Electronic Procedure and Medical Operation

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• Procedures are critical to conduct any complex operation

• 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 automated 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

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

Procedure Displays

Orion eProc (RPL XML)

Automated Scripts (e.g., SCL)

Send Command foo
Command bar
Wait 10 secs
Command foo2

execute foo
verify bar
Wait 10 secs
execute foo2
end

Uses of PRL

Procedure Authoring Tool (PAT)

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

Automated Scripts (e.g., SCL)
Capture Rich Procedure Content Once and Use It Everywhere!!
• **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.
Objective: To acquire images and measurements of the patient's right and left kidney.

Parts:
- Ultrasound C50
- Ultrasound Probe - C5-1
- Probe Scantech Cover
- Probe Connector Cover
- Reference Documents
- Keyboard and Probe Placement Card
- Ultrasound Echo Gel (one bottle)
- Dry Wipes

1.1 Configure the C50 Ultrasound Device with the C5-1 probe using procedure "5.3 Ultrasound - Configure C50 Device".

1.2 For "Preset" on the C50, select "Abd Renal"

1.3 The gel should be applied to the applied and resemble what is seen in Figure 1.

Figure 1 Ultrasound probe with gel applied to the scan head. The thumb lying over the indicator notch (red arrow). The gel application in this picture (blue arrow) is correct for any of the probes that are used for any ultrasound image application.

2. Scanning Procedure:

2.1 Expose the patient's abdomen.
WebPD - Automation
WebPD – Adding Image Notes

Objective: Perform a general health examination

1. Collect Patient Vitals
   1.1 [CMO] Enter Temperature (F) 99.6
   1.2 [CMO] Enter Blood Pressure 122/84
   1.3 [CMO] Enter Pulse 56
   1.4 [CMO] Enter Pulse Oximetry 48
   1.5 [CMO] Enter Respiratory Rate 52
   1.6 [CMO] Submit Vitals Done

2. Skin Examination
   2.1 [CMO] Launch Webcam Controller
   2.2 [CMO] Using webcam to document any rash, injury or other ailments that have developed
WebPD – Adding Text Notes

1. Collect Patient Vitals
   1.1 [CMO] Enter Temperature (F) 99.6
   1.2 [CMO] Enter Blood Pressure 122/84
   1.3 [CMO] Enter Pulse
   1.4 [CMO] Enter Pulse Oximetry 48
   1.5 [CMO] Enter Respiratory Rate 52
   1.6 [CMO] Submit Vitals

2. Skin Examination
   2.1 [CMO] Launch Webcam Controller.
   2.2 [CMO] Using webcam to document any rash, injury or other ailments that have developed
**Periodic Health Examination**

**Objective:** Perform a general health examination

1. **Collect Patient Vitals**
   1.1 [CMO] Enter Temperature (F) 99.6
   1.2 [CMO] Enter Blood Pressure 122/84
   1.3 [CMO] Enter Pulse
   1.4 [CMO] Enter Pulse Oximetry
   1.5 [CMO] Enter Respiratory Rate
   1.6 [CMO] Submit Vitals

2. **Skin Examination**
   2.1 [CMO] Launch Webcam Controller.

   [CMO] Using webcam to document any rash, injury or other ailments that have developed

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*WebPD - IM*
Medical Exam
Electronic Procedure

Use Case
The Exploration Medical System Demonstration (EMSD) will utilize the ISS as a test bed to demonstrate that several medical technologies and medical informatics tools, needed for collecting and managing evidence and decision making on an exploration mission, can be integrated into a single system and used by the on-orbit crew to optimize medical care delivery and data management.
EMSD

OPERATIONAL CONCEPT
EMSD Core Components

**Electronic Medical Record**  
Medical Data Storage

**Assisted Medical Procedures**  
User Interface to System  
Procedure Authoring  
Procedure Execution

**Middleware**  
Commanding  
Data Transfer Brokering  
Scalability

**Clinical Decision Support**  
Future Development
<table>
<thead>
<tr>
<th>Node</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ultrasound (U/S)</strong></td>
<td>Data File Import</td>
</tr>
<tr>
<td></td>
<td>Streaming Video</td>
</tr>
<tr>
<td><strong>Inventory Tracker</strong></td>
<td>Data File Import</td>
</tr>
<tr>
<td><strong>Webcam + Dental Camera</strong></td>
<td>Streaming Video</td>
</tr>
<tr>
<td></td>
<td>Image/Video File</td>
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<tr>
<td><strong>Biosensors (ECG)</strong></td>
<td>Commanding</td>
</tr>
<tr>
<td></td>
<td>Data File Import</td>
</tr>
<tr>
<td><strong>Crewmember</strong></td>
<td>Data Entry</td>
</tr>
<tr>
<td></td>
<td>Navigation</td>
</tr>
</tbody>
</table>

**EMSD Peripheral Devices**

**EMSD Core Components**

**ISS**

- Crewmember
- Peripheral Devices
  - Ultrasound (U/S)
  - RFID Scanner
  - Webcam
  - Dental Camera
  - Biosensors
- Vehicle Computer (SSC)
- Companion Software
EMSD

SYSTEM DESIGN
## Component Selection

<table>
<thead>
<tr>
<th>Assisted Medical Procedures</th>
<th>Procedure Authoring Tool</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Web Procedure Display (WebPD)</td>
</tr>
<tr>
<td>Electronic Medical Record</td>
<td>OpenEMR/CouchDB</td>
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<tr>
<td>Middleware</td>
<td>OpenDDS</td>
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<tr>
<td>Image/Video Capture</td>
<td>HTML5/VSee</td>
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</tbody>
</table>
Methods for Data Integration

- **File Transfer**
  Create files of shared data for others to consume and consume files that others have generated

- **Shared Database**
  Store the data they share in a common database

- **Remote Procedure Call**
  Expose some procedures that can be invoked by others remotely to initiate behavior and exchange data

- **Messaging**
  Applications connect to a common messaging system to exchange data and invoke behavior using messages
Physical Implementation – Single Host
What’s next?
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
Future Direction: Autonomous Ultrasound Ops.

1. Image detection software depiction of anatomical landmarks which define an adequate carotid image superimposed over an actual carotid artery ultrasound image

2. Robonaut 2 being remotely guided through carotid artery ultrasound imaging technique
Backup
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 to Enhance Crew Medical Training

Adjust the transducer according to the liver’s short axis by translating the probe towards the chest.
Augmented Reality (AR-eProc ARED)