DICOM Enhanced XA/XRF Object New Dimensions for X-Ray Projection Imaging

(DICOM Supplement 83)

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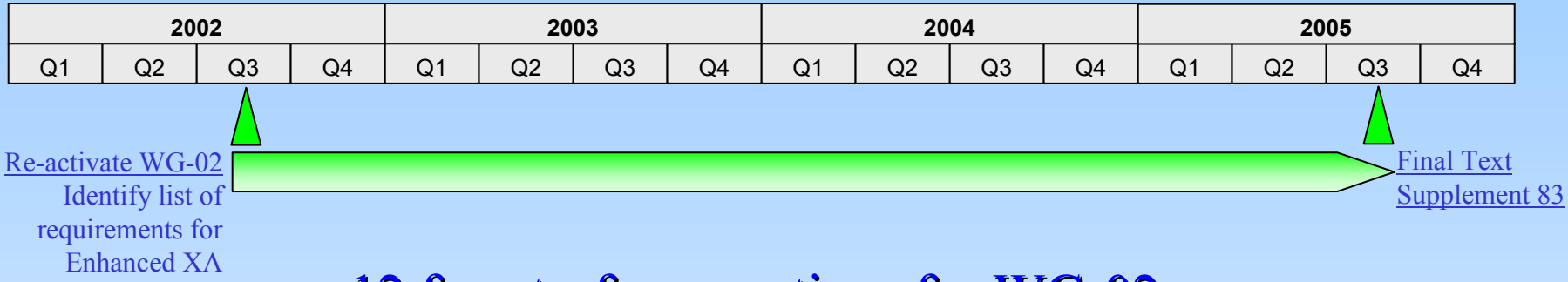
Presentation outline

- Overview
  - Drivers and Concepts
- Technical Benefits
  - Encoding aspects
- Scenarios
  - Interoperability aspects
- Conclusions

Why a new XA/XRF SOP Class ?

- Shortcomings of actual XA SOP-Class multi-frame definition encouraged new work-item
  - increasing number of attributes that change frame-to-frame require "per frame" encoding mechanisms like enhanced CT/MR
  - the "4 GB boundary" per file can be reached, and require mechanisms to allow splitting files
  - new applications and technologies require new attributes that shall be neither "private" nor "optional"
  - new type of acquisition contexts require to encode other dimensions than "time"

History of Supplement 83



- 12 face-to-face meetings for WG-02
- 7 Tcons for WG-02
- 5 meetings with WG-06
- about 30 revisions of the document
- from August 2002 (before ESC in Berlin) to August 2005 (WG-06 meeting in Washington)
- mostly 4 core members, secretary and guests

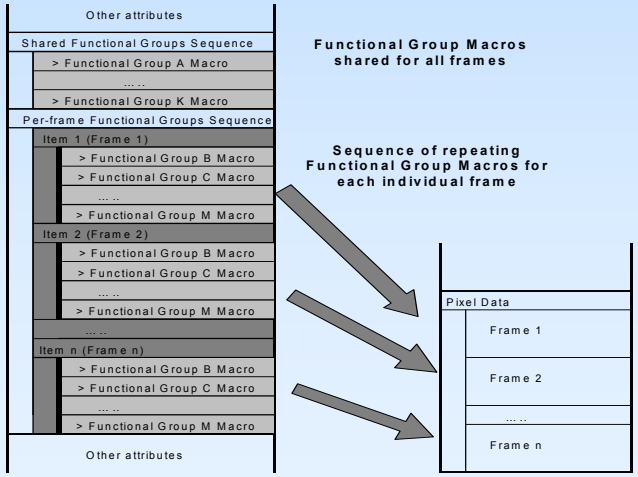
Concepts of Enhanced XA/XRF SOP Class

- Full Acquisition context and Time Relationship per frame with Functional Group Macros
- File splitting through Concatenation mechanism
- Scalability from "Mobile C-Arm" to "Catheterization Lab"
- Support new applications with new attribute definitions
  - image presentation → Frame Pixel Properties, Multi-frame Presentation, Improved Mask attributes
  - image processing → Pixel Intensity Relationship LUT
  - image calibration → Projection Pixel Calibration
  - volume recon → Per frame Acquisition Context and Geometry
  - image registration → Isocenter Reference System
  - quality control → Sensing Regions, detailed Frame Acquisition info
- Dimension context information from Dimension Module

Per Frame encoding with Functional Group Macros

Reuse of functional group solution introduced with enhanced CT/MR

- Optimized encoding of attributes that either change in a per-frame basis or are shared for all the frames, depending on the acquisition context



Note: The Functional Group Macros A, B, C, etc. are examples to illustrate the Multi-frame Functional Groups. The actual Functional Group Sequences are defined elsewhere.

Examples in Enhanced XA

• Frame Content:	absolute Times
• Cardiac Trigger:	exact reference to R-peak
• Frame VOI-LUT:	individual windowing
• Frame Pixelshift:	multiple individual values
• Patient Orientation:	individual orientations
• Frame Display Shutter:	individual positions
• Field of View:	individual size
• Projection Pixel Calibration:	individual magnification
• Frame Acquisition:	individual context
• Collimator:	individual blade movement
• Iso center Reference System:	individual registration

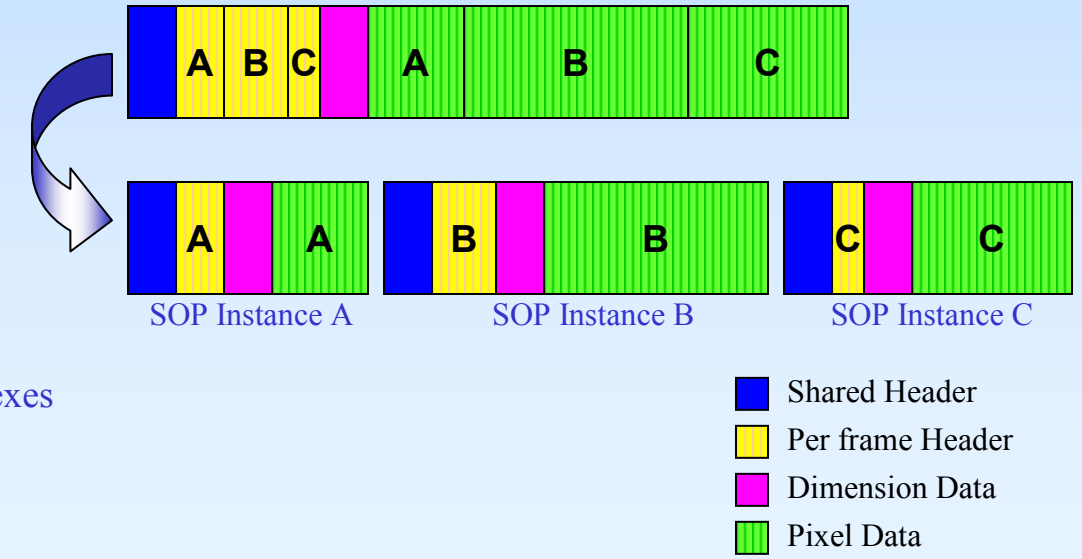
Splitting files with Concatenation mechanism

Reuse of concatenation solution introduced with enhanced CT/MR

- Ability to encode a single object (run acquisition) in different SOP Instances

BENEFITS:
- optimized storage on disk
- allow to exchange big objects on CD-R
- override limitations of >4GB file size

MECHANISM:
- concatenation is a set of SOP Instances
- in the same SERIES
- with same fixed header and dimension indexes
- all SOP Instances of a concatenation have:
  - the same Concatenation UID
  - the same Instance Number



Scalability on equipment capabilities

Introduce new attribute conditions based on equipment capability

- Ability to guarantee the presence of key attributes on images from complex equipment (Catheterization Lab)
- Enable the usage of Enhanced XA/XRF to simpler equipment (Mobile C-Arm)

EXAMPLE

The "Positioner Tabletop Relationship" attribute guarantees:

- **information related to patient orientations**
- **information about calibration**
- **information about equipment angulations and positions**

Scenario: Presentation of Images

Application needs:

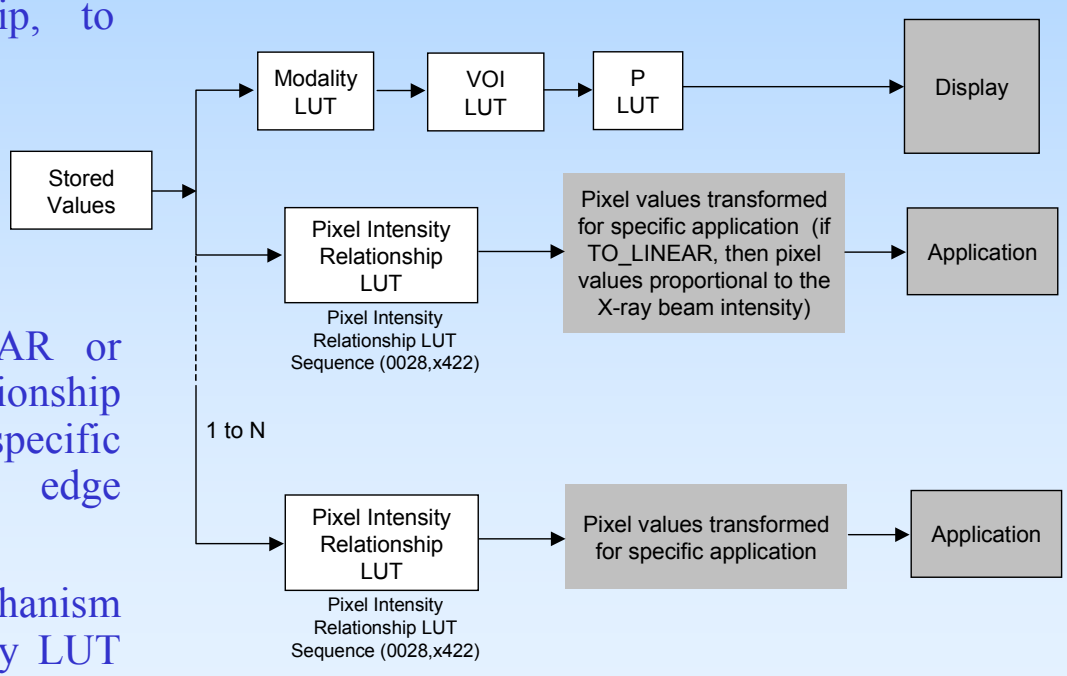
Enhanced cine review and pixel presentation capabilities

- **Enhanced cine review**: Group frames into ranges with individual settings:
  - frame-rate
  - display or skip flag
- **Enhanced presentation of pixels**: information about pixel pre-processing and « desired » presentation settings:
  - filter percentage value
  - advanced Mask module attributes for multi-mask DSA processing
  - enable adaptive processing based on provided pre-processing information attributes
  - now permitting MONOCHROME1 & 2

Scenario: create unprocessed pixels for further processing

Application needs:

Ability to get back to a known (reference) X-ray-to-pixel intensity relationship, to enable post-processing applications

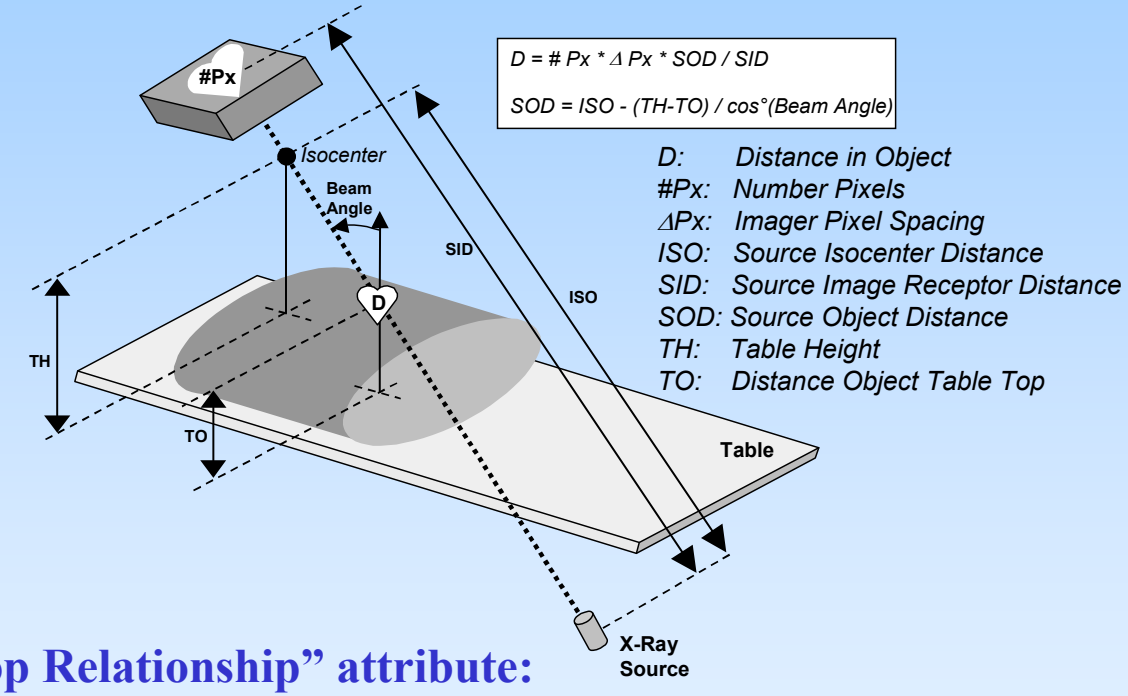


- A basic pixel "format" of LINEAR or LOGARITHMIC pixel intensity relationship may be needed prior to other specific processing steps (densitometry, edge detection, presentation LUTs…).
- The new Pixel Intensity LUT mechanism provides means to identify and apply LUT that deliver the intended result – "TO_LIN" or "TO_LOG" or even more…

Scenario: Projection Pixel Calibration

Application needs:

Ability to calculate the projected pixel size of objects of interest placed at a given distance from the table top

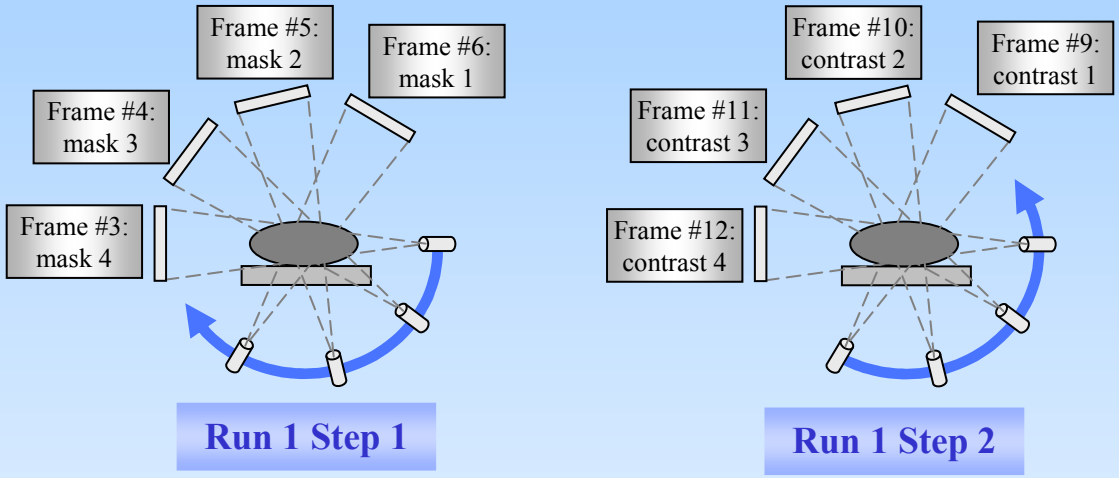


- **Requires "Positioner Tabletop Relationship" attribute:**
  - C-arm based equipment with system-provided angulations and distances
  - Equipment with system-provided Table Height and Beam Angle
- **Requires a real-world value of distance from interested object plane to table top**
  - To be provided by user or as system default.

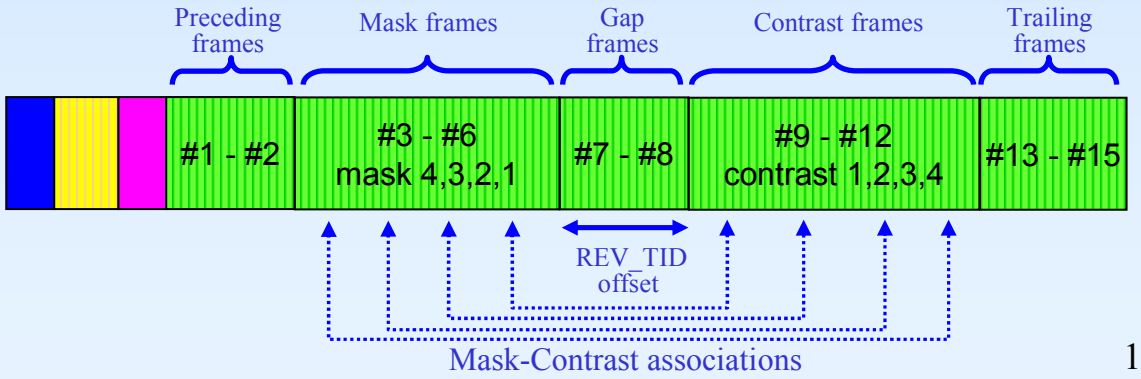
Scenario: Rotational DSA with bi-directional acquisition

Application needs:

Easily encode the association of the mask-contrast frames on bi-directional acquisitions



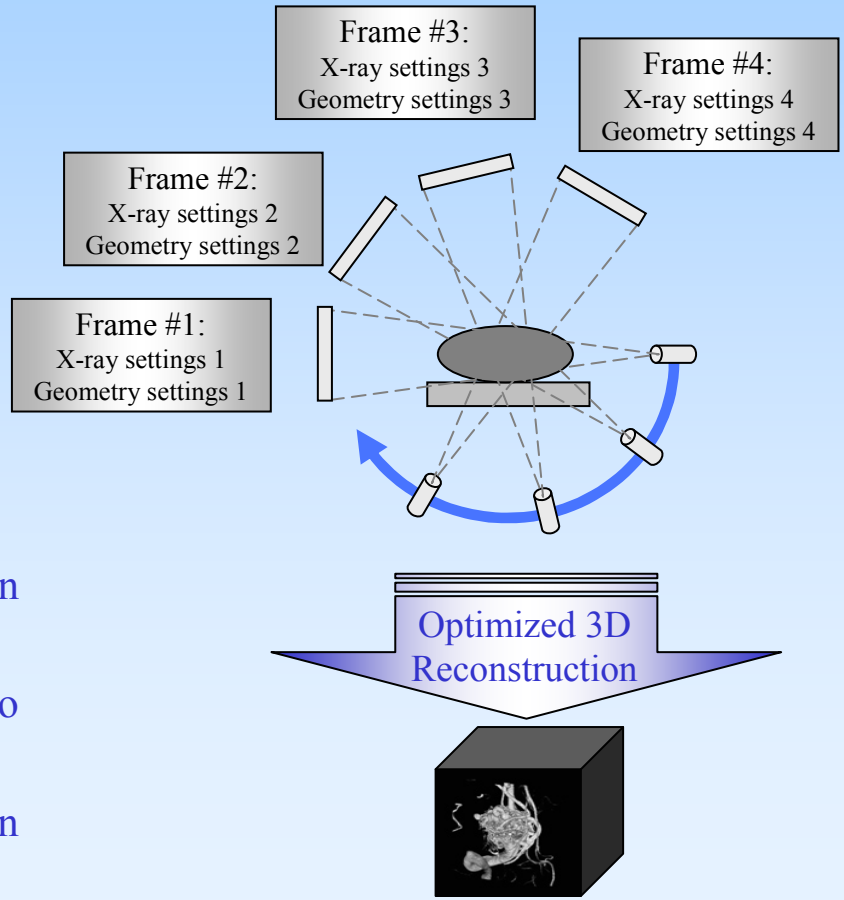
- **Improved Mask Module:** Reverse TID mask operation allows to define the mask-contrast associations of a bi-directional acquisition



Scenario: Volume reconstruction support

Application needs:

Knowledge of per-frame specific information (X-ray generation, detection and geometry) to optimize the 3D reconstruction algorithms

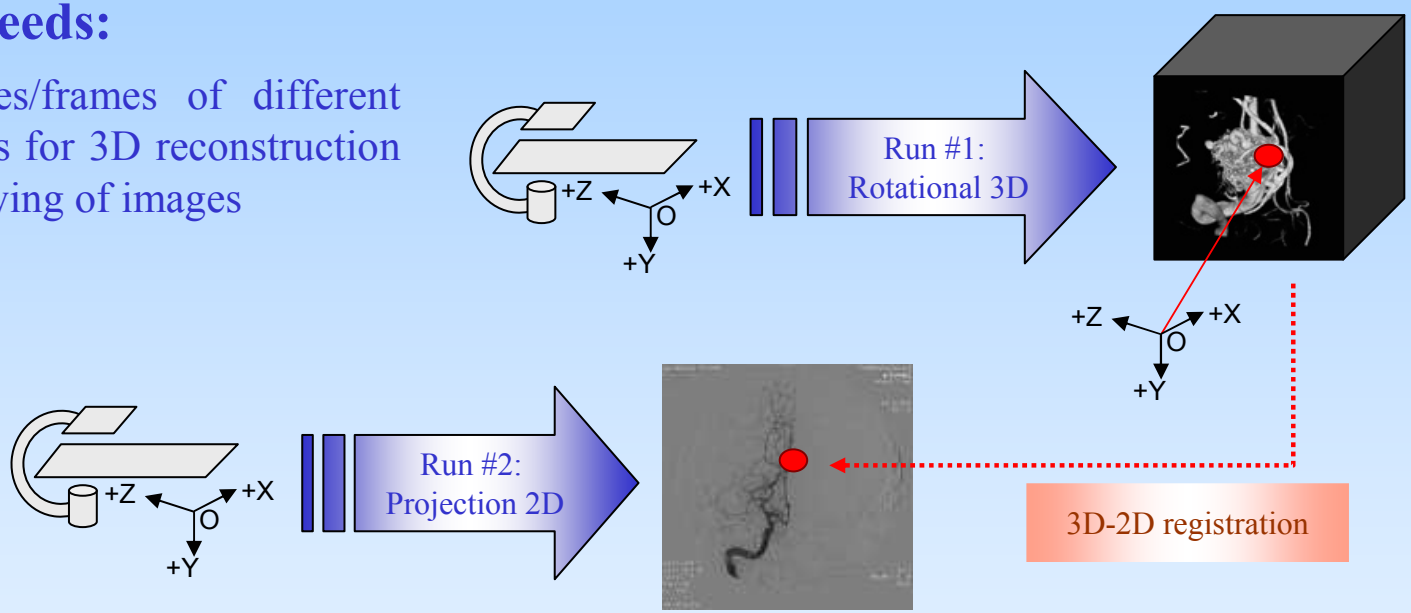


- X-Ray generation parameters (mA, kVp…) on frame level to allow intensity corrections
- Geometry properties (SID, ISO) on frame level to allow dynamic changes during run.
- Isocenter Projection for detectors to align projected image to isocenter reference point

Scenario: Use of Isocenter Reference System

Application needs:

Register images/frames of different acquisition runs for 3D reconstruction or blending/sewing of images



- **Requires "Positioner Tabletop Relationship" attribute**
  - C-arm based equipment with system-provided angulations and distances
  - Reference from image plane to equipment space (Isocenter based coordinates)

Conclusions and Next Steps

- Supplement 83 enhances interoperability and overcomes the known limitations of the current XA SOP Class
- It is open for today's and new applications / equipments
- DICOM WG-02 plans to disclose a technical document with practical scenarios on Enhanced XA usage

DICOM WG-02

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