Electronic and Augmented Reality Procedure Technology

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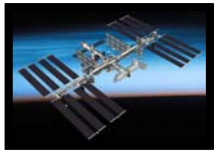
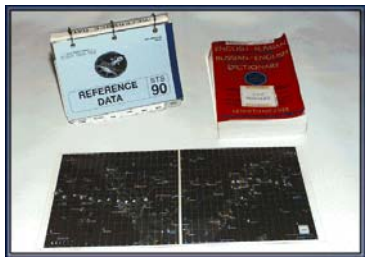
Evolution of Procedures

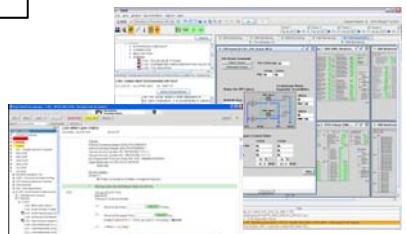




Apollo & Space Shuttle—Paper

Early ISS—PDF



Current ISS—IPV/XML

- No Automation or Computer Oversight

Orion; Enhanced XML (PRL)

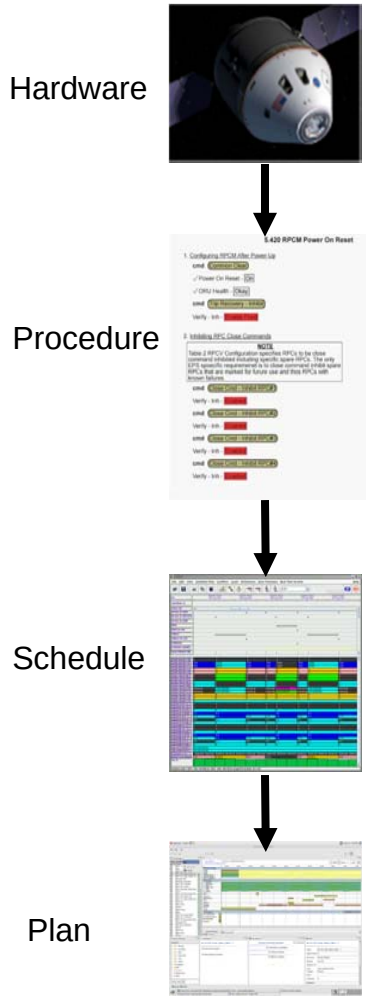
- Computer Oversight
- Automation

Deep Space Exploration- AR-eProc;

- PRL Extension
- Machine Vision and Marker-less Registration

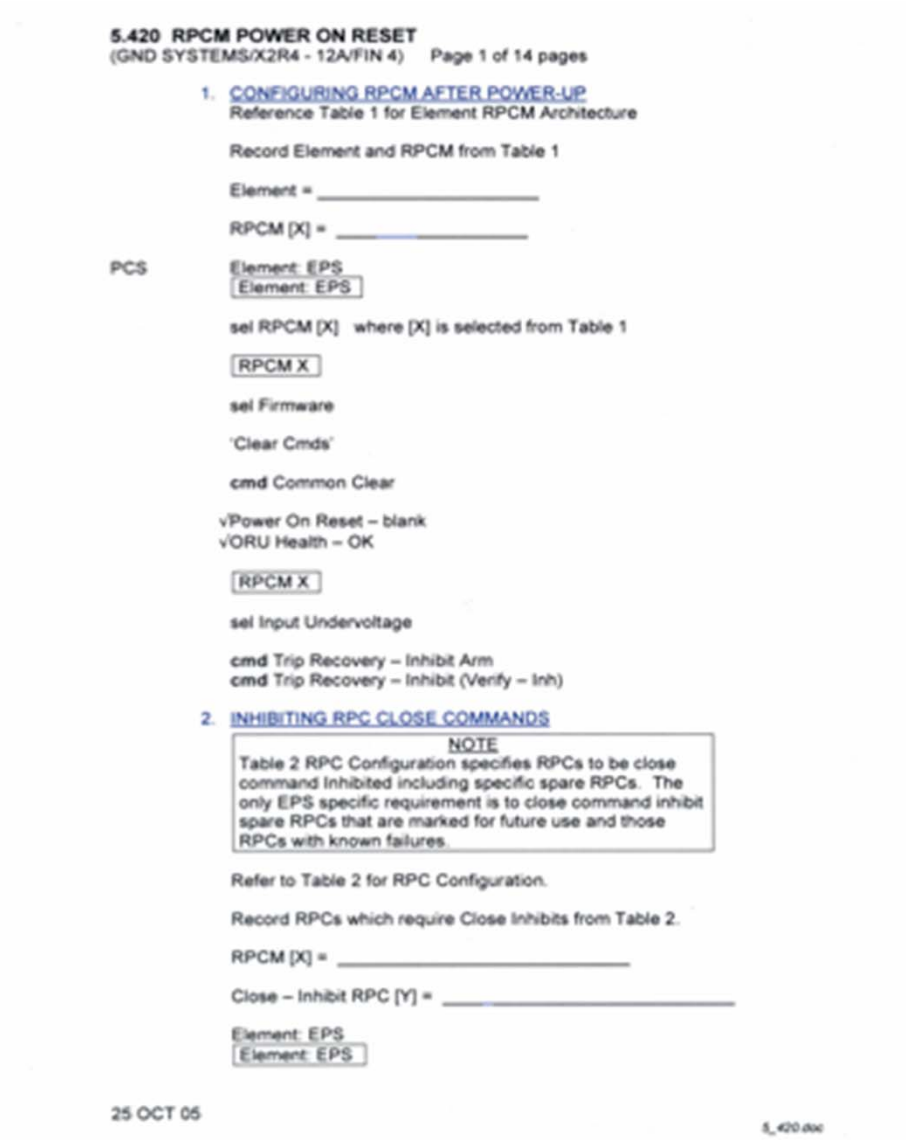
Background

- Mission Operations: Overview
  - Crew operate equipment using *procedures*
  - Mission Control staff operate equipment remotely using procedures
  - Mission Control staff maintain operations *schedules and plans*
  - Staffing, equipment configuration and manifests also require scheduling and planning



Flight Procedure

- Procedures contain knowledge about how to operate systems to achieve mission goals
- Procedures are the approved means by which a user operates a system
- Users of procedures include crew, flight controllers, instructors, mission designers, payload community, etc.



5.420 RPCM POWER ON RESET
(GND SYSTEMS/X2R4 - 12A/FIN 4) Page 1 of 14 pages

1. CONFIGURING RPCM AFTER POWER-UP
Reference Table 1 for Element RPCM Architecture

Record Element and RPCM from Table 1

Element = _____

RPCM [X] = _____

PCS Element: EPS
Element: EPS

sel RPCM [X] where [X] is selected from Table 1

RPCM X

sel Firmware

'Clear Cmds'

cmd Common Clear

√Power On Reset – blank
√ORU Health – OK

RPCM X

sel Input Undervoltage

cmd Trip Recovery – Inhibit Arm
cmd Trip Recovery – Inhibit (Verify – Inh)

2. INHIBITING RPC CLOSE COMMANDS

NOTE
Table 2 RPC Configuration specifies RPCs to be close command Inhibited including specific spare RPCs. The only EPS specific requirement is to close command inhibit spare RPCs that are marked for future use and those RPCs with known failures.

Refer to Table 2 for RPC Configuration.

Record RPCs which require Close Inhibits from Table 2.

RPCM [X] = _____

Close – Inhibit RPC [Y] = _____

Element: EPS
Element: EPS

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Procedure Requirements

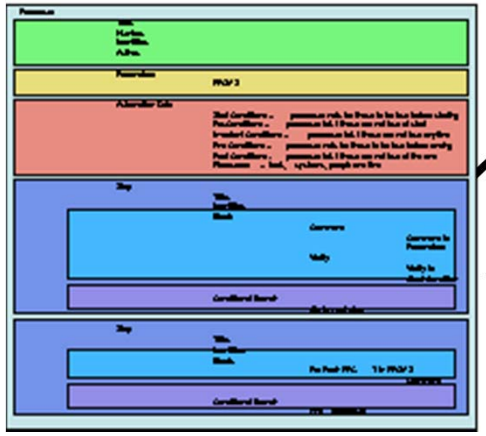
- Need support for automating procedure execution
  - Commands and telemetry
  - Safety conditions/context
  - Explicit control structures
- Don't want to lose human readability
  - Capturing "look-and-feel" of current procedures
  - Presentation of procedure content in a human-friendly way
- Improve quality of execution
  - Improved ease of use
  - Reduction of human error
  - Improved situational awareness
- Interleave human actions with spacecraft scripts

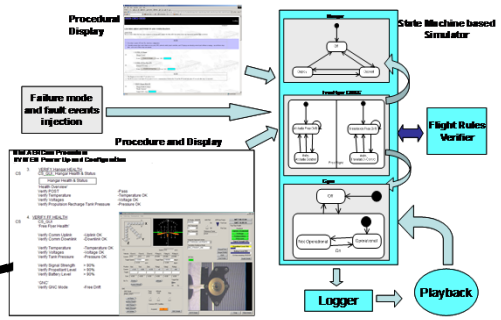
- Use *Procedure Representation Language*
  - Capture and formalized the above stated requirements
  - Started from NASA ODF standards and construct support automation

Uses of PRL

Procedure Representation Language (PRL) file

Procedure Authoring Tool (PAT)



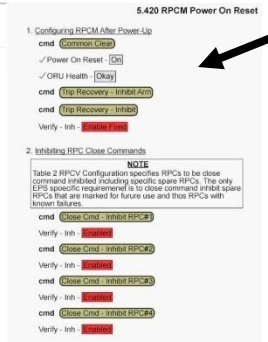


Procedure Verification Tools

Translator

Paper Procedure

Procedure Displays



Send
Command foo
Command bar
Wait 10 secs
Command foo2

Ground Control Tools (e.g., Thin Layer)

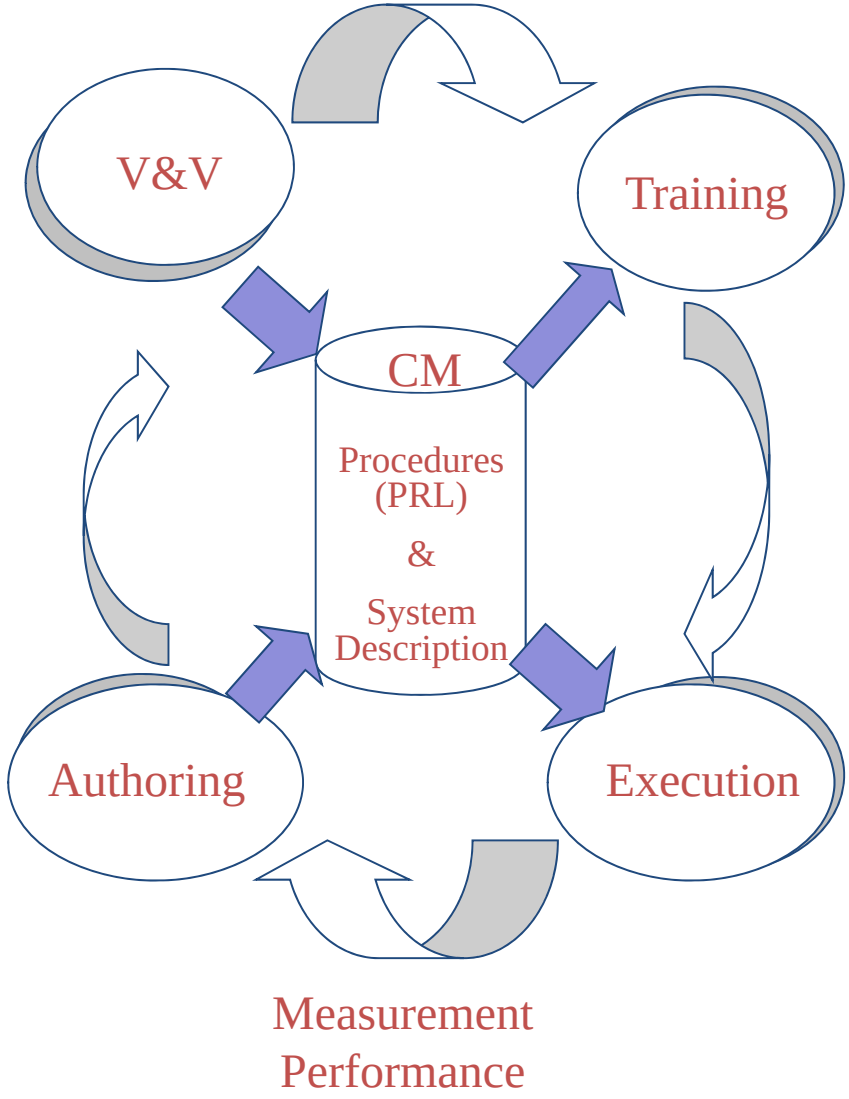
Orion eProc (RPL XML)

SCL
Execute foo
Verify bar
Wait 10 secs
Execute foo2
End

Automated Scripts (e.g., SCL)

Procedure Lifecycle Development

- **Procedure Authoring Tool (PAT)**
  - Procedure authors currently use IPV (Licensed software & not easy to use)
  - Need an easy-to-use authoring environment
  - Need an easy method to add telemetry & commands
- **Procedure verification & validation (PV)**
  - Procedure verifiers are human intensive
  - Need for desktop verification tools to catch simple mistakes
- **Procedure Library Admin. (PLA)**
  - Configuration control works reasonably well today
  - Need to be integrated with Procedure Repository and Procedure approval system
- **Procedure Viewer/Executor (PVE)**
  - Integration with crew time and Caution & Warning system
  - Need to view/execute/track anywhere and any configuration (stationary, mobile, hand-free. Etc.)
- **Procedure training**
  - Integration with Workflow CR and procedure verification and validation
  - Measure and track performance



System Representation

- Procedure language describes how to operate any system. They do not describe the system itself
- System representation needs to define
  - Telemetry
  - Commands and command parameters
  - System hierarchy and classes
    - e.g., commanding the Orion Display Pages
- Must be available during procedure editing, validation and execution
- We selected XML Telemetric & Command Exchange (XTCE) -- an industry and NASA standard

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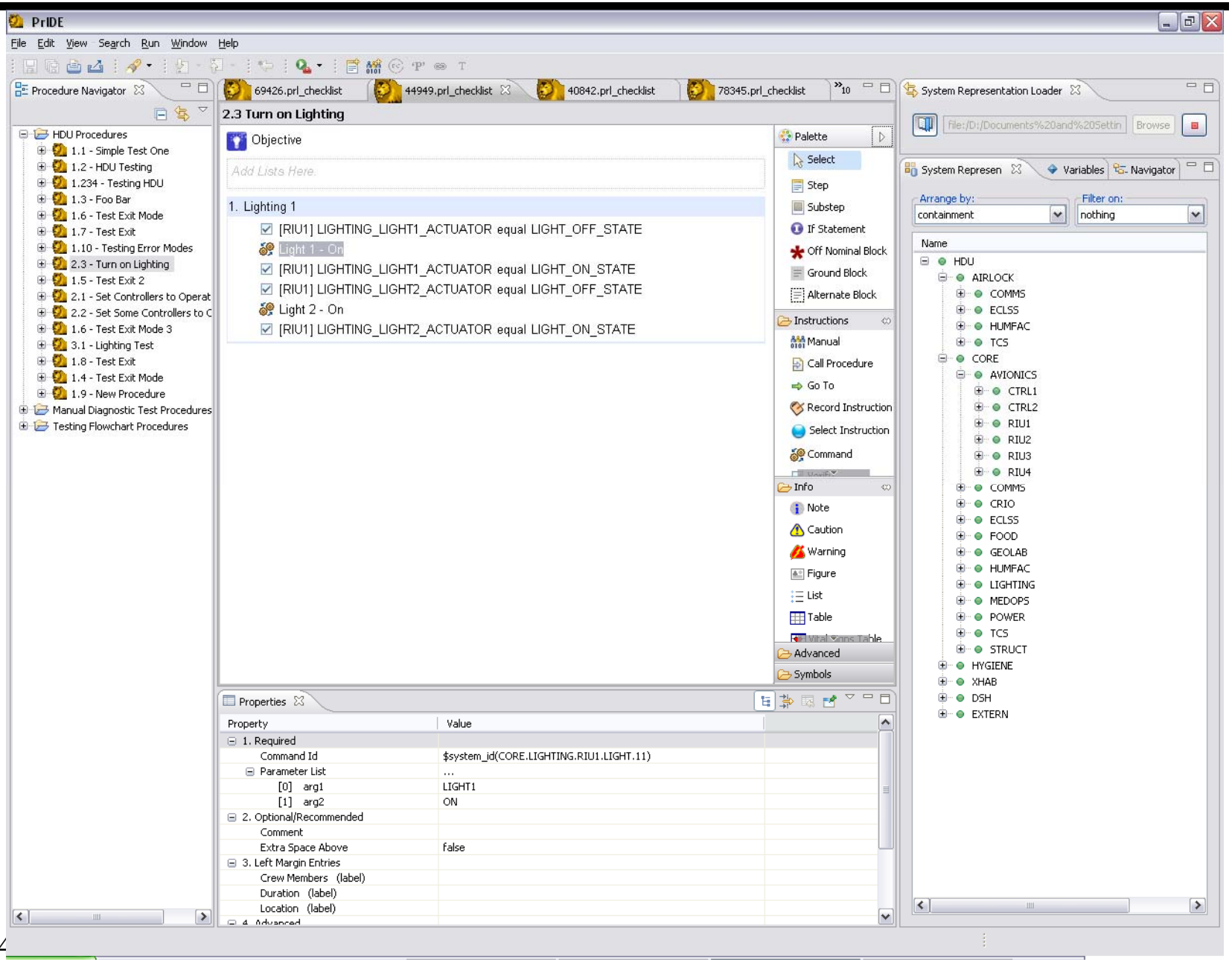
Procedure Authoring Tool



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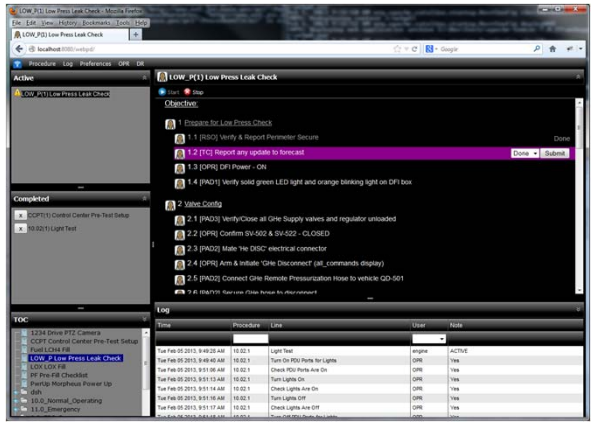
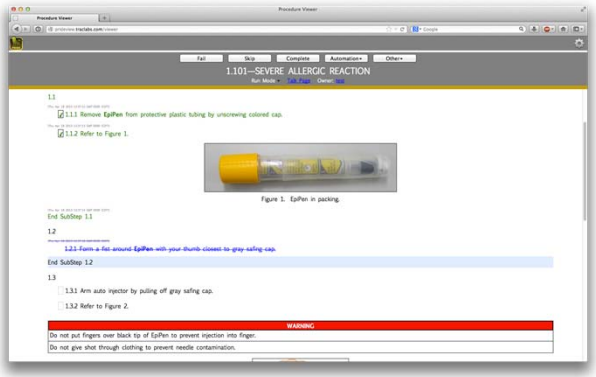
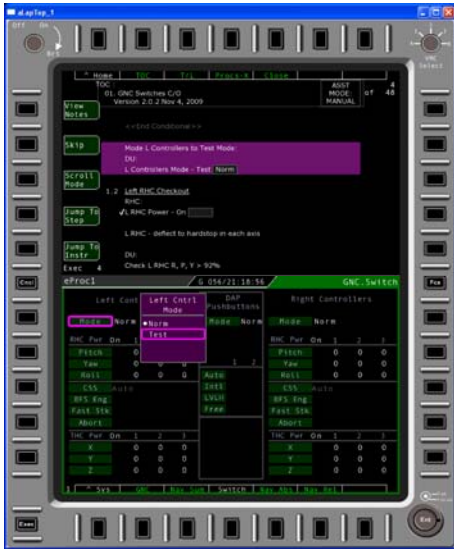
Procedure Viewer & Executor



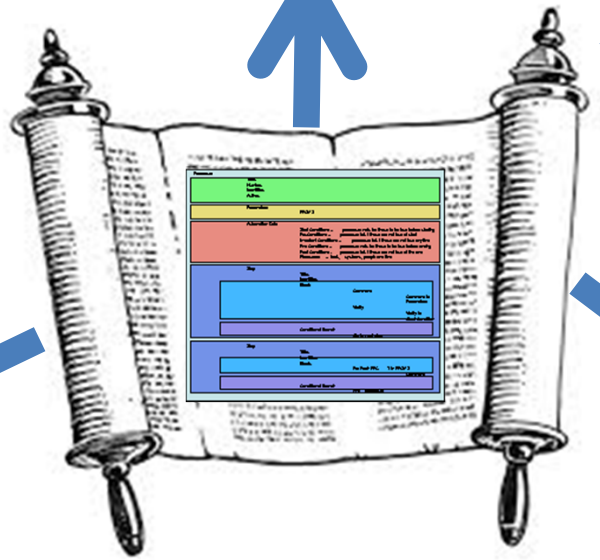
WebPD – Focus on C&W Integration



PRIDE View – focus on Procedure performance tracking



Orion eProc–Flight Deck – focus on Edge Keys Display & Keyboard-less interaction



Google Glass – Focus on Mobility & mobile interactions

AR-eProc– Focus on mixed reality interaction

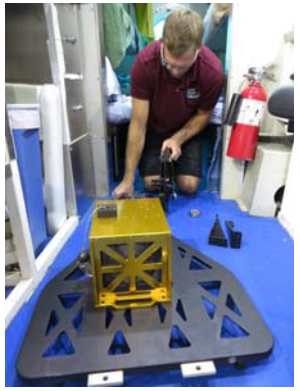
Capture Rich Procedure Content Once and Use It Everywhere!!

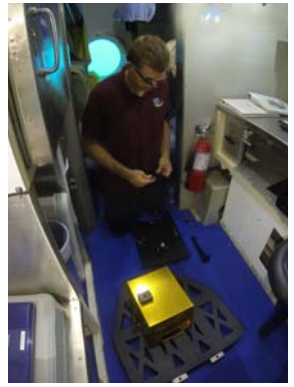
SEATEST II: Just-in-time training & procedure execution with Glass

Miniature Exercise Device (MED):

a. Equipment Assembly Task

b. Equipment Dis-Assembly Task





Just-in-time (JIT) training of a Sani-tank purge

After the task was completed using the Google Glass – the same JITT material was viewed on an iPad

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Augmented Reality Training Assistance

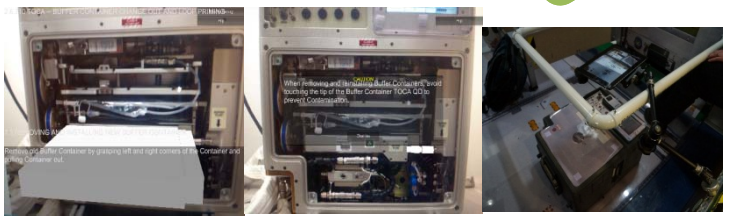
The AR-eProc Vision

AR ARED – Augmented reality Advanced Resistive Exercise Device Cylinder Evac. Procedure

AR DSH Locator - Deep Space Hab augmented reality assets monitoring

Autonomous Operation

AR Ultrasound - Autonomous guidance



AR TOCA - Augmented reality Total Organic Carbon Analyzer Buffer Change Out Procedure