

Supplement 212: XA Protocol Storage

**Supplement is developed by DICOM Working Group 02
(WG-02 Projection Radiography and Angiography)**

28 Jan 2019

- **Background & Rationale**
- **Overview of the Proposal**
- **XA Protocol Parameters**
- **Changes to the Standard**

Existing Standard

- Supp 121: Defines a method for storage and retrieval of CT acquisition protocols.

Limitations

- Supp 121 includes CT modality only.
- XA Image IODs include only a few protocol-related attributes, typically related to the appearance of the images.

Goals

- To define a method for storage and retrieval of XA acquisition protocols
- Similar use cases as for CT:
 - *Centralized edit of protocols and distribution to other systems of same model*
 - *Distribution of best practice protocols and general/specific protocols to maintain consistency in clinical trials*
 - *Store the protocol(s) used for a particular study, to repeat or perform comparable follow-up, and access to more detailed information about the acquisition protocol used*
- Export defined protocols from devices to a central repository to facilitate management of consistency and dose. Refer to [NEMA XR-27] “X-ray Equipment for Interventional Procedures User Quality Control Mode”

New Work Item Proposal approved: **[2018-09-A] XA_ModalityProtocolStorage**

New IODs

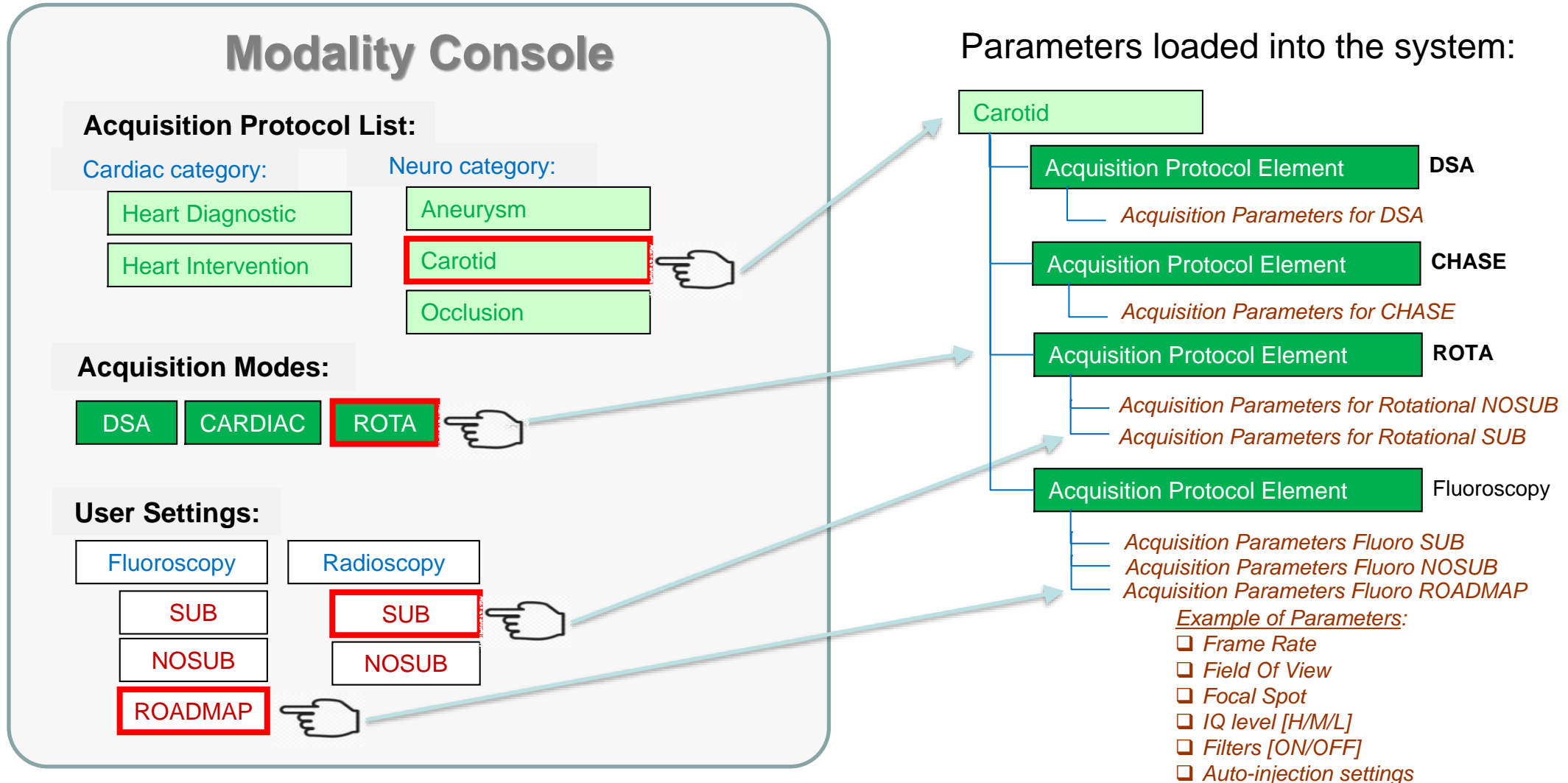
- The work will introduce two new IODs
 - *XA **Defined** Procedure Protocol*
 - *XA **Performed** Procedure Protocol*
- These IODs will use the constructs of the existing CT protocol management IODs introduced by Supp 121.

XA Protocols Content

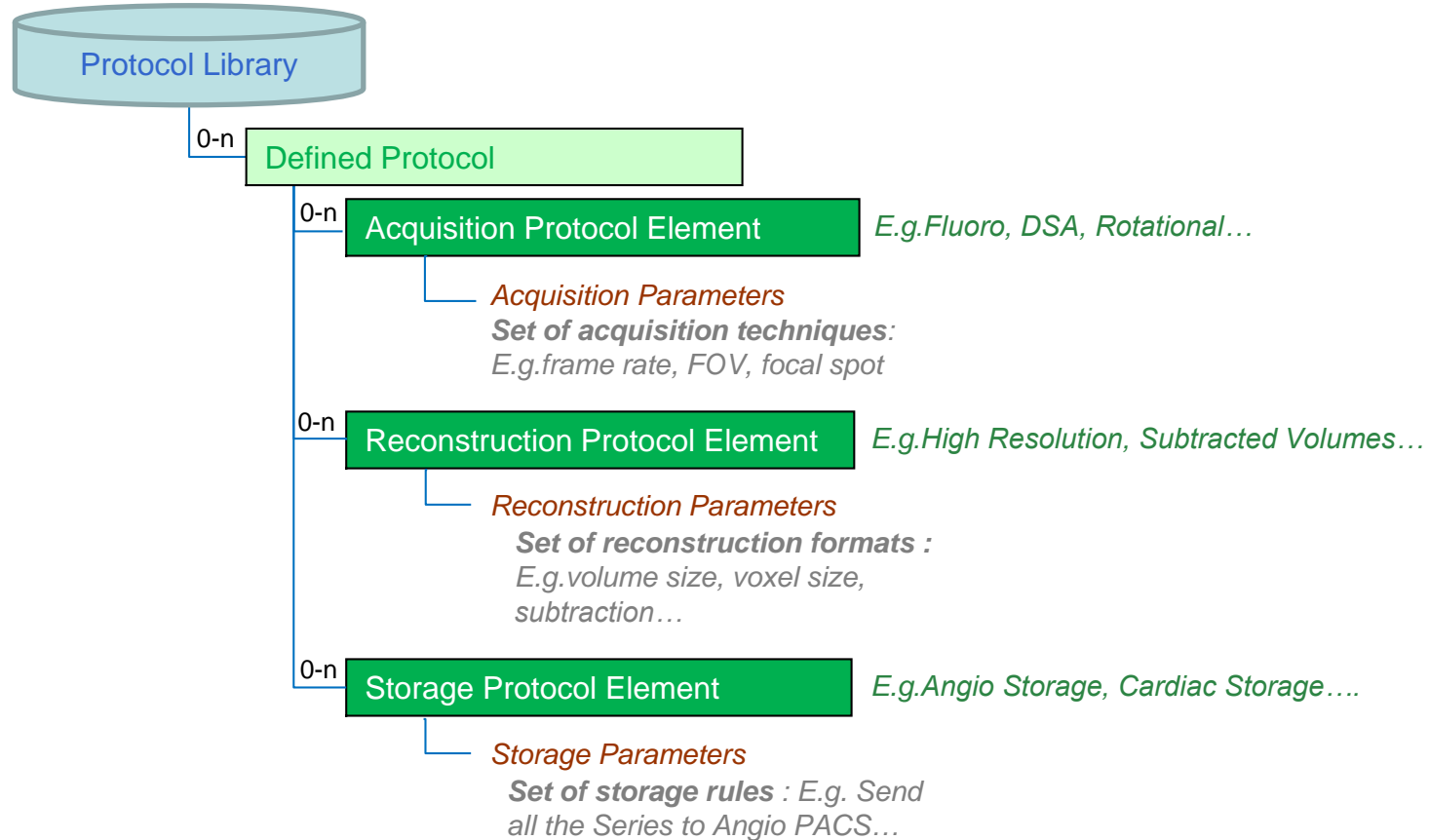
- XA protocol usage during the procedure is more “interactive” than CT, changing continuously the acquisition modes (Fluoroscopy, DSA, Rotational Angio...) and the parameters (Field of View, frame rate, IQ/Dose levels).
- XA **Defined Protocol** will contain all the **acquisition modes** and all their pre-defined **parameters** allowed in that protocol.
- Each **acquisition mode** will correspond to one **Protocol Element**.
- XA **Performed Protocol** will record the actual parameters applied during the various acquisition modes.
- Several XA Defined Protocols may be used during one single XA procedure

Overview of the Proposal

Example of Defined Acquisition Protocol Selection in the acquisition equipment

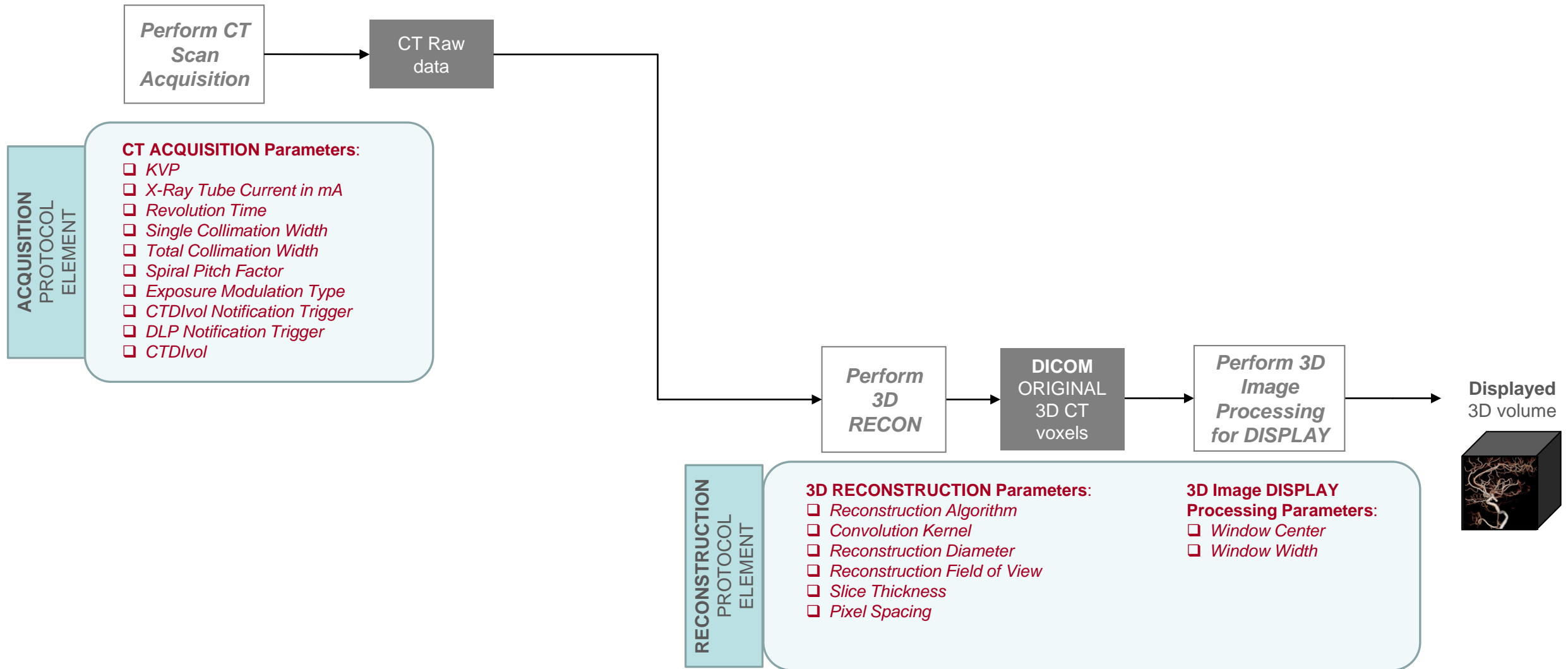


Example of Defined Procedure Protocol database in the acquisition equipment



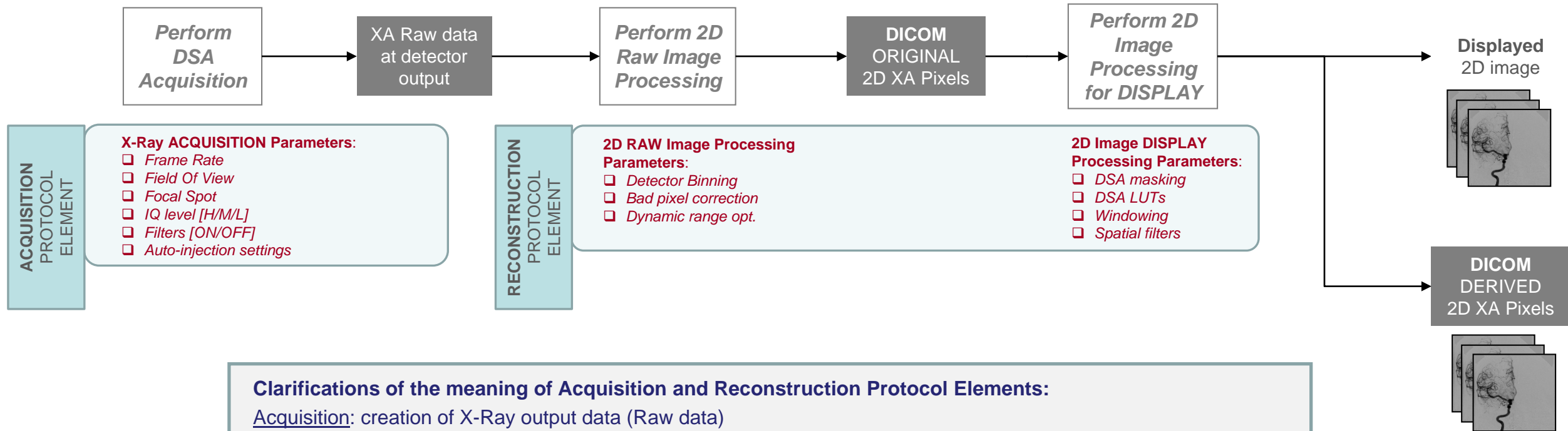
Overview of the Proposal

CT Defined Procedure Protocols: example of acquisition & 3D reconstruction workflow



Overview of the Proposal

Defined Procedure Protocols: XA example of DSA acquisition & 2D Processing for Display



Clarifications of the meaning of Acquisition and Reconstruction Protocol Elements:

Acquisition: creation of X-Ray output data (Raw data)

Reconstruction: manipulation of output data (raw data) to create a DICOM Instance (or an object for storage)

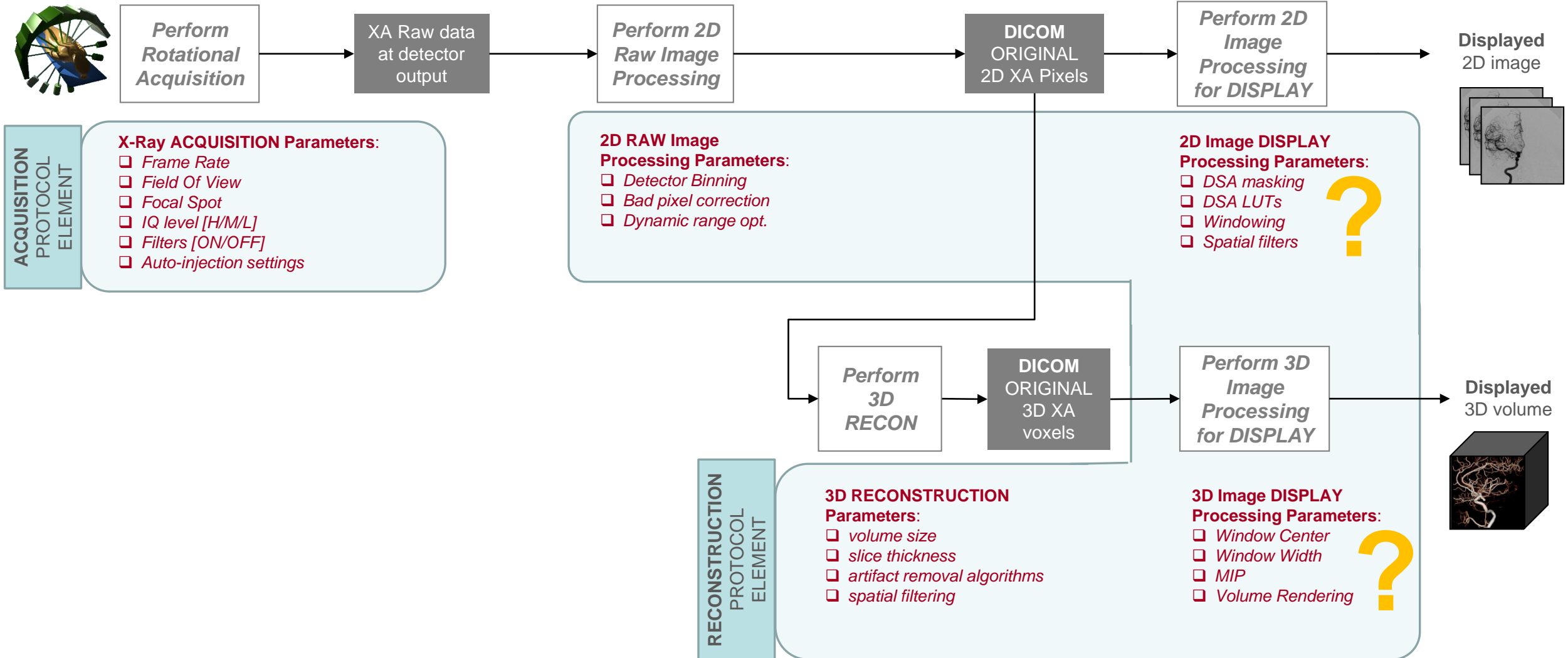
Notes:

1- Parameters to display an image on a non-persistent device (e.g. monitors) should not be in the protocols, it should be part of another Presentation workflow → **To Be Discussed**

2- Reconstruction elements includes 2D processing parameters... sounds strange in XA. Anyway, even if the 2D processing parameters are defined within the same module and same sequence as the 3D reconstruction parameters, in the implementation the 2D and 3D parameters will appear in two different elements of the sequence.

Overview of the Proposal

Defined Procedure Protocols: XA example of rotational acquisition & 3D reconstruction workflow



Green text are changes proposed to the Part 3 of the Standard.

Section 3.8 DICOM Information Object Definitions

Protocol Element – a sequential component of a protocol, consisting of all the parameters necessary to perform that component of the protocol.

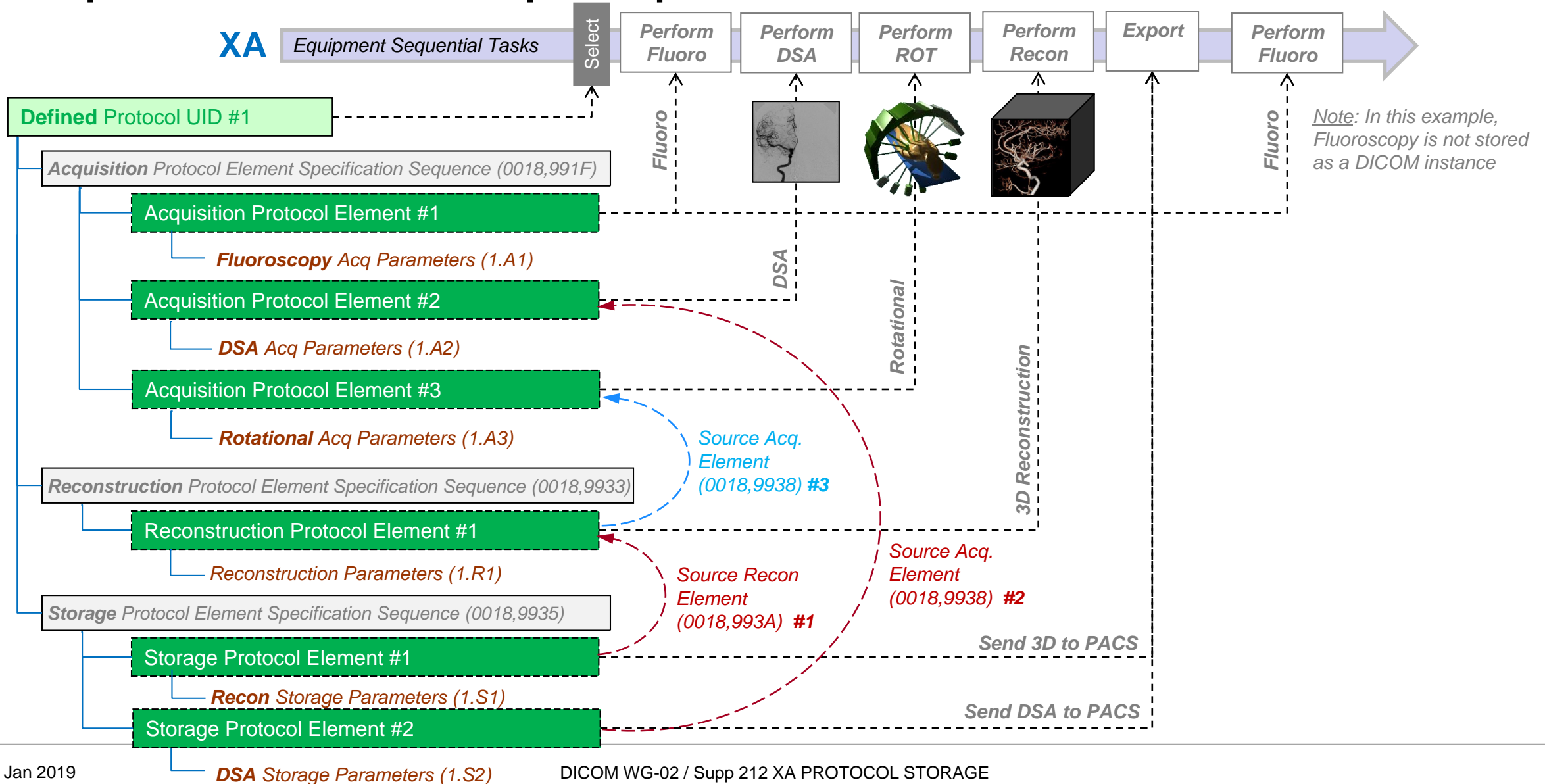
Acquisition Protocol Element – A sequential component of ~~a~~ **the acquisition portion of a** protocol, that contains the ~~SCANNING PARAMETERS~~ **parameters** necessary to perform a single ~~SCAN~~ **acquisition**. In the case of CT this would correspond to tube voltage, tube current, rotation time, spatial location, etc. and an Acquisition Protocol Element also corresponds to an XR-25 PROTOCOL ELEMENT. **In the case of XA this would correspond to technical factors and control algorithms designed to perform the image acquisition, e.g. kVp, mA, pulse width, Dose Related Parameters, IQ targets, rotation range, etc.**

Reconstruction Protocol Element – a sequential component of ~~a~~ **the reconstruction portion of a** protocol. **In the case of CT this would correspond to ~~,such as~~ generating CT thin images or multiplanar reformats. In the case of XA this would correspond to the processing parameters applied before (and after?) the creation of the X-Ray 2D images (such as binning, bad pixel correction, dynamic range optimization, DSA masking, DSA LUTs, windowing, spatial filters, etc.) and the reconstruction and processing parameters before (and after?) the creation of the X-Ray 3D volume (such as volume size, slice thickness, artifact removal algorithms, spatial filtering, MIP, Volume Rendering, etc.).**

Storage Protocol Element – a sequential component of ~~a~~ **the storage portion of a** protocol, such as sending a series of images to a PACS or an archive or a processing workstation.

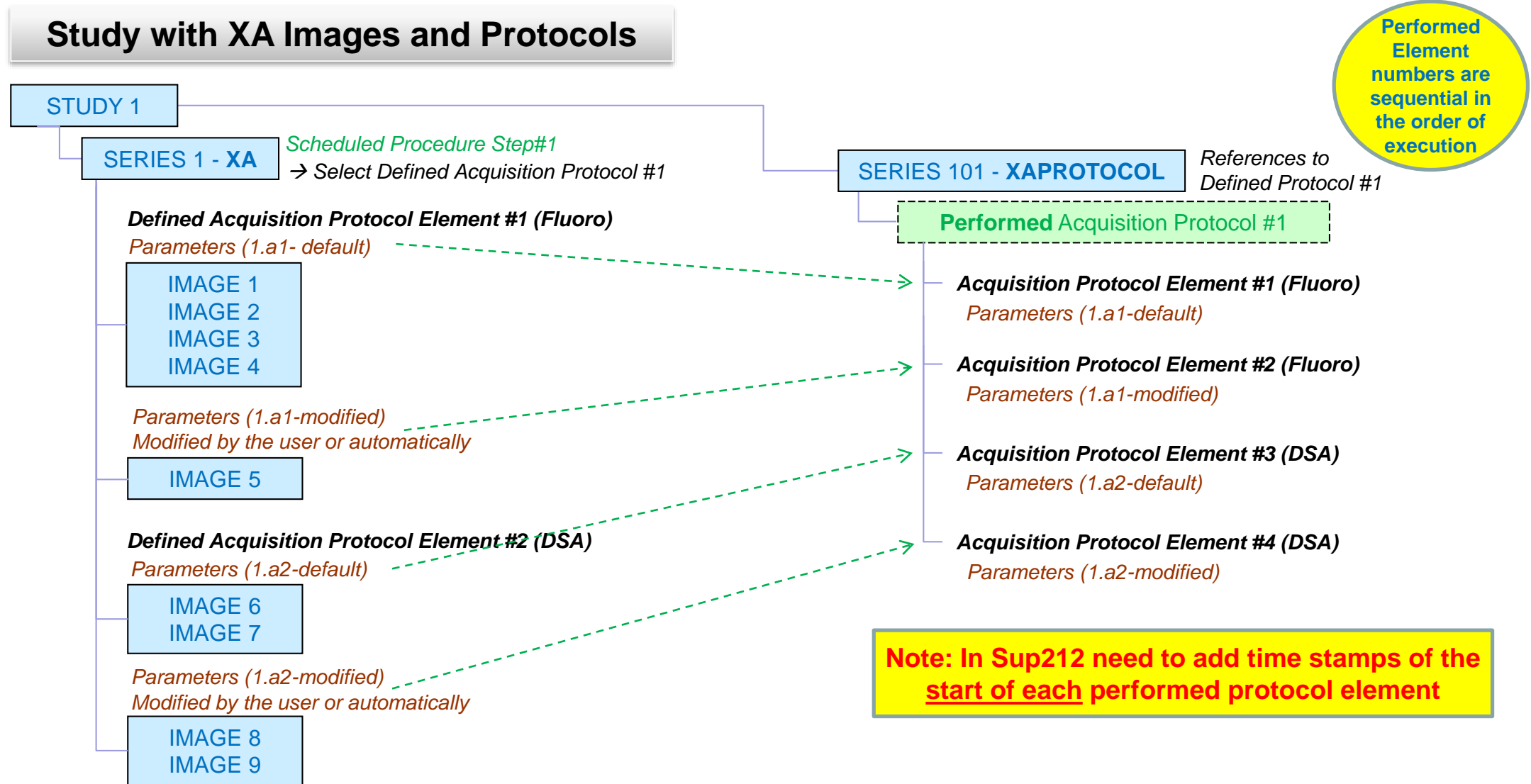
Overview of the Proposal

Example of XA Procedure Step – Acquisition and Reconstruction on same device



Overview of the Proposal

Performed Protocol Storage Example of one single Series



XA Protocol Parameters

Protocol Parameters: DICOM Attributes to be included as XA protocol parameters

Name	Standard or Private	Tag	Siemens	Philips	GE	Comment
General to ALL the Elements of the Protocol						
Protocol Category	NEW		X	X	X	New attribute to allow grouping protocols on the screen
Protocol Name	Standard	(0018,9423)	X		X	Protocol name as displayed on the screen
Anatomy	Standard	(0008.2218)			X	Anatomic Region Sequence and its modifier (0008.2220)
Acquisition Parameters (for each Acquisition Element)						
Type of Radiation	Standard	(0018,1155)	X		X	Only one value E.g. Fluoroscopy, Radioscopy
Acquisition Mode Name	Standard	(0018,9922)			X	Is the Protocol Element Name. Only one value E.g. For radioscopy: DSA, CHASE, DYNAMIC, ROTA, SingleShot, etc... For fluoroscopy: SUB, NOSUB, ROADMAP, BLENDED, etc...
Scan Options	Standard	(0018,0022)			X	Only one value TOMO, CHASE, STEP, ROT
Acquisition Sub Mode	Standard	(0028,1090)			X	DefinedValue{SUB, NOSUB} + default value. Same protocol element may have different parameters for SUB and for NOSUB selections.
Fluoro Store Number Of Frames	Standard	(0028,0008)			X	Number of frames to store during fluoroscopy. We could use (0028,0008) "number of frames" with a range (min,max)
Field of View Dimension(s)	Standard	(0018,1149)			X	DefinedValues{FOV1, FOV2, FOV3,...} + default value
Plane Identification	Standard	(0018,9457)	X		X	DefinedValues{MONOPLANE, PLANE A, PLANE B, BIPLANE} + default value
Acquisition Segment Duration (for each segment)	Standard	(0018,9073)	X		X	List(val1, val2, val3, etc...). Can it be multivalued? The X-Ray will/may be stopped latest when this time is reached.
Acquisition Segment Frame Rate (for each segment)	Standard	(0018,0040)	X	X	X	List(val1, val2, val3, etc...). Can it be multivalued?
KVP	Standard	(0018,0060)	X	X		
X-Ray Tube Current in mA	Standard	(0018,9330)		X		
Exposure in mAs	Standard	(0018,9332)		X		
Average Pulse Width	Standard	(0018,1154)	X	X		
FocalSpot	Standard	(0018,1190)	X	X	X	Range[FS min, FS max]
Filters	Standard	(0018,7052) (0018,7054)	X	X		And (0018,1160) Filter Type?
Primary Angle Rotation Range	Standard	(0018,9508)	X	X		Defined{10, 20, 40, etc...}, pre-selected value
Secondary Angle Rotation Range	Standard	(0018,9509)	X	X		Defined{10, 20, 40, etc...}, pre-selected value
Primary Angle Rotation Step	Standard	(0018,9514)	X			Defined{10, 20, 40, etc...}, pre-selected value
Secondary Angle Rotation Step	Standard	(0018,9515)	X			Defined{10, 20, 40, etc...}, pre-selected value
SID (distance source to detector)	Standard	(0018,1110)			X	Range[SID min, SID max], pre-selected value (e.g for rotational acq.)
Patient Position	Standard				X	Default value for patient position during the exam
AutoInjectEnabled	Standard				X	Boolean: YES/NO
AutoInjectInjectionDelayValue	Standard				X	FLOAT: value in sec. Can be positive (injection after X-Ray start) or negative (injection before X-Ray start)
AutoInjectContrastMedia	Standard	(0018,9425)	X		X	Contrast media type e.g. Defined{Iodine, CO2} or radio-opaque vs. non radio-opaque contrast agents

XA Protocol Parameters

Protocol Parameters: DICOM Attributes to be included as XA protocol parameters

Note: Need to create new attributes if the intended usage is different from the definition in Part 3 (e.g. Type of Radiation in Acq. And Recon)

Name	Standard or Private	Tag	Siemens	Philips	GE	Comment
Reconstruction Parameters (for each Reconstruction Element)						
Applicable Type of Radiation	Standard	(0018,1155)			X	Only one value E.g. Fluoroscopy, Radioscopy
Applicable Acquisition Mode Name	Standard	(0018,0022)			X	Only one value E.g. DSA, CHASE, DYNAMIC, ROTA, SingleShot, etc... Could we use (0018,0022) "Scan Options"?
Binning	Standard				X	
Recommended Viewing Mode	Standard	(0028,1090)	X		X	Only one value E.g. SUB, NAT
Mask Visibility Percentage	Standard	(0028,9478)			X	Only one value. May have a list of pre-defined settings.
Display Filter Percentage	Standard	(0028,9411)	X	X	X	Same as Spatial Filter Strength (edge enhancement factor)
Image Inversion	Standard	(0028,0004)	X			The "bone black, bone white" thing. We could use Photometric Interpretation (0028,0004) = MONOCHROME1 or MONOCHROME2. Question: what about Presentation LUT Shape (2050,0020) (IDENTITY or INVERSE)?
Image Flip	Standard			X		
Acquisition Device Processing Description	Standard	(0018,1400)	X			On/Off for DSA
Pixel depth encoding	Standard	(0028,0101)?	X			
Window Width	Standard	(0028,1051)	X			
Window Center	Standard	(0028,1050)	X			
3D Applicable Rotational Sub Mode	Standard				X	Only one value E.g. SUB, NAT. Indicates the type of acquisition to which this Protocol Element is applicable
3D Reconstruction Number Of Slices	Standard	(0054,0081)			X	Defined{256, 512, 1024, etc...}, pre-selected value
3D Reconstruction Slice Thickness	Standard				X	Range[min, max], pre-selected value
3D Window Width	Standard	(0028,1051)	X			
3D Window Center	Standard	(0028,1050)	X			
Storage Parameters (for each Storage Element)						
Export Image Rows	Standard		X	X		
Export Image Columns	Standard		X	X		

Changes to the Standard: new IODs & modules

IODs Modules	XA Performed Procedure Protocol	XA Defined Procedure Protocol
Patient	M	
Clinical Trial Subject	U	
General Study	M	
Patient Study	U	
Clinical Trial Study	U	
General Series	M	
Clinical Trial Series	U	
Enhanced Series	M	
XA Protocol Series	M	
Frame of Reference	M	
General Equipment	M	M
Enhanced General Equipment	M	M
Protocol Context	M	M
Patient Protocol Context	U	
Clinical Trial Context		U
Patient Specification		U
Equipment Specification		M
Instructions	U	U
Patient Positioning	U	U
Defined XA Acquisition		U
Performed XA Acquisition	U	
Defined XA Reconstruction		U
Performed XA Reconstruction	U	
Defined Storage		U
Performed Storage	U	
Protocol Approval		
SOP Common	M	M

Module	Reference	Usage
Patient	C.7.1.1	M
Clinical Trial Subject	C.7.1.3	U
General Study	C.7.2.1	M
Patient Study	C.7.2.2	U
Clinical Trial Study	C.7.2.3	U
General Series	C.7.3.1	M
Clinical Trial Series	C.7.3.2	U
Enhanced Series	C.7.3.3	M
XA Protocol Series	C.34.X1	M
Frame of Reference	C.7.4.1	M
General Equipment	C.7.5.1	M
Enhanced General Equipment	C.7.5.2	M
Protocol Context	C.34.2	M
Patient Protocol Context	C.34.3	U
Instructions	C.34.7	U
Patient Positioning	C.34.8	U
Performed XA Acquisition	C.34.X3	U
Performed XA Reconstruction	C.34.X5	U
Performed Storage	C.34.14	U
SOP Common	C.12.1	M

Module	Reference	Usage
General Equipment	C.7.5.1	M
Enhanced General Equipment	C.7.5.2	M
Protocol Context	C.34.2	M
Clinical Trial Context	C.34.4	U
Patient Specification	C.34.5	U
Equipment Specification	C.34.6	M
Instructions	C.34.7	U
Patient Positioning	C.34.8	U
Defined XA Acquisition	C.34.X2	U
Defined XA Reconstruction	C.34.X4	U
Defined Storage	C.34.13	U
SOP Common	C.12.1	M

Changes to the Standard

Section	Sub-Section	Modifications and additions
Part 2: Conformance		
Section A.1 Conformance Statement Overview	Table A.1-2 UID Values	Add two new SOP Classes for XA Defined and Performed Procedure Protocol Storage
Part 3: Information Object Definitions		
Section 2 Normatives and References	Section 2.6 Other References	Add reference to [NEMA XR-27] X-ray Equipment for Interventional Procedures User Quality Control Mode.
Section 3 Definitions	Section 3.8 DICOM Information Object	Modify definitions of Protocol Elements, to make them generic to all modalities (or at least, include XA XA examples in addition to CT)
Section A.1.4 Overview of the Composite IOD Module Content	Table A.1-9 Composite Information Object Modules Overview - Protocols	Add XA Defined and Performed Procedure Protocol IODs
Section A.82 Procedure Protocol Information Object Definitions	Section A.82 Procedure Protocol Information Object Definitions	Modify introduction to make it generic to all modalities Add sections for the two new XA Protocol IODs: A.82.Y1 XA Performed Procedure Protocol IOD A.82.Y2 XA Defined Procedure Protocol IOD
Section C.7.3.1.1 General Series Attribute Descriptions	Section C.7.3.1.1.1 Modality	Add XAPROTOCOL to the list of Modality Terms
Section C.34 Procedure Protocol Modules	Section C.34 Procedure Protocol Modules	Add modules for the two new XA Protocol IODs: C.34.X1 XA Protocol Series Module C.34.X2 Defined XA Acquisition Module C.34.X3 Performed XA Acquisition Module C.34.X4 Defined XA Reconstruction Module C.34.X5 Performed XA Reconstruction Module
Section C.34 Procedure Protocol Modules	Section C.34.7 Instructions	Make it not specific to CT, add XA in the conditions
Section C.34 Procedure Protocol Modules	Section C.34.8 Patient Positioning	Make it not specific to CT, add XA in the conditions
Section C.34 Procedure Protocol Modules	Section C.34.13 Defined Storage Module	Make it not specific to CT, add XA in the references (e.g. not only refer to Section C.34.9 which is CT-only)
Section C.34 Procedure Protocol Modules	Section C.34.14 Performed Storage Module	Add XA Protocol SOP Class UID in the conditions and in the Enumerated terms

Changes to the Standard

Section	Sub-Section	Modifications and additions	
Part 4: Service Class Specifications			
Section B.5	Standard SOP Classes	Table B.5-1 Standard SOP Classes	Add new SOP Class for XA Performed Procedure Protocol Storage
Section B.5.1	Specialization for Standard SOP Classes	Section B.5.1 Specialization for Standard SOP Classes	Add section: B.5.1.X1 XA Performed Procedure Protocol Storage SOP Class
Section GG.3	SOP Classes	Table GG.3-1 Standard SOP Classes	Add new SOP Class for XA Defined Procedure Protocol Storage to the Non-Patient Object Storage Service Class definition
Section GG.6	Application Behavior for Standard SOP Classes	Section GG.6.4 Defined Procedure Protocol Storage SOP Class	Add section: GG.6.4.X2 with details to XA Defined Procedure Protocol Storage
Part 6: Data Dictionary			
Section 6	Registry of DICOM Data Elements	Table 6-1 Registry of DICOM Data Eleme	Add new elements
Section A	Registry of DICOM Unique Identifiers (UIDs) (Normative)	Table A-1 UID Values	Add two new SOP Classes for XA Defined and Performed Procedure Protocol Storage
Section A	Registry of DICOM Unique Identifiers (UIDs) (Normative)	Table A-3 Context Group UID Values	Add new CIDs
Part 16: Content Mapping Resource			
Section B	DCMR Context Groups (Normative)	Section B DCMR Context Groups (Normative)	Add new CIDs
Section B	DCMR Context Groups (Normative)	CID 7030 Institutional Departments, Units and Services	Add new roles to CID 7030
Section D	DICOM Controlled Terminology Definitions (Normative)	Table D-1 DICOM Controlled Terminology Definitions	Add new definitions
Part 17: Explanatory Information			
Section AAAAA	Protocol Storage Examples and Concepts (informative)	Section AAAAA Protocol Storage Examples and Concepts (informative)	Make it generic to all modalities, not specific to CT
Section AAAAA	Protocol Storage Examples and Concepts (informative)	Section AAAAA.1 Protocol Storage Concepts	Make it generic to all modalities, not specific to CT
Section AAAAA	Protocol Storage Examples and Concepts (informative)	Section AAAAA.2 Routine Adult Head Protocol	Change the name to be CT-specific
Section AAAAA	Protocol Storage Examples and Concepts (informative)	Section AAAAA Protocol Storage Examples and Concepts (informative)	Add sections for XA-specific examples of Protocol Storage AAAAA.X1 XA Example 1 AAAAA.X2 XA Example 2

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Thank you for your attention!

APPENDIX

Protocol

A Protocol is a specification of actions prescribed by a Procedure Plan to perform a specific Procedure Step. A Scheduled Procedure Step (from Modality Worklist) contains only one Protocol, which may be conveyed by one or more Protocol Codes. A Protocol may be specified by a Defined Procedure Protocol to be used on any appropriate patient. A Protocol can be documented, once a Procedure Step has been performed, in a Performed Procedure Protocol.

Defined Procedure Protocol

A Defined Procedure Protocol describes a set of parameters and associated details for the prescribed action. The Defined Procedure Protocol may provide specific values for relevant parameters, or may provide constraints on those parameters (such as an acceptable range) to guide the choice of specific values.

Defined Procedure Protocol is not associated with any particular Patient or Scheduled Procedure Step. A Defined Procedure Protocol may contain parameters specific to a particular model or version of device, or it may be generic in that it only describes parameters common to multiple device models.

A Defined Procedure Protocol may include information such as the clinical purpose, indications, and appropriate device models, intended for selection and management.

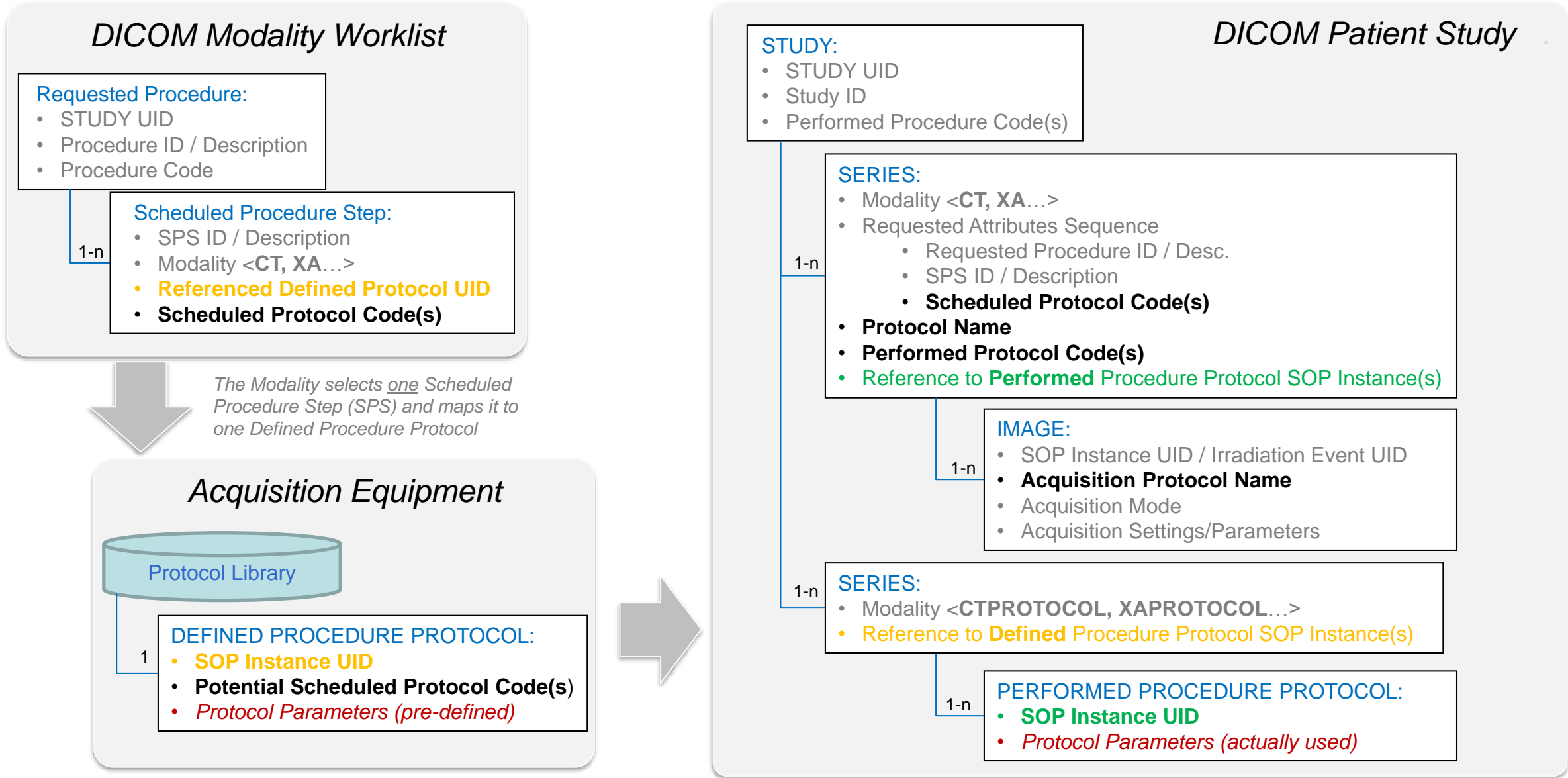
Performed Procedure Protocol

A Performed Procedure Protocol encodes the parameter values used. A Performed Procedure Protocol is always associated with a specific Patient and Performed Procedure Step. The Performed Procedure Protocol may reference the Defined Procedure Protocol on which it was based, but does not otherwise record the original constraints and whether or not they were satisfied by the final values as recorded in the Performed Procedure Protocol.

Workflow:

- Modality Worklist, Scheduled Procedure Step
- Protocol and Protocol Codes
- Defined Procedure Protocol
- Performed Procedure Protocol

Next slide: Mapping between Modality Worklist, Defined Procedure Protocol, Images and Performed Procedure Protocol



Defined Procedure Protocol

Open Point:

If the defined protocol can ONLY contain attributes that are defined in the Performed Protocol, but the “AAPM Defined Protocols” don’t know yet what will be the Performed Protocols... How does it work?

Action: → Add a use case of taking a generic protocol (e.g. AAPM) and transforming it into a specific device that does not support all the parameters defined by AAPM. And with parameters not defined yet in DICOM Part 3 (e.g. new features on the vendor model).

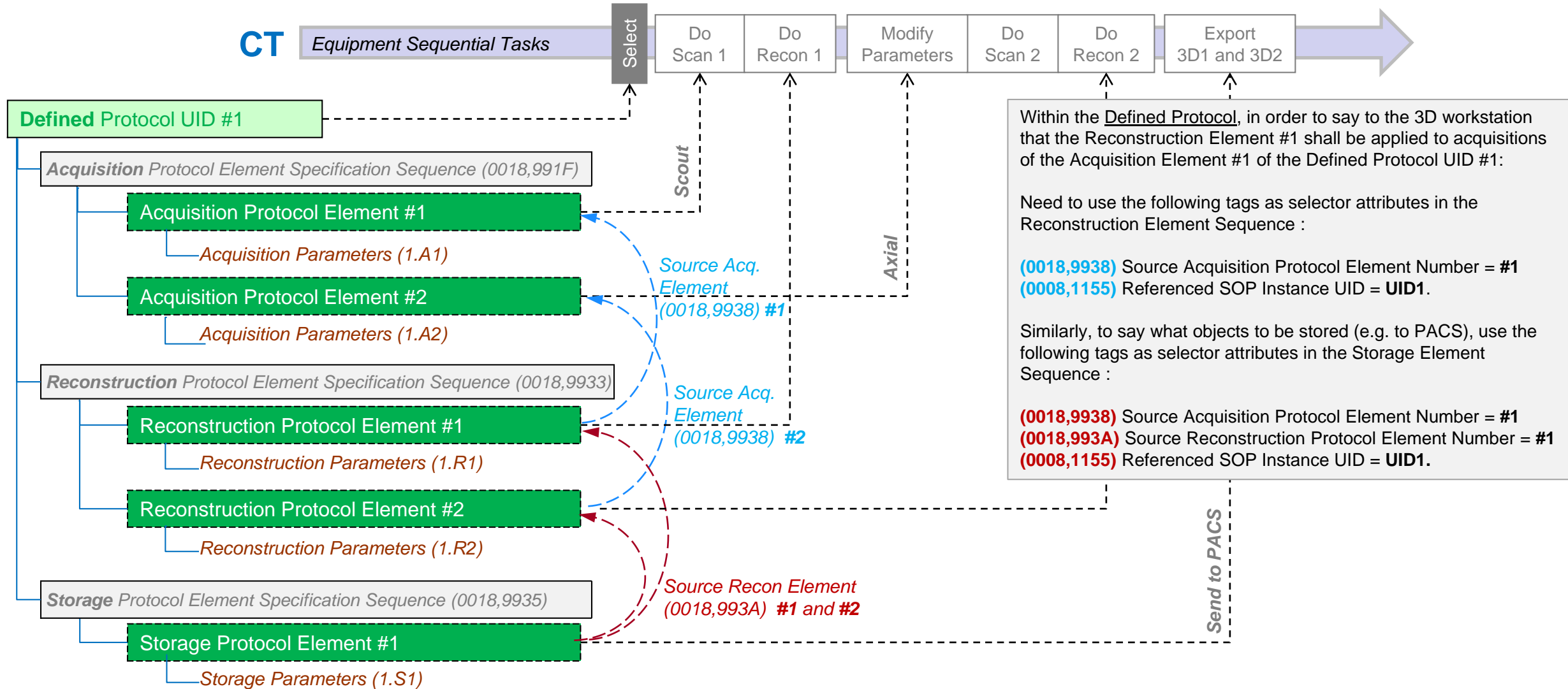
DEFINED Procedure Protocol

Comparison between CT and XA

DEFINED Protocol

DEFINED Protocol	Supplement 121 CT Protocol Storage	Supplement 212 XA Protocol Storage
Scope	Settings pre-defined for several scans, reconstructions and networking activities	Settings pre-defined for several acquisition modes, reconstructions, display and networking activities
1 Protocol Element	<p>E.g. 1 CT Acquisition (<i>e.g. one scan localizer, axial...</i>)</p> <p><i>Including parameters like mA, kV...</i></p>	<p>E.g. 1 XA acquisition mode (<i>e.g. DSA, Rotational, Chase, Fluoroscopy... for one or both planes of a biplane equipment</i>)</p> <p><i>Including parameters like focal spot, frame rate, rotation speed...</i></p>
1 Defined Protocol	<p>= 1-n protocol elements (in sequential order)</p> <p><i>E.g. localizer, chest with and without contrast</i></p> <p><i>Note: the recommended sequential order of the elements in the protocol is defined by the element number (0018,9921).</i></p>	<p>= 1-n protocol elements (in sequential order)</p> <p><i>E.g. Carotids in Neuro Intervention with DSA, Rotational and Fluoro modes.</i></p> <p><i>Note: the recommended sequential order of the elements in the protocol is defined by the element number (0018,9921)</i></p>

CT Procedure Step Example of Defined Protocol



To Do: **EXAMPLES** of usage of Defined Procedure Protocols

Describe two scenarios:

1- One single device for acquisition and reconstruction

Three sets of protocols (Acquisition, Reconstruction, Storage) on the Acq System

2- Two devices (acquisition system & 3D workstation):

Two sets of protocols in Acq System (Acquisition, Storage) and

Two sets of protocols on the 3D station (Reconstruction, Storage)

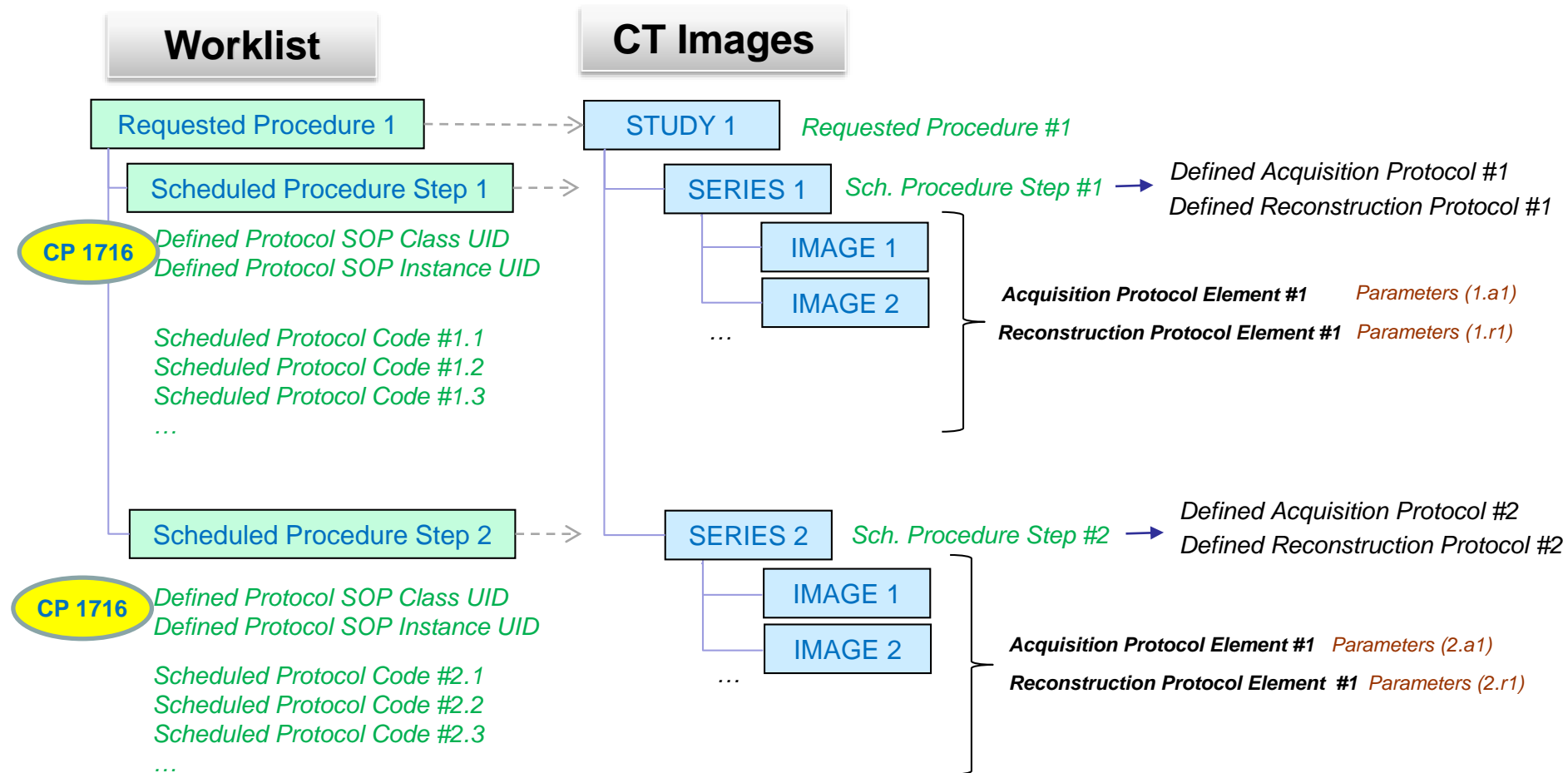
Show examples of how the protocols can be selected:

- A: user selects one protocol of each family
- B: user selects one Acq protocol, the others are selected automatically
- C: in workstation, select the protocol automatically based on the content of the image header

Add scenario 2 to Part 17

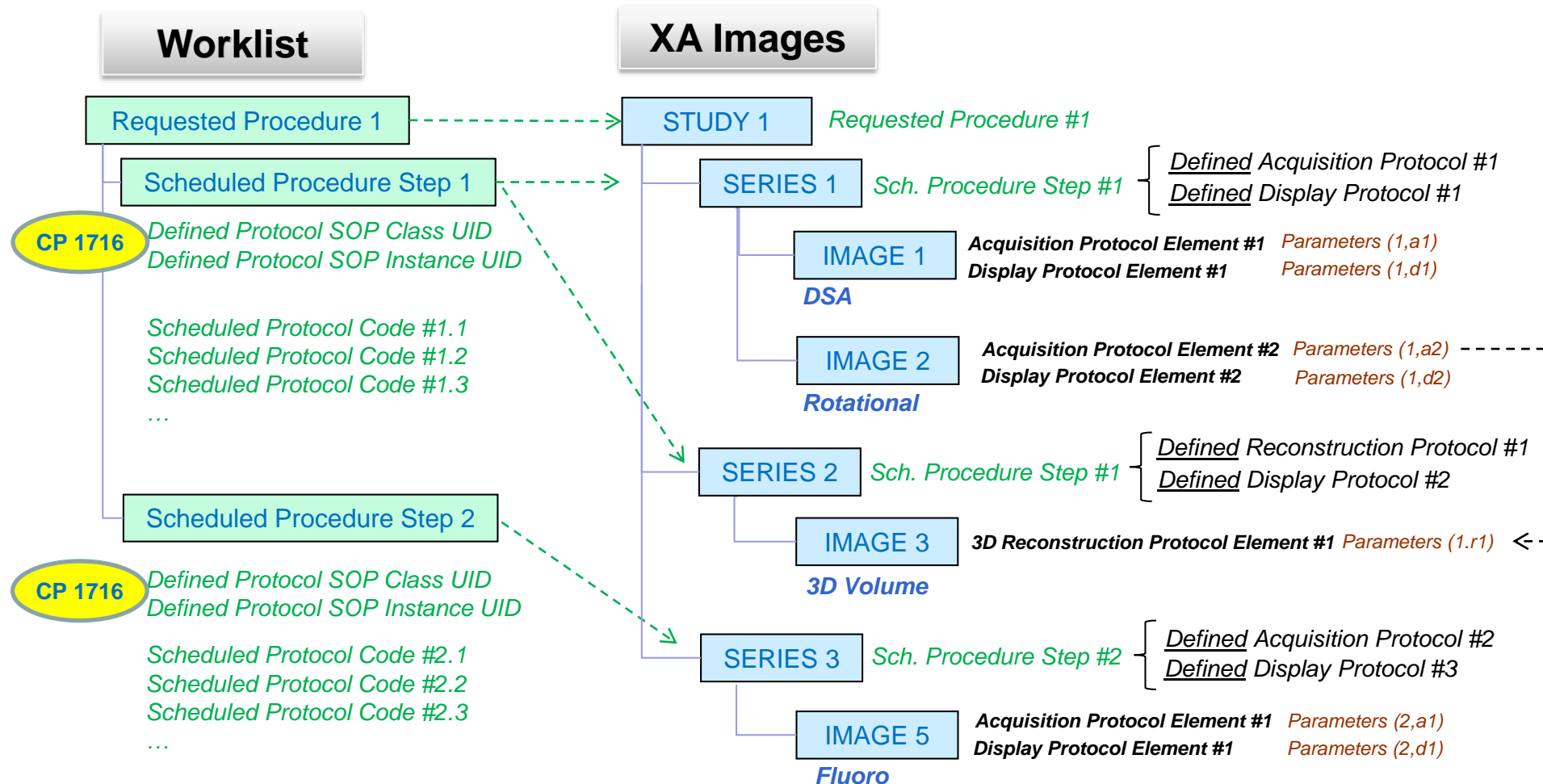
Data Structure of CT Acquisition Workflow

Example of usage of Defined Protocols and mapping with Worklist protocols:



Data Structure of XA Acquisition Workflow

Example of usage of Defined Protocols and mapping with Worklist protocols:



PERFORMED Procedure Protocol

Comparison between CT and XA

PERFORMED Protocol

PERFORMED Protocol	Supplement 121 CT Protocol Storage	Supplement XXX XA Protocol Storage
Scope	Parameters actually set on the machine for several performed scans, reconstructions and storage/networking activities	Parameters actually set on the machine for several performed acquisitions, reconstructions, display and storage/networking activities
1 Protocol Element	E.g. 1 CT Acquisition <i>(e.g. one scan scout, one axial with contrast, one axial without contrast...)</i> <i>Including parameters like mA, kV...</i>	E.g. 1 XA acquisition mode <i>(e.g. DSA, Rotational, No-SUB...for both planes of a biplane system)</i> <i>Including parameters like focal spot, frame rate, rotation speed...</i> <i>Several Irradiation Events may be created within the same Performed Protocol Element.</i>
1 Performed Protocol	= 1-n protocol elements <i>(e.g. chest with and without contrast)</i> <i>Typically uses one Defined Protocol, may use more than one in a Group Case.</i>	= 1-n protocol elements <i>(e.g. Carotids in Neuro Intervention, with Fluoro, DSA, Rotational acquisitions) – protocol elements are recorded in the same order as they were applied</i>
1 Study	= 1-m Performed Protocols through the different steps of the CT procedure <i>(e.g. chest + legs)</i>	= 1-m Performed Protocols through the different phases/steps of the Angiographic procedure <i>(e.g. Carotids diagnostic + intervention)</i>

