Electronic and Augmented Reality Procedure Technology

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Evolution of Procedures

- Early ISS—PDF
- Apollo & Space Shuttle—Paper
- 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
• 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

Background
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.
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
Procedure Authoring Tool (PAT)

Procedure Representation Language (PRL) file

Procedure Verification Tools

Translator

Paper Procedure

Procedure Displays

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

Send
Command foo
Command bar
Wait 10 secs
Command foo2

Orion eProc (RPL XML)

SCL
Execute foo
Verify bar
Wait 10 secs
Execute foo2
End

Automated Scripts (e.g., SCL)

Uses of PRL
Procedures

• **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.
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!!
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 ARED – Augmented reality Advanced Resistive Exercise Device Cylinder Evac. Procedure

AR DSH Locator - Deep Space Hab augmented reality assets monitoring

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

Autonomous Operation