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
• 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.
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 Authoring Tool (PAT)**
  - Paper Procedure
  - Procedure Displays

- **Procedure Verification Tools**
  - Ground Control Tools (e.g., Thin Layer)
  - Automated Scripts (e.g., SCL)

- **Procedure Representation Language (PRL) file**

- **Translator**
  - Send Command foo
  - Command bar
  - Wait 10 secs
  - Command foo2

- **Orion eProc (RPL XML)**
  - Execute foo
  - Verify bar
  - Wait 10 secs
  - Execute foo2
  - End
• **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
• 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
Capture Rich Procedure Content Once and Use It Everywhere!!
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
Augmented Reality Training Assistance

The AR-eProc Vision

AR Ultrasound - Autonomous guidance

AR DSH Locator - Deep Space Hab augmented reality assets monitoring

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

Autonomous Operation