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R2CP INTEGRATION GUIDELINES

Software Functional Description and Implementation

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Table of Updates

Revision	Date	Changes / Remarks	Affected Sections	Author
A	3/12/2018	Document created	All	J.Antonio Gonzalez
B	11/06/2020	Added CP section Added description for AutomaticTechniqueMode Removed TechService configuration	RAD Databank Techservice tool	Angel Sánchez

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1. **R2CP XRAY SYSTEM**

R2CP is the protocol used to connect between different XRays for systems like ChallengeX.

By extension, the positioner, the generator, the console, and the image system interface, should implement this protocol, which refers to all the information needed to:

- Setup XRay parameters
- Setup the required position to make the XRay exposure
- Setup the Collimation parameters
- Display the patient and study information in the tube head console
- Dose management
- Postexposure information required to attach in the exposure image

This protocol is based in proprietary messages over TCP/IP.

1.1 System Architecture

The system is composed by a unique connection part, called **smart hub**, to which each part will be connected to.

Only those components registered in the SmartHub could stablish a connection on the system:

- Generator
- Positioner
- Console
- Image system

Each component is determined by:

- Node ID
- Description
- Messages subscribed to

Ceiling suspensión
POSITIONER ID=2

Generator
SHFR ID=6

SMART HUB
ID=1

ConfigR2CP.xml

TCP/IP NETWORK

IMAGESYSTEM ID=4

Tube head GUI
CONSOLE ID=5

Detector

Patient Worklist

Image
Processing &
RAD technique
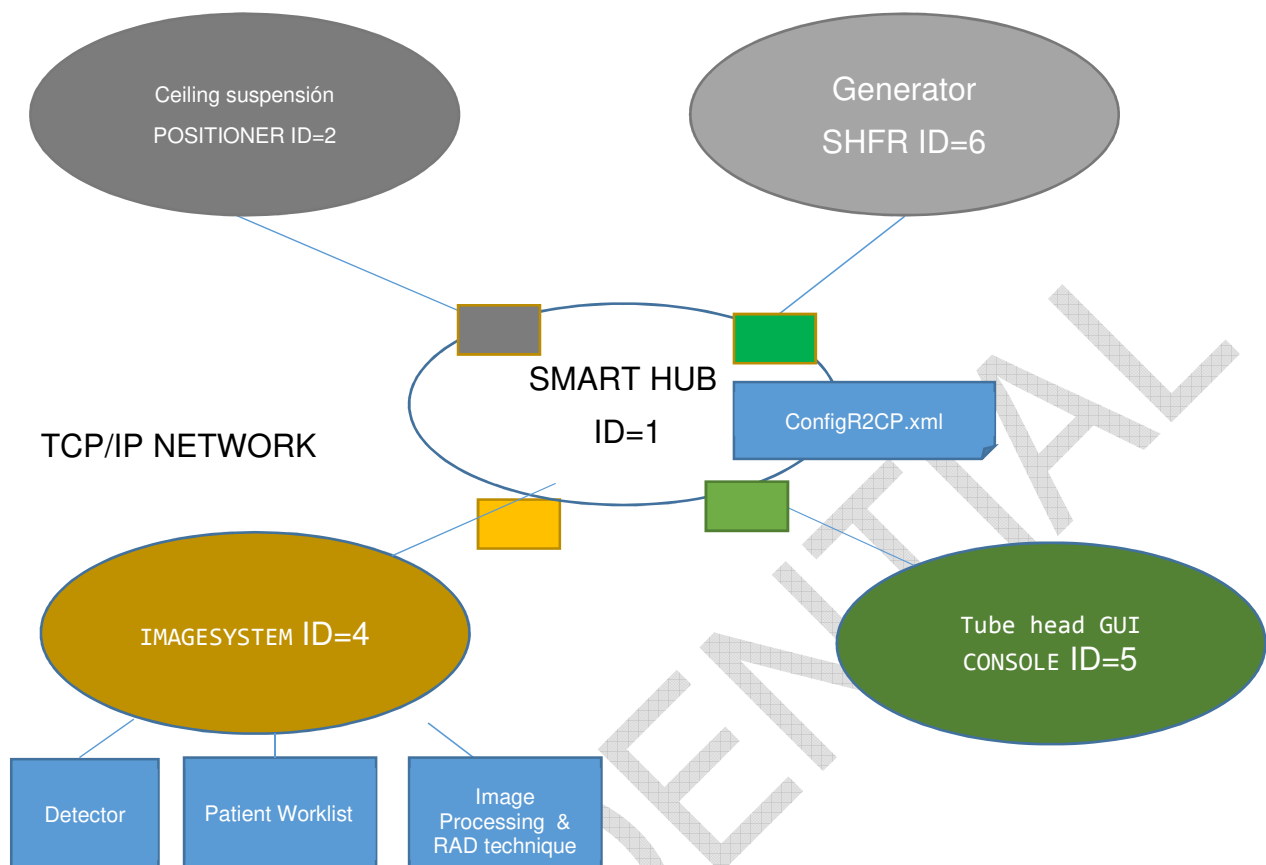
Figure 1. Logical connexions

Ceiling suspensión
POSITIONER ID=2

Linux

EBOX

SHFR
ID=6

CAN

Generat
or
ucontroller

Ethernet

Ethernet

Tube head
GUI CONSOLE
ID=5

Ethernet

HUB

WIN7 PC

Ethernet

IMAGESYSTEM ID=4

Detector

Patient Worklist

Image
Processing &
RAD technique
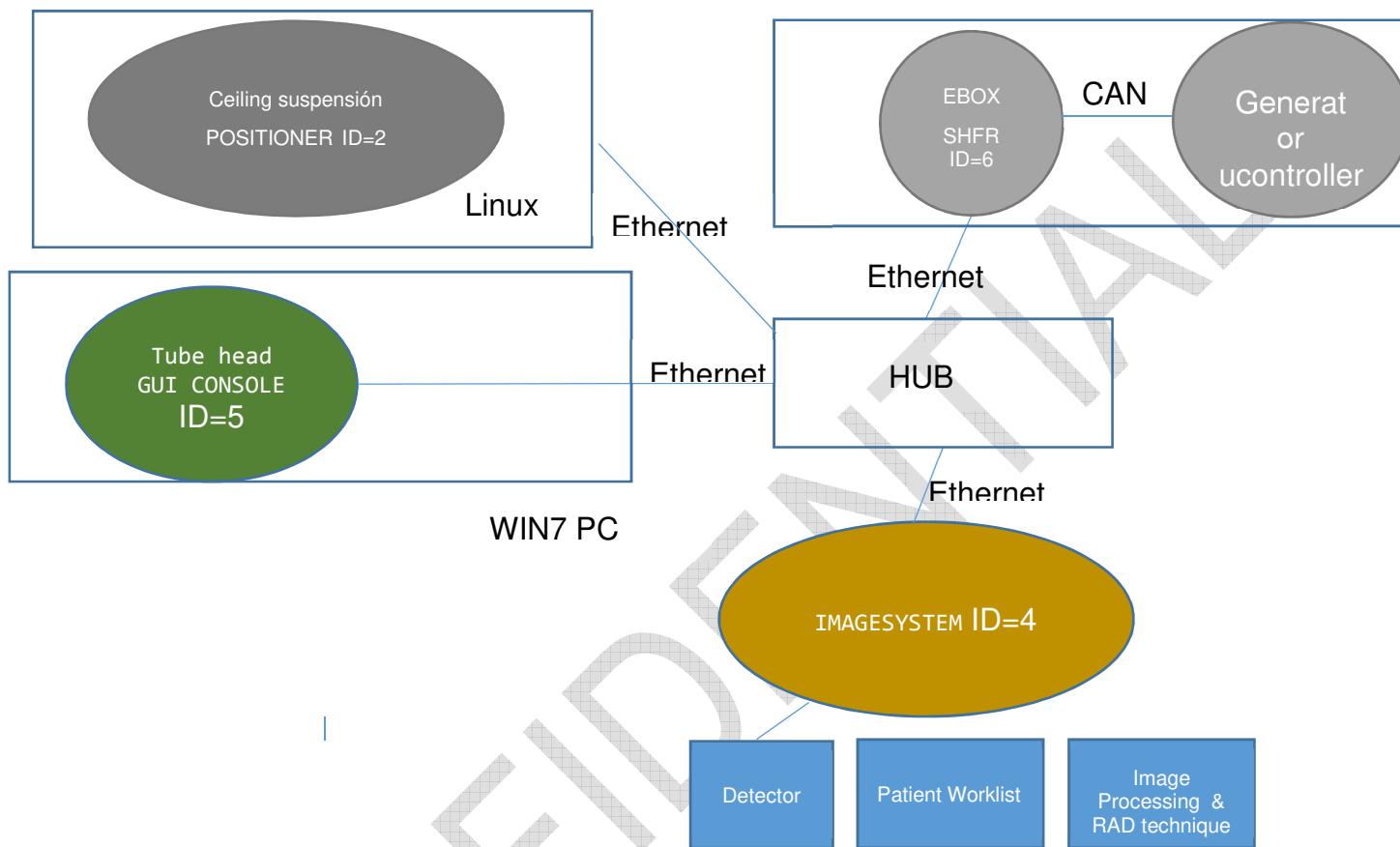
Figure 2. Physical Connections

Generator: runs in a micro Controller

Positioner: Linux platform

Tube head GUI/Console: .NET 4.6

Communication DLLS: .NET 4.0

Smarthub: .NET 4.0

1.1.1 Routing and addressing.

To allow console replication, messages are addressed to those nodes that need that information.

- Generator and positioner broadcast information
- Nodes requesting to positioner or/and generator, should address their messages to positioner or/and generator.

Messages are routed to the required component according to the SmartHub routing table, which considers:

- Message source ID
- Message index ID
- Message subindex

Like this, a Node could receive messages sent by the generator if it has previously subscribed to the Generator Message Source ID, and Generator message type ID.

The routing table is defined in ConfigR2CP.xml file.

```xml
  </node>
- <node type="ImageSystem">
    <id>3</id>
    <name>IS</name>
    <ip>192.6.1.105</ip>
  - <subcriptions>
      <subcription source="6" index="0x20" subindex="*" />
      <subcription source="2" index="0x40" subindex="*" />
      <subcription source="2" index="0x60" subindex="*" />
      <subcription source="0" index="0xA0" subindex="*" />
      <subcription source="0" index="0x80" subindex="*" />
      <subcription source="0" index="0xE0" subindex="*" />
      <subcription source="0" index="0xF0" subindex="*" />
    </subcriptions>
```

Figure 3. ImageSystem configuration in R2CPConfig.xml file

The NODE ID 3, will receive messages

- From node 6 (generator), those of index 0x20 (Generator), any subindex.
- From node 2 (positioner), those of index 0x40 (Positioner), any subindex.
- From node 2 (positioner), those of index 0x60 (dosimeteter), any subindex

- From any node (generator&positioner), those of index 0xA0 (Network), any subindex
- From any node, those of index 0x80 (system), any subindex
- From any node, those of index 0xE0 (Patient workflow), any subindex
- From any node, those of index 0xF0 (workflow), any subindex.

This file is shared by all nodes, and is shared by the Windows IIS service in **¡Error! Referencia de hipervínculo no válida.** HUB IP/Configuration/ConfigR2CP.xml

Figure 4. Index list

Figure 5. Generator subindex list

Index codes can found by looking at `Sedecal.Atomium.Comms.GPIO.Messages.Enum`:

```
public enum EGPIOIndex
```

Subindex code can be checked at `Sedecal.Atomium.Comms.GPIO.Messages.Enum`

```
public enum EGPIOCanCommonSubIndex
```

```
public enum EGPIOSubIndex
```

```
public enum EGPIODosimeterSubIndex
```

```
public enum EGPIOGeneratorSubIndex
```

```
public enum EGPIOPositionerSubIndex
```

```
public enum EGPIORFIDSubIndex
```

```
public enum ReadoutIntervalDosimeterEVENTMessage
```

```
public enum EGPIOSystemSubIndex
```

```
public enum EGPIONetworkSubIndex
```

```
public enum EGPIOPatientWorkflowSubIndex
```

```
public enum EGPIOWorkflowSubIndex
```

1.1.2 Index description

- CanCommon: Information about SW / HW versions.

- SerialPort: not used
- Generator: Information about xray settings
- Positioner: Information about positioning
- Dosimeter: Information about dosimetry
- System. Information about system messages
- Network: Information about node connections
- Service: not used
- PatientWorkflow: Procedure definition, and patient info.
- Workflow: Command Processed acknowledge

Index Code	Message group	System message sends to
0x20	Generator	Generator
0x40	Positioner	Positioner
0x80	System	Generator and Positioner
0xA0	Network	No need to send messages
0xE0	Patient Workflow	Generator and positioner
0XF0	Command Processed	Generator and positioner

1.1.3 How to access to ConfigR2CP.xml file

The ConfigurationManager() class can read and provide you the required functionality to find the nodes ID according to the node functionality.

```
private Sedecal.Atomium.Comms.LogManager.ILogManager log =
            Sedecal.Atomium.Comms.LogManager.Instance;

IConfigurationManager configuration =
    new Sedecal.Atomium.Comms.Configuration.ConfigurationManager(log);


configuration.LoadConfiguration(urlConfigFile);

byte genId = (byte)configuration.GetNodeIDByNodeType(NodeType.Generator);

byte posId = (byte)configuration.GetNodeIDByNodeType(NodeType.Positioner);

byte systemConsoleID = (byte)configuration.GetNodeConfiguration("ImageSystem").Id;
```

Where *ImageSystem* is the string identification done in the XML file for that node

```
 </node>
- <node type="ImageSystem">
    <id>3</id>
    <name>IS</name>
    <ip>192.6.1.105</ip>
  - <subcriptions>
      <subcription source="6" index="0x20" subindex="*" />
      <subcription source="2" index="0x40" subindex="*" />
      <subcription source="2" index="0x60" subindex="*" />
      <subcription source="0" index="0xA0" subindex="*" />
      <subcription source="0" index="0x80" subindex="*" />
      <subcription source="0" index="0xE0" subindex="*" />
      <subcription source="0" index="0xF0" subindex="*" />
  </subcriptions>
```

1.1.4 Configure Internet Information Server to access shared files

1) Create a website. The folder that you select should be where are the configuration shared files.
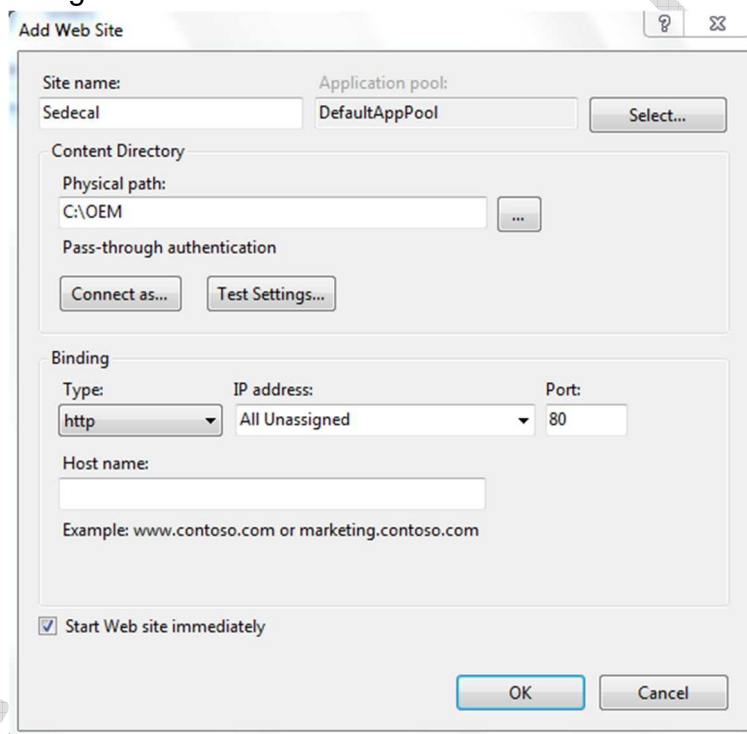
2) The folder where are the configuration files, you can give read permissions to web user (IIS_xxxx), or you can give read permissions to everyone group.
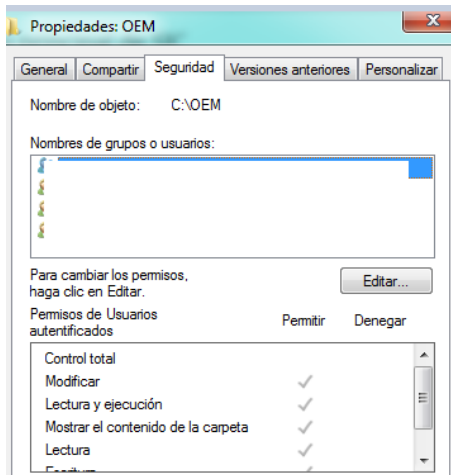
3) Open an internet browser and try to connect to the configuration file ConfigR2CP.xml. You can use the url: **¡Error! Referencia de hipervínculo no válida.**

You should watch the content of the file in the browser

1.2 Image system

The image system application is responsible of

- Open an exam
- Define which **detector** will be used
  - Position (table, wallstand, free)
- Define the **default RAD exposure** parameters required for each study. In the same way that image processing depends on the body part, the Image system will store as well the exposure parameters (anatomical programmer table), since these values depend as well on the sensibility of the detector.
  - kV, mA-ms or mAs, Focus,
  - AEC
- Define the **default Positioner** parameters required for that exam
  - Autoposition (SID)
  - Collimator FOV
  - Collimator Filter
- Facilitate the patient name (for visualization purposes)
- Facilitate the procedure name (for visualization purpose)
- Get the XRay image after the exposure
- Attach the real generator parameters used in the exposure
  - kV, mA, ms, Focus
  - AEC,
  - Dose

- Attach the real positioner parameters used in the exposure
  - SID
  - Collimator Filter
  - Collimator FOV
- Close an exam

1.3 System Messages

System message includes any condition that:

- Should be displayed on the operator screen, like errors, warnings, notifications…
- Should disable xrays
- Should disable movements

1.3.1 Actions

Indicates how the generator and positioner should react regarding exposures and movements respectively when a system message is active.

- *Inhibit Exposure* and *Inhibit Generator phase*: No exposures will be allowed. Generator will be allowed to go up to an specific phase. ie.
  - *Positioner is moving, generator cannot expose, but it can reach ready status, to start the exposure as soon as target position is reached.*
  - *Study Patient is closed. Generator phase = standby. Since no valid technique is selected, no need to let the generator to start an exposure*

  Special case: Abort Exposure. If an exposure is in progress when this message is set, it will be aborted. For example: *i.e.*
  - *Door open.*
  - *Detector not ready*
- *Inhibit Movement*. No movements will be allowed. i.e.
  - *obstacle found in moving path*

  Special case: not an exposure inhibit, nor a movement inhibit: Just for user notification. i.e
  - *maximum kv value.*
  - *Grid required*
  - *Parameters manually adjusted*
- Is Activated. Indicates if the condition is active or not
- Source Node: the source node is the *proprietary* of the system message. It's responsible to set and clear the inhibit.

Other information that we consider in the Sedecal Console to handle errors is:

1.3.2 Clear system message

Indicates how the system message is cleared on the screen.

- Device. The device that set the system message, should clear it.
  - o *Door open* (generator)
  - o *SID-Grid mismatch* (positioner)
- User. The operator should clear the system message, it would be as a user confirmation:
  - o *AEC error*
- Timeout. System message disappears after some time
  - o *Maximum kV value*
- Never. Error never disappears. Requires a system reset

1.3.3 GUI behavior

Indicates how the Tube console will react to the system message.

- Sound. Tube console will beep discontinuously.
- Record in log files. The system message will be recorded in the service log.
- Pop up. A pop up message window will be displayed. ie *Emergency stop*

i.e. behavior code 0x22800, used by the Tube console to manage errors.

0010-0010-1000-0000

Generator Phase	Sound
	Record
	Popup
Abort exposure Exposure Inibhit Movement inhibit Warning	Clear by device Clear by user Clear by timeout never

The meaning of a system message can be queried in the system_messages.sqlite DB. Which can be queried by using a DB browser for SQLite.

An image system can set and clear a system message, but a code behavior should be defined and included in the system message DB to be handled by the system.

Figure 6 System Message text description

1.4 Heartbeat

Smarthub request a HeartBeatGETMessage message to every node, and waits for an answer within an interval defined in <keepAliveInterval>10</keepAliveInterval> ConfigR2CP.xml file, and vice versa. If the expected message is not received, communications are reestablished in the node or smarthub.

1.5 CP (Command proccess)

CP is a R2CP message called CPEVENTMessage, that is managed internally by communication dlls. Mainly, it is useful:

- Not allow the next request until the previous one is finished.

- To know if your request was managed correctly or not.

Every SET/GET message request must be confirmed with the CP. It is not necessary to subscribe to this message and is easily visible in communication logs.

CPEVENTMessage is placed in a class called *Response,* that is used in all communication methods. This way is easy to access the CP without subscriptions. Communication method example:

```
Response SendCommandSync(IR2CPCommand cmd, NodeType type);
```

IIS0069SFUN Rev. B

The CPEVENTMessage has two important fields:
- *ReturnCode*: This field is 0 if the transaction was correct, any other value is an error. The type of errors depends on the request, and you can find them as enum in every R2CP message class, for example, in LoadRADDataBankSETMessage:

```
public enum ReturnCode {

        Ok = 0,

        DatabankIdOutOfRange = 1,

        PatientSizeCodeOutOfRange = 3, …
```

- *RequestSequence:* it allows to check if the CP is the correct confirmation for the request. This byte will be the same as the field *Header.Sequence* in the request. This relation is managed internally by the communication dlls, so it is unnecessary to check it again.

2. **RAD CONSOLE**

We will describe what messages should be managed to accomplish the Image system responsibilities.

2.1 WORKSTATION

Workstation is the set of Generator, Tube, Positioner, image receptor location.

```
<Workstation>
        <Id>1</Id>
        <Tube>1</Tube>
        <Generator>1</Generator>
        <Positioner>1</Positioner>
        <Detector>1</Detector>
        <Procedure>rad</Procedure>
        <ReceptorPlace>Free</ReceptorPlace>
        <ReceptorSync>direct</ReceptorSync>
        <AEC>0</AEC>
        <RoomName>ChallengeX</RoomName>
        <ReceptorName>DR Wifi</ReceptorName>
        <Description>Portable Panel</Description>
</Workstation>
```

When defining procedure, you should consider which system **workstation** you should use, regarding the placement of the detector (table, wallstand, or free). This is closely related to the system configuration.

Normally, the Challenge (one tube) system is configured such as

	Workstation 1	Workstation 2	Workstation 3
ID	1	2	3
Detector Position	FREE	Table	Wallstand
AEC	No	Yes	Yes
Detector	X, portable detector	Y for fix detector	Z for fix detector
		X for portable detector	X for portable detector
Autopos numbers	1-99	100-199	200-299

However, the SHFR generator does not use this concept yet, and the value used in this field is linked to whatever has been predefined with the Tech Service tool:

Programas (7)
Tech Service Console 1.1.4
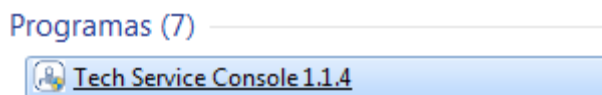
Figure 7. SHFR Service application. Requires RS232 Connections

Workstations Configuration

Workstation 1	TUBE 1 ▼	BUCKY ▼	BUCKY 1 ▼	NO AEC ▼
Workstation 2	TUBE 1 ▼	BUCKY ▼	BUCKY 1 ▼	NO AEC ▼
Workstation 3	TUBE 1 ▼	BUCKY ▼	BUCKY 1 ▼	NO AEC ▼
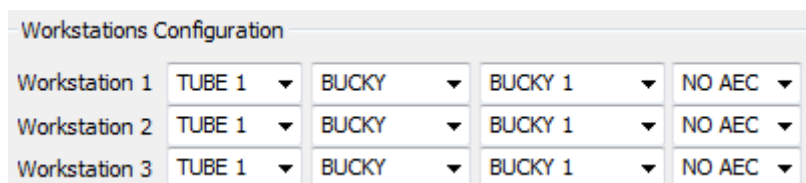
Figure 8. SHFR Workstation configuration for ChallengeX

TechService Tool Password 2434/Configuration/Store Data/OK
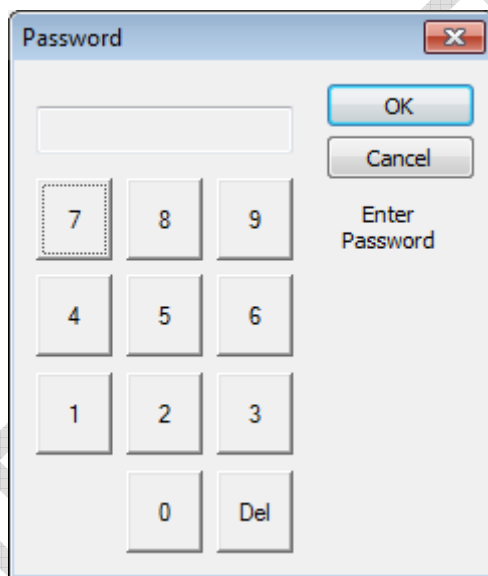
Figure 9. Type 2434 password to run the SHFR Configuration tool
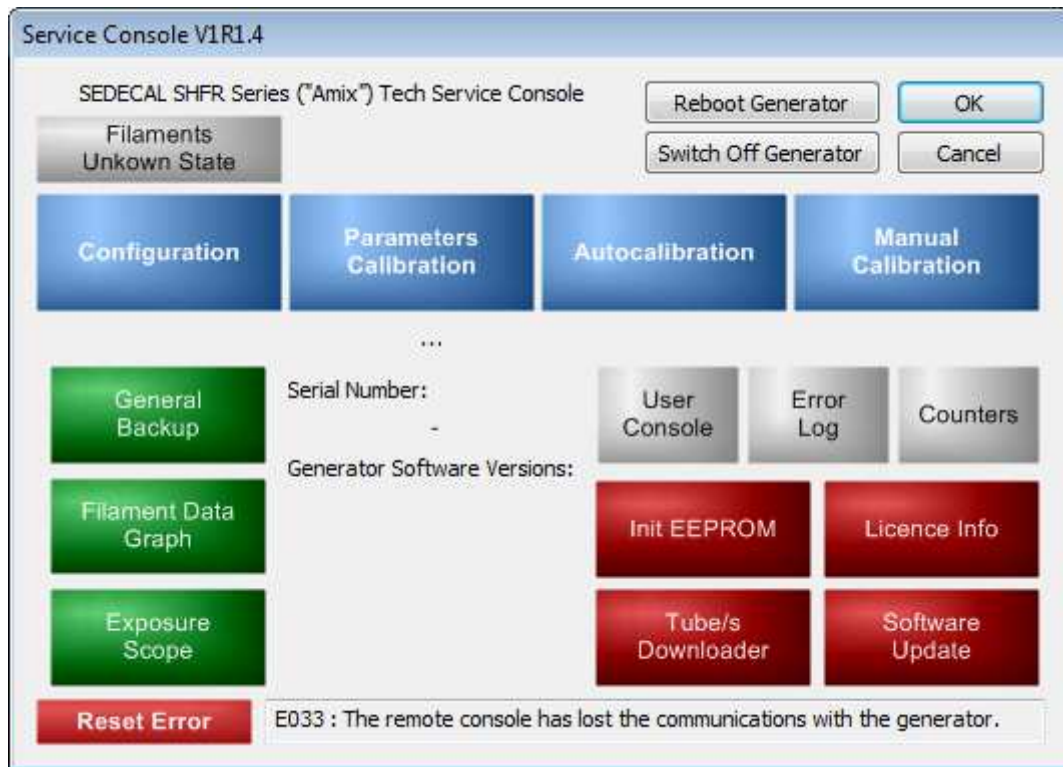
Figure 10. Enter in SHFR Configuration
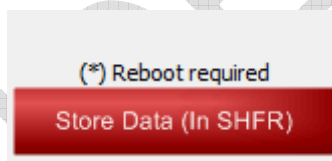
Figure 11. Save SHFR Configuration
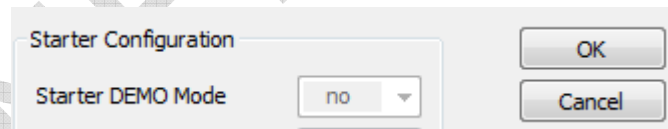
Figure 12. Exit SHFR Configuration Screen

The Challenge workstation configuration file is located at http://192.6.1.103/Configuration/workstations.xml

This file can be read by using the `ConfigurationService` class (singleton).

```
using Sedecal.Services.WSConfiguration;
using Sedecal.Services.WSConfiguration.Entities;


ConfigurationService service = ConfigurationService.Instance;
service.LoadConfiguration("http://192.6.1.103/Configuration/");
List<Workstation> workstations = service.WorkstationList;
```

The workstation class will contain the information described above:

```
public class Workstation
```

```
    {
        public Workstation();

        public uint AEC { get; set; }
        public string Description { get; set; }
        public uint Detector { get; set; }
        public uint Generator { get; set; }
        public uint Id { get; set; }
        public uint Positioner { get; set; }
        public string Procedure { get; set; }
        public string ReceptorName { get; set; }
        public string ReceptorPlace { get; set; }
        public string ReceptorSync { get; set; }
        public string RoomName { get; set; }
        public uint Tube { get; set; }
    }
```

So, you could match your detector with the Workstation as follows:

```
Workstation ws = workstations.Find(x=>x.ReceptorName == detectorID);
```

2.2 PROCEDURES

- Procedure Numbering starts at 1.
- A procedure is linked to one Workstation.
- No more than 5 procedures can be defined at a time.
- There is a special procedure 0 managed internally (when no procedure is defined at all), but NO exposures will be allowed in this procedure 0. Generator and positioner will notify a system message mentioning this condition.
- **No procedure reconfiguration is allowed**. A procedure needs to be deleted if it any of its parameter has to be redefined.

2.3 DATABANKS

- DataBank Numbering starts at 1.
- No more than 10 Databanks can be defined at a time.
- There is a special databank 0 managed internally when no procedure is defined (procedure 0).
- Databank numberings for RAD and Fluoro should not overlap (ie, ID cannot be repeated regardless of RF/RAD Type)
- Databanks numberings for generator and positioner (FOV collimator, Filter collimator, positioning) start at 1.

DataBankID: 1	DataBankID: 2
Technique Mode: ThreePoints	KVP: 40
KVP: 70 SET	MA: 10
MA: 20	Ms: 5
MAs: 0,5	Max Exposure Time 100
Ms: 25	PPS: 0
Max Exposure Time 2500	ABC: ☐
Focus: Large	High Dose: ☐
AEC Sensitivity: Low	KV Scan: ☐
AEC Density: 0	Q by PPS: ☐
AEC Chamber: ☐ L ☐ C ☐ R	Dose Level ID: 0
Tube power: 100	Patient Size: Medium
FPS: 30	Paediatric: ☐
Tracking: 0	Curve ID 0
Patient Size: Medium	Curve ID:
Paediatric: ☐	
Adjust Params: ☐	

Figure 13 Rad DB   **Figure 14 Fluoro DB**

Data Bank ID 1	Data Bank ID 1
Collimator trans 200	Filter 1
Collimator long 200	
Max Collimator trans 400	**Figure 16 Coll Filter DB**
Max Collimator long 400	

Figure 15 FOV DB

LoadAutoposSETMessage	ushort AutoposId	
LoadFreeAutoposSETMessage	bool CollisionAvoidancePath	
	PositionMessageFormat Position	
	bool SetDetentsOnAfterPositioning	
	bool SetTrackingOnAfterPositioning	
	AutoposType Type	Absolute = 0, RelativeTable = 1, RelativeWallstand = 2

Figure 17 Position DB

PositionMessageFormat		Stitching Alpha = 0
Alpha		0
(Angle)		
(ArmAngle)	Does not apply to challenge X	
Beta		0 deg
ImageReceptorPosition		**Table stitching**
Rotation		Don't care
SID		**X** **(same for all exposures)**
TableHeight	Cannot be set?, but read	Don't care
Table Image Receptor Holder Rotation	Cannot be set auto, but read	Don't care
Table Tilting angle	Does not apply to challenge X	Don't care
Table Top X	Cannot be set auto, but read. Useless for images system	Don't care
Table Top Y	Cannot be set auto, but read. Useless for images system	Don't care
Wallstand Column Position	Does not apply to challenge X	Don't care
Wallsatand Column Rotation	Does not apply to challenge X	Don't care
Wallstand Height		**Wallstand stitching**
Wallstand Image Receptor Holder Rotation	Cannot be set auto, but read	Don't care
Wallstand Tilting angle		0 deg
X	Normally, used for free pos	Don't care
Y	Normally, used for free pos	Don't care
Z	Normally, used for free pos	Don't care

Figure 18. Positioner Info

How to set a free position.

2.4 DATABANK ASSIGNMENT

- Assigning more than one databank per procedure, is intended for studies such as "stitching", "dual energy", or multienergy. The generator/Positioner will have the techniques preloaded, to make exposure transitions as fast as possible.
- When assigning databanks to procedure (`AssignExposureDataBankSETMessage`), the system will know in advance what databank will be use in the exposure order.
- This transitions could be done
  - o setting the property `GeneratorDataBankSequencing` in the `ProcedureSETMessage` to false: By sending the `ActivateProcedureDataBankSETMessage` exposure by exposure.
  - o setting the property `GeneratorDataBankSequencing` in the `ProcedureSETMessage` to true. This way the system will load/activate automatically the databank for the following exposure.
- Assign numbering start at 1.

2.5 DATABANK ACTIVATION

- Activation can be done by sending the message `ActivateProcedureDataBankSETMessage` if `SwitchFromButtonPedal` property in `ProcedureSETMessage` MESSAGE set to false.
- By pressing the assigned pedal number (defined in `ButtonPedalIndex`) when the procedure was defined `ActivateProcedureDataBankSETMessage` if `SwitchFromButtonPedal` property in `ProcedureSETMessage` MESSAGE set to true.
- `SwitchFromButtonPedal` activation is intended to change "PROCEDURES", not exposure index. In other words, you might use the pedal to activate a "stitching sequence", or a "single rad" exposure, or a "dual energy" exposure, not to activate the 2nd or 3rd exposure for stitching.

2.6 *Procedure definition for 1 exposure studies (standard RAD):*

There are several ways of using the XRay system. Here we propose some of them.

2.6.1 One procedure with one databank.

Clear, define, assign and activate the desired procedure and databank according to the detector, and reload the databank when needed (for AEC or non-AEC selection).
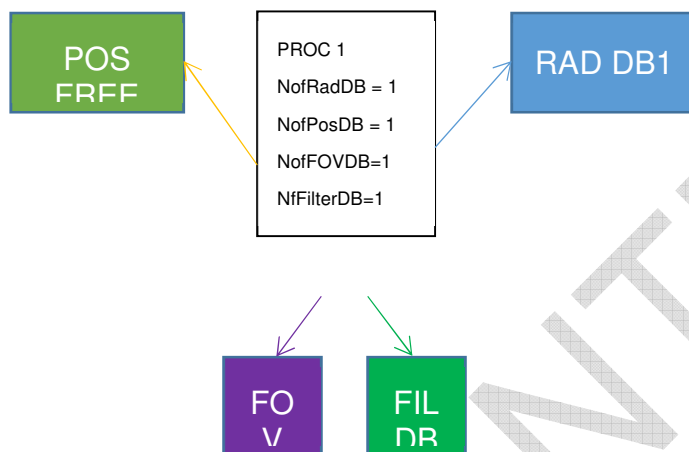
One databank per position, rad params, FOV and collimator filter. Redefine values when needed. Clear procedure when a new detector (workstation) is requested (if possible).

This is the basic and simpler Procedure/Databanks/Assignment/Activation configuration.

2.6.2 One Procedure with N datanks.

Define the right procedure for the workstation being used, define N Databanks, and Assign & activate **one** desired Databank when needed (i.e one data bank for Large patient, medium, small exposures).

Procedure 1: Standard Rad, Standard Positioning, Pedal 1, **WS1 (free)**, Number of Gen DB: 3
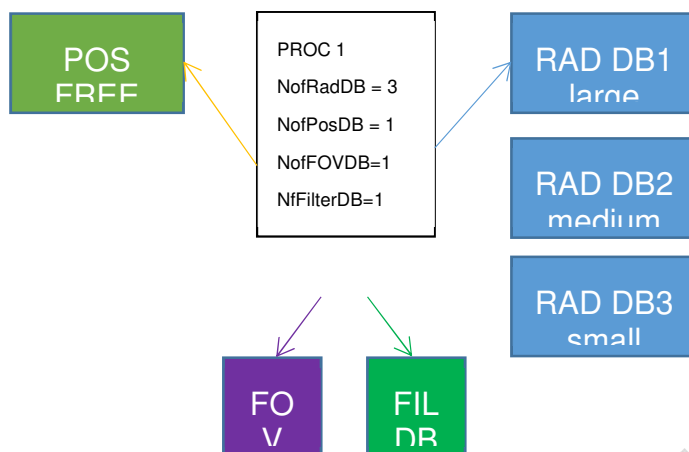
3 DATABANKS defined for generator parameters and positioning for large, medium and small patient size.

1 DATABANK (same for every detector) is defined for AUTOPOSITION, COLLIMATOR FOV and COLLIMATOR Filter. RAD DATABANKS assignments will be modified according to patient selection.

N Procedures with one Databank each

Define, assign and activate the desired number of procedures according to the available detectors (workstations), and reload the databank when needed (i.e. for AEC or non-AEC exposures)
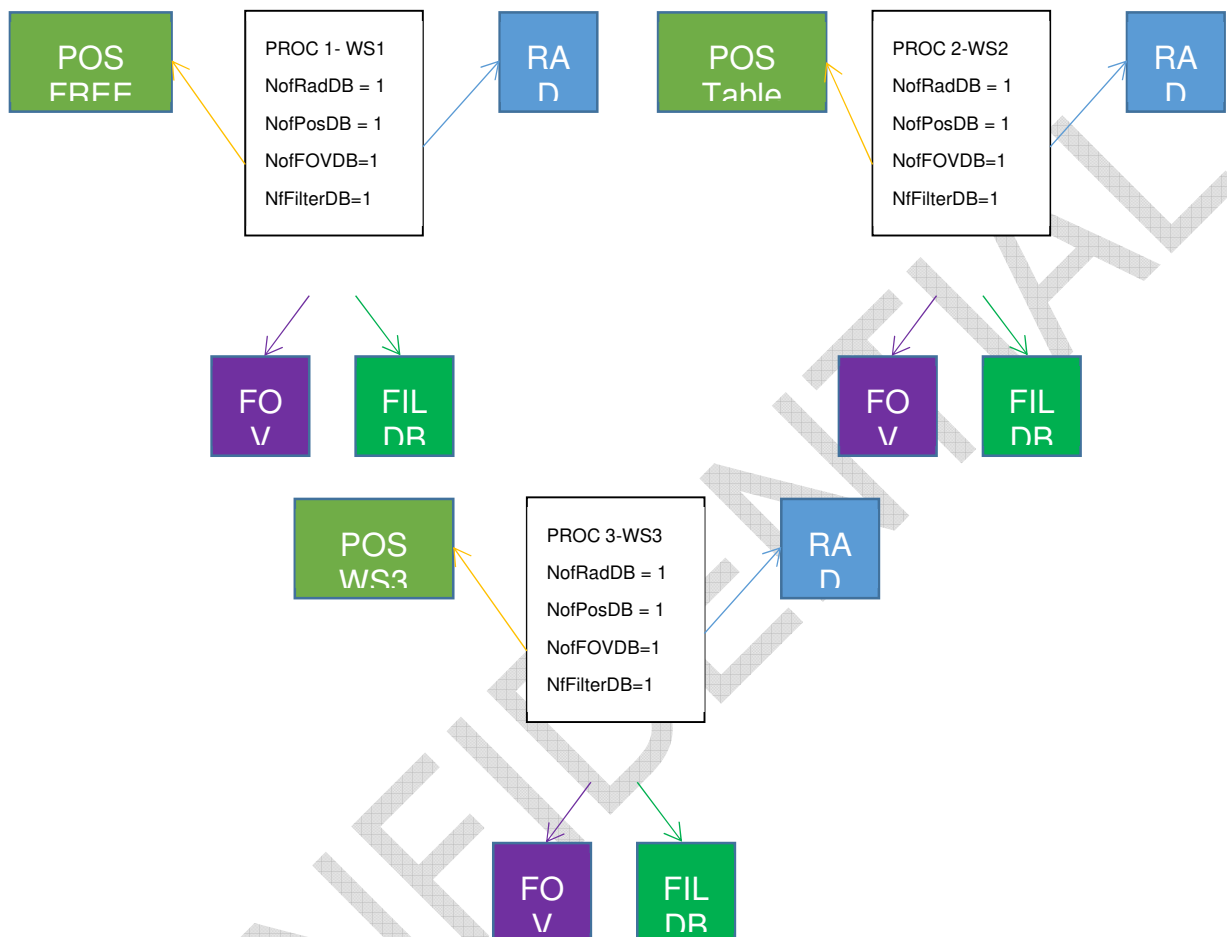
3 DATABANKS defined for positioning (table, wallstand, free)

1 DATABANK (same for every position) is defined for RAD, AUTOPOSITION, COLLIMATOR FOV and COLLIMATOR Filter.

RAD DATABANKS can be overwritten when needed.

You could mix more RAD Databanks per procedure, if different patient size techniques want to be managed, for example.

2.7 Procedure definition for Stitching:

One Procedure with N datanks. Define the right procedure for the workstation being used, **define and assign N Databanks** (one databank for each exposure required). Activate the procedure, and the following databanks will be activated according to the exposure in progress.

Set the Gen,Pos, FOV DB Sequence properties to ActivateNextDatabank

Set the Collimator Filter Sequence property to NotApplicable (same filter during the whole stitching)
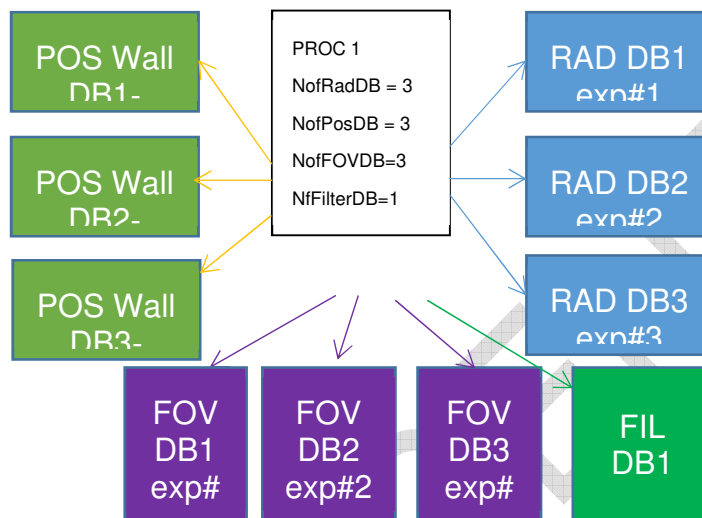
3DB for RAD, positioning and collimator FOV defined & assigned

1DB for collimator filter.

System will load automatically and sequentially the databank for RAD, positioning and collimator FOV after every exposure.

2.8 *Procedure definition for Dual Energy:*

One Procedure with 2 datanks. Define the right procedure for the workstation being used, **define and assign 2 RAD Databanks** (one databank for each exposure required). Activate the procedure, and the following databanks will be activated according to the exposure in progress.

Set the Gen ActivateNextDatabank

Set the Pos, FOV DB Sequence properties to Collimator Filter Sequence property to NotApplicable (same filter during the whole stitching)
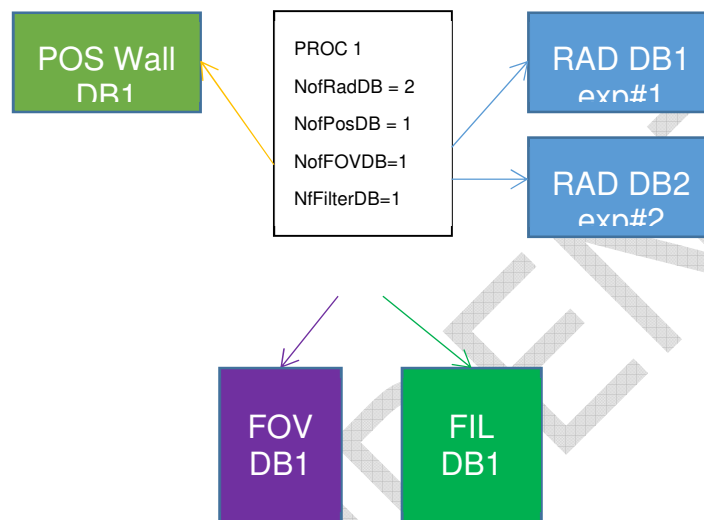
2DB for RAD defined & assigned

1DB for positioning, collimator FOV and collimator filter.

System will load automatically and sequentially the databank for RAD, keeping the same position collimator aperture and filter.

2.9 Suggested procedure flow for Static Studies

We propose three ways to set Generator and positioner settings. We consider that normally generator and positioner settings are different for each workstation.

1. Define one procedure per study. Assign and load databanks. **Redefine procedure** when a workstation change is requested or another study is selected.

Procedure definition flow on a Static Patient Exam
Considering one workstation for a study

1. One Procedure definition for study
2. Redefine procedure for workstation change

Open Patient → Reset Dosimetry → Load Study → Clear Procedures → Define Procedure → Activate the Default procedure → Activate Procedure J → Press pedal → Expose → Get Post Exposure Params → Close Patient

Press Pedal

Workstation Change Request

Select next Study

◯ Action on Image System
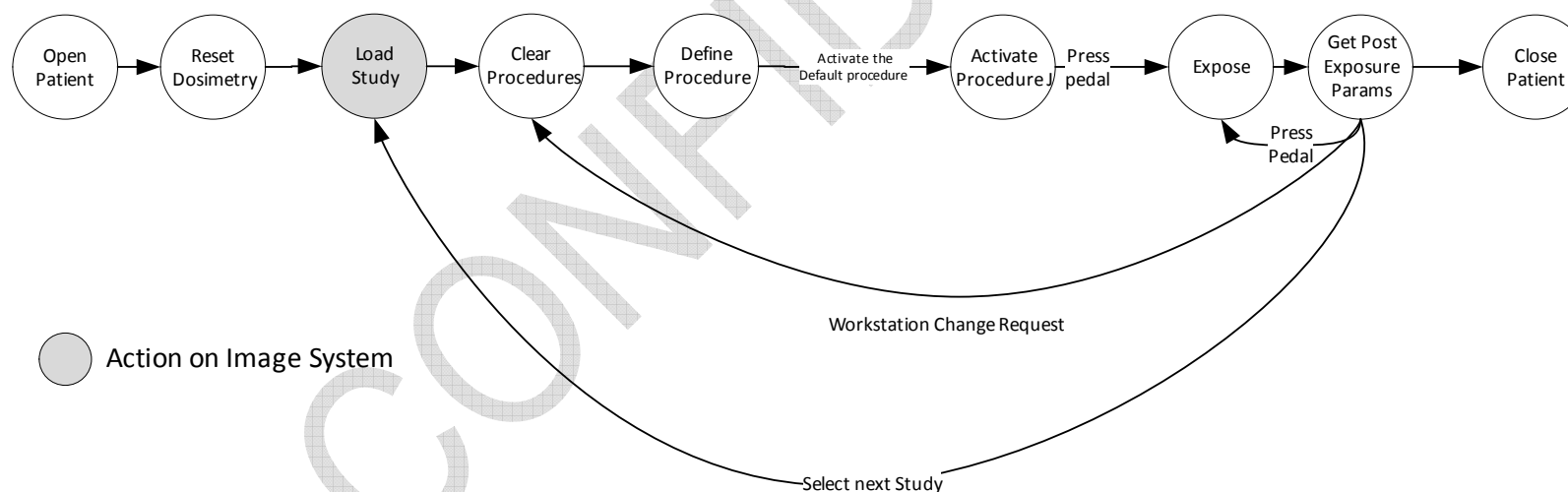
2. Define three procedures at startup (one per workstation), load one databank for Gen, Pos, Coll FOV and Coll Aperture, and assign same databank to all procedures. **Reload databank** and **activate procedure** when a workstation change is requested or another study is selected. Clear procedures when application is closed

Procedure definition flow on a Static Patient Exam
Considering 3 workstation for study

1. Three procedure defintion at startup
2. Reload Databanks per study
3. Activate required procedure for workstation change

Start → Clear Procedures → Define Procedure Table / Define Procedure WallStand / Define Procedure Free → Open Patient → Reset Dosimetry → Load Study → ReLoad DataBank → Activate Procedure → Press pedal → Expose → Press Pedal → Get Post Exposure Params → Close Patient → End → Clear Procedures

Workstation Change Request

Select next Study

3. Define three procedures per study (one per workstation), load and assign different databanks. **Activate procedure** when a workstation change is requested or another study is selected

Procedure definition flow on a Static Patient Exam
Considering 3 workstation for study

Suggested procedure definition to implement the selected study
1. Three procedure definition per study .
2. Activate required procedure for workstation change
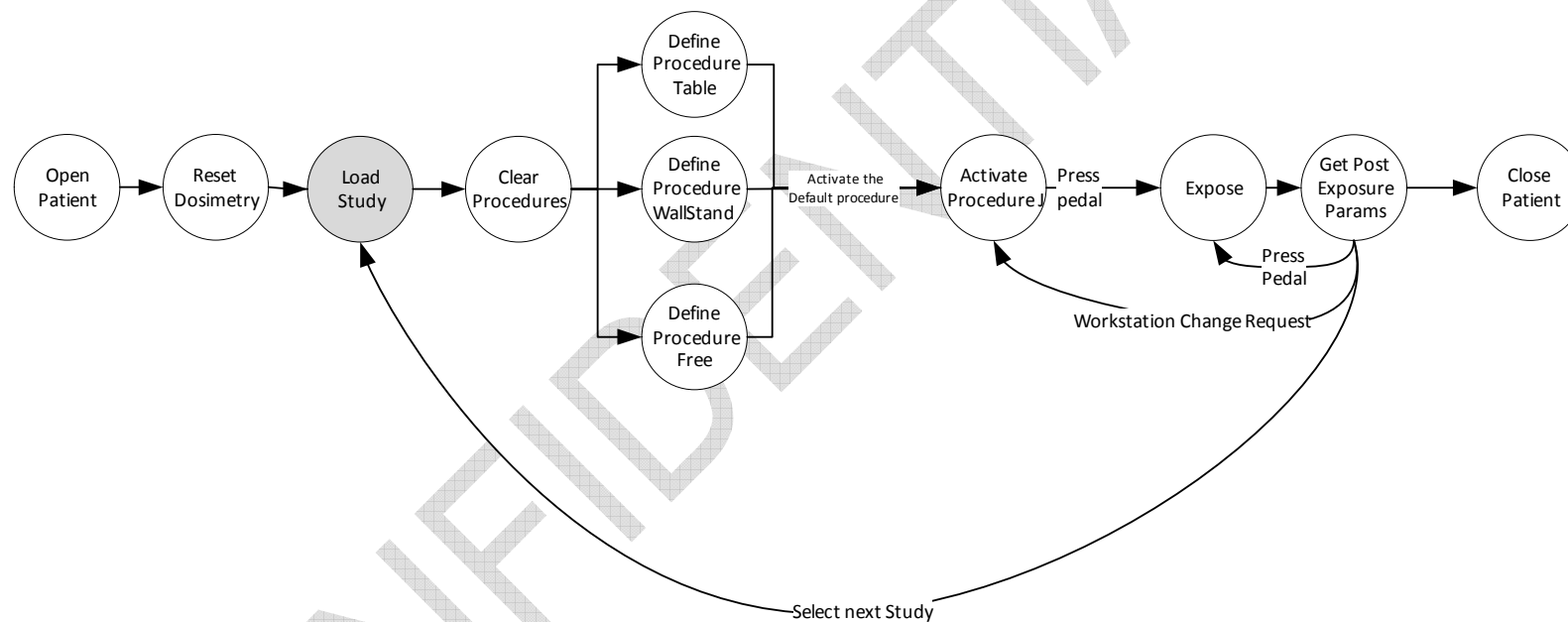
3. DYNAMIC CONSOLE

This section explains how to set the generator for dynamic studies.

Common characteristics:

- For dynamic studies, more than one procedure is defined over the same workstation (i.e. fluoro and rad)
- For those procedures defined over the workstation that will be used, the option switch from pedal should be active.
- To activate a procedure automatically by hardware (pedal/handswitch inputs are pressed) a different button/pedal index should be assigned.
- If only one pedal is used for more than one procedure, switch from pedal sould be set to false, and activation should be done via "ACTIVATE PROCEDURE" message.
- Fluoro positioning procedures might have a different filter databank assigned from the other defined generator procedures. We have not indicated to simplify configuration.

3.1 Procedure definition for Positioning Fluoro and RAD

Same position & collimator settings for Rad and fluoro procedures

Databank 1 always RAD, assigned to a RAD procedure

Databank 2 Fluoro, assigned to a Fluoro procedure

PROC - RAD

Pos PROC – Std Pos

NofRadDB = 1

NofPosDB = 1

NofFOVDB=1

NfFilterDB=1

Worksation 1

Pedal 1

Switch Pedal: Yes

RAD DB1

FL DB2

Gen PROC – FLUORO

Pos PROC – Std Pos

NofRadDB = 1

NofPosDB = 1

NofFOVDB=1

NfFilterDB=1

Worksation 1

Pedal 2

Switch Pedal: Yes

POS FREE DB1

FOV DB1

FIL DB1

3.2 Procedure definition for High Fluoro and RAD

Gen PROC - RAD

Pos PROC – Std Pos

NofRadDB = 1

NofPosDB = 1

NofFOVDB=1

NfFilterDB=1

Worksation 1

Pedal 1

Switch Pedal: Yes

RAD DB1

FL DB2

Gen PROC – FLUORO

Pos PROC – Std Pos

NofRadDB = 1

NofPosDB = 1

NofFOVDB=1

NfFilterDB=1

Worksation 1

Pedal 2

Switch Pedal: Yes

POS FREE DB1

FOV DB1

FIL DB1

3.3 Procedure definition for Multirad (+ RAD, + Fluoro)

Gen PROC - RAD
Pos PROC – Std Pos
NofRadDB = 1
NofPosDB = 1
NofFOVDB=1
NfFilterDB=1
Worksation 1
Pedal 1
Switch Pedal: Yes

RAD DB1

Gen PROC – FLUORO
Pos PROC – Std Pos
NofRadDB = 1
NofPosDB = 1
NofFOVDB=1
NfFilterDB=1
Worksation 1
Pedal 2
Switch Pedal: Yes

FL DB2

Gen PROC -DSI
Pos PROC – Std Pos
NofRadDB = 1
NofPosDB = 1
NofFOVDB=1
NfFilterDB=1
Worksation 1
Pedal 3
Switch Pedal: Yes

RAD DB2

POS FREE DB1

FOV DB1

FIL DB1

3.4 Procedure definition for DSI (+ RAD, + Fluoro)

As defined in Multirad but don't activate AEC in the linked RAD DB

3.5 Procedure definition for CINE (+ RAD, + Fluoro)

Gen PROC - RAD
Pos PROC – Std Pos
NofRadDB = 1
NofPosDB = 1
NofFOVDB=1
NfFilterDB=1
Worksation 1
Pedal 1
Switch Pedal: Yes

RAD DB1

Gen PROC – FLUORO
Pos PROC – Std Pos
NofRadDB = 1
NofPosDB = 1
NofFOVDB=1
NfFilterDB=1
Worksation 1
Pedal 2
Switch Pedal: Yes

FL DB2

Gen PROC - CINE
Pos PROC – Std Pos
NofRadDB = 1
NofPosDB = 1
NofFOVDB=1
NfFilterDB=1
Worksation 1
Pedal 3
Switch Pedal: Yes

RAD DB2

POS FREE DB1   **FOV DB1**   **FIL DB1**

3.6 Procedure definition for DSA (+ RAD, + Fluoro)

Gen PROC - RAD
Pos PROC – Std Pos
NofRadDB = 1
NofPosDB = 1
NofFOVDB=1
NfFilterDB=1
Worksation 1
Pedal 1
Switch Pedal: Yes

RAD DB1

Gen PROC – FLUORO
Pos PROC – Std Pos
NofRadDB = 1
NofPosDB = 1
NofFOVDB=1
NfFilterDB=1
Worksation 1
Pedal 2
Switch Pedal: Yes

FL DB2

Gen PROC - DSA
Pos PROC – Std Pos
NofRadDB = 1
NofPosDB = 1
NofFOVDB=1
NfFilterDB=1
Worksation 1
Pedal 3
Switch Pedal: Yes

RAD DB2

POS FREE DB1   **FOV DB1**   **FIL DB1**

3.7 Procedure definition for Tomography (+Fluoro)

Gen PROC - Tomoghraphy

Pos PROC – Tomography

NofRadDB = 1

NofPosDB = 1

NofFOVDB=1

NfFilterDB=1

Worksation 1

Pedal 3

Switch Pedal: Yes

RAD DB1

FL DB2

Gen PROC – FLUORO

Pos PROC – Std Pos

NofRadDB = 1

NofPosDB = 1

NofFOVDB=1

NfFilterDB=1

Worksation 1

Pedal 2

Switch Pedal: Yes

POS FREE DB1

FOV DB1

FIL DB1

POS db1
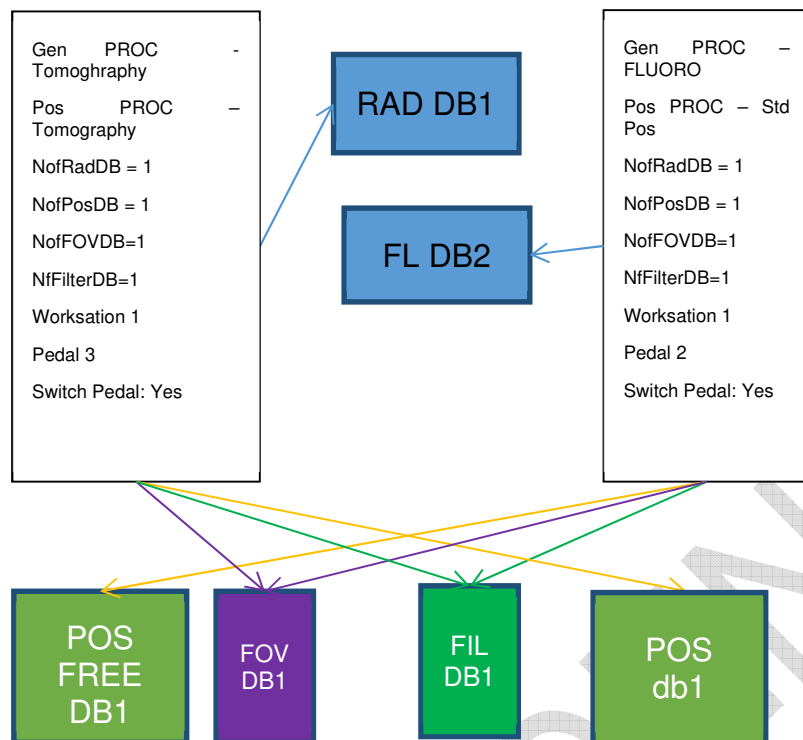
3.8 Procedure definition for Tomosynthesis (+Fluoro)

Gen   PROC   –
FLUORO

Pos PROC – Std
Pos

NofRadDB = 1

NofPosDB = 1

NofFOVDB=1

NfFilterDB=1

Worksation 1

Pedal 2

Switch Pedal: Yes

RAD DB1

FL DB2

Gen PROC - DSI

Pos PROC – Tomosynthesys

NofRadDB = 1

NofPosDB = 1

NofFOVDB=1

NfFilterDB=1

Worksation 1

Pedal 3

Switch Pedal: Yes

POS FREE DB1

FOV DB1

FIL DB1

POS DB1

4. **Medical Radiology and procedure definitions**

Normal workflow for procedure settings is as follows:

1. Open Patient
    a. Dosemeter reset
2. Select the type(s) of medical study(ies) to be performed to the patient on the Image System Unit
3. For each study,
    a. Clear Procedures
    b. Set up required procedures
    c. If more than one procedure is set at a time, assign different pedals for automatic procedure activation
    d. Expose/Perform procedure
    e. Request post exposure parameters
4. Close exam

4.1 Suggested procedure flow for Dynamic Studies

We propose a ways to set Generator and positioner settings. We consider that normally generator and positioner settings are different for each workstation.

Procedure definition flow on a Dynamic Patient Exam
Considering one workstation
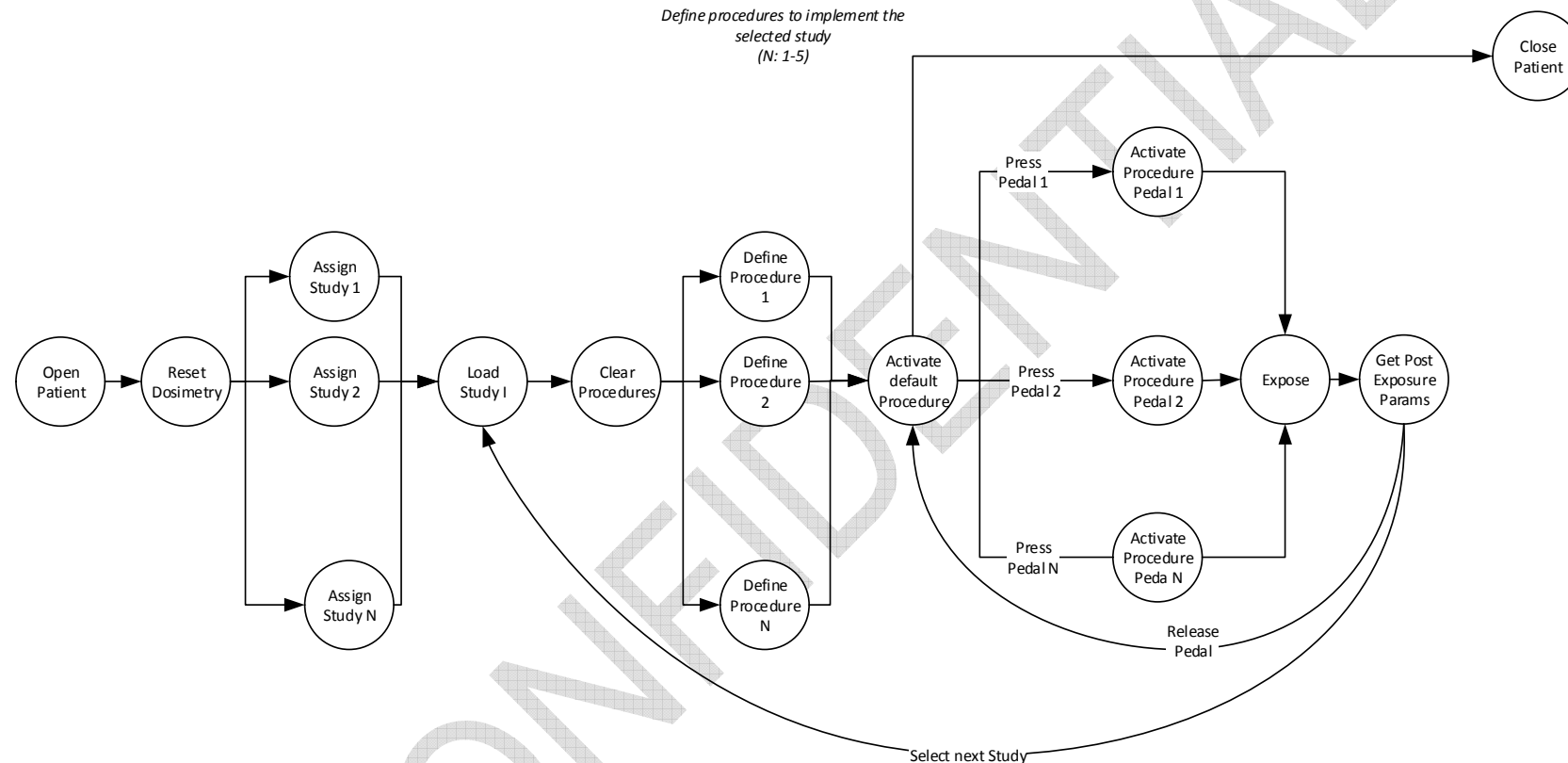
4.2 Suggested procedure definitions for Dynamic Studies

		MEDICAL STUDIES for ONE workstation

Procedure definition		STD Rad	STD Radiography + Fluoro Positioning		Stiching + FL Positioning		Dual Energy + FL Positioning		Angiography		
Generator Procedure types	RAD	RAD	RAD	Standard Fluoro	Stitching	Standard Fluoro	RAD	Standard Fluoro	DSA	RAD	Standard Fluoro
Positioner Procedure types	Standard Position	Standard Position	Standard Position	Standard Position	Stitching	Standard Position	Standard Position	Standard Position	Standard Position	Standard Position	Standard Position
N ºData Banks	Nº of exposures DB	1RAD	1RAD	1FL	1/N RAD ([1])	1 FL	2RAD	1 FL	1RAD	1RAD	1 FL
	Nº of Position DB	1	1	1	N	1	1	1	1	1	1
	Nº of FOV DB	1	1	1	1/N ([2])	1	1	1	1	1	1
	Nº of Filter DB	1	1	1	1	1	1	1	1	1	1
DB Sequencing	Generator DB Sequence	NA	NA	NA	Activate Next	NA	Activate Next	NA	NA	NA	NA
	Positioning DB Sequence	NA	NA	NA	Activate Next	NA	NA	NA	NA	NA	NA
	FOV DB Sequence	NA	NA	NA	Activate Next	NA	NA	NA	NA	NA	NA
	Filter DB Sequence	NA	NA	NA	Activate Next	NA	NA	NA	NA	NA	NA

Table 1 Procedure definition for Dynamic Studies

---

[1] 1 DB to use the same rad parameters for all exposures. N DB if each exposure have different parameters.

[2] 1 DB if all images use the same area detector. N DB if each stitching image have a different size.

		MEDICAL STUDIES					
Procedure definition		DSI		Tomography		Tomosynthesis	
Generator Procedure types	RAD	DSI	Standard Fluoro	Tomography	Standard Fluoro	DSI	Standard Fluoro
Positioner Procedure types	Standard Position	Standard Position	Standard Position	Tomography	Standard Position	Tomosynthesis	Standard Position
Nº Data Banks	Nº of exposures DB	1		1 RAD	1 FL	1 RAD	1 FL
	Nº of Position DB	1		1	1	1	1
	Nº of FOV DB	1		1	1	1	1
	Nº of Filter DB	1		1	1	1	1
DB Sequencing	Generator DB Sequence	NA		NA	NA	NA	NA
	Positioning DB Sequence	NA		NA	NA	NA	NA
	FOV DB Sequence	NA		NA	NA	NA	NA
	Filter DB Sequence	NA		NA	NA	NA	NA

Table 2 Procedure definition for dynamic studies

STD Radiography + FI Positioning

Field	Value	Field	Value
Procedure ID	1	Procedure ID	2
Generator Proc T	StandardRAD	Generator Proc T	StandardFluor
Positioner Proc T	StandardPositi	Positioner Proc T	StandardPositi
Button Pedal Ind	1	Button Pedal Ind	2
Switch from butt	✓	Switch from butt	✓
Workstation	1	Workstation	1
Num Gen DB	1	Num Gen DB	1
Num Position DB	1	Num Position DB	1
Num FOV DB	1	Num FOV DB	1
Num Filter DB	1	Num Filter DB	1
Gen DB Sequenc	NotApplicable	Gen DB Sequenc	NotApplicable
Pos DB Sequence	NotApplicable	Pos DB Sequence	NotApplicable
FOV DB Sequenc	NotApplicable	FOV DB Sequenc	NotApplicable
Filter DB Sequen	NotApplicable	Filter DB Sequen	NotApplicable

Stiching + FI Positioning

Field	Value	Field	Value
Procedure ID	1	Procedure ID	2
Generator Proc T	Stitching	Generator Proc T	StandardFluor
Positioner Proc T	Stiching	Positioner Proc T	StandardPositi
Button Pedal Ind	1	Button Pedal Ind	2
Switch from butt	✓	Switch from butt	✓
Workstation	1	Workstation	1
Num Gen DB	3	Num Gen DB	1
Num Position DB	3	Num Position DB	1
Num FOV DB	3	Num FOV DB	1
Num Filter DB	1	Num Filter DB	1
Gen DB Sequenc	ActivateNextD	Gen DB Sequenc	NotApplicable
Pos DB Sequence	ActivateNextD	Pos DB Sequence	NotApplicable
FOV DB Sequenc	ActivateNextD	FOV DB Sequenc	NotApplicable
Filter DB Sequen	NotApplicable	Filter DB Sequen	NotApplicable

Dual Energy + FI Positioning

Field	Value	Field	Value
Procedure ID	1	Procedure ID	2
Generator Proc T	StandardRAD	Generator Proc T	StandardFluor
Positioner Proc T	StandardPositi	Positioner Proc T	StandardPositi
Button Pedal Ind	1	Button Pedal Ind	2
Switch from butt	✓	Switch from butt	✓
Workstation	1	Workstation	1
Num Gen DB	2	Num Gen DB	1
Num Position DB	1	Num Position DB	1
Num FOV DB	1	Num FOV DB	1
Num Filter DB	1	Num Filter DB	1
Gen DB Sequenc	ActivateNextD	Gen DB Sequenc	NotApplicable
Pos DB Sequence	NotApplicable	Pos DB Sequence	NotApplicable
FOV DB Sequenc	NotApplicable	FOV DB Sequenc	NotApplicable
Filter DB Sequen	NotApplicable	Filter DB Sequen	NotApplicable

RAD+Fluoro+DSA

Procedure ID	1	Procedure ID	2	Procedure ID	3
Generator Proc T	StandardRAD ▼	Generator Proc T	StandardFluor ▼	Generator Proc T	DSA ▼
Positioner Proc T	StandardPositi ▼	Positioner Proc T	StandardPositi ▼	Positioner Proc T	StandardPositi ▼
Button Pedal Ind	1	Button Pedal Ind	2	Button Pedal Ind	3
Switch from butt	✔	Switch from butt	✔	Switch from butt	✔
Workstation	1	Workstation	1	Workstation	1
Num Gen DB	1	Num Gen DB	1	Num Gen DB	1
Num Position DB	1	Num Position DB	1	Num Position DB	1
Num FOV DB	1	Num FOV DB	1	Num FOV DB	1
Num Filter DB	1	Num Filter DB	1	Num Filter DB	1
Gen DB Sequenc	NotApplicable ▼	Gen DB Sequenc	NotApplicable ▼	Gen DB Sequenc	NotApplicable ▼
Pos DB Sequence	NotApplicable ▼	Pos DB Sequence	NotApplicable ▼	Pos DB Sequence	NotApplicable ▼
FOV DB Sequenc	NotApplicable ▼	FOV DB Sequenc	NotApplicable ▼	FOV DB Sequenc	NotApplicable ▼
Filter DB Sequenc	NotApplicable ▼	Filter DB Sequenc	NotApplicable ▼	Filter DB Sequenc	NotApplicable ▼

Tomography

Procedure ID	1	Procedure ID	2	Procedure ID	3
Generator Proc T	StandardRAD ▼	Generator Proc T	StandardFluor ▼	Generator Proc T	Tomography ▼
Positioner Proc T	StandardPositi ▼	Positioner Proc T	StandardPositi ▼	Positioner Proc T	Tomography ▼
Button Pedal Ind	1	Button Pedal Ind	2	Button Pedal Ind	3
Switch from butt	✔	Switch from butt	✔	Switch from butt	✔
Workstation	1	Workstation	1	Workstation	1
Num Gen DB	1	Num Gen DB	1	Num Gen DB	1
Num Position DB	1	Num Position DB	1	Num Position DB	1
Num FOV DB	1	Num FOV DB	1	Num FOV DB	1
Num Filter DB	1	Num Filter DB	1	Num Filter DB	1
Gen DB Sequenc	NotApplicable ▼	Gen DB Sequenc	NotApplicable ▼	Gen DB Sequenc	NotApplicable ▼
Pos DB Sequence	NotApplicable ▼	Pos DB Sequence	NotApplicable ▼	Pos DB Sequence	NotApplicable ▼
FOV DB Sequenc	NotApplicable ▼	FOV DB Sequenc	NotApplicable ▼	FOV DB Sequenc	NotApplicable ▼
Filter DB Sequenc	NotApplicable ▼	Filter DB Sequenc	NotApplicable ▼	Filter DB Sequenc	NotApplicable ▼

Tomosynthesis

Procedure ID	1	Procedure ID	2	Procedure ID	3
Generator Proc T	StandardRAD	Generator Proc T	StandardFluor	Generator Proc T	DSINEnergyTc
Positioner Proc T	StandardPositi	Positioner Proc T	StandardPositi	Positioner Proc T	Tomosynthesi:
Button Pedal Ind	1	Button Pedal Ind	2	Button Pedal Ind	3
Switch from butt	✓	Switch from butt	✓	Switch from butt	✓
Workstation	1	Workstation	1	Workstation	1
Num Gen DB	1	Num Gen DB	1	Num Gen DB	1
Num Position DB	1	Num Position DB	1	Num Position DB	1
Num FOV DB	1	Num FOV DB	1	Num FOV DB	1
Num Filter DB	1	Num Filter DB	1	Num Filter DB	1
Gen DB Sequenc	NotApplicable	Gen DB Sequenc	NotApplicable	Gen DB Sequenc	NotApplicable
Pos DB Sequence	NotApplicable	Pos DB Sequence	NotApplicable	Pos DB Sequence	NotApplicable
FOV DB Sequenc	NotApplicable	FOV DB Sequenc	NotApplicable	FOV DB Sequenc	NotApplicable
Filter DB Sequen	NotApplicable	Filter DB Sequen	NotApplicable	Filter DB Sequen	NotApplicable

6. **Programming Scenarios for RAD Image system integrations**

Kind of messages exchanged in R2CP:

GET: this message is sent/received from node to node to get specific information. The status should be notified with an EVENT message.

SET: this message is sent/received from a node to node to request a status change. The status change should be notified with an EVENT message.

COMMAND PROCCESSED:

- Should be sent when a node finishes a GET or SET request.

EVENT:

- Should be sent to all nodes for a status change (system notification). No destination is specified in the Sendxxx Function
- Should be sent to the node that requested (GET message) the specific information.

Here the most common scenarios for static systems is described.

6.1 Bootup sequence

We propose

1. Load R2CPConfig.xml configuration
   ```
   configuration = new ConfigurationManager(log);

   configuration.LoadConfiguration(urlConfigFile);
   ```
2. Get generator and positioner ID's
   ```
   genId = (byte)configuration.GetNodeIDByNodeType(NodeType.Generator);

   posId = (byte)configuration.GetNodeIDByNodeType(NodeType.Positioner);
   ```

3. Get your ID
   ```
   systemConsoleID = (byte)configuration.GetNodeConfiguration("ImageSystem").Id;
   ```
4. Create the communication object
   ```
   comms = CommManagerFactory.GetCommManager();
   ```
5. Subscribe to these events:
   a. `ConnectedToSmartHub`. To know when your node connects/disconnects to the Smarthub
   b. `DisconnectedFromSmartHub`
   c. `DestinationConnected`. To find out about other node status
   d. `DestinationDisconnected`
6. Open the R2CP connection
   ```
   comms.Connect(id, urlConfigFile);
   ```
7. When your node is connected to the smarthub, subscribe to other R2CP Messages EVENTS that might interest you

See `BootupSequence()`

The following information can be requested to the generator:
- Request to the generator for the actual status: `SyncUpGETMessage`
- Maximum number of available Databanks: `MaxDataBanksNumberGETMessage/ MaxDataBanksNumberEVENTMessage`
- Maximum number of available Procedures: `MaxProceduresNumberGETMessage/ MaxProceduresNumberEVENTMessage`
- Generator limits: `RADParameterRangesGETMessage/RADParameterRangesEVENTMessage`
- Generator power limit can be adjusted (long tube life): `GenPowerLimitGETMessage/GenPowerLimitEVENTMessage/GenPowerLimitSETMessage`
- Reset system message *101001 – X Rays disabled*, for the image system to handle exposure scenarios
    - `SystemMsgSETMessage ID = 101001, IsActivated = false.`

The following information can be requested to the positioner:
- Request to the positioner for the actual status: `SyncUpGETMessage.`
- Maximum number of available Databanks: `MaxDataBanksNumberGETMessage/ MaxDataBanksNumberEVENTMessage`
- Maximum number of available Procedures: `MaxProceduresNumberGETMessage/ MaxProceduresNumberEVENTMessage`

6.2 Open an exam

Reset Dosimetry `ResetDosimeterSETMessage`

Send Patient Name `PatientInfoEVENTMessage`

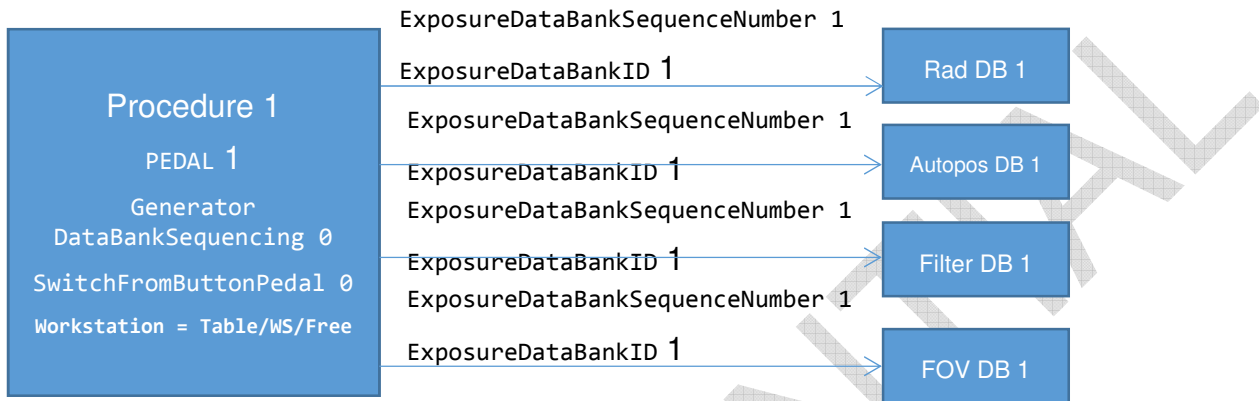Send Procedure Name `ProcedureInfoEVENTMessage`

6.3 *Define a procedure*

Send the `ProcedureSETMessage` message

The responses will be `ProcedurePositionerEVENTMessage, ProcedureGeneratorEVENTMessage`

The goal is to define a simple procedure with only one databank assigned for RAD, Autoposition, Collimation filtering and FOV.

Standard RAD:

6.4 **Define, assign and Databanks**

6.4.1 **RAD Databank**

Get the right exposure parameters for the study from the database (`radSetParams`), set the patient size, and AEC Settings.

Tube power limit can be set to a default value or always set to 100%

FPS is meaningless for RAD Consoles

With "AdjustParametersAutomatically" set to true, will adapt ma-ms to keep mAs if there are tube power limitations.

With "AutomaticTechniqueMode" set to true, will allow to modify technique mode according to parameter change:

  ➢ If ma-ms is changed generator will understand that mode is 3 points and change the technique mode if is it was necessary
  ➢ If mAs is changed generator will understand that mode is 2 points and change the technique mode if is it was necessary

6.4.1.1 Load parameters in generator Rad DB1

`LoadRADDataBankSETMessage msgLoadRadDB = new LoadRADDataBankSETMessage();`

Generator will responde with the `LoadRADDataBankEVENTMessage` message.

6.4.1.2 **Assign Rad DB1to Procedure 1**

`AssignExposureDataBankSETMessage` msg = `new AssignExposureDataBankSETMessage`();

Generator will respond with `AssignExposureDataBankEVENTMessage` message

6.4.2 **Autoposition Databank**

Define an autopos number in the DB1.

Normally, autopos numbers are linked to the position defined for the workstation procedure.

6.4.2.1 Load autopos number in positioner DB1

`LoadAutoposSETMessage` msg = `new LoadAutoposSETMessage`();

Positioner will responde with the `ReadStandardPositionEVENTMessage` message.

6.4.2.2 Assign autopos DB1 to Procedure 1

`AssignPositioningDataBankSETMessage` msg = `new AssignPositioningDataBankSETMessage()`

Postioner will respond with `AssignPositioningDataBankEVENTMessage`

If a specific position that does not match any of the predifined autopositions wants to be applied, the `LoadFreeAutoposSETMessage` can be used instead.

- Specify if the position is for `RelativeTable` (table), `RelativeWallstand` (wallStand) or `Absolute` (free) on the `Type` property.
- Set only those properties whose values to be set / moved on the `Position` field:
  - o Free: `Alpha, Beta, X, Y, Z`
  - o Table or Wallstand: `SID, Angle, Rotation`, `ImageReceptorPosition`
    - ▪ `Table: TableTiltingAngle, TableHeight, TableTopX, TableTopY, TableImageReceptorHolderRotation, TableImageReceptorRotation`
    - ▪ Wallstand: `WallStandHeight, WallStandTiltingAngle, WallstandColumnPosition, WallstandColumnRotation, WallstandImageReceptorHolderRotation, WallstandImageReceptorRotation`

6.4.3 Collimator Filter Databank

The collimator filters codes are

Collimator filtering	Code
No filter	0
2mmAl	1
1mmAl 0.2mmCu	2

1mmAl0.1mmCu	3

6.4.3.1 Load collimator filter number in collimator filter DB1

`LoadFilterSETMessage` msg = `new` `LoadFilterSETMessage`();

Collimator will respond with the `LoadFilterEVENTMessage` message.

6.4.3.2 Assign collimator filter DB1 to Procedure 1

`AssignCollimatorFilterDataBankSETMessage` msg = `new` `AssignCollimatorFilterDataBankSETMessage`()

The positioner will respond with `AssignCollimatorFilterDataBankEVENTMessage` Message

6.4.4   Collimator FOV Databank

Collimator FOV (field of interest) depends on the anatomical part to be radiated.

Also, the limit for the maximum aperture, depends on the detector size being used.

6.4.4.1 Load collimator FOV in collimator fov DB1

`LoadFOVSETMessage` msg = `new` `LoadFOVSETMessage`();

Collimator will respond with `LoadFOVEVENTMessage` message

6.4.4.2   Assign collimator FOV DB1 to Procedure 1

`AssignCollimatorFOVDataBankSETMessage` msg = `new` `AssignCollimatorFOVDataBankSETMessage`();

The generator will respond with `AssignCollimatorFOVDataBankEVENTMessage`

Message

6.5 Activate procedure

Now that we have defined a procedure with all required settings, we need to activate it.

`ActivateProcedureDataBankSETMessage` msg = `new` `ActivateProcedureDataBankSETMessage`();

At this point the system will respond with

`ActivateGenProcedureDataBankANSWERMessage`

`ActivatePosProcedureDataBankEVENTMessage`

The system is ready to expose if no system messages are active.

6.6 Grid Information

The image system can notify to the positioner is the grid is required for this exam. Like this, the positioner will display information to request the operator to insert/remove the grid, and to inhibit exposures when the wrong grid is inserted.
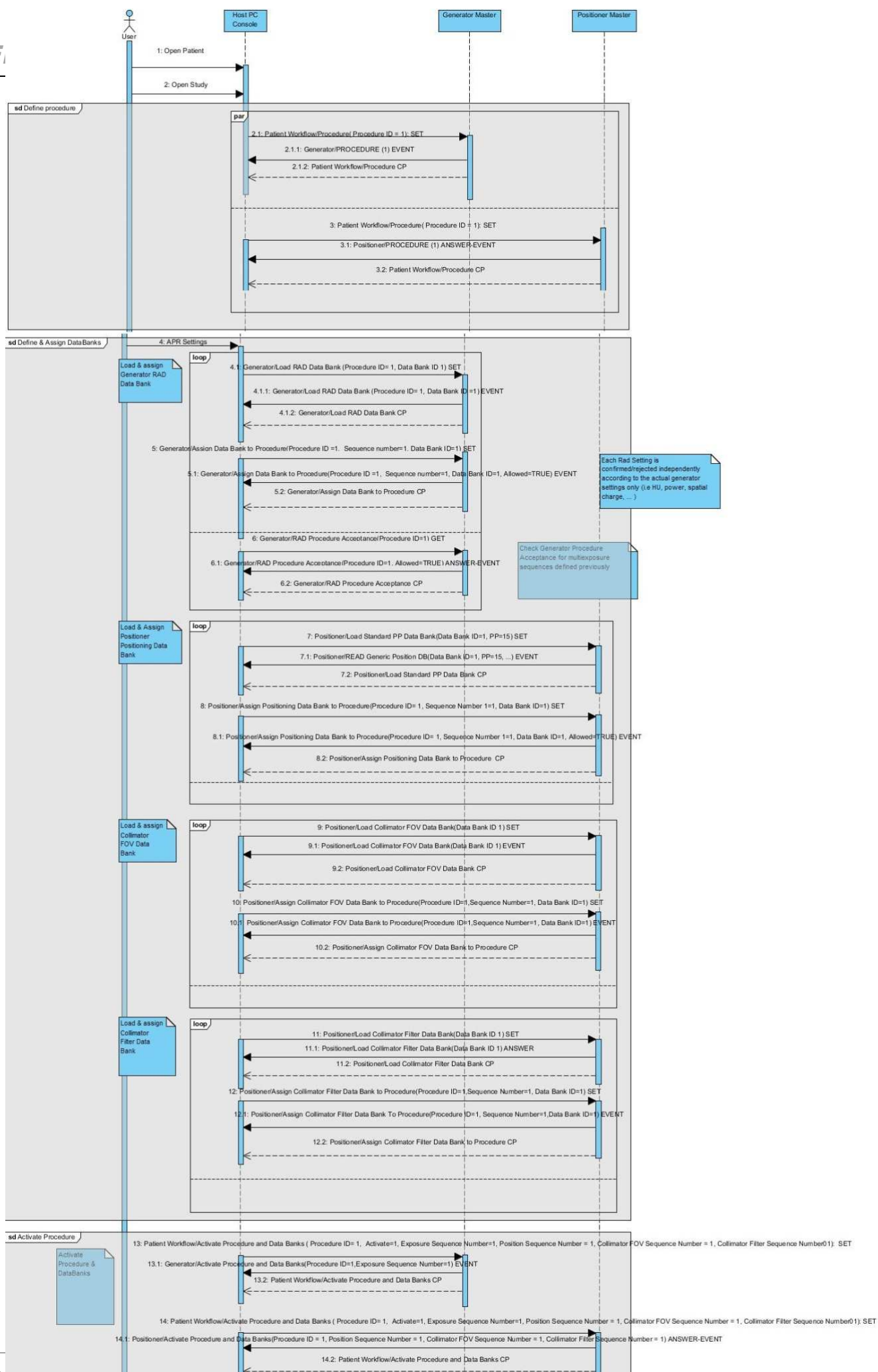
Use the `RequestGridSETMessage` message.

Figure 19 Procedure definition diagram

6.7 Modify Generator parameter selection

To modify only one parameter of the active databank the following messages can be used:

- KvSETMessage
- MaSETMessage
- MasSETMessage
- MsSETMessage
- TechniqueModeSETMessage
- FocalSpotSETMessage
- AECFieldsSETMessage
- AECSensitivitySETMessage
- AECDensitySETMessage
- TubePowerLimitSETMessage
- MaxIntegrationTimeSETMessage

6.8 Actual Generator parameter selection

The parameters that the generator will use for the actual exposure, are always notified with the following messages:

- CurrentRADParamsEVENTMessage
- CurrentKvEVENTMessage
- CurrentMaEVENTMessage
- CurrentMasEVENTMessage
- CurrentMsEVENTMessage
- CurrentTechniqueModeEVENTMessage
- CurrentFocalSpotEVENTMessage
- CurrentAECFieldsEVENTMessage
- CurrentTubePowerLimitEVENTMessage
- CurrentMaxIntegrationTimeEVENTMessage

6.9 Actual Positioner parameters

The parameters that the positioner will use for the actual exposure, are always notified with the following messages:

- CollimatorParameterEVENTMessage / CollimatorParameterGETMessage
- CurrentDetectorRotationEVENTMessage / CurrentDetectorRotationGETMessage
- CurrentGeometricParametersEVENTMessage / CurrentGeometricParametersGETMessage
- CurrentGridEVENTMessage / CurrentGridGETMessage
- PositionEVENTMessage / PositionGETMessage

6.10 Workstation Change Request

This message is notified to the Image System so that a new procedure related to the workstation requested is reloaded.

In some cases the Image system might not allow a detector change in the middle of an exam. For example, detector is preset when user opens an exam. In that case, the Image system should not take any action when receiving this message.
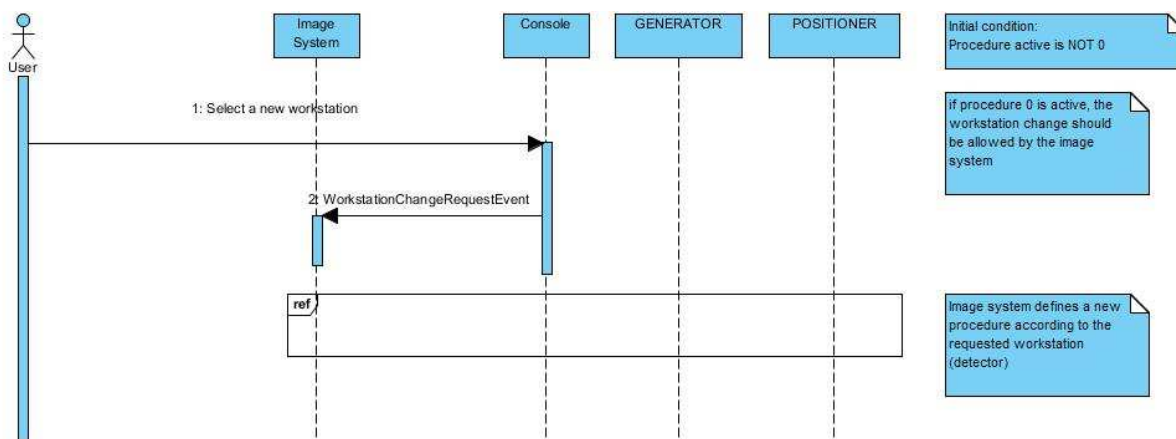

Figure 20. Workstation change request diatram

6.11 Exposure Sequence

The system will not expose if there is a System Message active whose property "Exposure Interlock" is active.

Some of those scenarios can be: xray tube not pointing to detector, generator is in error status, emergency stop has been pressed.

Press the handswitch to start an exposure. Depending on how the workstation was configured, the generator react differently:

- DIRECT MODE: exposes right away. Immediate transitions from Ready => Exposure Request => Exposure In progress
- BUCKY MODE: generator will wait for the detector response to start the exposure. Response can be done by hardware or software.

6.11.1   Hardware synchronization:

- When generator is ready to start the exposure, the `GeneratorStatusEVENTMessage` indicates phase `ExposureRequest,` and waits until hardware request to start exposure
- When hardware responds, generator goes to exposure in progress phase, and exposure starts
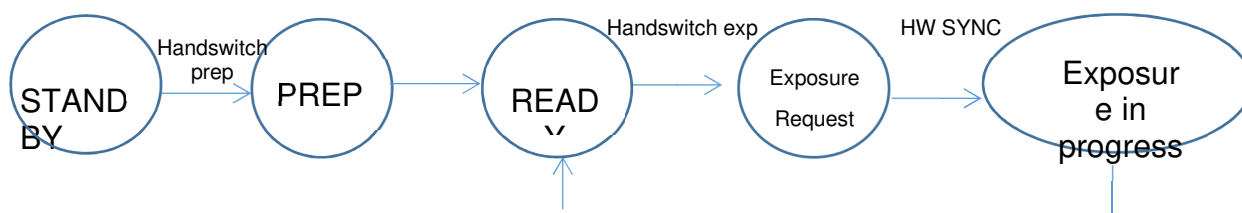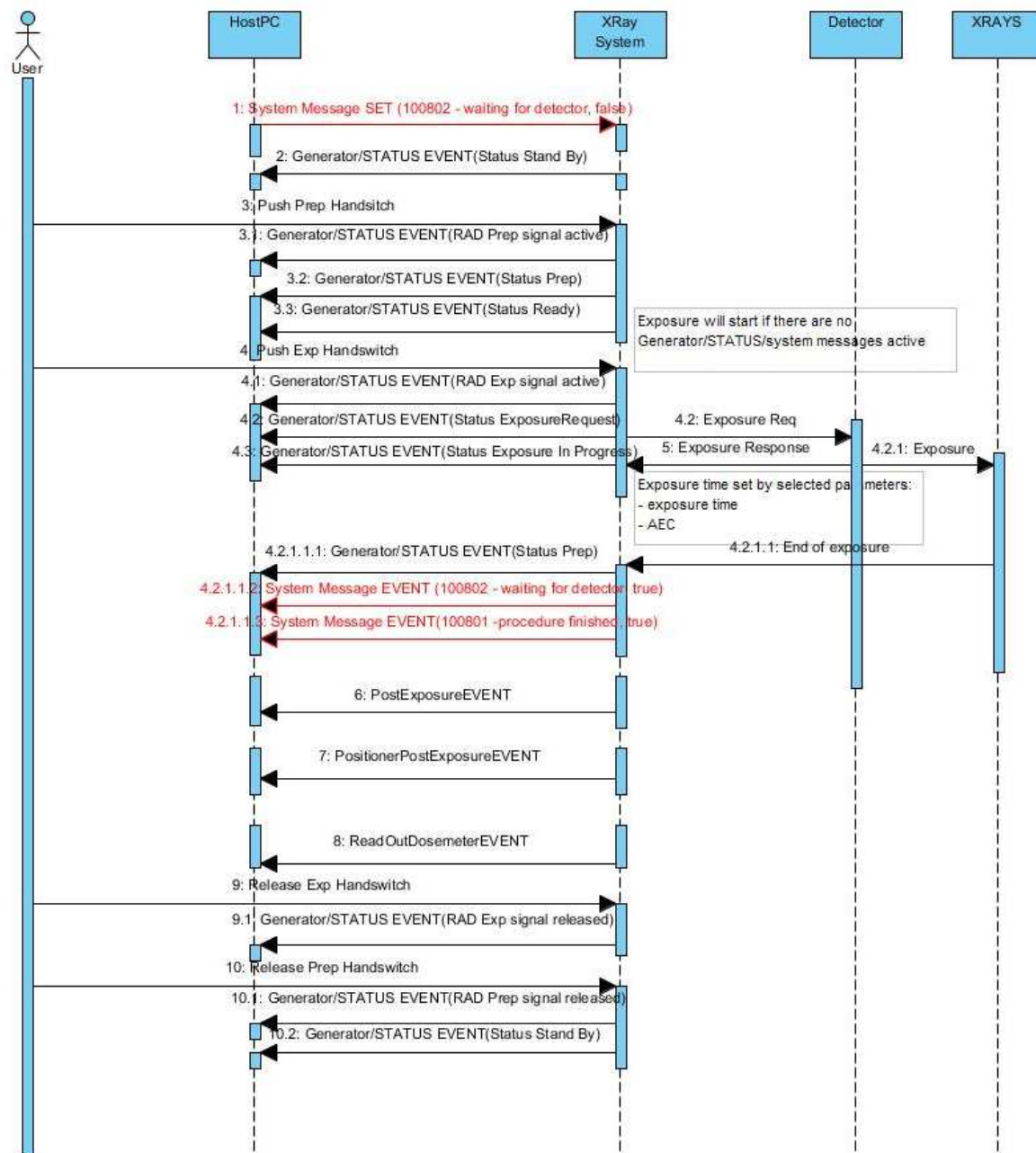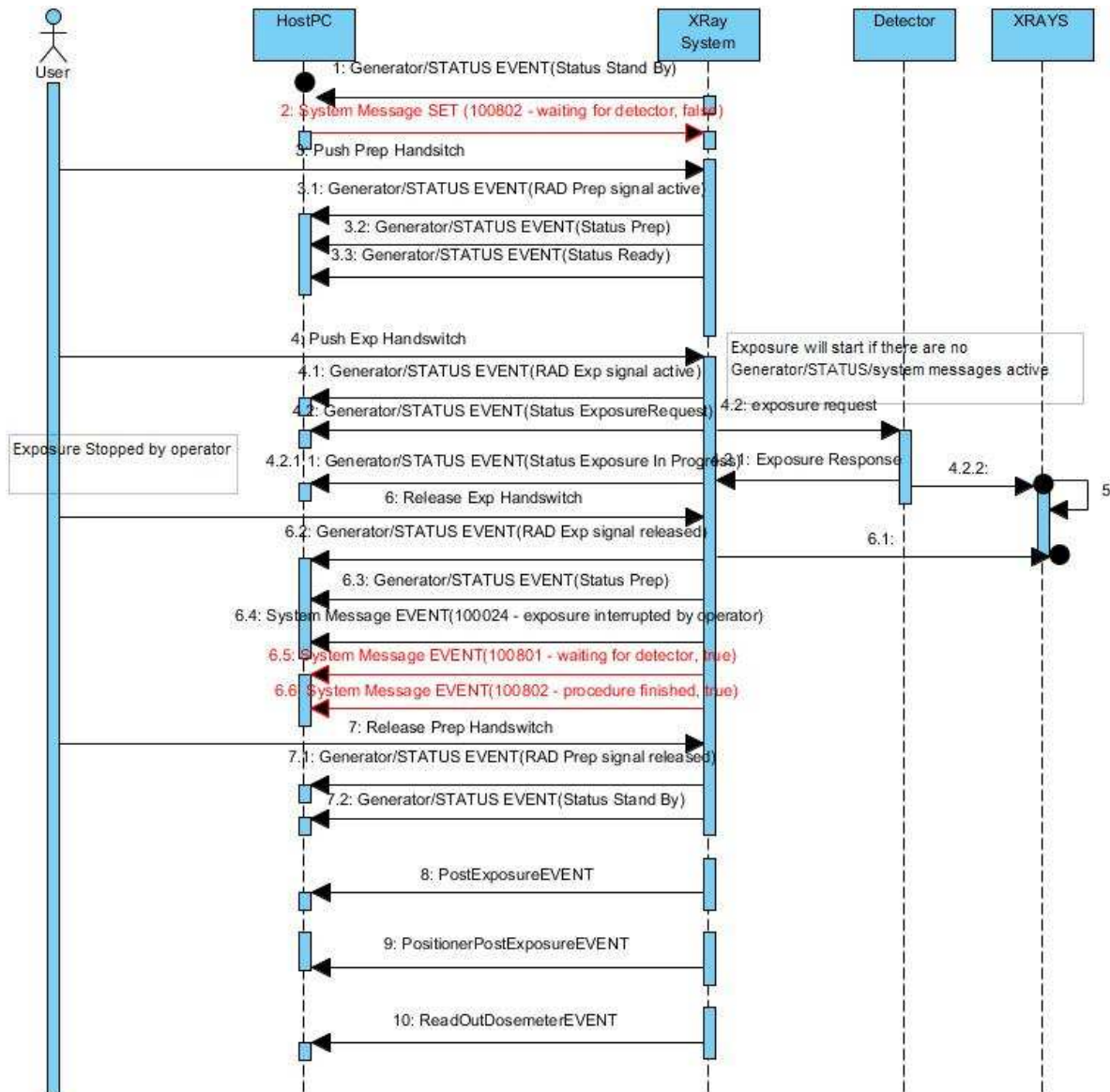
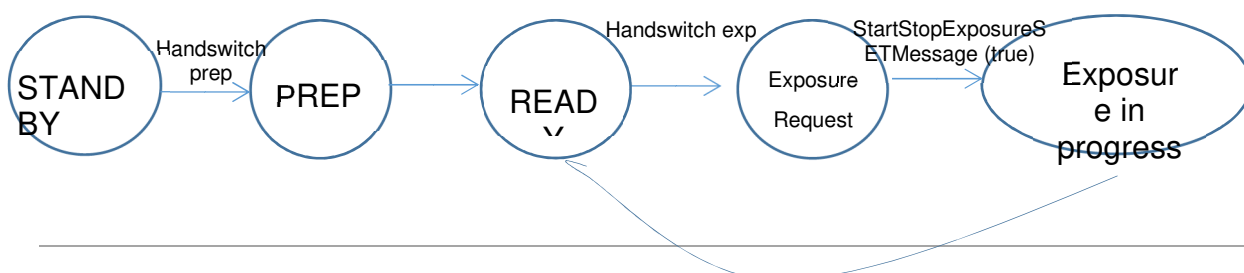**Figure 21 Hardware exposure diagram**

Figure 22. Hardware exposure aborted by operator diagram

6.11.2   Software synchronization

- When generator is ready to start the exposure, the `GeneratorStatusEVENTMessage` indicates phase `ExposureRequest,` and waits until Image system request to start exposure.
- `StartStopExposureSETMessage` message sent from Image System to the generator. generator goes to exposure in progress phase, and exposure starts
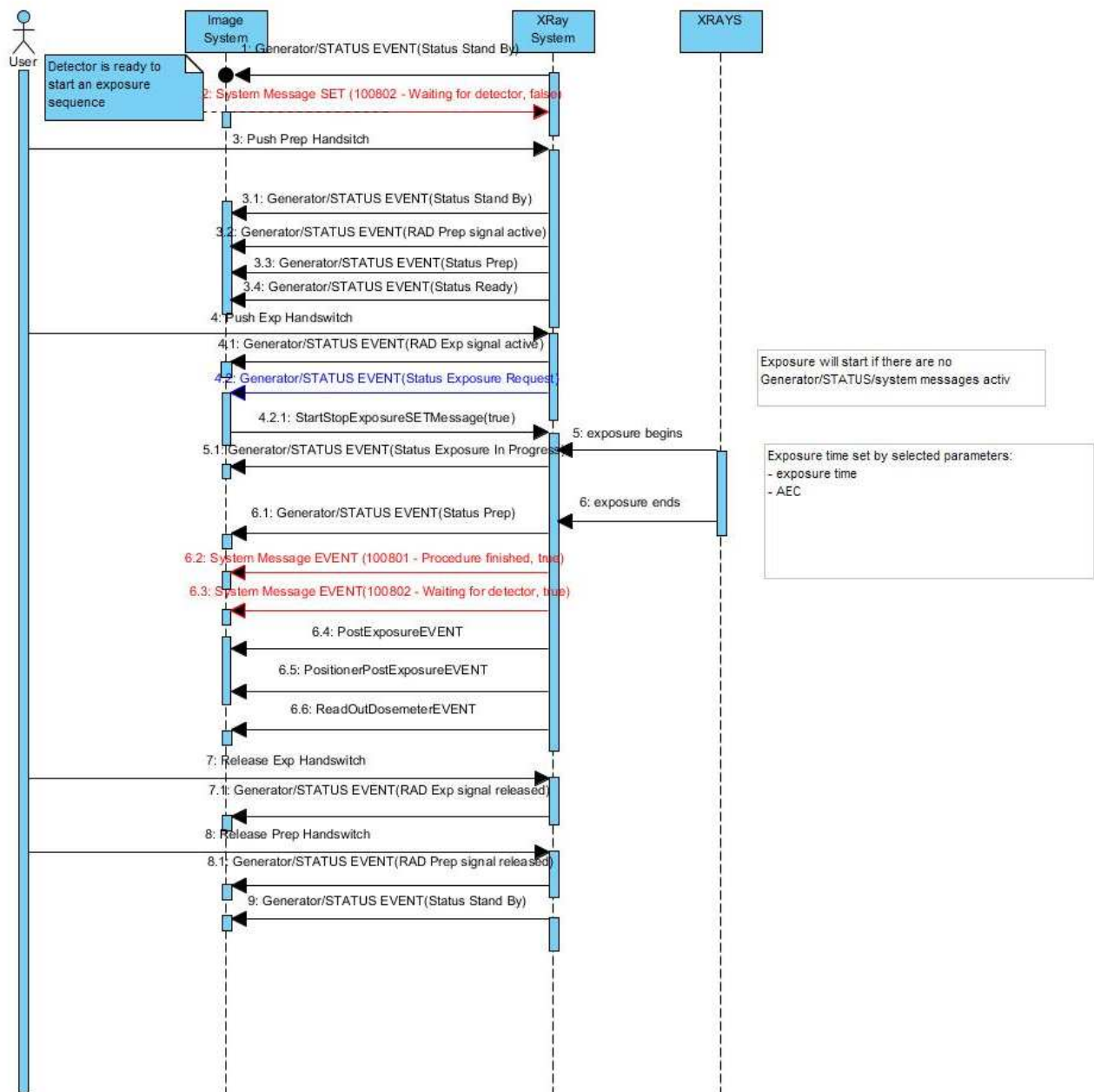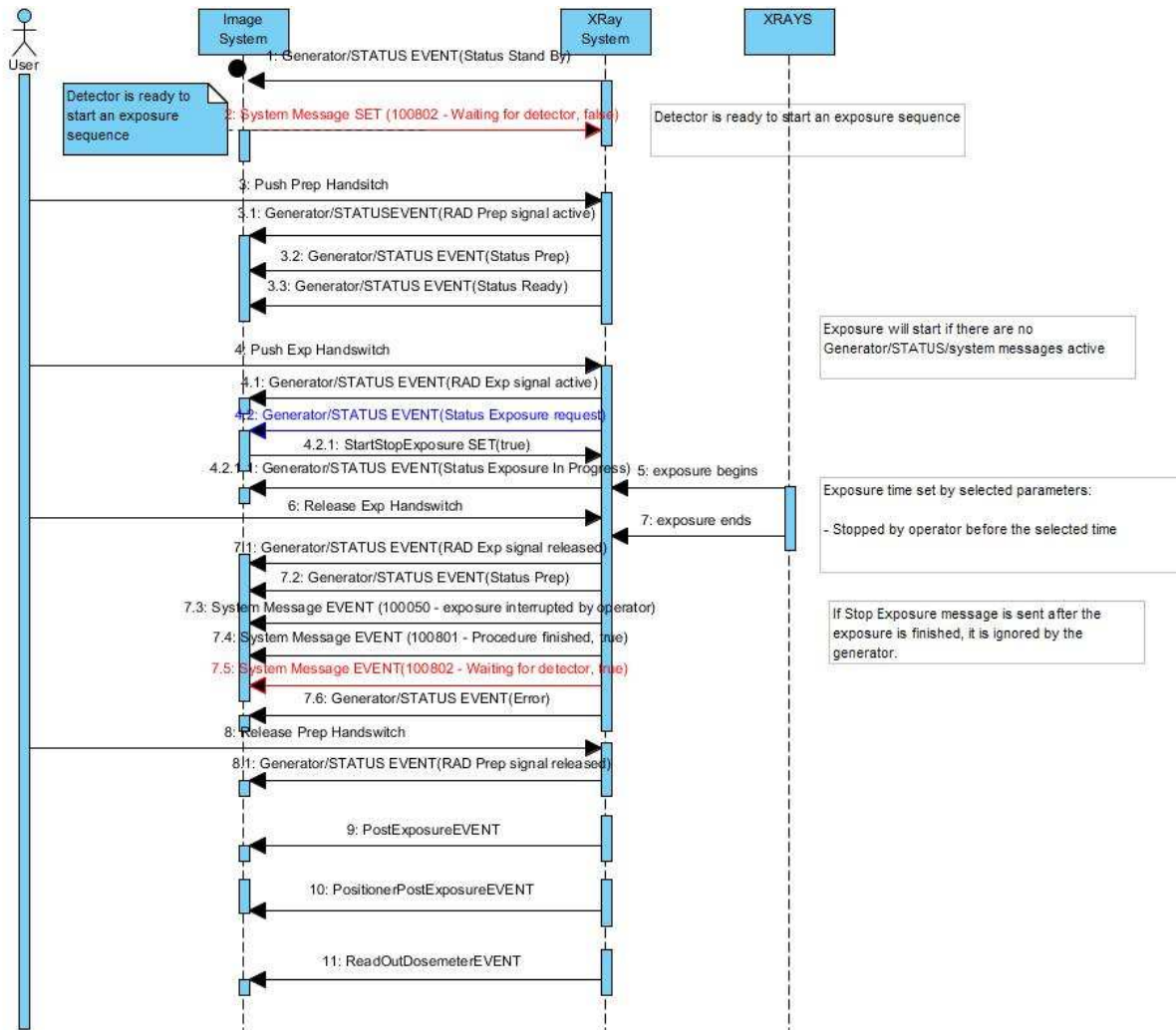
Figure 23. Software Exposure sequence diagram

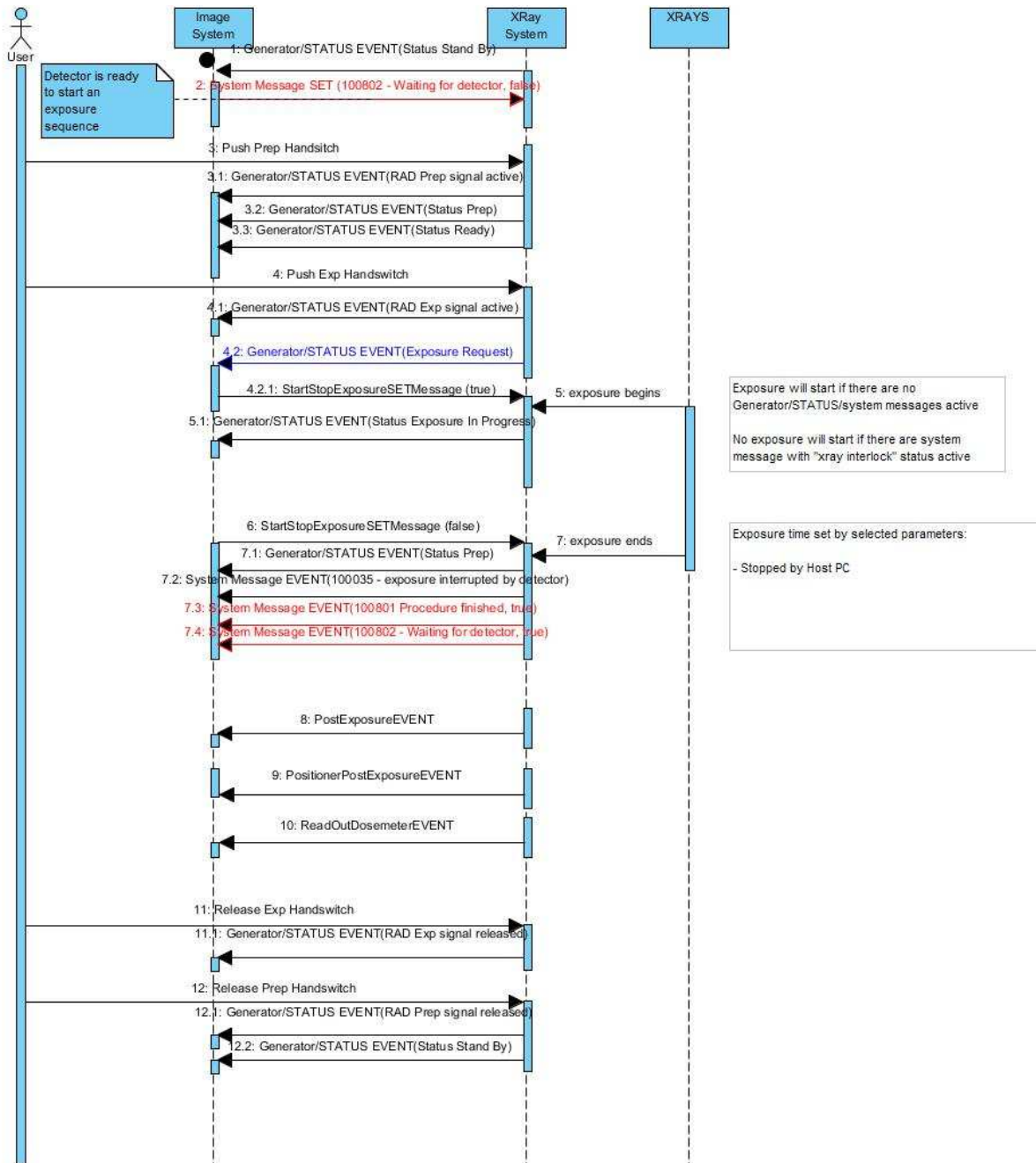**Figure 24.Software exposure sequence aborted by opeartor diagram**

Figure 25. Software exposure aborted by panel diagram

6.12 Post Exposure

Get the Post exposure information by sending the following messages:

PostExposureGETMessage

PositionPostExposureGETMessage

ReadoutDosimeterGETMessage

The generator will respond with PostExposureEVENTMessage

The positioner will respond with PositionPostExposureEVENTMessage

The collimator will respond with `ReadoutDosimeterEVENTMessage`

6.13 Close an exam

Reset Patient Name and Procedure Name (value set to null).

Reset Dosemeter `ResetDosimeterSETMessage`

Clear Procedure `ClearAllProceduresSETMessage`

6.14 *Power off sequence*

The power off sequence will be initiated when the Image System sends the `PowerOffSETMessage` message to the generator. At that point, the generator will notify the power removal within the specified interval to all components of the system, including the Image System with the `PowerOffEVENTMessage`.

The power off sequence can be initiated by operator using the RCC (power off button), where all the components will be notified with the `PowerOffRequestEVENTMessage`. At that point, the device (normally the image system) that will take care of the power off sequence, will answer to the positioner with the `PowerOffConfirmSETMessage` message.

The power off sequence can be cancelled only before the `PowerOffSETMessage` message is sent by sending `PowerOffCancelSETMessage` to the generator.
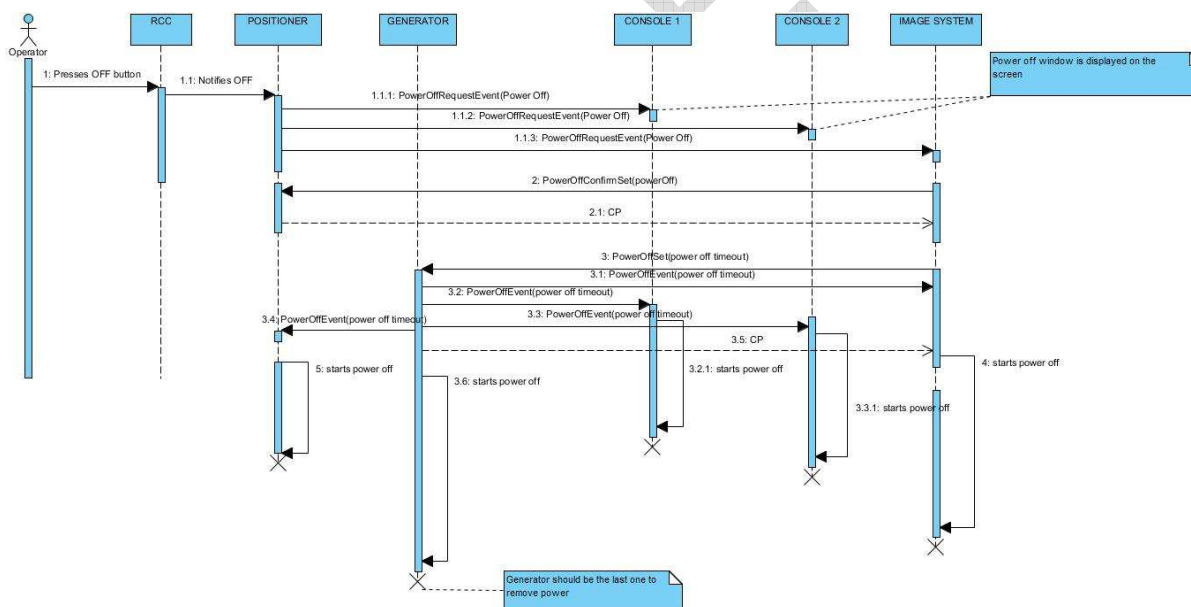

Figure 26 Power off diagram

6.15 Virtual desktops

Virtual desktops IDs can be obtained from the following navigation tree:
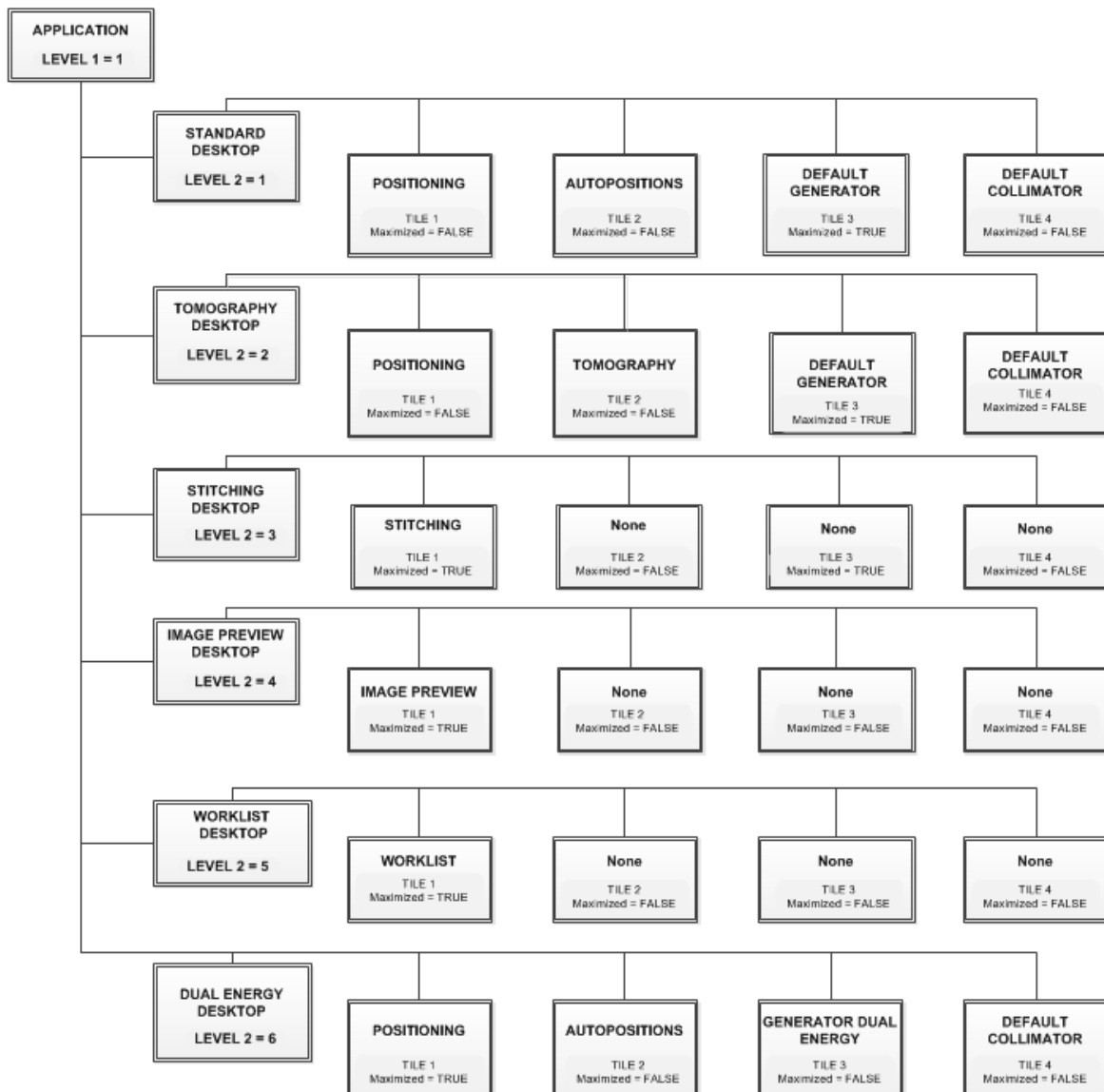
Figure 27 Virtual Desktops IDs

6.16 Worklist display

Table content is set row by row, indicating in the MultiColumnTablesSETMessage as many times as rows for the table, with the following fields:

- Desktop ID where the table is located: 1-5
- Desktop Tile ID: 1
- Table ID: 1
- Row to be filled: from 1.. N
- Number of columns on the table: 4. Each column stands for the following info:
  o Column 1: Workstation (byte)
  o Column 2: Procedure description (char[])
  o Column 3: Is Procedure Selected (byte)
  o Column 4: Is Procedure Performed (byte)

- Row Data content, is represented by an array of byte arrays:
  - RowDataContent[0] = 1
  - RowDataContent[1] ='s', 'k', 'u', 'l', 'l',' ' , 'A', 'P'
  - RowDataContent[2] = 1
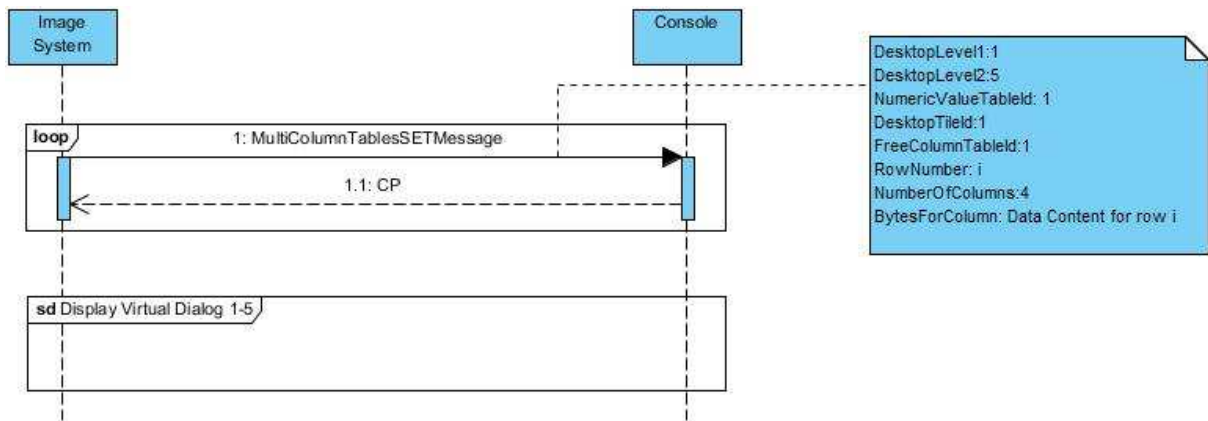 - RowDataContent[3] = 0

Figure 28. Define patient woklist content

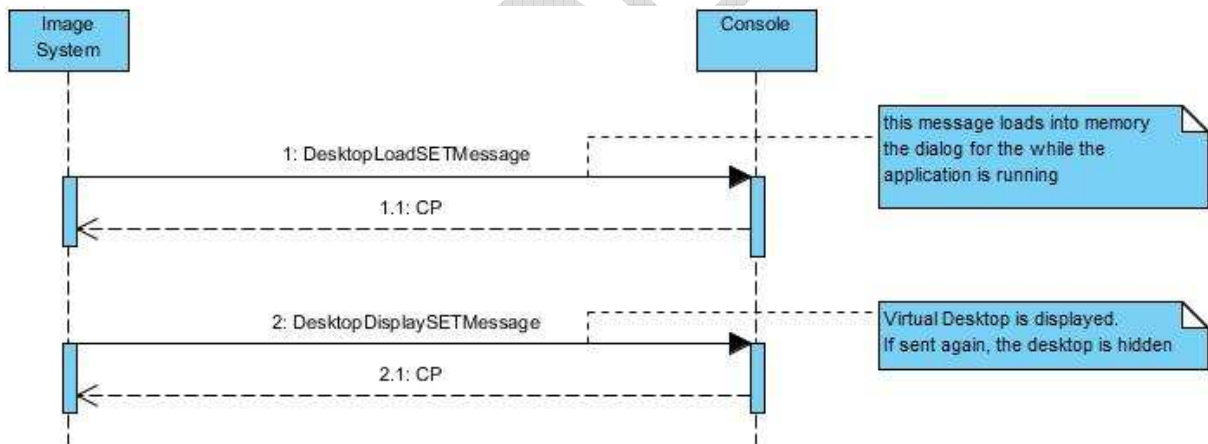And display the Desktop 1-5 when need:

Figure 29 Load and display virtual desktops

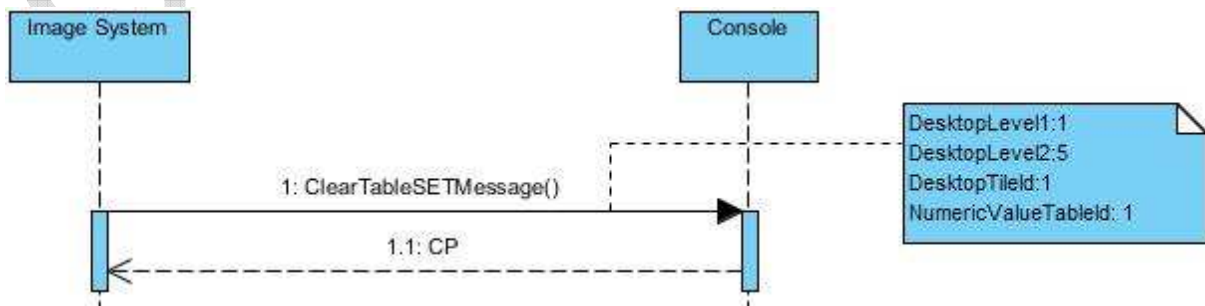To delete one row, you should clear and fill up again the table with new content:

Figure 30. Clear patient worklist content

6.17 Image preview

A preview of the acquired image can be displayed on the tube console using the following steps:

- Upload the preview image as byte[], named as "preview.jpg". See *GuideforImageSystemAccessConfiguration* document.
- load the desktop 1-4: only once after console is loaded and running.
- display desktop: as many times as the image preview functionality is needed. See Figure 29 Load and display virtual desktops.

6.18 Stitching sequence

See *Stitching* document.

6.19 System Messages

The Image system should reset the following inhibits:

- *100802 - Waiting for Detector.* This system message is set by the generator to wait for the detector to be ready to acquire to start the exposure sequence. It is intended to avoid hardware or software synchronization before the detector is ready to handle it. So, it should be cleared before starting a new exposure sequence. And it will be set right after finishing an exposure.
- *100801 - Procedure Finished.* This system message is set by the generator when the procedure defined by the image system has been performed. If the same or a new procedure has to be repeated, it should be cleared. For example, for a procedure defined with 4 exposures, it will be set right after the 4th exposure has been done. In case of a 1 exposure procedure, it will be set right after the exposure, together with system message 100802

The image system, could set inhibits in case movements or exposures should be disabled. These codes should be agreed with the Console. Some predefined codes are:

- *500001. Press move button to go to stitching setup position*. Information message to be displayed on the tube console.
- *500002. Stitching in setup mode*. XRays inhibits until stitching parameters are introduced by operator.
- *500003. Keep the handswtich pressed.* Information message to remind the operator to keep the handswitch pressed during the whole stitching sequence.
- *500004. Selecting technique*. Xrays inhibits while setting the procedures required for this exam.

To Reset a system message generated by other node (that is not you) on the system call the `SystemMsgSETMessage` message with

- `MessageId` field of the system message to be cleared.
- `IsActivated` set to false.
- Send the system message to the:

- o Generator, if xrays are inhibited
- o Positioner, if movements are inhibited
- o Both, if xrays and movements are inhibited
- o Console, if it is just a message to be displayed (no xrays or movements are inhihibit)

To Set a system message call the `SystemMsgSETMessage` message with
- `MessageId` field of the system message to be activated.
- `IsActivated` set to true.
- Set the `InhibitExposures` to true or false if xrays should/shouldn't be disabled.
- Set the `InhibitMovement` to true or false if movements should/shouldn't be disabled.
- Send the system message to the:
  - o Generator, if xrays are inhibited
  - o Positioner, if movements are inhibited
  - o Both, if xrays and movements are inhibited
  - o Console, if it is just a message to be displayed (no xrays or movements are inhihibit)

To Reset a system message generated by the image system, call the `SystemMsgEVENTMessage`
- `MessageId` field of the system message to be cleared.
- `IsActivated` set to false.
- Send it to all nodes in the system

It is recommended that Image systems gets the connection status for generator and positioner nodes, in order to manage this scenario (no exposures will be possible).

To query information about system messages, (see Guid for Image System Access Configuration file)
1. Instance the DataProvider object "Sedecal.Console.Data.Infrastructure".
2. With the DataProvider instanced, use the method "GetById<SystemMessage>(Id system message (uint type))". This function return a SystemMessage object ("Sedecal.Common.Infrastructure"). In SystemMessage are the properties:
   - Code
     - o Unique ID for system message
   - Description
     - o Explanation text for the system message to be displayed on the screen
   - HelpIcon
     - o For console, to display an icon next to the image system.
   - HelpText
     - o A more detailed description for the system message.
   - LogDescription
     - o Text to be logged.

- Behaviour. String with the behaviour conditions. To know the behaviour conditions are these properties:
    - ClearCondition
        - **MainConsole**, (also known as Acquisition SW / System Console / Service Console): System Message is reset when Main Console resets it. This means that an applications takes the responsibility of resetting the System Message when conditions are satisfied. Waiting for detector, Procedure finished, Enable Disable/RX, Comms timeout are examples of this type.
        - **AfterDisplay**, message is active for 5 seconds to be displayed, after this time, it should be removed from the list.
        - **UserConfirm**, message is active until operator confirmation.
        - **IssuingDevice**, message is active until it is reset automatically when condition disappears. For example, when a procedure is defined, when detector is ready, when image system connects…

        A system message will never be cleared if none of the above conditions applies.

    - IsExposureInhibit
        - No exposures allowed
    - MustBeLogged
        - For console to display message until next bootup
    - MustShowPopup
        - For console, to display a pop up window with message
    - Sound
        - For console, to beep if a system message is active
    - SourceNodeId

Node that is reporting the system message. To clear message, send a system message with "clear" field to this Node

6.20 Communication time out System Message

This error (system message) is raised to avoid exposures without any control displaying mandatory indications.

6.21 Errors

Scenario errors that the Image system should consider are:

1) Generator or positioner is not connected
2) Define a procedure, response from generator and positioner differ.
3) A command can result in an error on generator or position (node) side. When a request is sent to the generator or positioner, there is a `Response` answer, indicating wether:
    a. Node is disconnected.
    b. Error sending message.

   c. Token is not granted. Belongs to another Node.

   d. The request has not been processed.

   e. The request has timeout. For some reason, the node has not processed the request.

   f. The request has been processed. Check for the `CPEvent.ReturnCode` property .

       i. 0 value means Command Processed OK

      ii. Else, check for the `enum ReturnCode` of the original request class.

6.22 Management of system messages

There is no special need for the image system to handle System Messages.

However a System Message can be sent to the system if some information is desired to be displayed on the tube console, inhibit exposures or movements.

7. SIMULATORS

7.1 SHFR Simulator

7.1.1 Techservice tool

See the document *CC-1149*

7.1.2 EBox configuration tool

Install the "Adapter_Ethernet_Can\setup.exe" to run the "Can2Eth_Adapter" program.

Use ADMINISTRATOR Settings to install and run the application

Password: 2434

Enter into IP Configuration menu.
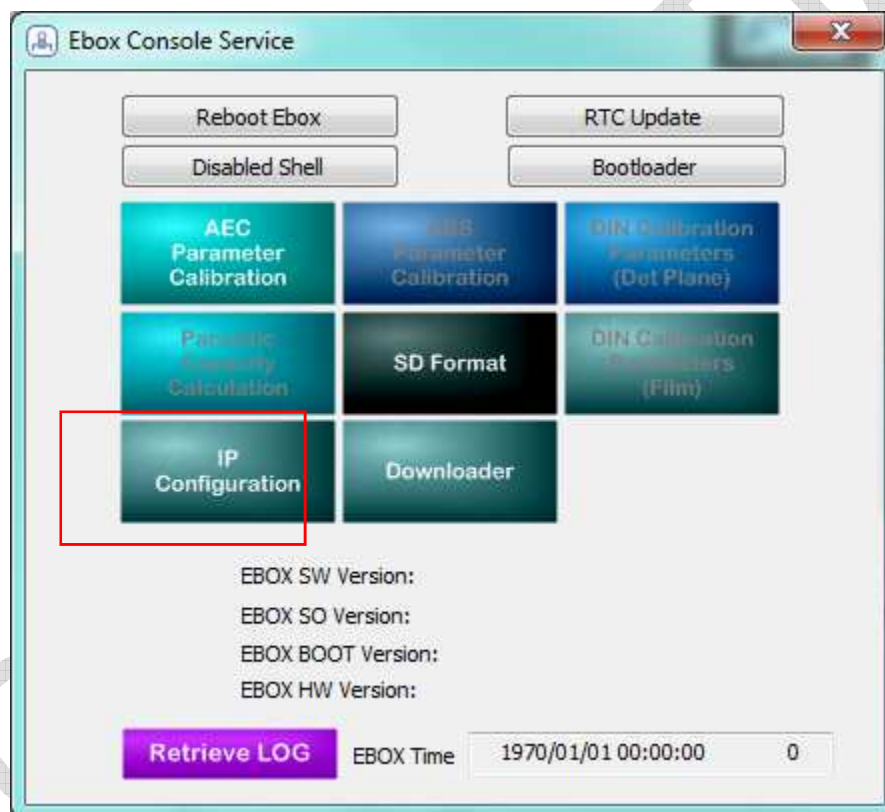
From that application, you can set the final IP used by the generator to connect to the smarthub on the "Smarthub IP field". Be sure to match also the network mask.

- Smarthub IP
- IP Gateway
- NTP Server

Should match with the IP address of the PC where the smarthub will run, and the one used during smarthub installation proccess.

Connections: Connect the Ethernet cable from the J9 connector on A9587 board to the Ethernet board on the PC configured with the 192.6.1.103 ip address for ChallengeX or 192.168.0.4 for a generator only.

7.1.3 Downloader SHFR tool

Install "SHFR Firmware upgrade\Setup 1.0.4 20150506.exe" to run "Downloader" program.7

Use the USB-Can Adapter. Normally windows will install this driver automatically. But it is provided with the file FTDI_Windows_Driver_Setup.exe

Connections: Connect the Ethernet cable from the J7 connector on A9587 board to the USB-CAN BOX. Connect the usb cable on the USB-CAN BOX to your PC.

7.2 ChallengeX Simulator

The Simulator runs in a Linux Virtual Machine.

StartMasterSimulator shortcut runs the VM. The positioner simulator will be launched automatically.

In case you need to stop/restart the positioner simulator, you can use the KillMaster/LaunchMaster shortcuts.
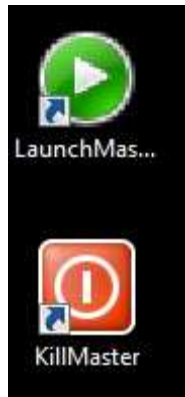
7.3 Tube head console

This console can be used for display purposes.

7.4 SmartHub Monitor

Monitorizes what nodes are connected to the smarthub.

8. Appendix

8.1 Message class summary List

Message subscription & message sending has been grouped according to functionality in the following classes:

In blue, messages required for a generator/positioner console

In purple, messages required for an integration with an digital image system.

	Messages Subscribed	MessagesSent
GeneralSettingsManagement	**Generator Info Console**	
	GenPowerLimitEVENTMessage	GeneratorStatusGETMessage
	GeneratorStatusEVENTMessage	SystemMsgRequestGETMessage
	SystemMsgEVENTMessage	SystemMsgSETMessage
		GenPowerLimitGETMessage
		GenPowerLimitSETMessage
RADManagement	**Generator Info Console:**	
	KvEVENTMessage	CurrentKvGETMessage
	MaEVENTMessage	KvGETMessage
	MasEVENTMessage	KvSETMessage
	MsEVENTMessage	CurrentMaGETMessage
	MasEVENTMessage	MaGETMessage
	MaxIntegrationTimeEVENTMessage	MaSETMessage
	FocalSpotEVENTMessage	CurrentMasGETMessage
	AecFieldsEVENTMessage	MasGETMessage
	AECDensityEVENTMessage	MasSETMessage
	AECSensitivityEVENTMessage	
	TubePowerLimitEVENTMessage	MsSETMessage
		MsGETMessage
	CurrentKvEVENTMessage	CurrentMsGETMessage
	CurrentMaEVENTMessage	MaxIntegrationTimeGETMessage
	CurrentMsEVENTMessage	CurrentMaxIntegrationTimeGETMessage
	CurrentMasEVENTMessage	MaxIntegrationTimeSETMessage
	CurrentMaxIntegrationTimeEVENTMessage	FocalSpotGETMessage
	CurrentFocalSpotEVENTMessage	CurrentFocalSpotGETMessage
	CurrentAECFieldsEVENTMessage	FocalSpotSETMessage
	CurrentTubePowerLimitEVENTMessage	CurrentAECSensitivityGETMessage
	CurrentRADParamsEVENTMessage	AECSensitivityGETMessage
		AECSensitivitySETMessage
		CurrentAECDensityGETMessage
	FpsEVENTMessage	AECDensityGETMessage
	TrackingIdEVENTMessage	AECDensitySETMessage
	KVScanEVENTMessage	CurrentAECFieldsGETMessage

	MAScanEVENTMessage	AECFieldsGETMessage
		AECFieldsSETMessage
	CurrentFpsEVENTMessage	CurrentTubePowerLimitGETMessage
	CurrentTrackingIdEVENTMessage	TubePowerLimitGETMessage
	CurrentKVScanEVENTMessage	TubePowerLimitSETMessage
	CurrentMAScanEVENTMessage	
	CurrentRADParamsEVENTMessage	TechniqueModeSETMessage
		CurrentTechniqueModeGETMessage
		TechniqueModeGETMessage
		CurrentRADParamsGETMessage
		FpsGETMessage
		CurrentFpsGETMessage
		FpsSETMessage
		TrackingIdGETMessage
		CurrentTrackingIdGETMessage
		TrackingIdSETMessage
		CurrentKVScanGETMessage
		KVScanGETMessage
		KVScanSETMessage
		CurrentMAScanGETMessage
		MAScanGETMessage
		MAScanSETMessage

Generator System Image console:

	LoadRADDataBankEVENTMessage	LoadRADDataBankSETMessage
	PostExposureEVENTMessage	LoadRADDataBankGETMessage
		PostExposureGETMessage
FluoroManagement	FluoroProcedureAcceptanceEVENTMessage	FluoroKVpSETMessage
	FluoroKVpEVENTMessage	FluoroMAGETMessage
	FluoroMAEVENTMessage	FluoroMASETMessage
	FluoroMsEVENTMessage	FluoroMsGETMessage
	FluoroMaxIntegrationTimeEVENTMessage	FluoroMsSETMessage
	FluoroPpsEVENTMessage	FluoroMaxIntegrationTimeGETMessage
	FluoroAbcEVENTMessage	FluoroMaxIntegrationTimeSETMessage
	FluoroHighDoseEVENTMessage	FluoroPpsGETMessage
	FluoroKVpScanEVENTMessage	FluoroPpsSETMessage
	FluoroQbyPpsEVENTMessage	FluoroAbcGETMessage
	FluoroDoseLevelEVENTMessage	FluoroAbcSETMessage

	FluoroCurveEVENTMessage FluoroTimeResetEVENTMessage FiveMinuteFluoroAlarmResetSETMessage	FluoroHighDoseGETMessage FluoroHighDoseSETMessage FluoroKVpScanGETMessage FluoroKVpScanSETMessage FluoroQbyPpsGETMessage FluoroQbyPpsSETMessage FluoroDoseLevelGETMessage FluoroDoseLevelSETMessage FluoroCurveGETMessage FluoroTimeResetSETMessage FiveMinuteFluoroAlarmResetEVENTMessage
	Generator System Image Console (RF Only)	
	LoadFluoroDataBankEVENTMessage	LoadFluoroDataBankSETMessage LoadFluoroDataBankGETMessage
RADManagement	**Generator System Image Console**	
	ClearAllProceduresGeneratorEVENTMessage ClearProcedureGeneratorEVENTMessage ProcedureGeneratorEVENTMessage AssignExposureDataBankEVENTMessage ActivateGenProcedureDataBankEVENTMessage ExposureDataBankAcceptanceEVENTMessage RADProcedureAcceptEVENTMessage WorkstationChangeRequestEVENTMessage	ClearAllProceduresSETMessage ClearProcedureSETMessage ProcedureSETMessage ProcedureGETMessage AssignExposureDataBankGETMessage AssignExposureDataBankSETMessage ActivateProcedureDataBankSETMessage ExposureDataBankAcceptanceGETMessage ExposureDataBankAcceptanceGETMessage RADProcedureAcceptGETMessage
	Positioner System Image Console	
FilterDBManagement	LoadFilterEVENTMessage AssignCollimatorFilterDataBankEVENTMessage	LoadFilterSETMessage LoadFilterGETMessage AssignCollimatorFilterDataBankSETMessage AssignCollimatorFilterDataBankGETMessage
FOVDBManagement	LoadFOVEVENTMessage AssignCollimatorFOVDataBankEVENTMessage	LoadFOVSETMessage LoadFOVGETMessage AssignCollimatorFOVDataBankSETMessage AssignCollimatorFOVDataBankGETMessage

PositionDBManagement	ReadStandardPositionEVENTMessage AssignPositioningDataBankEVENTMessage	LoadAutoposSETMessage ReadStandardPositionGETMessage AssignPositioningDataBankSETMessage AssignPositioningDataBankGETMessage LoadFreeAutoposSETMessage
PositionerManagement	ClearAllProceduresPositionerEVENTMessage ProcedurePositionerEVENTMessage ActivatePosProcedureDataBankEVENTMessage PositionPostExposureEVENTMessage	PositionPostExposureGETMessage
DosemeterManagement	ReadoutDosimeterEVENTMessage	ResetDosimeterSETMessage ReadoutDosimeterGETMessage
PatientManagement		PatientInfoEVENTMessage ProcedureInfoEVENTMessage
Workstation change	WorkstationChangeRequestEVENTMessage	NewWorkstationSETMessage
Power Off	PowerOffEVENTMessage PowerOffCancelEVENTMessage PowerOffRequestEVENTMessage	PowerOffSETMessage PowerOffCancelSETMessage PowerOffConfirmSETMessage
Virtual Desktops	DesktopDisplayEVENTMessage DesktopLoadEVENTMessage DesktopTileEnableEVENTMessage xxxPropertySetupEVENTMessage	DesktopDisplaySETMessage DesktopLoadSETMessage ClearTableSETMessage xxxPropertySetupGETMessage xxxPropertyValueSETMessage SingleUserRequestEVENTMessage
Databanks	MaxDataBanksNumberEVENTMessage MaxProceduresNumberEVENTMessage	MaxDataBanksNumberGETMessage MaxProceduresNumberGETMessage
	RADParameterRangesEVENTMessage	RADParameterRangesGETMessage
Software exposure Synchronization		StartStopExposureSETMessage
Others		SyncUpGETMessage

Sample Projects at:

https://svn.sedecal.com/atomium/Samples/trunk/AppCommonInfrastructure

https://svn.sedecal.com/atomium/Samples/trunk/ImageSystemR2CP