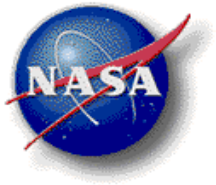


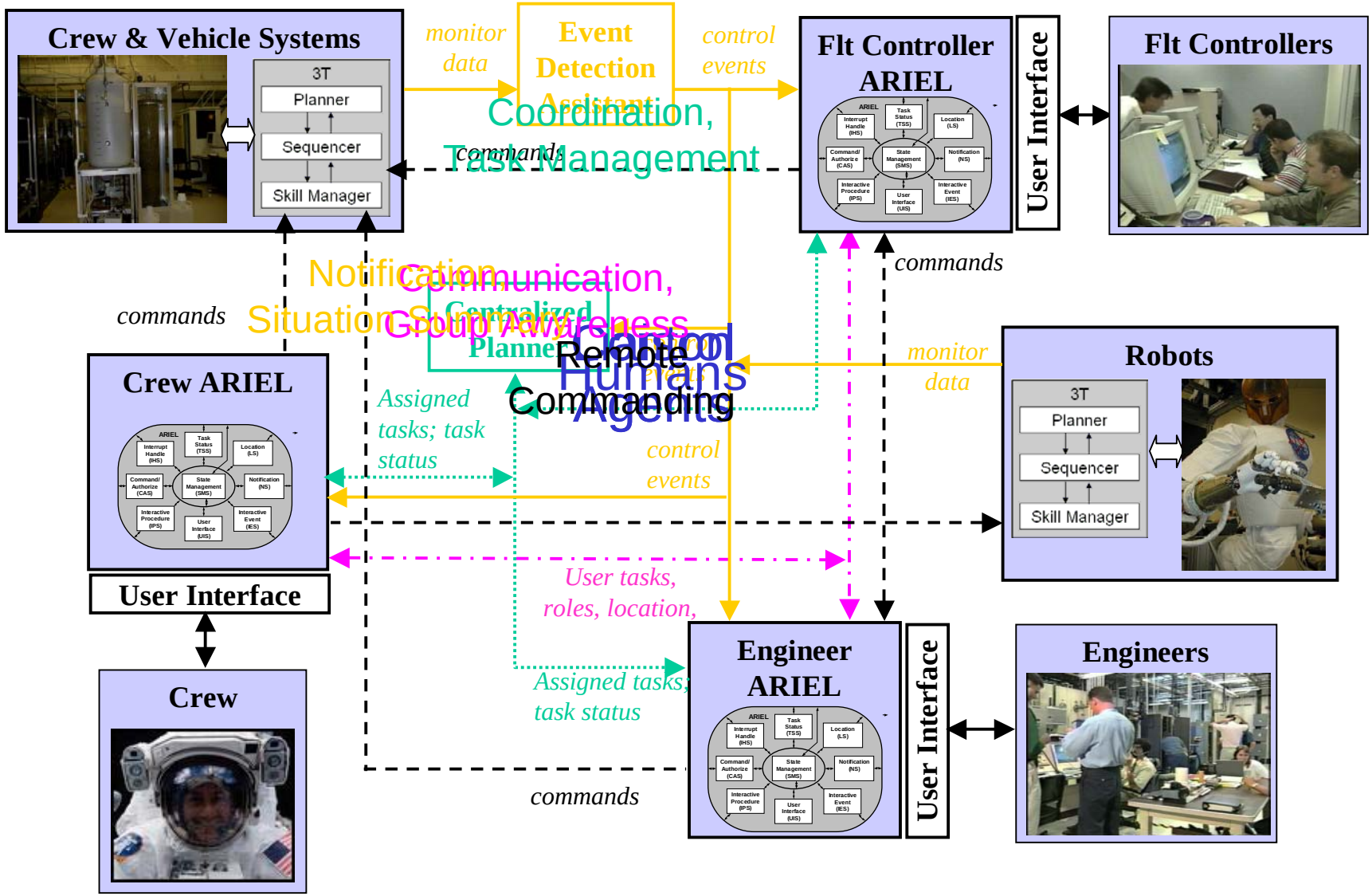
Distributed Crew Interaction with Advanced Life Support Control

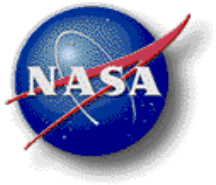
October 2003

NASA Johnson Space Center

Debra Schreckenghost, PI
Pete Bonasso
Tod Milam
Richard Day
Cheryl Martin
David Kortenkamp
Carroll Thronesbery

Human-Agent Community for Manned Space OPS



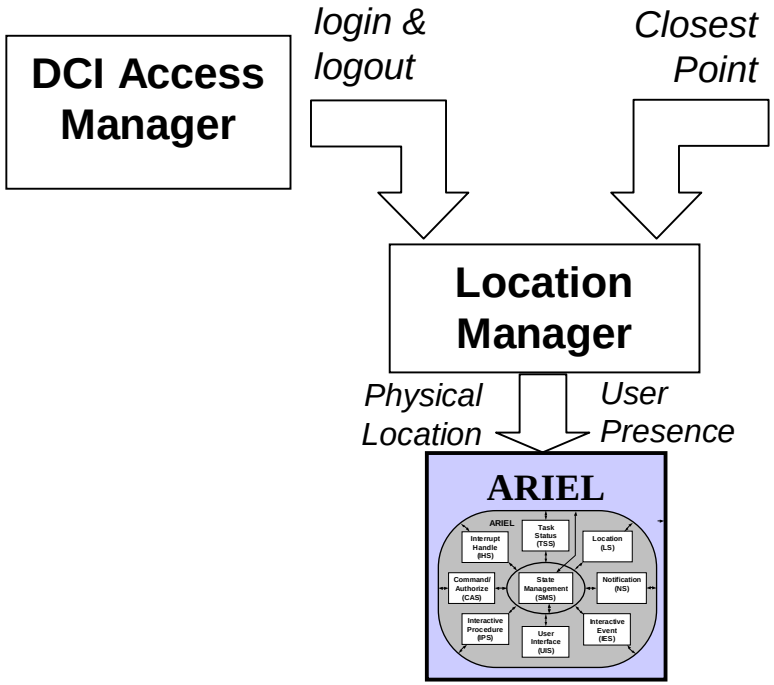


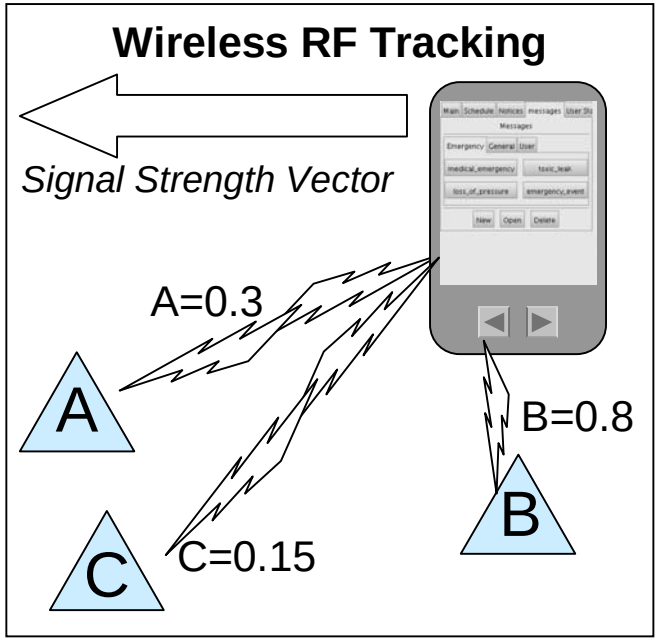
Models of Human-Agent Interaction

- **Human Interaction with Liaison Agent**
  - **Agent Reconfiguration**: Liaison agent can be configured for different user groups (e.g., crew versus ground controllers)
  - **Notification**: Agent uniformly notifies human using saliency annotations (latency, focus of attention) and modality
    - Research issue: Non-intrusive notification, including multi-modal interfaces
  - **Plan Management**: Agent updates human schedule in response to fault diagnosis, waiver of flight rule, unavailable human, and procedure tracking
- **Interaction between Human and Organization via Liaison Agent**
  - **Managing Organizational States and Policies**: Authorized human updates states and policies managed by the organization
    - Research issue: Managing flight rules as organizational policies
- **Interaction among Humans in a Group via Liaison Agent**
  - **Agent Communication:** Agent assists communication among humans
    - Quick Send Messages and Interactive Events: Human notifies the group quickly
  - **Awareness of Distributed Group**: Human tracks other team members
    - Service improvements (location, activity) provide better tracking of group
- **Remote Interaction with Agents**
  - **Wireless and Portable Computing**: Human uses handheld or tablet to interact with liaison agent

ARIEL Service: Location Tracking

- Key Technology: wireless radio frequency tracking, ontology mapping
- Maps location readings to physical location ontology
  - Tracks machine locations where users login/logout of ARIEL
  - Compute location using signal strength relative to wireless access points
    - Mobile platform measures signal strength from wireless access points
    - Measurements are matched to a signal strength map
    - Currently map to nearest access point; later triangulate the current position within a building
- Translates location readings and online/offline to user presence





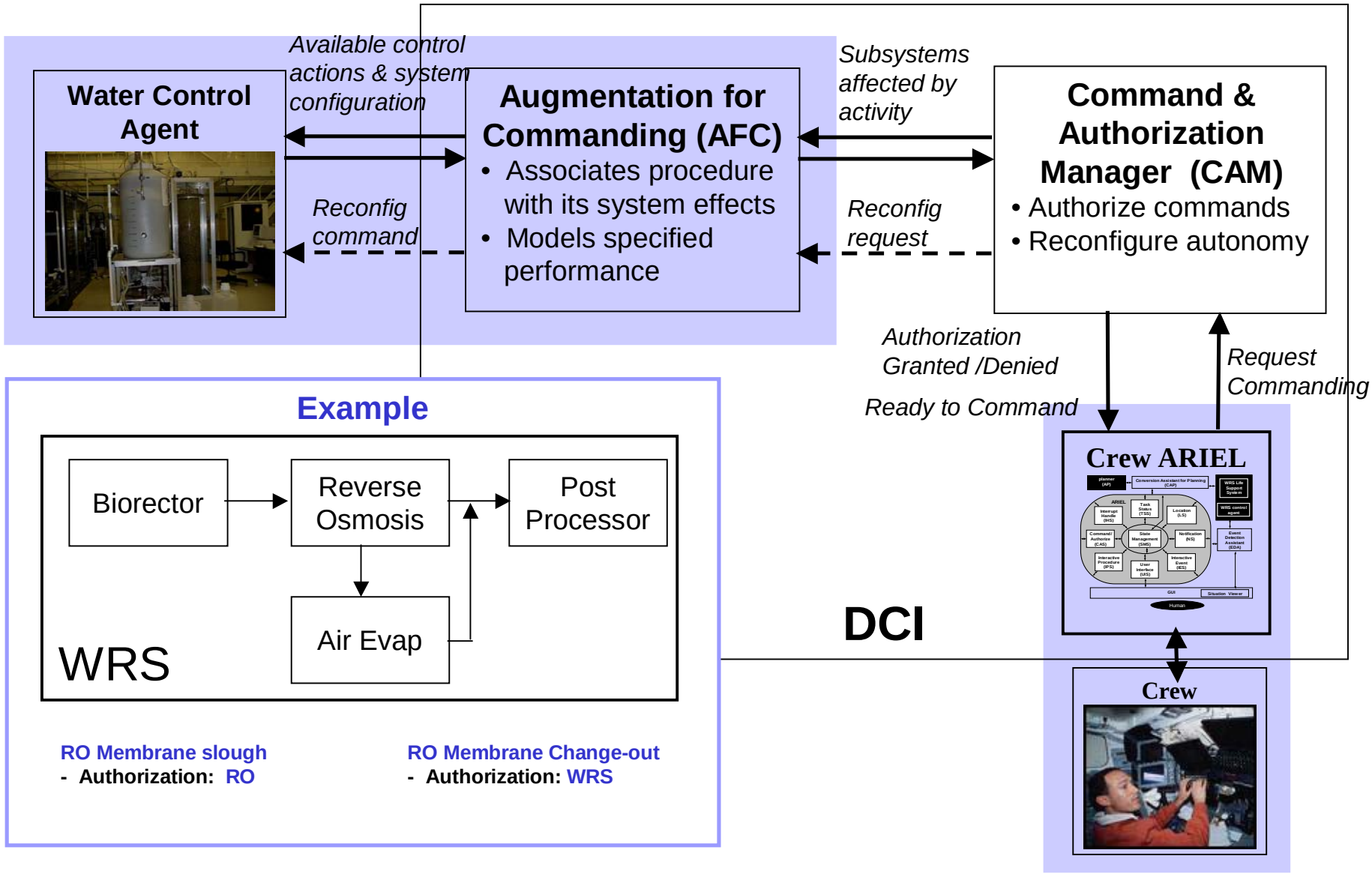
Models of Human-Agent Interaction

- **Interaction between Human & Control Agent via Liaison Agent**
  - **Remote Commanding**: Human interacts with hardware while autonomous control agent is active
    - Requires authorization of manual commands and reconfiguration of automation to prevent conflicts
    - Research issues
      - Dynamic allocation of task responsibility among humans and automation
      - Interleaving automated and manual tasks for joint tasking
  - **Situation Summarization**: Control agent informs human of important events, including anomalies
    - Detect complex event structure in data and reveal this structure to user in general viewer
    - Research issues
      - User specification of complex event patterns
      - Human guided search of data for engineering and operational analysis

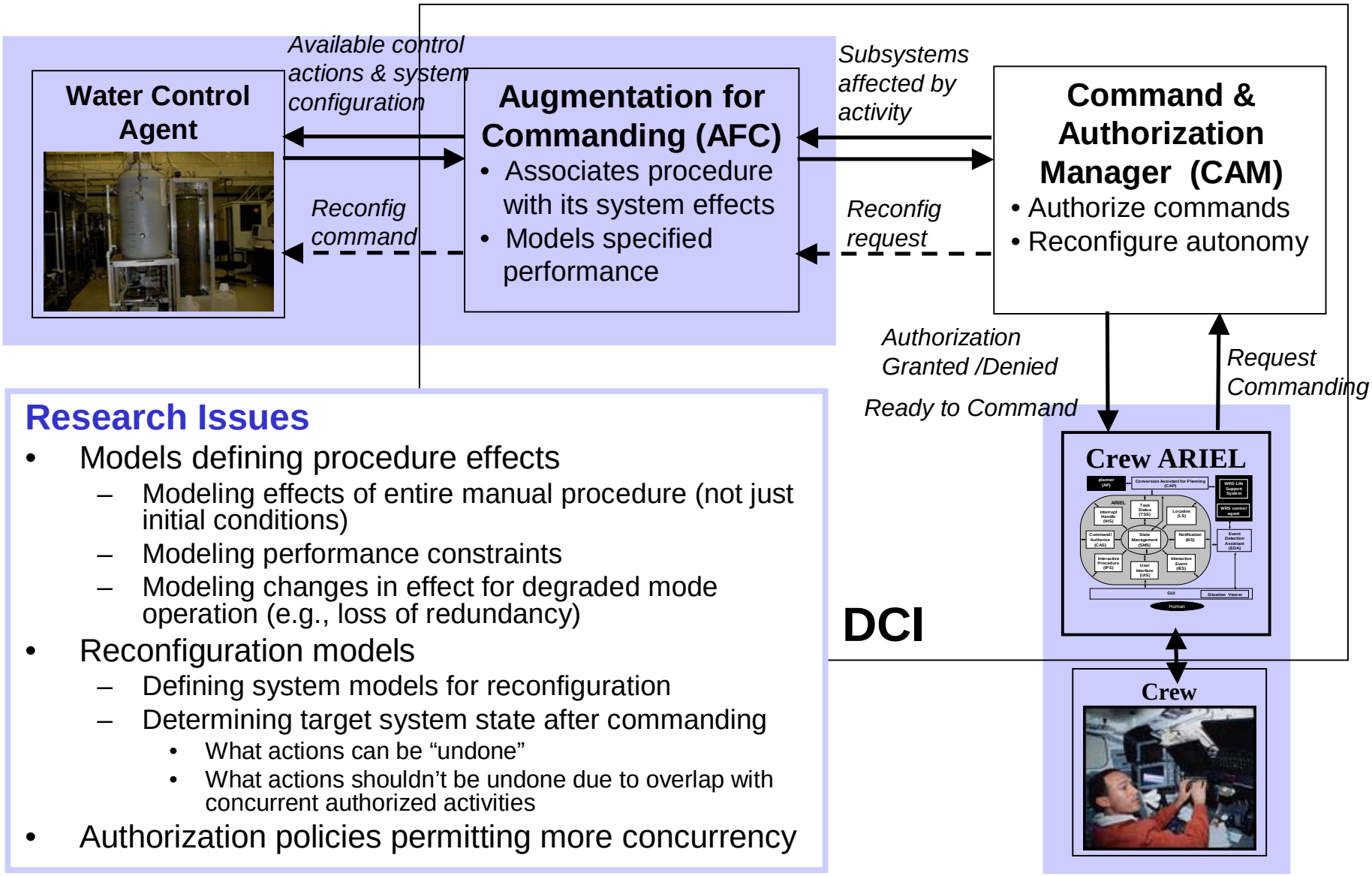
Command and Authorization Service

- Assist humans in distributed, concurrent commanding of systems normally managed by automated control agents
  - Grant authorization if requested procedure does not conflict with other ongoing activities
    - Constrain authorized actions based on the scope of their effects on a system and its constituent subsystems
    - Consider system operating configuration when determining scope of the effect (e.g., loss of capability can change scope of effect)
    - Reconfigure automated control agent to ensure compliance with authorization granted
  - Notify user requesting authorization
    - When conflicts prevent authorization and when they no longer exists
    - Potential conflicts if choose to override authorization
  - Release authorization once manual commanding is complete
    - Return automated control agent to former configuration
    - Notify users waiting for authorization due to potential conflicts
  - Key Technologies
    - Models of tasks, models of system connectivity and configuration
    - Policies for control authorization

Command and Authorization Service

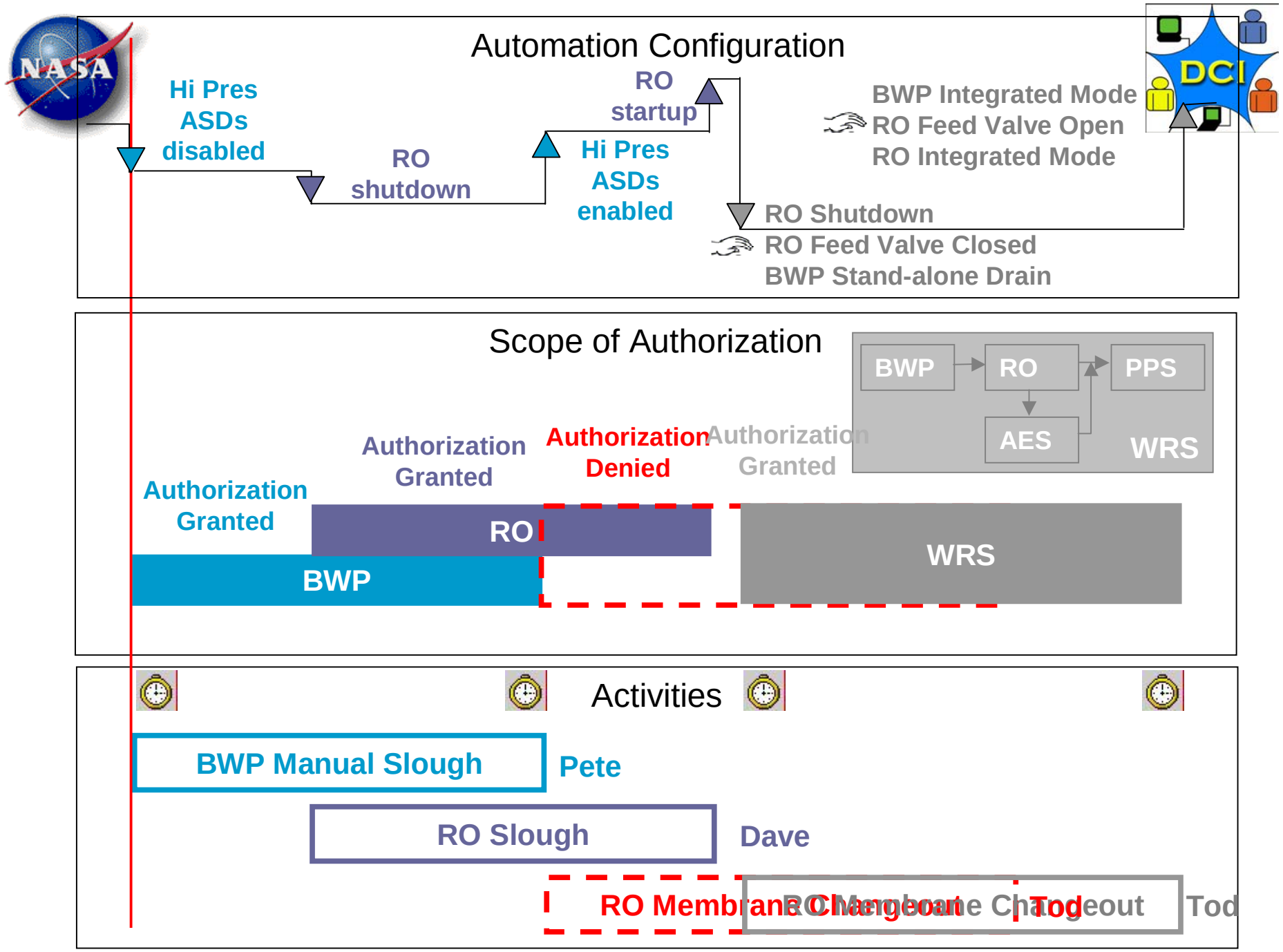


Command and Authorization Service



Research Issues

- Models defining procedure effects
  - Modeling effects of entire manual procedure (not just initial conditions)
  - Modeling performance constraints
  - Modeling changes in effect for degraded mode operation (e.g., loss of redundancy)
- Reconfiguration models
  - Defining system models for reconfiguration
  - Determining target system state after commanding
    - What actions can be “undone”
    - What actions shouldn’t be undone due to overlap with concurrent authorized activities
- Authorization policies permitting more concurrency


Automation Configuration
Hi Pres ASDs disabled
RO shutdown
RO startup
Hi Pres ASDs enabled
BWP Integrated Mode
RO Feed Valve Open
RO Integrated Mode
RO Shutdown
RO Feed Valve Closed
BWP Stand-alone Drain
DCI
Scope of Authorization
BWP
RO
PPS
AES
WRS
Authorization Granted
Authorization Granted
Authorization Denied
Authorization Granted
RO
BWP
WRS
Activities
BWP Manual Slough
Pete
RO Slough
Dave
RO Membrane Change
Tod

Models of Human-Agent Interaction

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    - Research Issues
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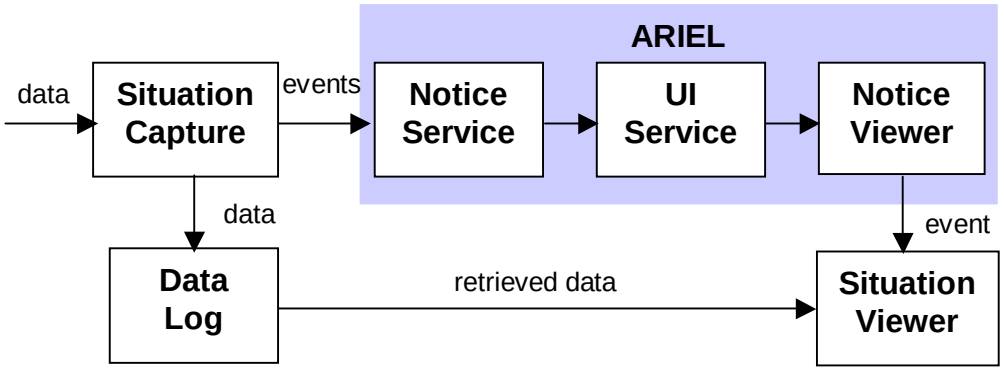
Situation Summarization

- Situation capture using NASA Phase II SBIR software for Complex Event Recognition (J. Firby, INet)
  - Key Technology: applies language recognition principles to detect event patterns with complex temporal & hierarchical relationships among them
  - Revised recognizers based on evaluation with multiple data sets
  - Wrote recognizers for new WRS events (e.g., bioreactor sloughs)
  - Separated parameter logging from capturing situation
    - Capture event sequences in CERA when event occurs
    - Retrieve associated data parameters when event is viewed



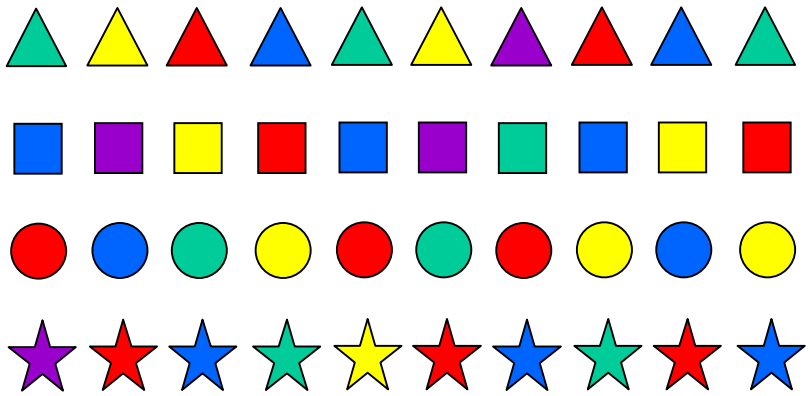
- Revised Situation Viewer used by ARIEL agent

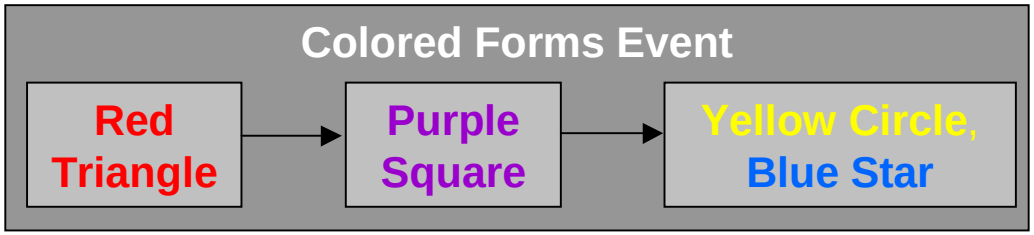
Example: Recognizing Events with CERA

Colored Forms Event

- InOrder
  - Red Triangle Event
  - Purple Square Event
  - OneOf
    - Blue Circle Event & Green Star Event
    - Yellow Circle Event & Blue Star Event

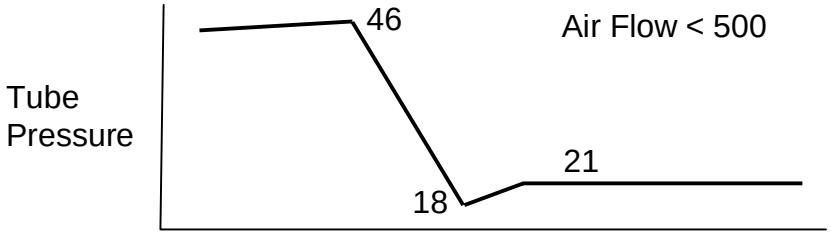
Data Stream ⇨





BWP Manual Slough in Bioreactor

- BWP Manual Slough
  - Buildup of bacteria in 8 nitifier tubes can cause increased tube pressure
  - Human forces water through the tubes to clear out excess bacteria
  - Expected pressure profile in the tubes during manual slough



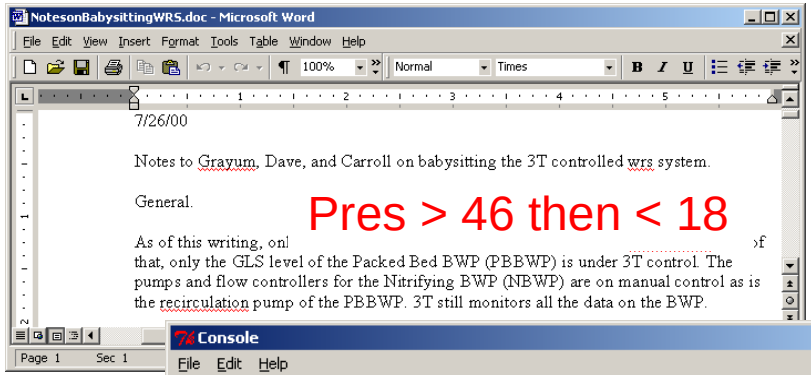
  - Types of sloughs
    - Observed: observe the pressure drop
    - Inferred: infer the pressure drop

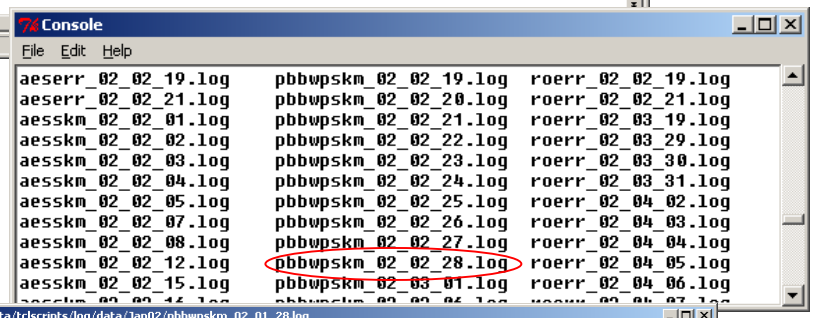
Detecting Manual Slough in Water Test

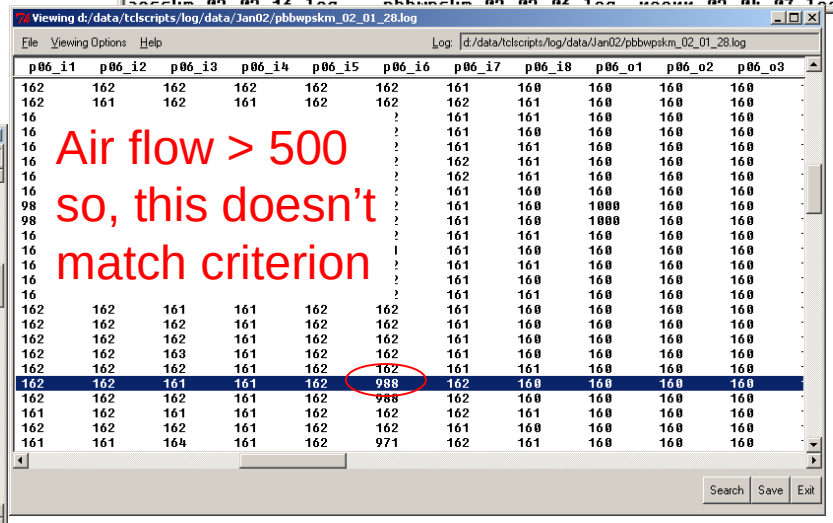
1. Find expected values for manual slough in situation description notes

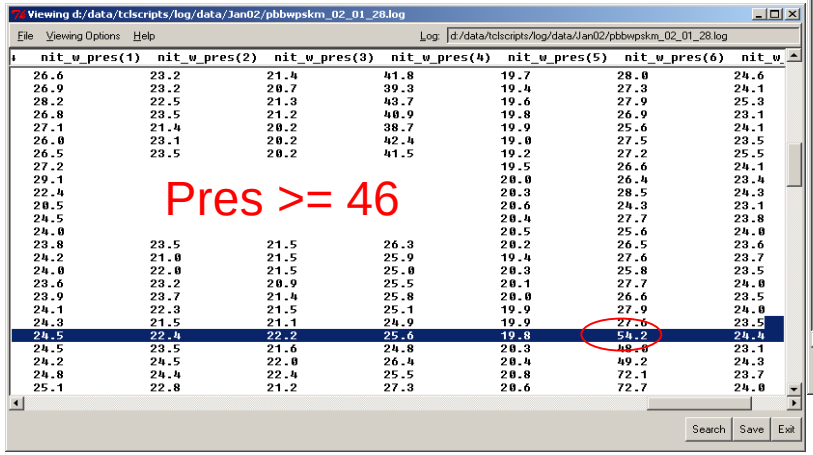
2. Find log file for time region of interest

3. Compare values in log file to values in situation descriptions



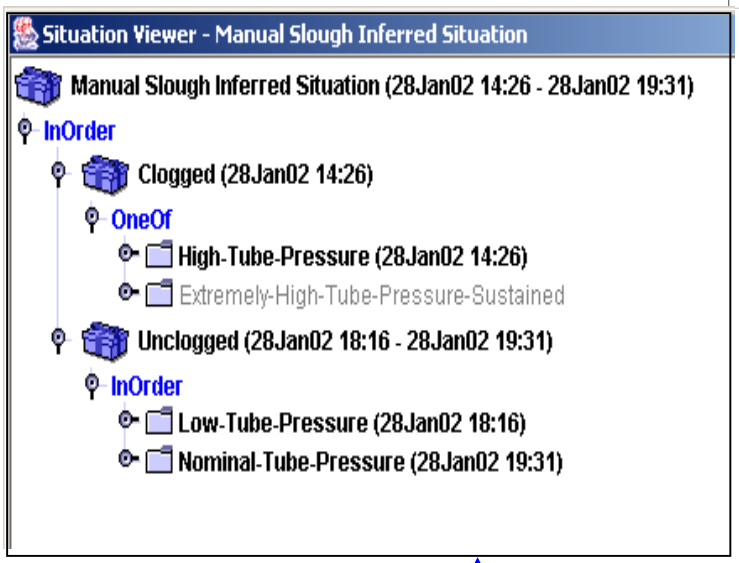


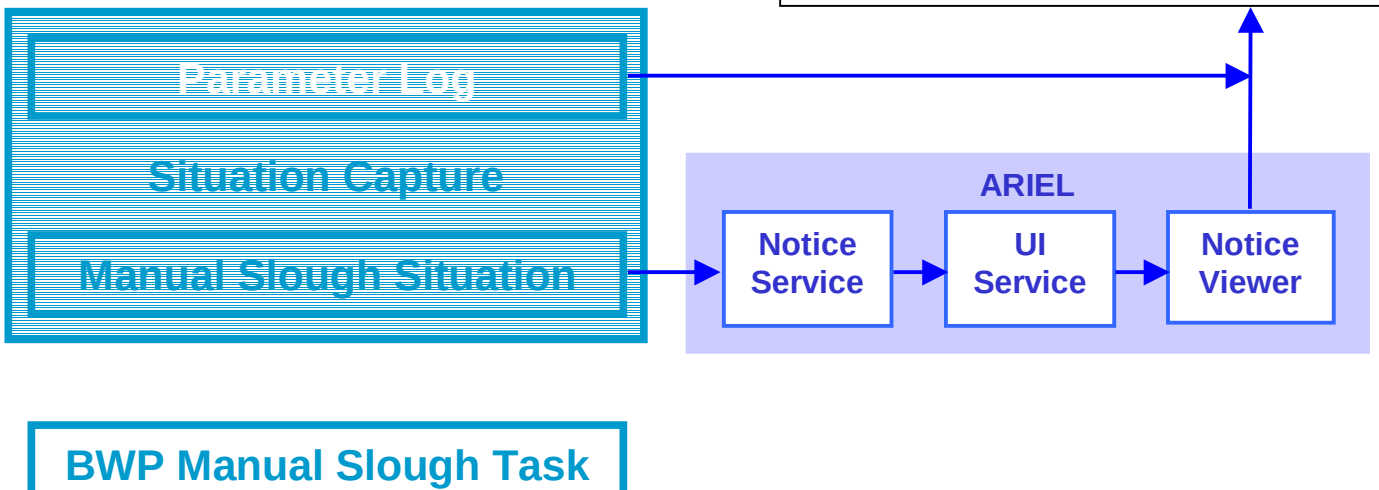




BWP Manual Slough Example

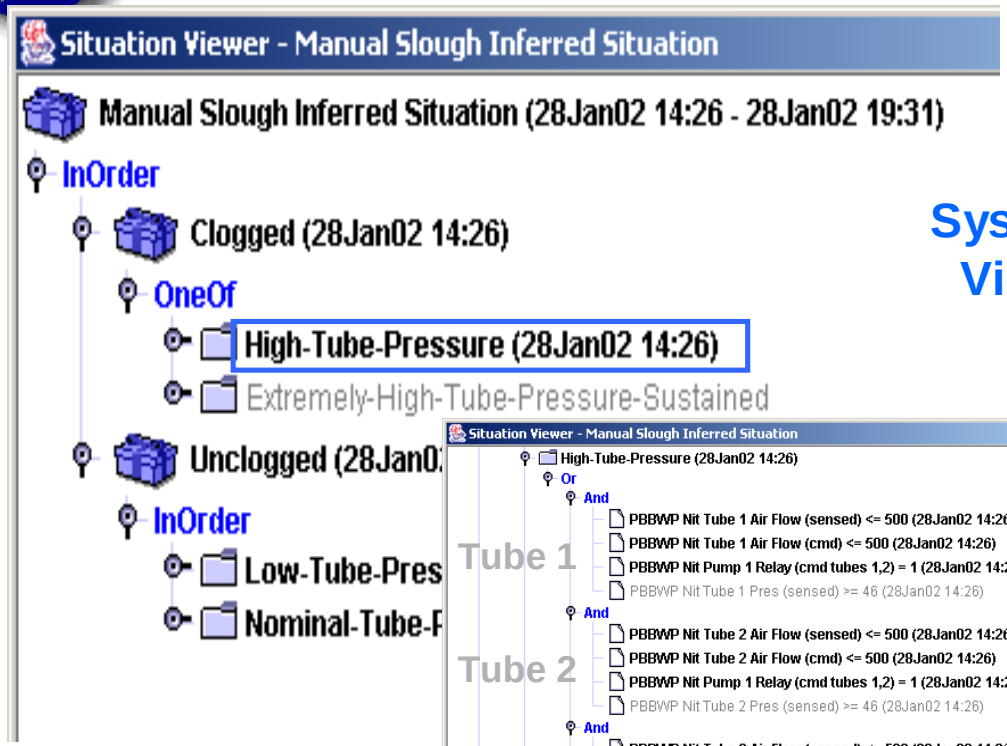
- Observed events in context of possible events
- Alternative views of situation: events & system parameters
- Parameters are retrieved from data log not passed in situation



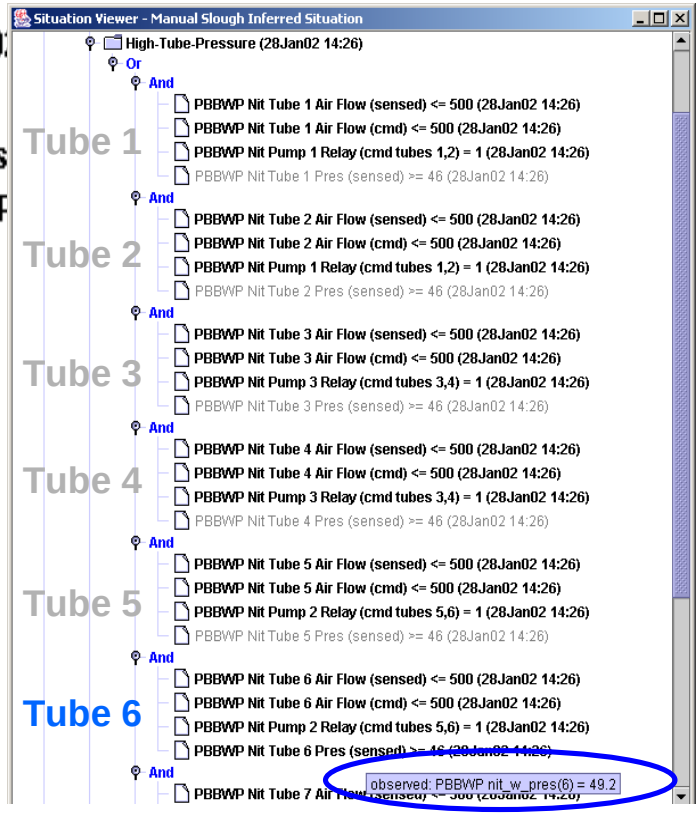


BWP Manual Slough Task

Alternative Views of Situation

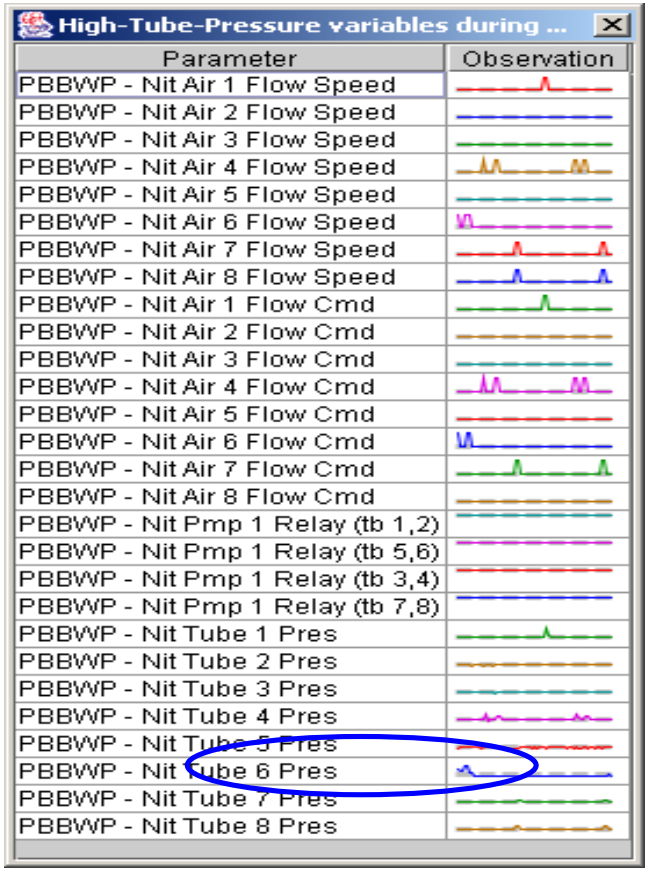


System View



Detailed Events

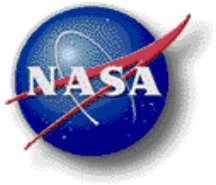
Tube 6 sloughed



Tooltip with sensed value

Proposed Work

- **Multimodal interfaces for non-intrusive notification**
  - Model intrusiveness: consider User Interruptibility, Notice Significance, and User Tolerance for Interruption; coordinate with Dr. Jiajie Zhang
  - Effectiveness of the model of intrusiveness in determining whether to interrupt or queue notices
  - Evaluate multimodal interfaces with Dr. Nadine Sarter/OSU
    - Strategies for information presentation that encode notices on multiple perceptual channels as well as increase saliency within a channel.
- **Automated sequence execution and tracking of procedures**
  - Adjust autonomy to support interleaved manual and automated tasks
    - Represent procedures to support interleaved manual and automated sequence execution
    - Maintain agent's situation awareness and operational context throughout both manual and automated operation (e.g., tracking completion of manual procedures)
    - Identify types of human-automation interaction techniques needed to make the agent useful in operational situations
- **Evaluation in the Advanced Water Lab at JSC**
  - Test of Post-Processing System (PPS) hardware begins this fall and will last approximately a year (Sep/03 – Dec/04)
  - Deploy and evaluate ARIEL agents in use during this test
    - Initially support notification and task re-assignment at anomalies
    - Later phases include situation capture and remote commanding



Workshops and Demonstrations

Video (DVD)

DCI Support for Advanced Water Lab:

Loss of Communication in Advanced Water Lab.
Includes copies of recent publications. Artistic Direction: R. Peter Bonasso.

Demonstrations

Demonstration: Liaison Agents for Distributed Space Operations.

IJCAI Intelligent System Demonstration.
Acapulco, Mexico. August 2003.

Agents for Distributed Team Operations.

Demonstrated JSC Sept 25, Oct 22.
Demonstrated HCC Workshop Oct 28.

Organized Related Workshops

M. Freed, D. Kortenkamp, and D. Schreckenghost.

Workshop on Human Interaction with Autonomous Systems in Complex Environments.
AAAI Spring Symposium 2003.
Stanford University, CA. March 2003.

C. Martin and D. Schreckenghost.

Workshop on Humans and Multi-Agent Systems
2nd International Conference on Autonomous Agents and Multi-Agent Systems
Melbourne, Australia, 2003. July 14, 2003.

C. Martin and D. Schreckenghost

Workshop on Interaction Between Humans and Autonomous Systems over Extended Operation
AAAI Spring Symposium 2004
Stanford University, CA. March 2004

Publications

https://postdoc.arc.nasa.gov/postdoc/t/folder/main.ehtml?url_id=82878

Journals and Magazines

Schreckenghost, D., C. Thronesbery, P. Bonasso, D. Kortenkamp, and C. Martin. "Applying Human-Centered Computing to Intelligent Control of Life Support for Space Missions". *IEEE Intelligent Systems*, special issue on Human-Centered Computing at NASA. Sept/Oct 2002.

Schreckenghost, D., C. Martin, P. Bonasso, D. Kortenkamp, T. Milam, & C. Thronesbery. Supporting group interaction among humans and autonomous agents. *Connection Science*. Vol 14, No 4. 2002. pp 361-369.

Conferences

Schreckenghost, D., C. Martin, and C. Thronesbery. Specifying Organizational Policies and Individual Preferences for Human-Software Interaction. AAAI Fall Symposium. *Workshop on Etiquette for Human-Computer Work*. Nov 2002

Martin, C., D. Schreckenghost, P. Bonasso, D. Kortenkamp, T. Milam, and C. Thronesbery. Aiding Collaboration among Humans and Complex Software Agents. AAAI Spring Symposium. *Workshop on Human Interaction with Autonomous Systems in Complex Environments*. March 2003.

Martin, C. E., D. Schreckenghost, R. P. Bonasso, D. Kortenkamp, T. Milam, and C. Thronesbery, "Helping Humans: Agents for Distributed Space Operations," presented at The *7th International Symposium on Artificial Intelligence, Robotics and Automation in Space*, Nara, Japan, 2003. May 19-23.

Martin, C. E., D. Schreckenghost, R. P. Bonasso, D. Kortenkamp, T. Milam, and C. Thronesbery, "An Environment for Distributed Collaboration Among Humans and Software Agents," presented at *Workshop on Humans and Multi-Agent Systems* at the *2nd International Conference on Autonomous Agents and Multi-Agent Systems*, Melbourne, Australia, 2003. July 14-18..

Thronesbery, C., and Schreckenghost, D., Situation Views: Getting Started Handling Anomalies. *IEEE International Conference on Systems, Man, and Cybernetics*. Washington, D. C. Oct 5-8, 2003