NASA Electronic Procedure Technology

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Autonomy Panel

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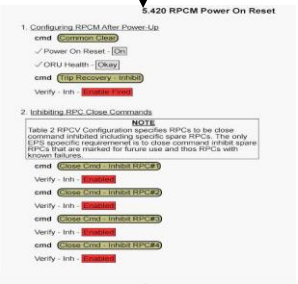
Background – Mission Operation Overview

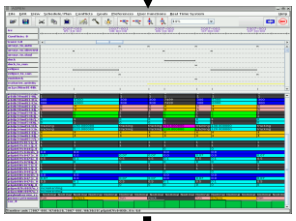
- Crew operate equipment using *procedures*
- Mission Control staff operate equipment remotely using *procedures*
- Mission Control staff maintain operations using *schedules and plans*
- Staffing, equipment configuration and manifests also require scheduling and planning

Hardware

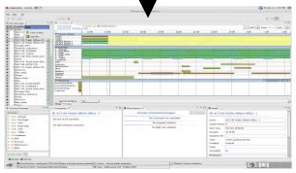
Procedure



Schedule



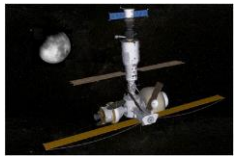
Plan

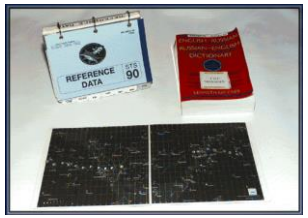


Evolution of Procedures

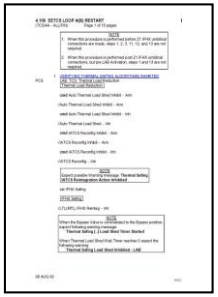




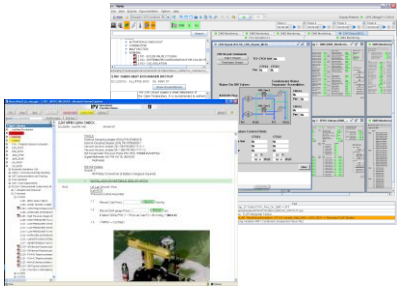


Apollo & Space Shuttle—Paper



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

So, What is Procedures?

Flight Procedure

- Procedures are used to conduct any complex operation
- Procedures contain knowledge about how to operate systems to achieve mission goals / tasks
- 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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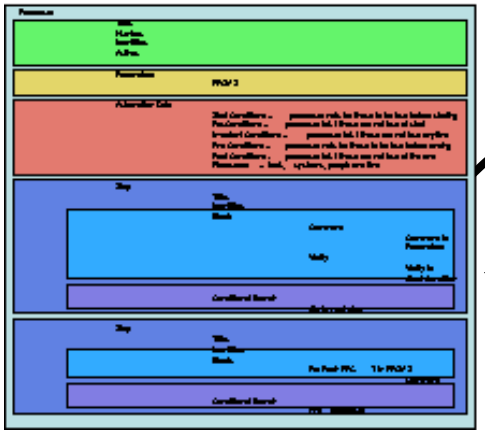
Procedure Requirements

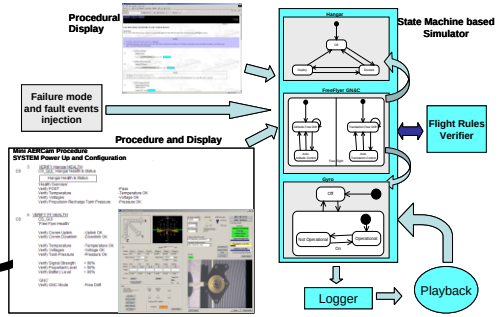
- ***Need support for automating procedure execution***
  - Commands and telemetry
  - Safety conditions/context
  - Explicit control structures
- ***Don't want to lose human readability***
  - Capturing "look-and-feel" of current procedures
  - Presentation of procedure content in a human-friendly way
- ***Interleave human actions with automated scripts***
- ***Integrate multimodal interfaces to enhance user performance by providing***
  - Context sensitive cues
  - On-demand real-time assistant
- ***Use <u>Procedure Representation Language</u>***
  - Capture and formalized the above stated requirements
  - Started from NASA Onboard Data File standards and construct support automation

Uses of PRL

Procedure Representation Language (PRL) file

Procedure Authoring Tool (PAT)

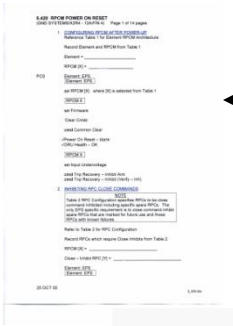


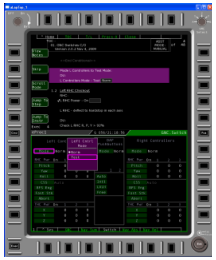


Procedure Verification Tools

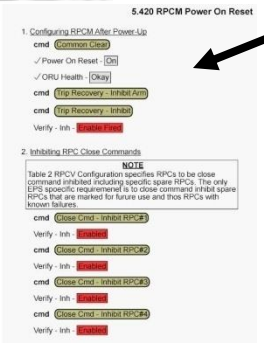
Translator

Paper Procedure





Orion eProc (RPL XML)



Procedure Displays

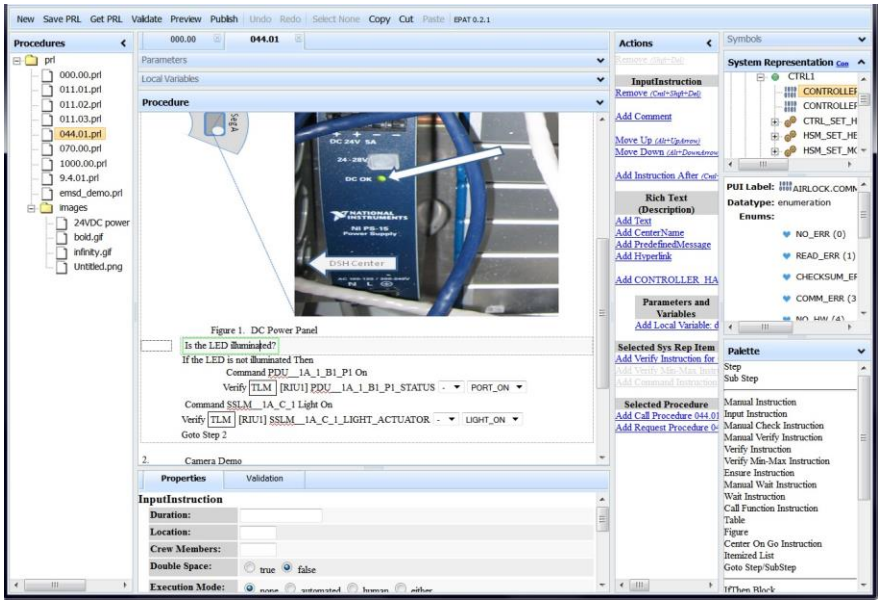
Send
Command foo
Command bar
Wait 10 secs
Command foo2

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

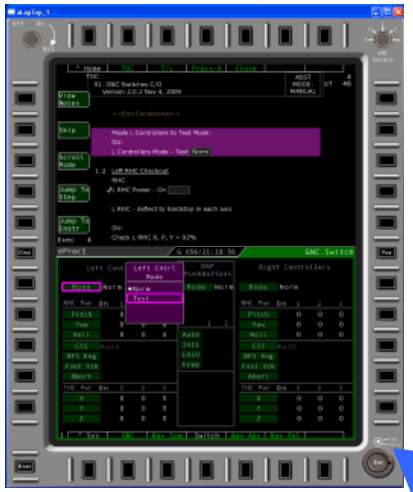
AR Authoring

Advanced Procedure Authoring Tool

- Full PRL features
- Full PRL compliant
- Drag-n-drop user interface
- Leverage on web based & html5 technologies
- Benefits
  - No executable download or plug-in installation require
  - Centralized application deployment
  - More robust media support from html5 better integration editing, viewing and execution



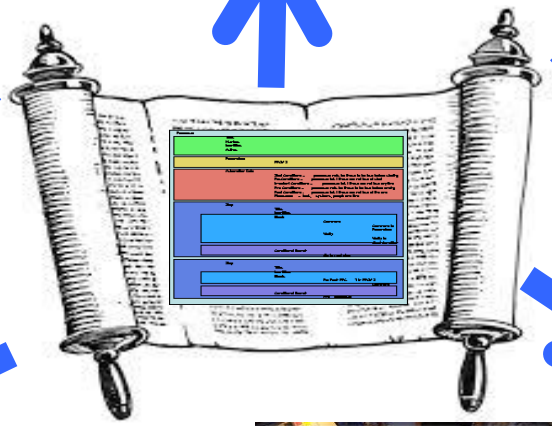
Procedure Viewer & Executor



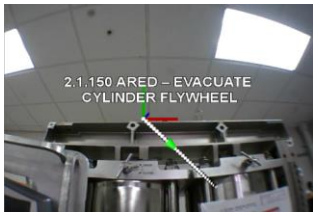
Orion eProc–Flight Deck – focus on Edge Keys Display & Keyboard-less interaction

WebPD – Focus on C&W Integration

AR-eProc– Focus on mixed reality interaction with tablet device



Google Glass – Focus on Mobility & mobile interactions

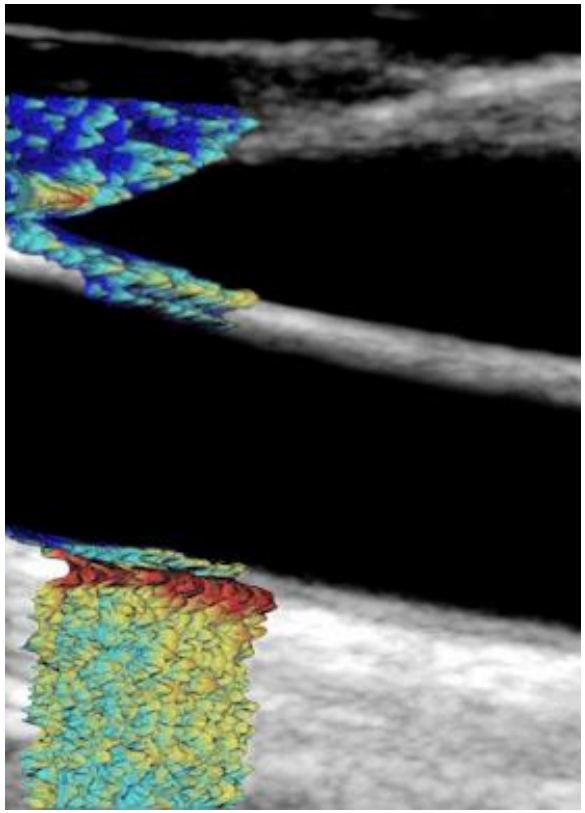


AR-eProc– Focus on mixed reality interaction hands-free operation

Capture Rich Procedure Content Once and Use It Everywhere!!

What's next?

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

Challenges / Needs

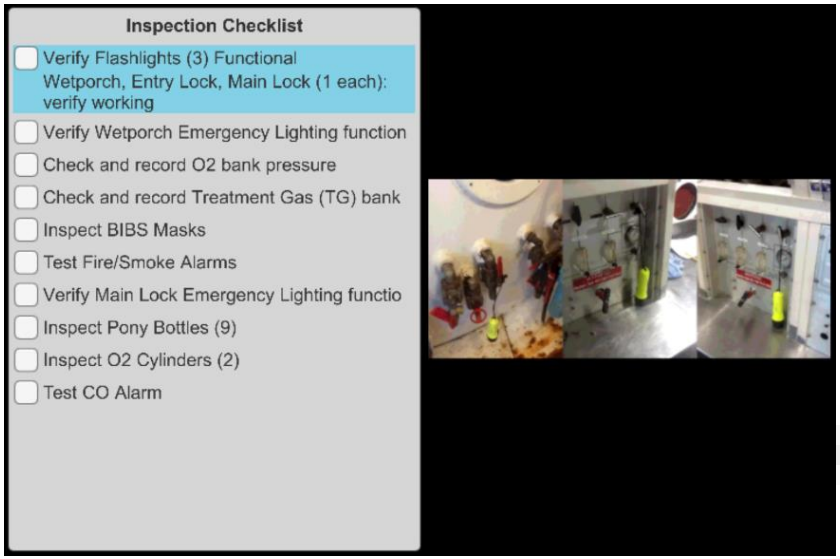
- ***Reliable Machine Vision system to work in an unstructured environment using a mobile glasses device***
  - Object recognition under occlusion
  - Robust Object tracking
  - Computing architecture
- ***Data Fusion***
  - Health Sensors integration
  - System telemetry monitoring and commanding
- ***Simplify Augmented Reality Authoring and Procedure Content Management***
  - Automate the 3D model creation
  - Simply workflow to associate AR content to procedure instructions

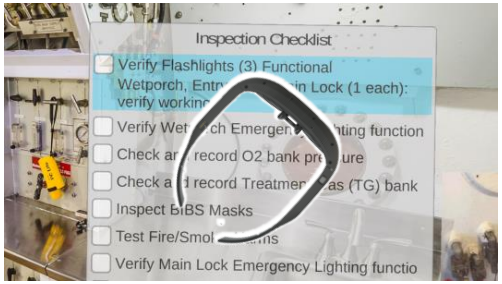
Backup

Augmented Reality Electronic Procedures for JITT "Pinnable"

"Pinnable Procedures" Introduction

- Procedures designed to be an intuitive blend of text, still photos
- Quick "reminder" checklist
- Procedure can be moved and kept out of the direct worksite, yet accessible at a glance
- Wearable headset (ODG Glasses R-6)





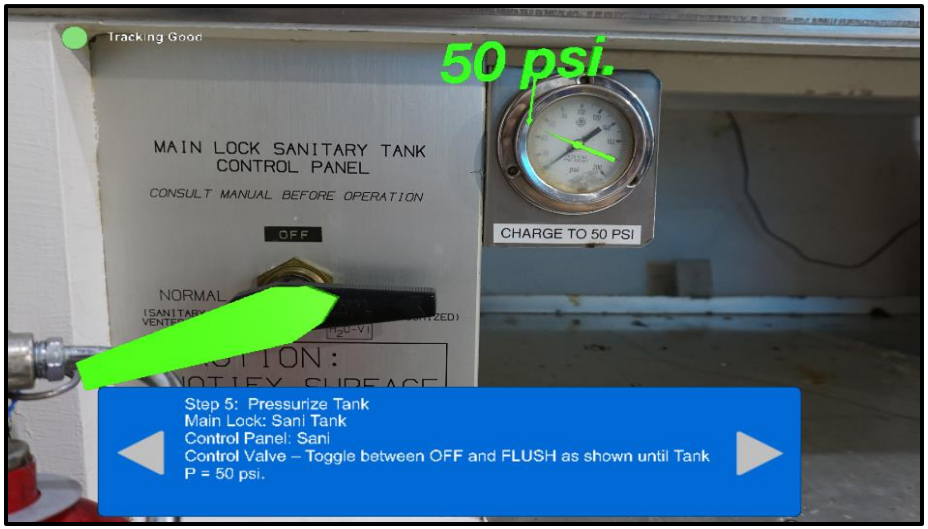
- Active step expands, showing additional information
- Check steps as complete
- Images provide additional context

Return

Augmented Reality Electronic Procedures for JITT "Marker-less"

"Augmented Reality Electronic Procedures" Introduction

- Step by step guidance reduces need for prior training
- Complex tasks are broken into a series of simpler guided steps
- Procedures provide context sensitive animations on top of the real world workspace



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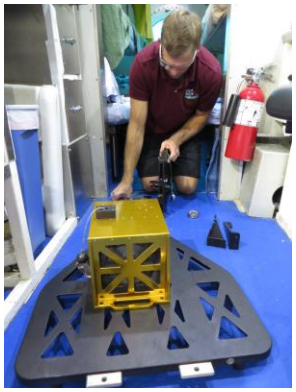
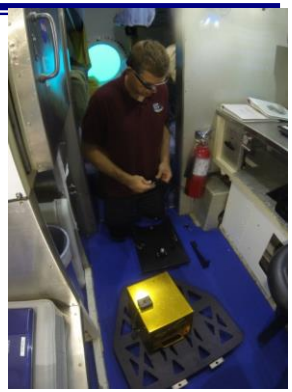
SEATEST II: Just-in-time training & procedure execution with Glass

Miniature Exercise Device (MED):

a. Equipment Assembly Task

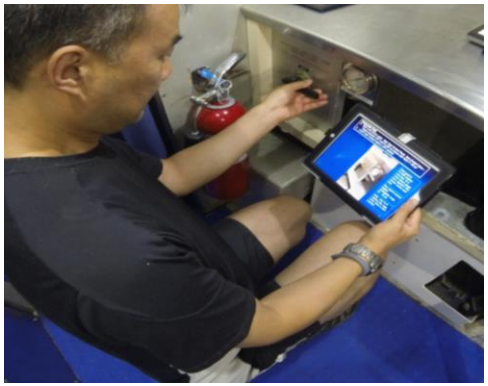
b. Equipment Dis-Assembly Task





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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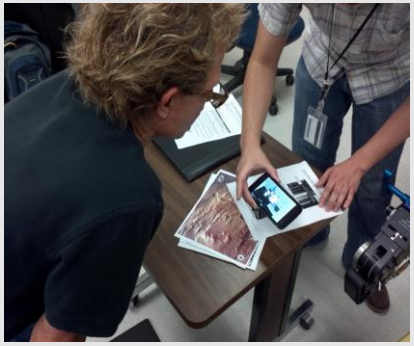
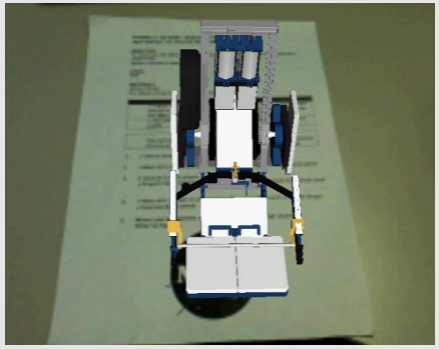
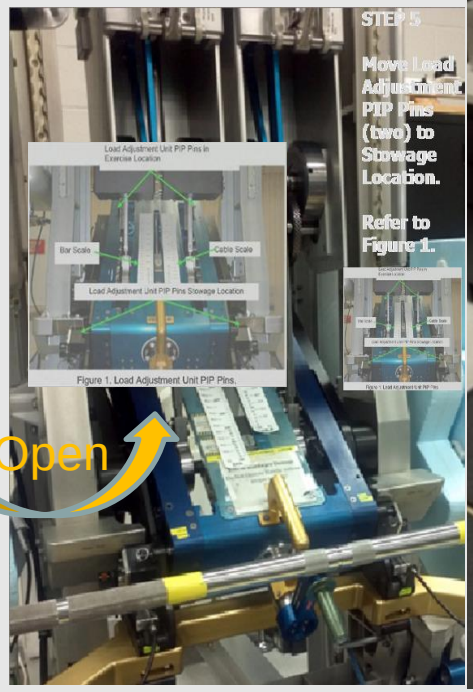
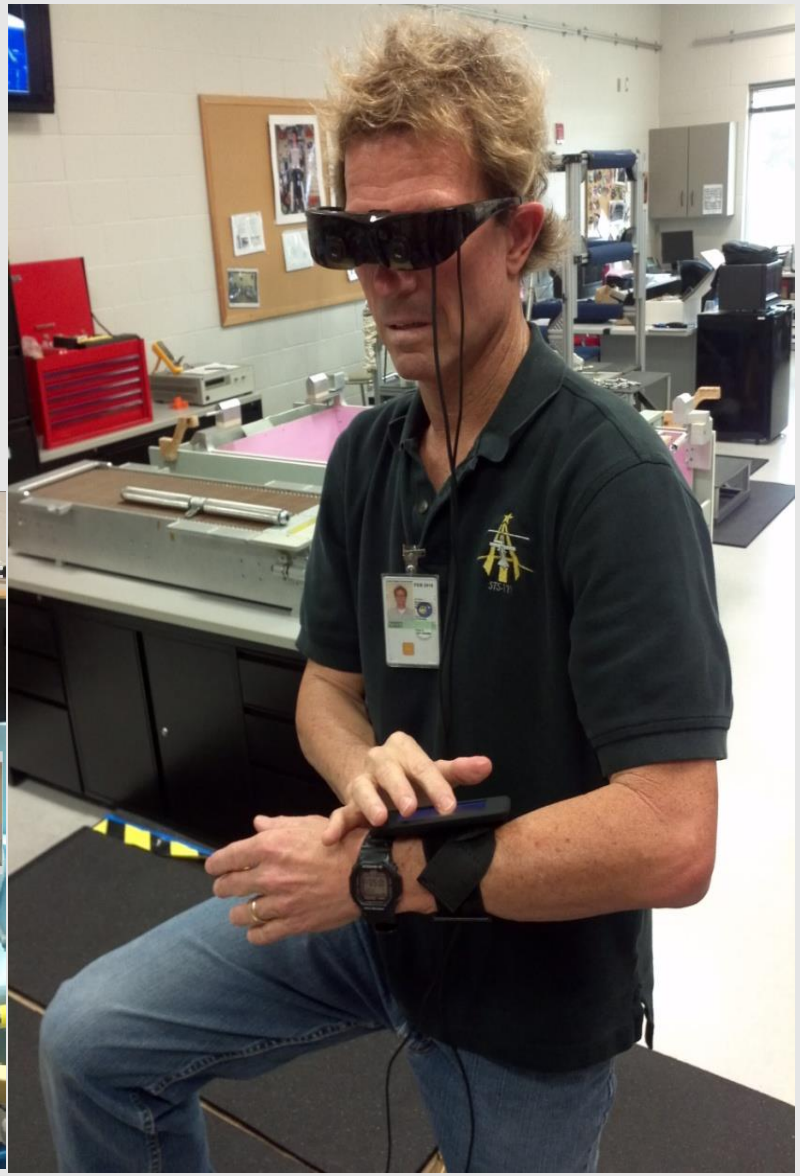
Augmented Reality to Enhance Crew Medical Training

Augmented Reality (AR-eProc ARED)

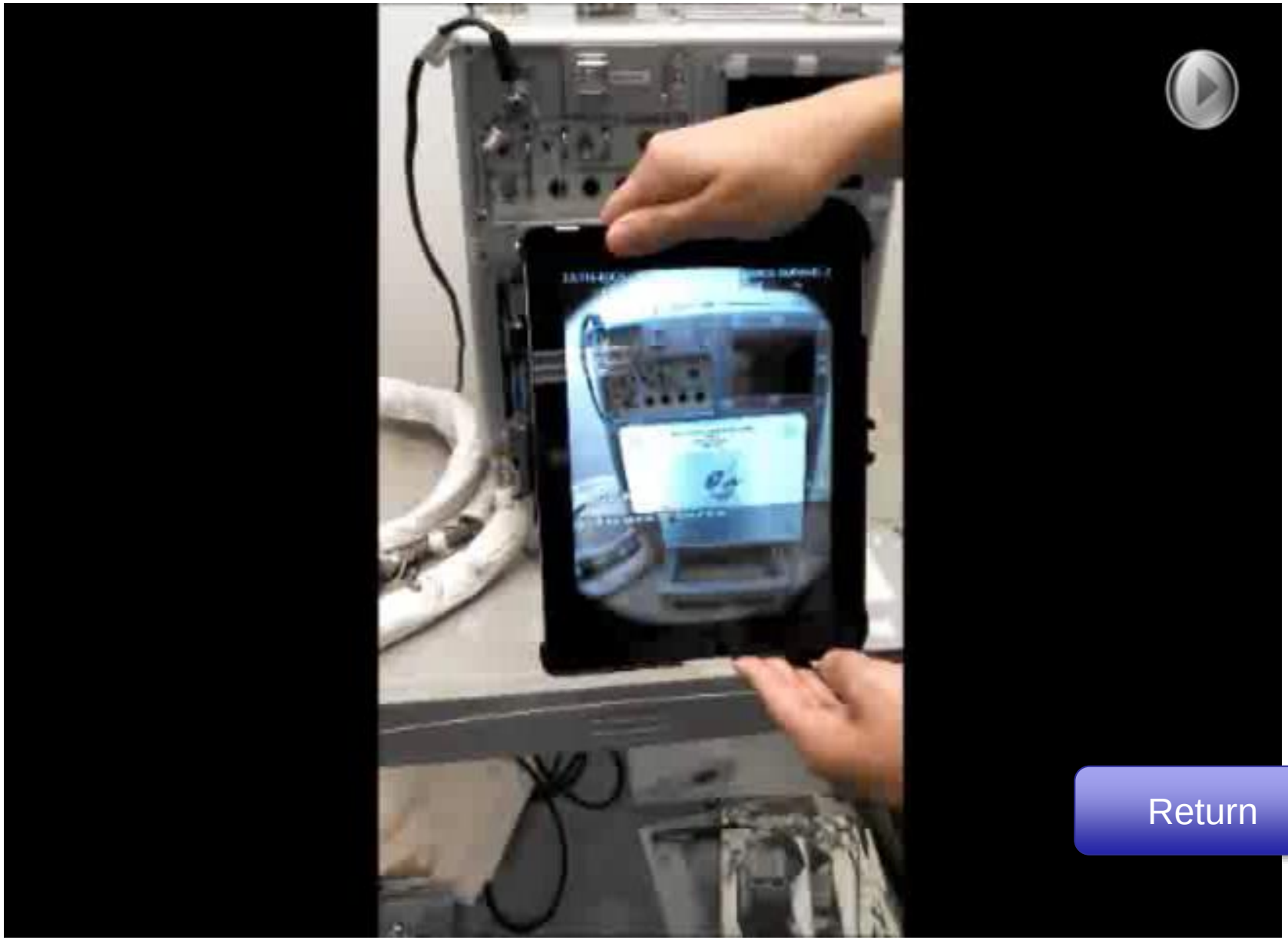








Augmented Reality (AR-eProc TOCA)



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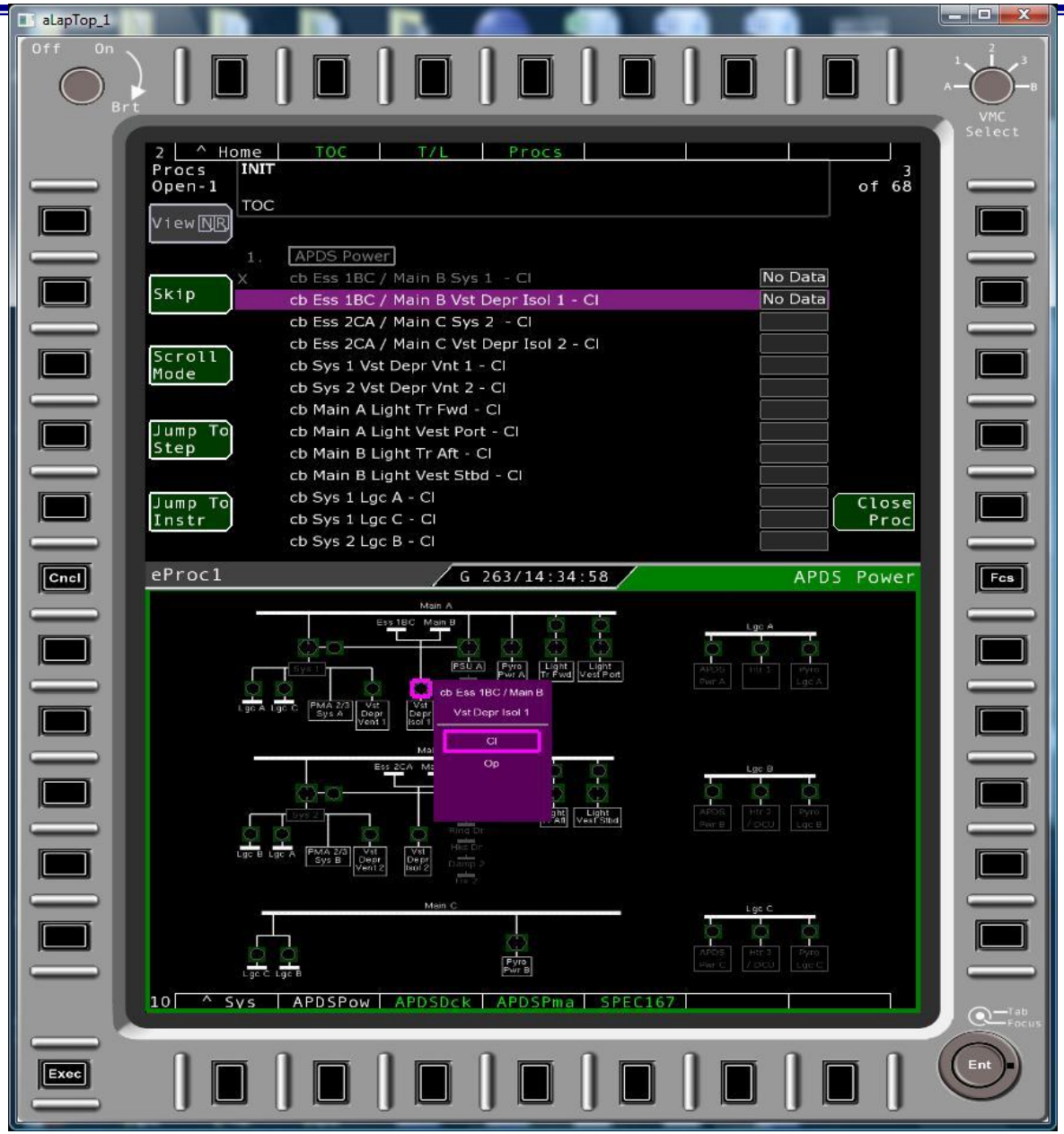
Orion Electronic Procedures



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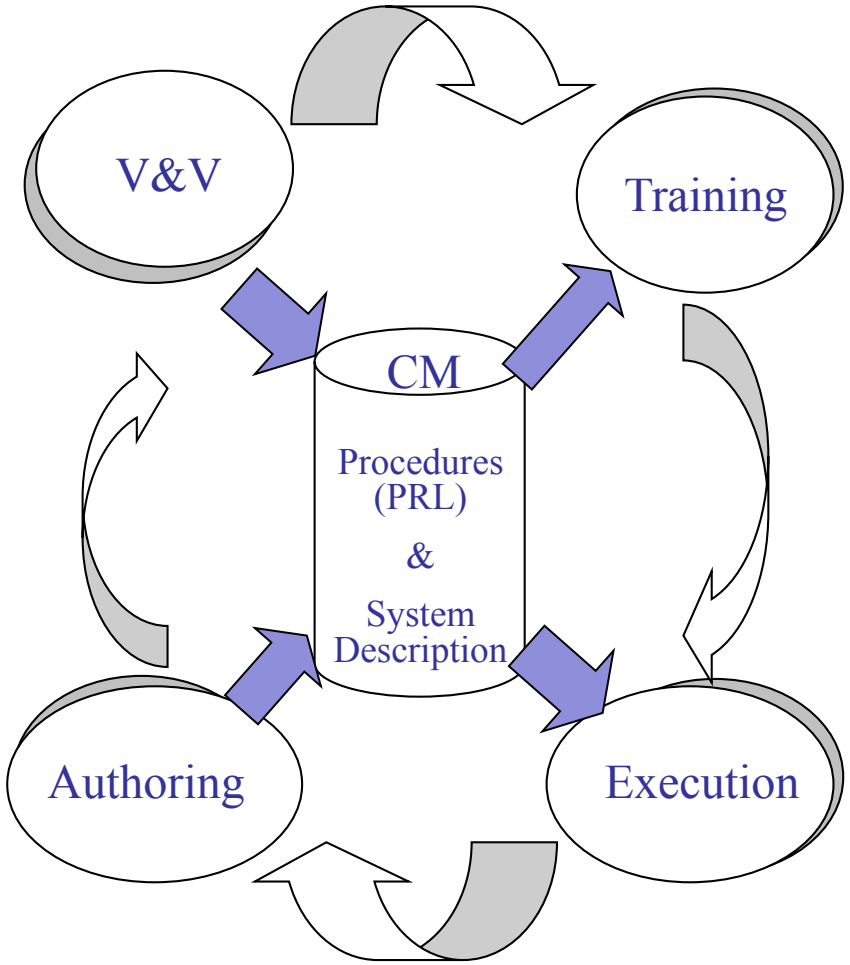
Procedure Lifecycle Development

- **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

WebPD

Procedure Log Preferences

Recommended

Active

5.10(1) Ultrasound - Kidney Scan

Completed

TOC

- 2.01 T61P Device Changeout
- 2.02 Hard Drive Not Functioning
- 2.1a T61P Device Changeout Without Unstow
- 2.1b T61P Device Changeout Without Unstow Or St
- 2.2a Power On and Login To Laptop
- 3.01 Atrium H20 Resupply - Main
- 3.02 Atrium H20 Resupply - Aux
- 3.03 Terminate Atrium H20 Resupply
- 3.04 Atrium Main Transfer - Flow High
- 3.05 Atrium Aux Transfer - Flow High
- 3.06 Atrium H2O Resupply With A3 Failed High
- 3.07 Atrium Main Transfer - Flow Low
- 3.08 Atrium Aux Transfer - Flow Low
- 4.01 Filter Changeout
- 4.02 IRED Canister Inspection and Cleaning
- 5.01 Calf and Bicep Muscle Atrophy and Pain
- 5.02 SLM Measurement
- 5.03 Ultrasound - Configure CX50 Unit
- 5.04 Ultrasound - Appendicitis Scan
- 5.05 Examination - Abdominal Pain
- 5.06 Genitourinary Anatomy
- 5.07 Treating Pain
- 5.08 Vital Signs
- 5.09 Genitourinary Procedure - Urine Retention and
- **5.10 Ultrasound - Kidney Scan**
- 5.11 Ultrasound - Gallbladder Scan
- 5.12 Ultrasound - Bladder Scan
- 6.01 Sample Transfer
- 6.02 Plant Soil pH Determination
- 7.01 24 VDC Power Supply LED Check
- 7.02 28 VDC Power Supply Check
- 7.03 Wireless Sensor Node Off Line
- 7.04 cRIO 1 9477 Card Off Line
- 7.05 28 V Power Supply Failed
- 7.06 cRIO 1 Off Line
- 7.07 24 V Power Supply Off Line
- 8.01 DSH Back Side Camera Survey
- 2.0.106 EXAM - PERIODIC HEALTH EVALUATION

5.10(1) Ultrasound - Kidney Scan

Start Stop

Objective:
To acquire images and measurements of the patient's right and left kidney.

PARTS:
- Ultrasound CX50
- Ultrasound Probe - C5-1
- - Probe Scanhead Cover
- - Probe Connector Cover
- - Reference Documents
- - Keyboard and Probe Placement Cue Card
- Ultrasound Echo Gel (one bottle)
- Dry Wipes

U 1 CONFIGURE CX50 ULTRASOUND DEVICE

NOTE

- The body has two kidneys and they are not always symmetrical in shape or position. As a result the operator will have to image and measure both kidneys. The right kidney is usually lower in the body by 1-2 inches and is easier to find.
- Supine position (lying down) is preferred for the patient and they can roll to the right and left for the right and left kidneys, respectively.

U 1.1 Configure the CX50 Ultrasound Device with the C5-1 probe using procedure "5.3 Ultrasound - Configure CX50 Device" Done Submit

U 1.2 For "Preset" on the CX50, select "Abd Renal"

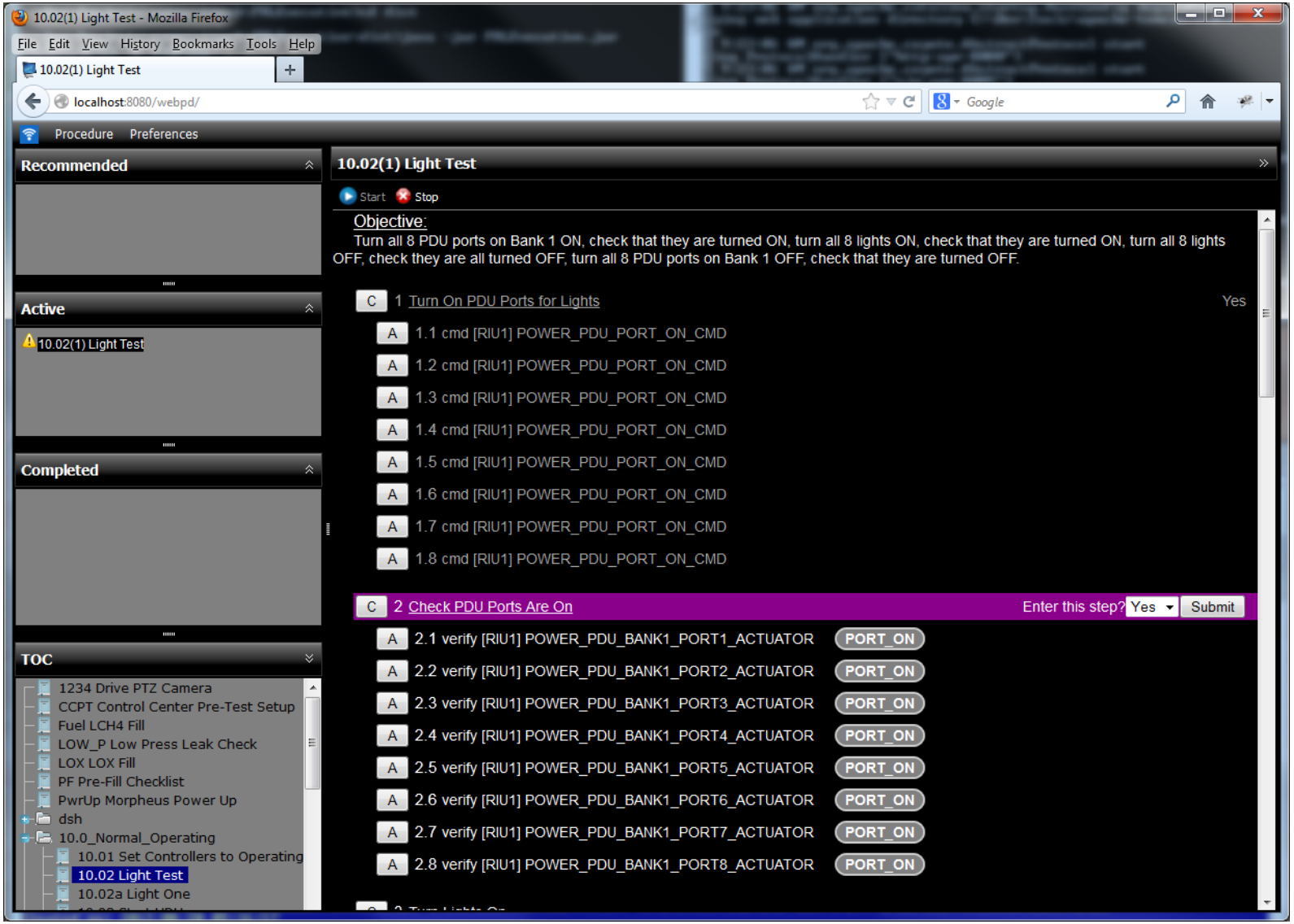
U 1.3 The gel should be applied to applied and resemble what is seen in Figure 1.

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.

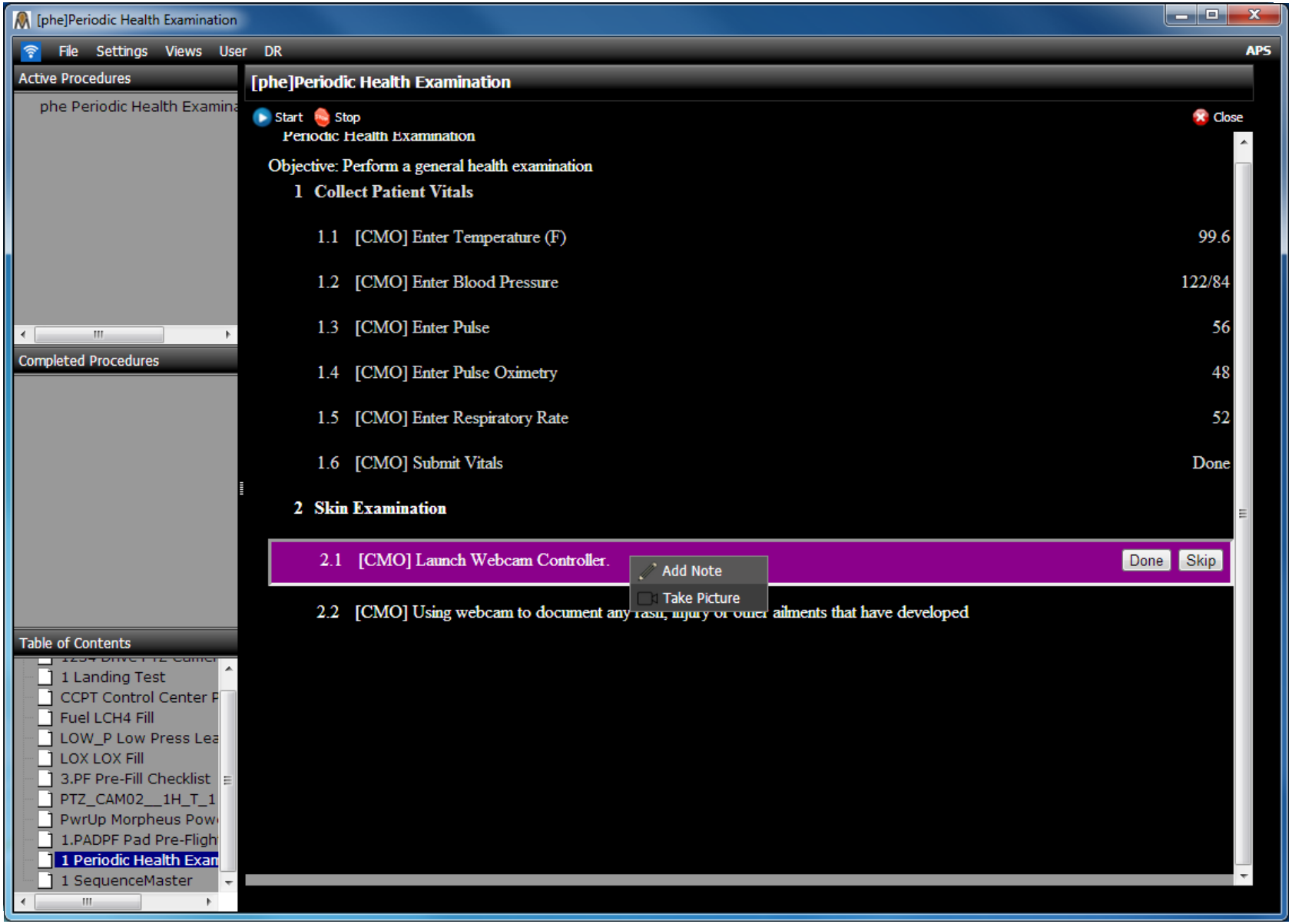
U 2 SCANNING PROCEDURE

U 2.1 Expose the patient's abdomen.

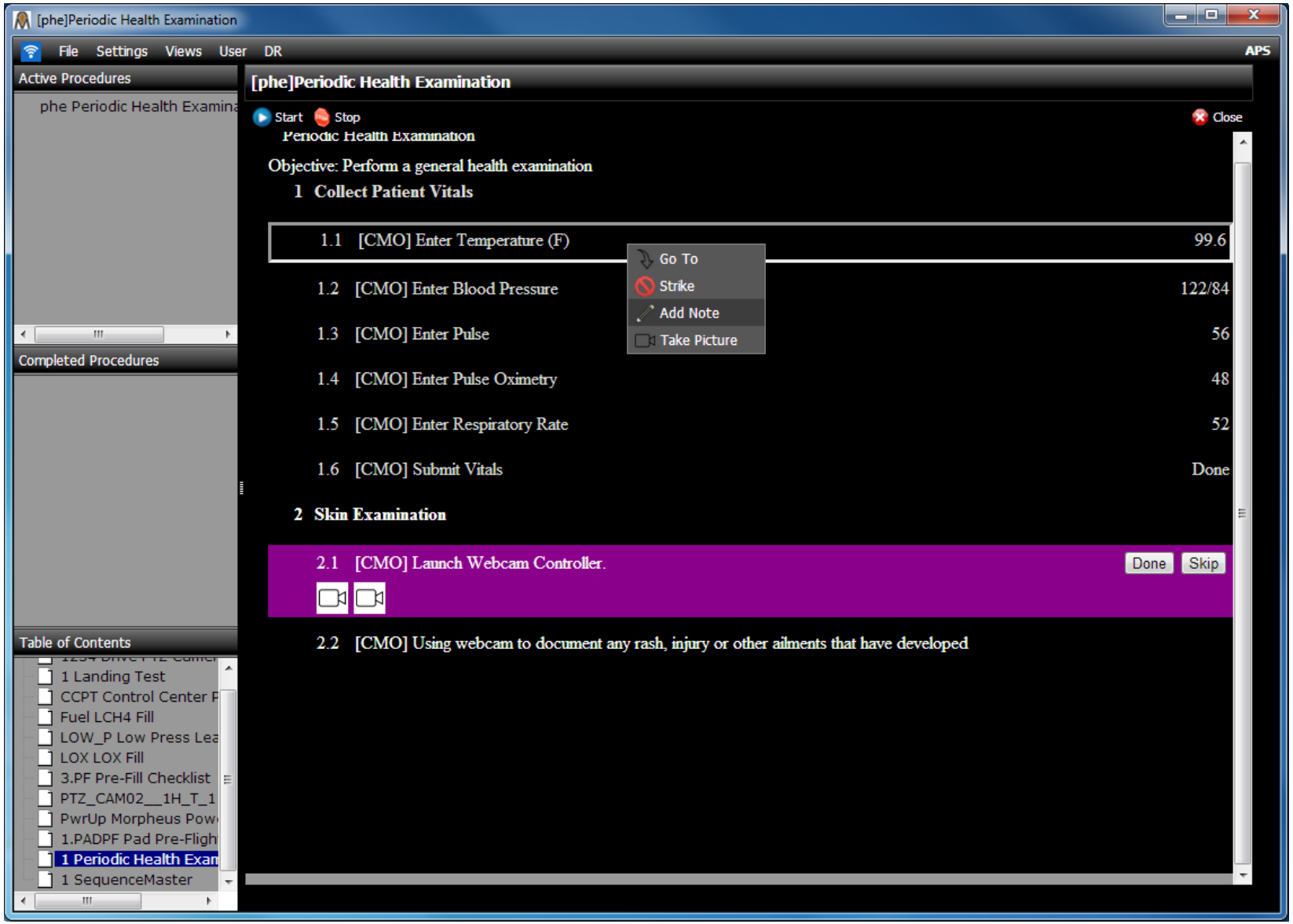
WebPD - Automation



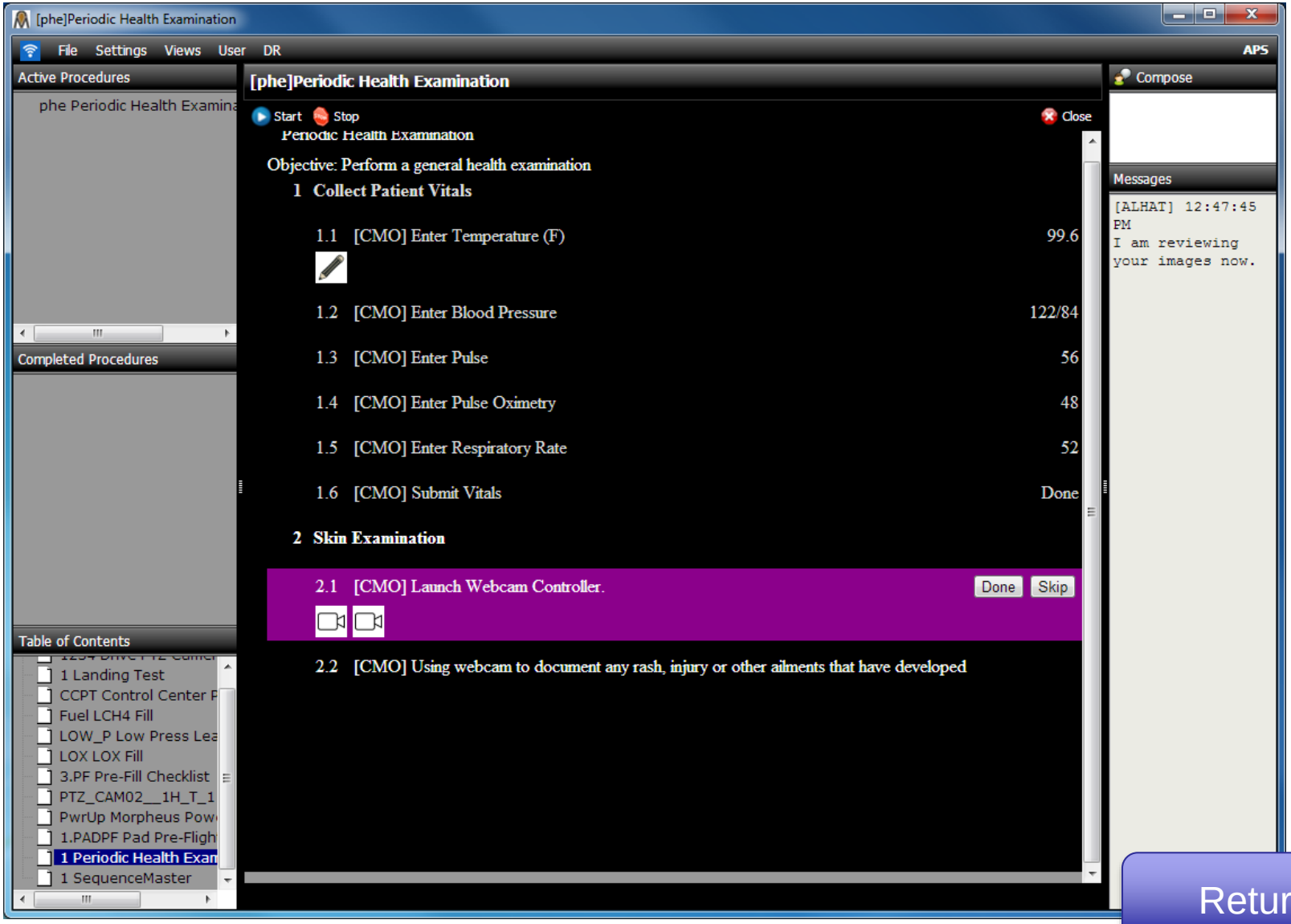
WebPD – Adding Image Notes



WebPD – Adding Text Notes



WebPD - IM



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