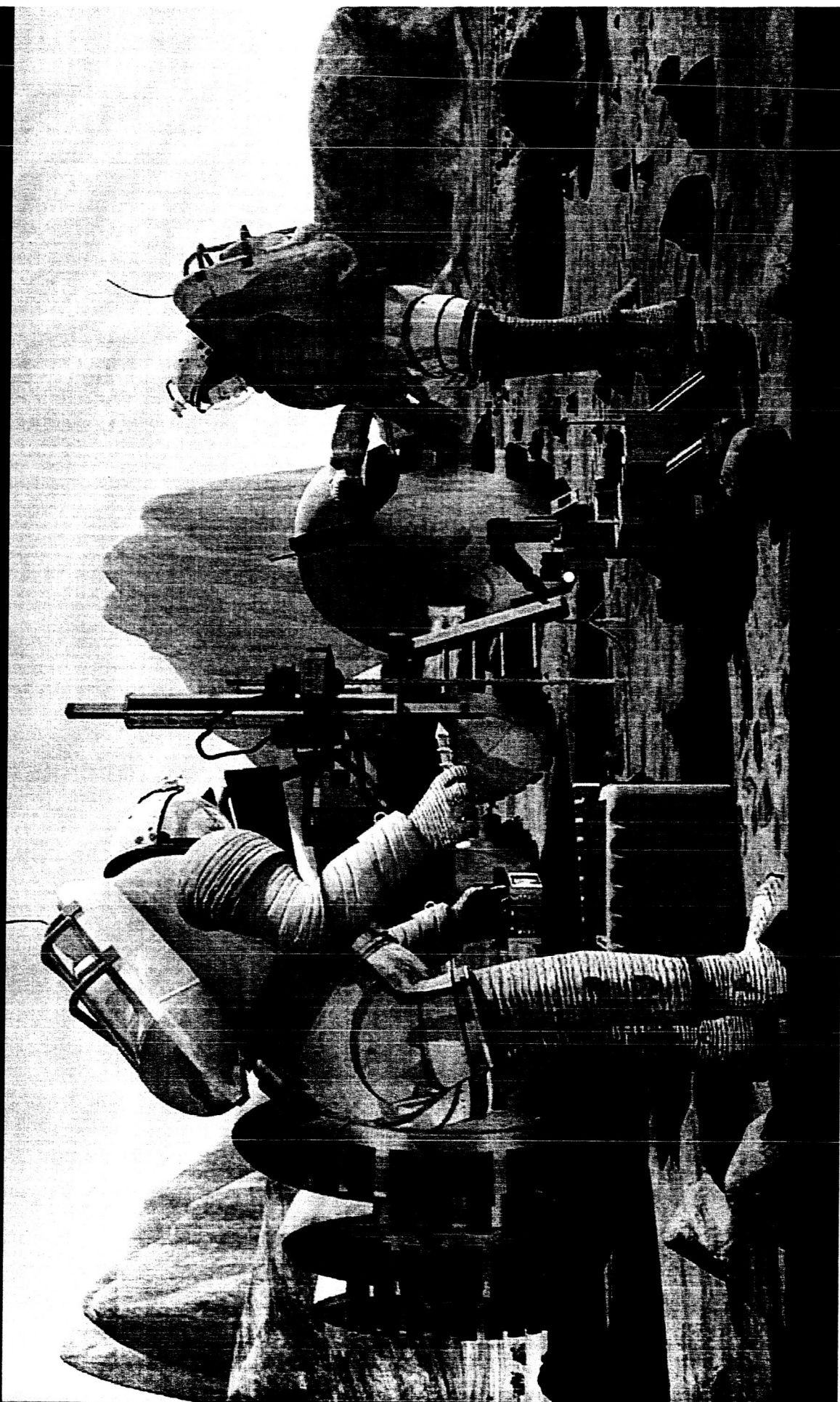
Voice annotation is recorded and transmitted to database in habitat & to RST on earth

Robot in "follow me" mode

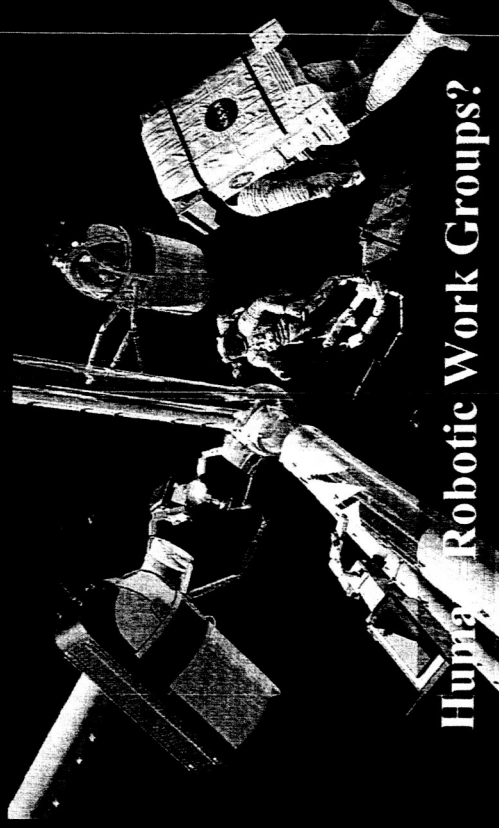
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Recommendations



A Key Point



Human-Robotic Work Groups?

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...

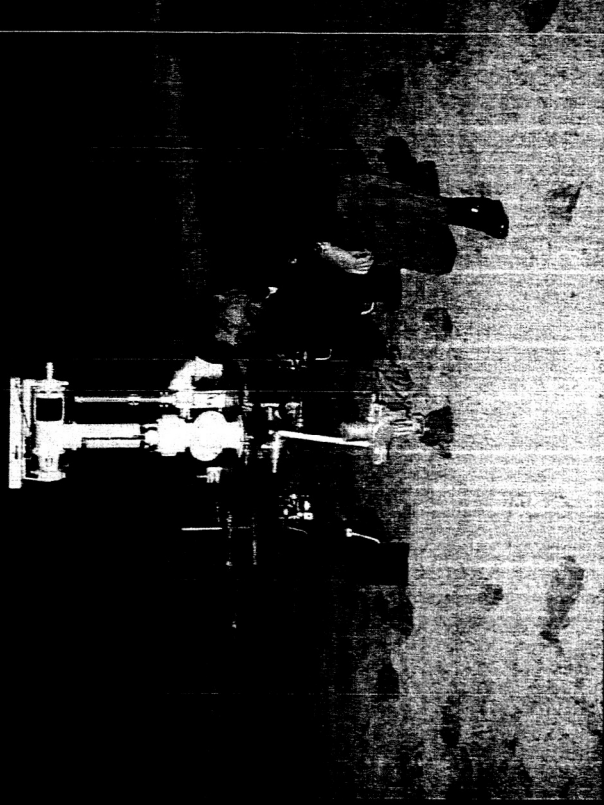
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<http://bill.clancey.name>

- 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)