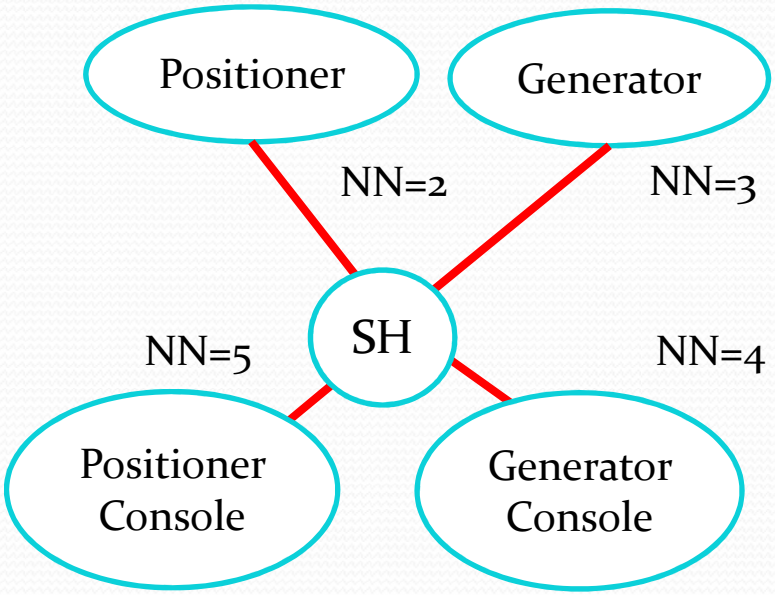
R2CP Interface to Sedecal Room Platform (abridged version) 1.4

4. R2CP

- 1. Based on ethernet sockets
  - Smart Hub
  - Message format
  - Routing & Filtering
- 2. R2CP SW interface with the room: a new paradigm
  - Workflow oriented vs device oriented
    - Procedure definition
    - Procedure activation
    - System messages

1. Ethernet

- Smart Hub (SH)
  - SW module that runs on Windows
  - Minimizes socket connections on Positioner and Generator
    - All nodes connected to SH
    - SH routes messages between nodes



- Message format

Priority	SEQ	Destination Node Number	Issuing Node Number	Index	Subindex	Function	Data Length
2	6	8	8	8	8	8	16

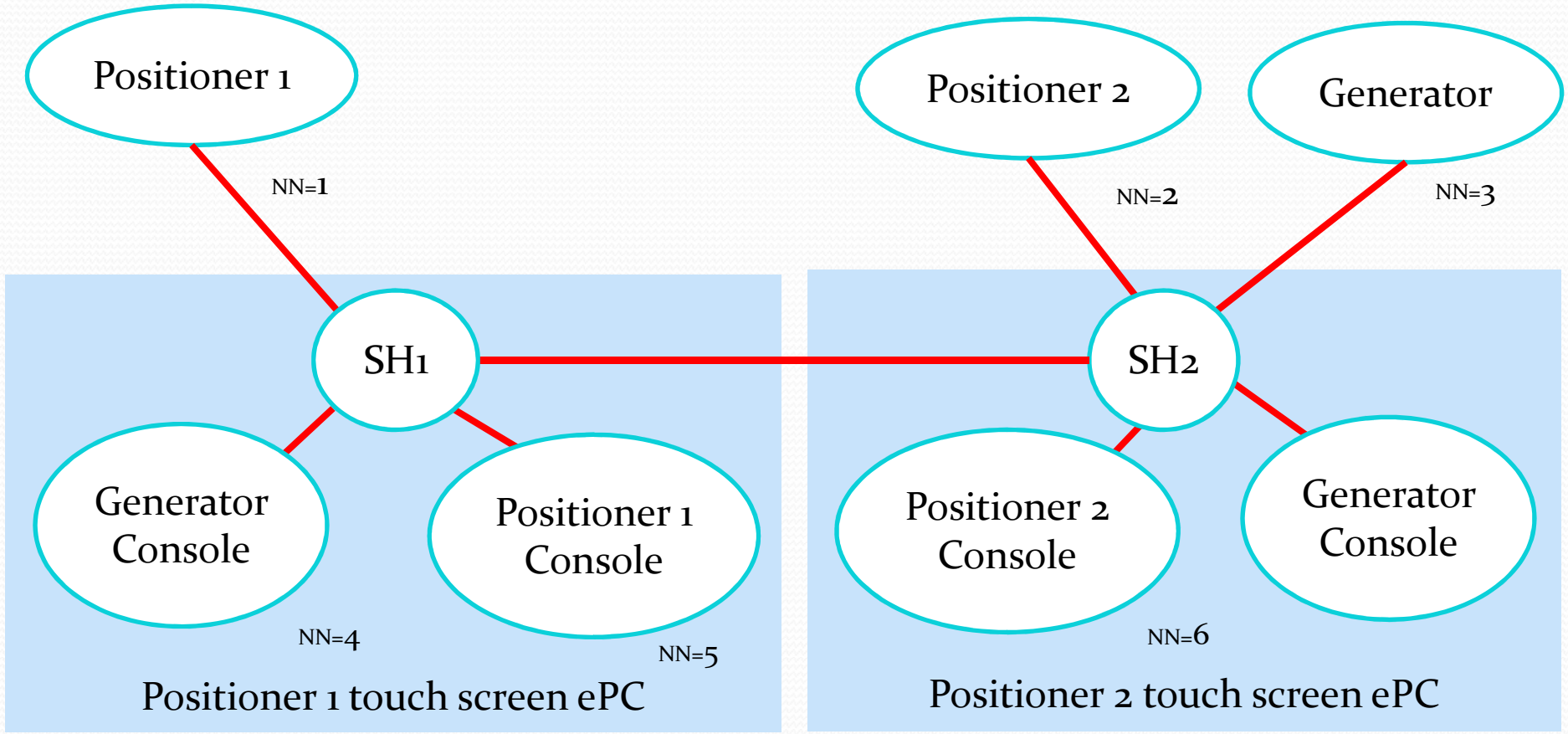
PP	Priority
SEQ	Sequence Number, local to each issuing number
DNN	Destination Node Number 0 **Broadcast** mesage (ANSWER/EVENT) NN Message to node number NN (SET or GET)
INN	Issuing Node Number
Index	Parameter Group • 0x20 Generator • 0x40 Positioner • 0x60 Dosimeter • **0x70 Custom** • 0x80 GUI & Fileshare (System Messages) • 0xA0 Network • 0xE0 Patient Workflow • 0xF0 Message Workflow
Subindex	Parameter

Function	• SET • GET • ANSWER/EVENT • COMMAND PROCESSED
Data Length	Number of bytes in the data field

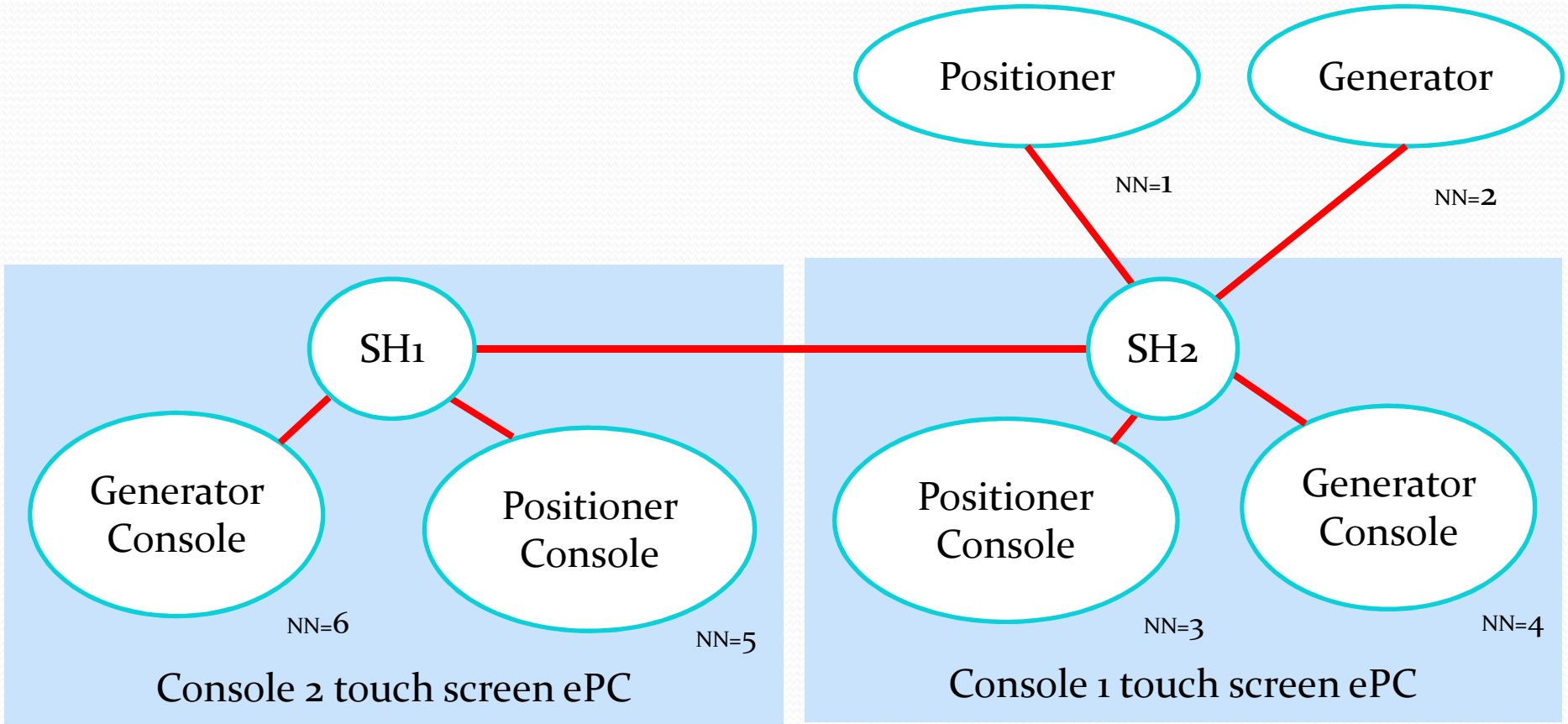
- Routing and filtering: rules

Implicit Rule	All messages received from any node with DNN = NN will be forwarded to node number NN
Broadcast Message	Smart Hub will forward to NN node all the messages with DNN=0x00 when NN node is registered to receive messages from the INN and the range of Index/Subindex specified in the rules
	Rule 1 INN=A, specifies the issuing node number the rule applies to. Index Subindexes: they can be defined as individual indexes and ranges.
	Rule 2 INN=B Index Subindexes

- Routing & Filtering: Nested SH's: If destination node is not in the list of local nodes, message will be forwarded to the SH in which node is local.
  - Two positioners & 2-tube generator.


Positioner 1
NN=1
Positioner 2
NN=2
Generator
NN=3
SH1
SH2
Generator Console
NN=4
Positioner 1 Console
NN=5
Positioner 2 Console
NN=6
Generator Console
Positioner 1 touch screen ePC
Positioner 2 touch screen ePC

- Adding an additional console is as simple as connecting two instances of SH with the same local nodes connected (different NN).



- R2CP SW interface with the room: a new paradigm
  - Workflow oriented vs Device oriented
  - Related settings defined at once
  - Unified reporting of system events and messages to the user
  - Native support for RF

- Intuitive

"Perform a table top procedure for abdomen. Use a wifi detector"

- **Procedure**
  - Standard RAD
  - 1 Exposure: 1 set of exposure parameters
  - 1 Position: table.
  - 1 Filter
  - 1 Collimator FOV

- **Workstation** → Place → Table top → Image receptor over the table

- **Image receptor**: 43x43 wifi detector

Implementing worflow:

- Procedure definition
- Load DB's
- Assign DB's
- Activate DB's

- Workstation
  - Refers to image receptor location and the devices involved for the xray procedure to be performed

DATA	FORMAT
Workstation ID	1..31
Description	String
Generator #	Generator Node Number
Tube #	Tube number
Positioner #	Positioner Node Number
Image Receptor ID	1..255
Image Receptor Location	0 – Free 1 – Table 2 – Wallstand
AEC Chamber Connected to	0 – No AEC 1 – Generator 2 – eBox
AEC Input	0 – No AEC 1..4 – AEC Input

Procedure

- Type of XRAY examination: generator procedure type and positioner procedure type.
- Workstation
- Number of exposures
- Number of positions – filters – collimator FOV's

BYTE	DATA	FORMAT
1	Procedure ID	[1..255]
2	Generator Procedure Type	0 – Not defined 1 – Std RAD 2 – Stitching 3 – Tomography 4 – DSI: single energy, multi energy, tomosynthesis. 6 – CINE 7 – DSA 100 – Std Fluoro 101 – Roadmap Mask Fluoro 102 – Roadmap Fluoro
3	Positioner Procedure Type	0 – Not defined 1 – Std Position 2 – Stitching 3 – Tomography 4 – Tomosynthesis
4	Handswitch / Footswitch ID	[1..255]
5	Activate When Handswitch/Footswitch is pressed	0, Do not Activate procedure when Footswitch/Handswitch pressed. Procedure is activated with Patient Workflow message. 1, Activate procedure when Footswitch/Handswitch pressed
6	Workstation	[1..255]

7	Total Number of Exposure Data Banks in Procedure	[1..255]
8	Total Number of Positioning Data Banks in Procedure	[1..255]
9	Total Number of Collimator FOV Data Banks in Procedure	[1..255]
10	Total Number of Collimator Filter Data Banks in Procedure	[1..255]
11	Generator Data Bank Sequencing	0 – N/A 1 – Activate next Exposure Data Bank 2 – Pause Procedure until next Exposure Data Bank is activated by a Patient Workflow message
12	Positioning Data Bank Sequencing	0 – N/A 1 – Activate next Positioning Data Bank 2 – Pause Procedure until next Positioning Data Bank is activated by a Patient Workflow message
13	Collimator FOV Data Bank Sequencing	0 – N/A 1 – Activate next Collimator FOV Data Bank 2 – Pause Procedure until next Collimator FOV Data Bank is activated by a Patient Workflow message
14	Collimator Filter Data bank Sequencing	0 – N/A 1 – Activate next Collimator Filter Data Bank 2 – Pause Procedure until next Collimator Filter Data Bank is activated by a Patient Workflow message

Data Banks (DB's): store the values required by the procedure

- RAD or FL: contains RAD or FL exposure parameters
- Position: contains position information
  - Parameters that define a position
  - Index to a position from library
- Filter: contains filter information
- Collimator FOV: trans and long collimator blades opening

Procedure definition: R2CP Patient Workflow - SET Procedure

- Message sent from image acquisition workstation to generator and positioner

Image Acquisition Workstation
Procedure ID = 1
Generator Procedure Type = Std RAD
Positioner Procedure Type = Std Position
Number of Exposure DB's = 1
Number of Positioning DB's = 1
Number of Filter DB's = 1
Number of Collimator FOV DB's = 1

Generator
Procedure ID = 1
Generator Procedure Type = Std RAD
Positioner Procedure Type = Std Position
Number of Exposure DB's = 1

Positioner
Procedure ID = 1
Generator Procedure Type = Std RAD
Positioner Procedure Type = Std Position
Number of Positioning DB's = 1
Number of Filter DB's = 1
Number of Collimator FOV DB's = 1

Load RAD exposure DB: R2CP Generator message from image acquisition workstation to generator

BYTE	DATA	FORMAT
1	Data Bank ID	**1**
2(1-4)	Patient Size	0: Small 1: Medium 2: Large
2(5-8)	Pediatric	0: Non Pediatric 1: Pediatric
3(1-6)	Technique Mode	0: 0Point 1: 1Point 2: 2Point 3: 3Point
4 **5**	kV * 10	[20..150] * 10
6 **7** **8**	mAs * 1000	[0.1..3200] * 1000
9 **10** **11**	**mA * 100**	**[1..1000] * 100**
12 **13** **14**	ms * 100	[1..20000] * 100
15 **16**	Minimum Integration Time (ms)	[1..20000]
17 **18**	Maximum Integration Time (ms)	[1..20000]
19	Focal spot	0: small 1: large 2: super small
20	AEC Sensitivity	0: low 1: medium 2: high
21	AEC Density	[-8 .. 8] (INT8)

22	AEC Chamber off(0) / on(1) status	Bit 1: left AEC status Bit 2: center AEC status Bit 3: right AEC status Bit 4: landscape (0) / portrait (1) AEC orientation
23	Tube Power Limit (%)	[0..100]
24 **25**	FPS x 10	[0..1200] 0 – Single Shot
26	Tracking ID	[0..255] 0 – None
27(1) **27(2)**	kV Scan mA Scan	0 – Not Active 1 – Active 0 – Not Active 1 – Active

Load Fluoro exposure DB: R2CP Generator message from image acquisition workstation to generator

BYTE	DATA	FORMAT
1	Data Bank ID	[1..255]
2(1-4) **2(5-8)**	Patient Size Pediatric	0: Small 1: Medium 2: Large 0: Non Pediatric 1: Pediatric
3 **4**	kV * 10	[40..125] * 10
5 **6**	mA * 100	[0.01..30] * 100
7 **8** **9**	ms * 100	[1..1000] * 100
10 **11**	Maximum Integration Time (ms)	[1..1000]
12 **13**	PPSx10	[0..1200] 0 – Continuous
14	ABC	0 ABC OFF 1 ABC ON
15	High Dose	0 High Dose OFF 1 High Dose ON
16	KV SCAN	0 KV SCAN OFF 1 KV SCAN ON
17	QbyPPS	0 OFF 1 ON
18	Dose Level ID	[0..255] 0 – None
19	Curve ID	[0..255] 0 – None

Load position DB: R2CP Positioner message from image acquisition workstation to positioner

BYTE	DATA	FORMAT
1	Data Bank ID	**1**
2	Programmable	18
3	Position ID	

Load filter DB: R2CP Positioner message from image acquisition workstation to positioner

BYTE	DATA	FORMAT
1	Data Bank ID	**1**
2	Filter	2

Load Collimator FOV DB: R2CP Positioner message from image acquisition workstation to positioner

BYTE	DATA	FORMAT
1	Data Bank ID	**1**
2 **3**	Collimator Trans 1	200
4 **5**	Collimator Trans 2	200
6 **7**	Collimator Long 1	200
8 **9**	Collimator Long 2	200
10 **11**	Max Collimator Trans 1	2150
12 **13**	Max Collimator Trans 2	2150
14 **15**	Max Collimator Long 1	2150
16 **17**	Max Collimator Long 2	2150

Assign exposure DB 1 to Procedure 1: R2CP Generator message from image acquisition workstation to generator

BYTE	DATA	FORMAT
1	Procedure ID	1
2	Exposure Sequence Number	1
3	Exposure Data Bank ID	1

Assign position DB 1 to Procedure 1: R2CP Positioner message from image acquisition workstation to positioner

BYTE	DATA	FORMAT
1	Procedure ID	1
2	Positioning Program Sequence Number	1
3	Positioning Data Bank ID	1

Assign collimator filter DB 1 to Procedure 1: R2CP Positioner message from image acquisition workstation to positioner

BYTE	DATA	FORMAT
1	Procedure ID	1
2	Collimator Filter Sequence Number	1
3	Collimator Filter Data Bank ID	1

Assign collimator FOV DB 1 to Procedure 1: R2CP Positioner message from image acquisition workstation to positioner

BYTE	DATA	FORMAT
1	Procedure ID	1
2	Collimator FOV Sequence Number	1
3	Collimator FOV Data Bank ID	1

Activate Procedure and DB's: R2CP Patient Workflow message from image acquisition workstation to generator and positioner

BYTE	DATA	FORMAT
1	Procedure ID	**1**
2	Command	**1** Activate Procedure
3	Exposure Data Bank Sequence Number	**1** Activate Exposure Data Bank Sequence Number 1
4	Positioning Data Bank Sequence Number	**1** Activate Positioning Data Bank Sequence Number 1
5	Collimator FOV Data Bank Sequence Number	**1** Activate Collimator FOV Data Bank Sequence Number 1
6	Collimator Filter Data Bank Sequence Number	1 Activate Collimator Filter Data Bank Sequence Number

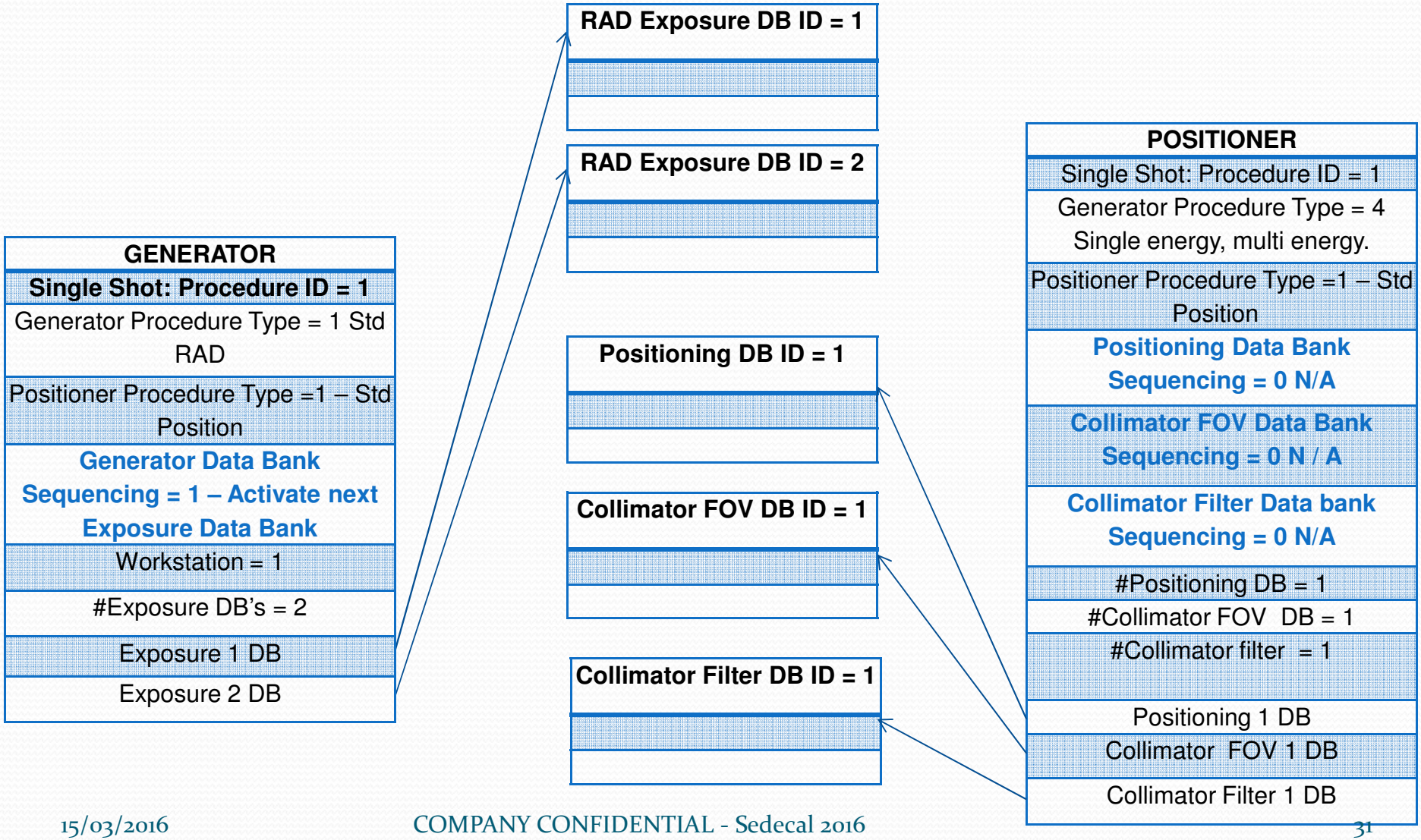
Procedure and DB's activation

- Generator: sets exposure parameters with DB 1 contents
- Positioner
  - Position DB: sets as target position programmable position 18
  - Collimator Filter DB: sets filter 2, collimator will turn filter disc until filter 2 is selected.
  - Collimator FOV DB: sets 40x40 FOV, collimator will move blades to achieve this FOV.

Application example: Dual Energy

- Two RAD exposure DB's
- 1 Position DB
- 1 Collimator Filter DB
- 1 Collimator FOV DB

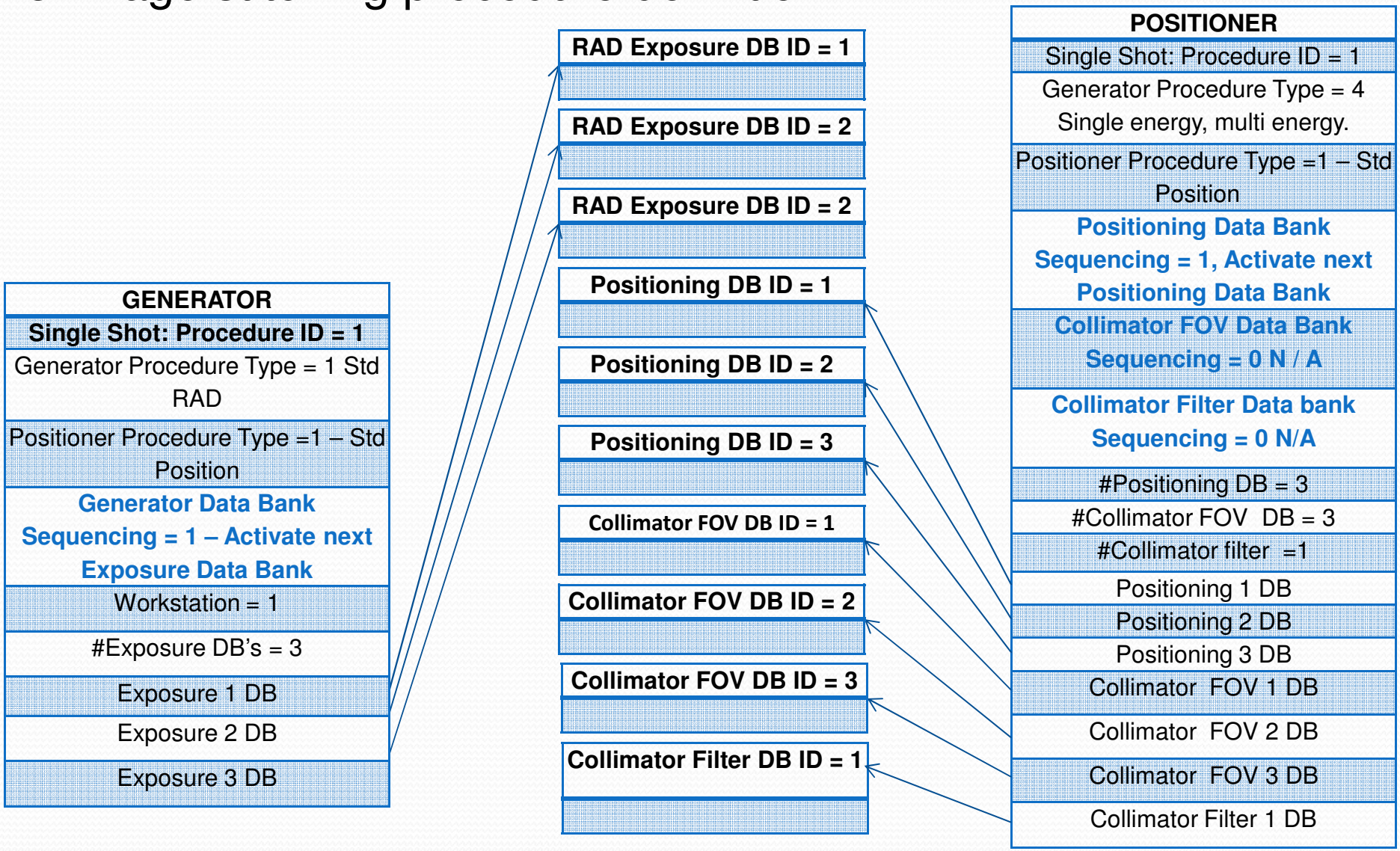
Dual Energy procedure definition



Application example: 3-image stitching

- 3 RAD exposure DB's
- 3 Position DB
- 1 Collimator Filter DB
- 3 Collimator FOV DB

3-Image stitching procedure definition



System Messages

- Unified reporting of system events and messages to the user
  - Door open: message to the user and exposure inhibit. Message and inhibit cleared when door closes.
  - AEC error: message to the user. Generator is blocked until error (not enough dose) is acknowledged by the user.
  - Incorrect grid inserted: exposure inhibit and message displayed until correct grid is inserted.
  - Fatal error on filament board: Call service.
- Included in R2CP 0x80 Index
  - Unique System Message ID
  - Custom system messages can be added

System Message Parameters: Category

- Warning: message to the user
- Abort Exposure: if it occurs during and exposure, it can abort it.
- Inhibit RX
  - Generator Phase: define if inhibits exposure but allows prepping to ready.
- Inhibit Movements
- User Action required: insert correct grid

System Message Parameters: Clear Conditions

- Clear after display
- Clear after user confirmation
- Clear by source device
- Cannot be cleared

System Message Parameters: GUI Indications

- Display modal popup window
- Icon

	Warning		Inhibit
	Error		User action required
	Emergency button		
	Information		

R/F Systems

R/F or Dynamic Systems: SW Interface

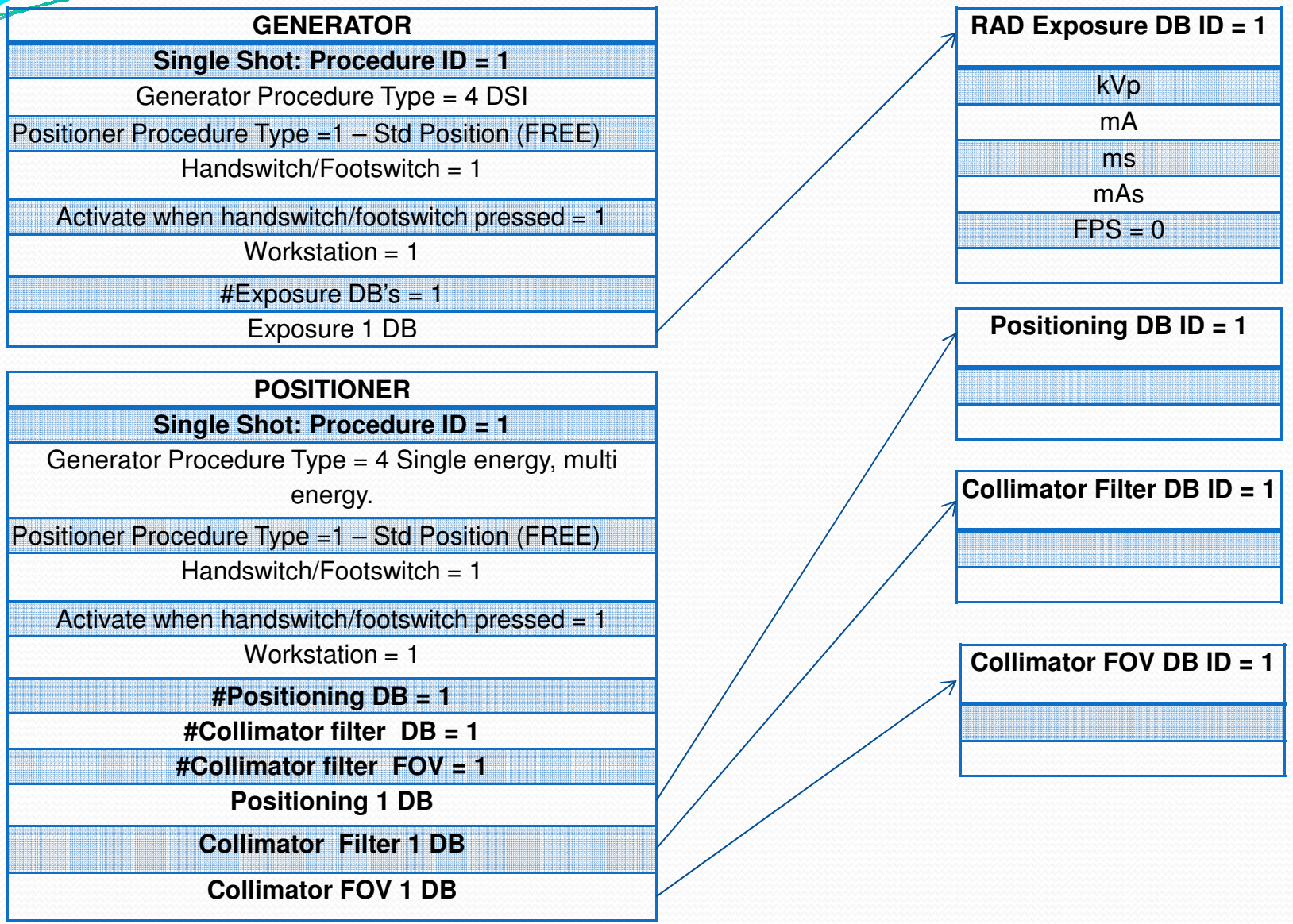
- More than one procedure defined, typically a fluoro procedure and at least 1 RAD procedure.
- Procedures can be activated by a message of by a handswitch / footswitch being pressed.
- Procedure definition message includes handswitch / footswitch ID and activation type.

BYTE	DATA	FORMAT
4	Handswitch / Footswitch ID	[1..255]
5	Activate When Handswitch/Footswitch is pressed	0, Do not Activate procedure when Footswitch/Handswitch pressed. Procedure is activated with Patient Workflow message. **1, Activate procedure when Footswitch/Handswitch pressed**

- A fluoro procedure is usually defined as default, meaning that it gets activated when no handswitch / footswitch is pressed.
- Only one procedure can be active at a time, collimator filter and FOV can be different between procedures.

Application example: 1 fluoro procedure, 1 single shot procedure, 1 multi RAD procedure. Procedure ID=3 is default procedure

Procedure ID	1	2	3
Generator Procedure Type	4 – DSI: single energy, multi energy,	4 – DSI: single energy, multi energy,	100 – Std fluoro
Positioner Procedure Type	1 – Std Position (FREE)	1 – Std Position (FREE)	1 – Std Position (FREE)
Handswitch / Footswitch ID	1	2	3
Activate When Handswitch/Footswitch is pressed	1	1	1
Workstation	1	1	1
Total Number of Exposure Data Banks in Procedure	1	1	1
Total Number of Positioning Data Banks in Procedure	1	1	1
Total Number of Collimator FOV Data Banks in Procedure	1	1	1
Total Number of Collimator Filter Data Banks in Procedure	1	1	1
Exposure DB ID	1	2	3
Positioning DB ID	1	1	1
Collimator filter DB ID	1	1	2
Collimator FOV DB ID	1	1	2


GENERATOR
Single Shot: Procedure ID = 1
Generator Procedure Type = 4 DSI
Positioner Procedure Type =1 – Std Position (FREE)
Handswitch/Footswitch = 1
Activate when handswitch/footswitch pressed = 1
Workstation = 1
#Exposure DB's = 1
Exposure 1 DB
POSITIONER
Single Shot: Procedure ID = 1
Generator Procedure Type = 4 Single energy, multi energy.
Positioner Procedure Type =1 – Std Position (FREE)
Handswitch/Footswitch = 1
Activate when handswitch/footswitch pressed = 1
Workstation = 1
#Positioning DB = 1
#Collimator filter DB = 1
#Collimator filter FOV = 1
Positioning 1 DB
Collimator Filter 1 DB
Collimator FOV 1 DB
RAD Exposure DB ID = 1
kVp
mA
ms
mAs
FPS = 0
Positioning DB ID = 1
Collimator Filter DB ID = 1
Collimator FOV DB ID = 1