DICOM Educational Conference
Brisbane, Australia

SEPTEMBER 24-25, 2018

DICOM REAL-TIME VIDEO

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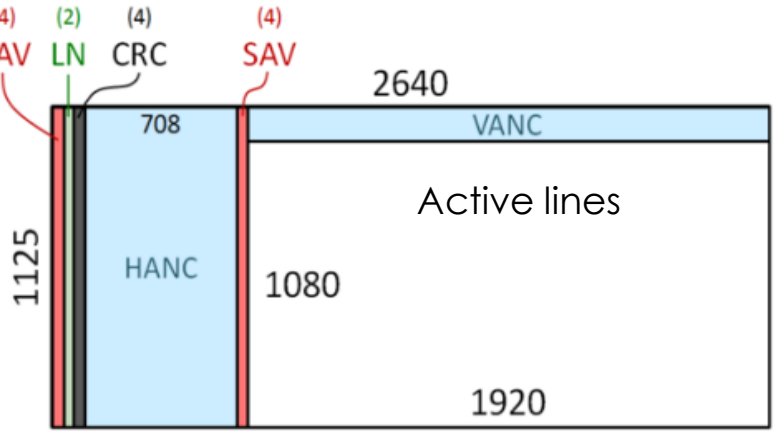
CO-CHAIR DICOM WG13

Technology Background

VIDEO OVER IP FOR TV STUDIOS

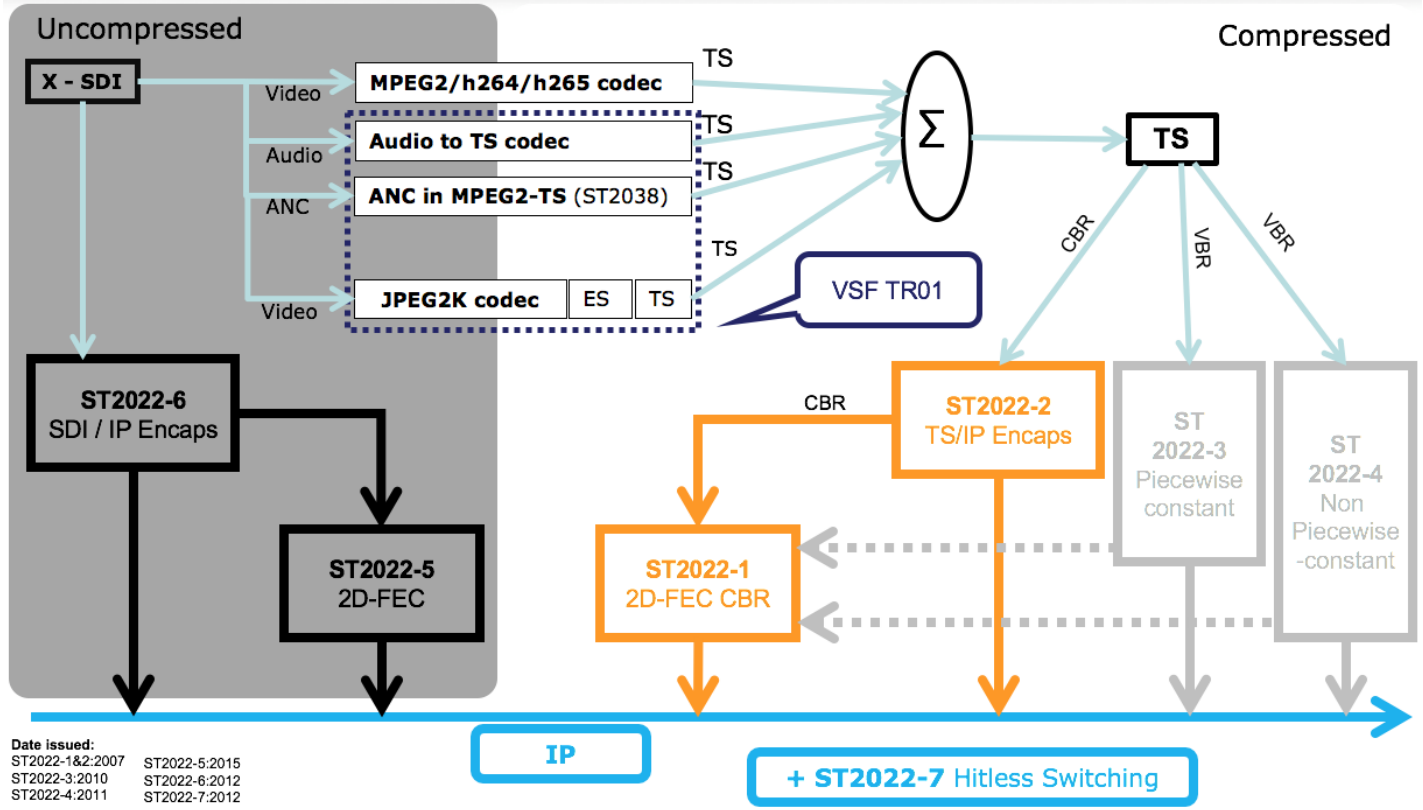
Multiplexed Video Over IP

- Mimics coaxial cable by multiplexing all information in the same stream
- Audio and ancillary data (subtitles…) are embedded in the hidden parts of the video
- That is neither efficient (latency…) nor flexible
- Addresses audio-video sy

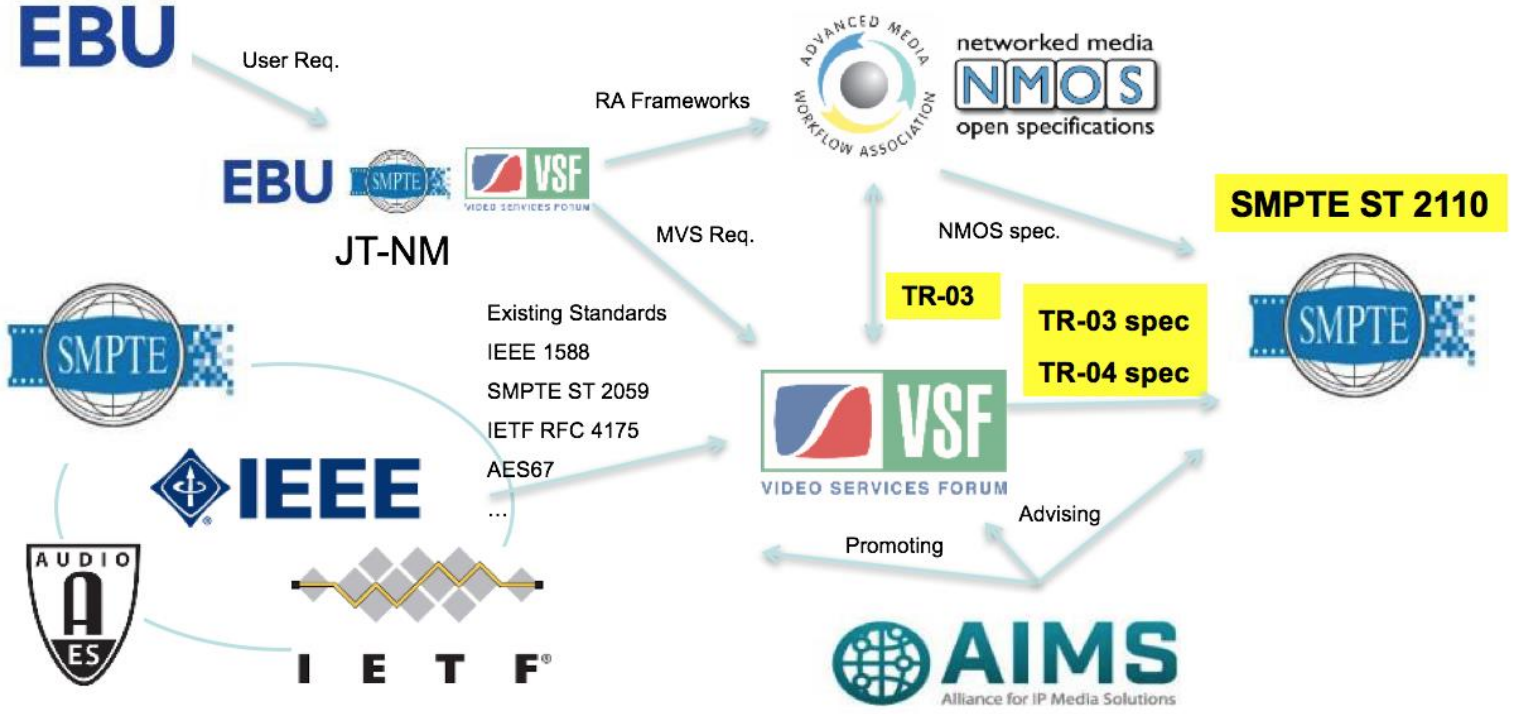


SAV: Start of Active Video
EAV: End of Active Video
LN: Line Number
CRC: Cyclic redundancy check
VANC: Vertical Ancillary data
HANC: Horizontal Ancillary data

Maze of SMPTE IP Video Standards



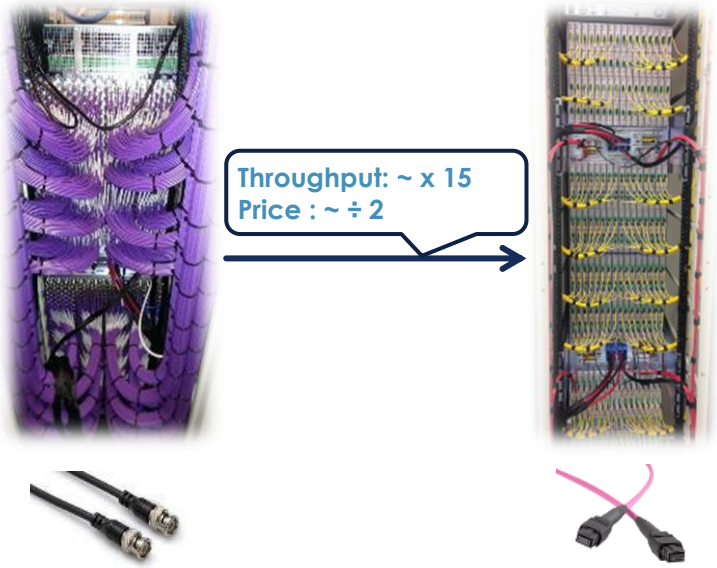
Convergence on SMPTE ST2110



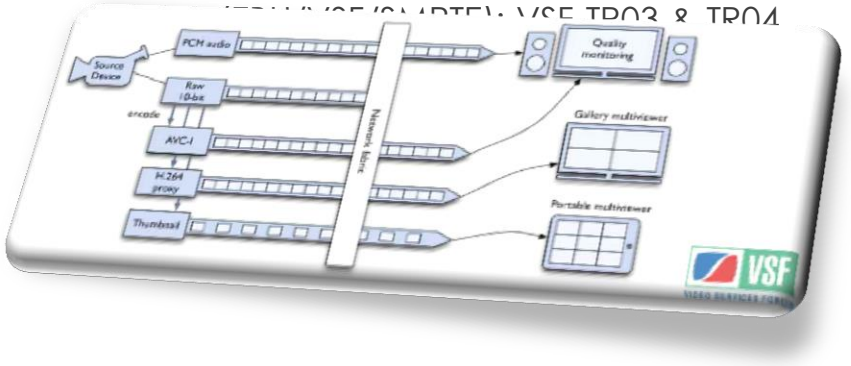
Courtesy: Felix Poulin / EBU

Professional AV world (R)evolution

- From 1998 to 2012:
  - Migration of pro AV transport from coax infrastructure to networking technologies: Ethernet (IP), first for long haul, then for intra-studio applications (ProMPEG, VSF, SMPTE, IETF, ISO).



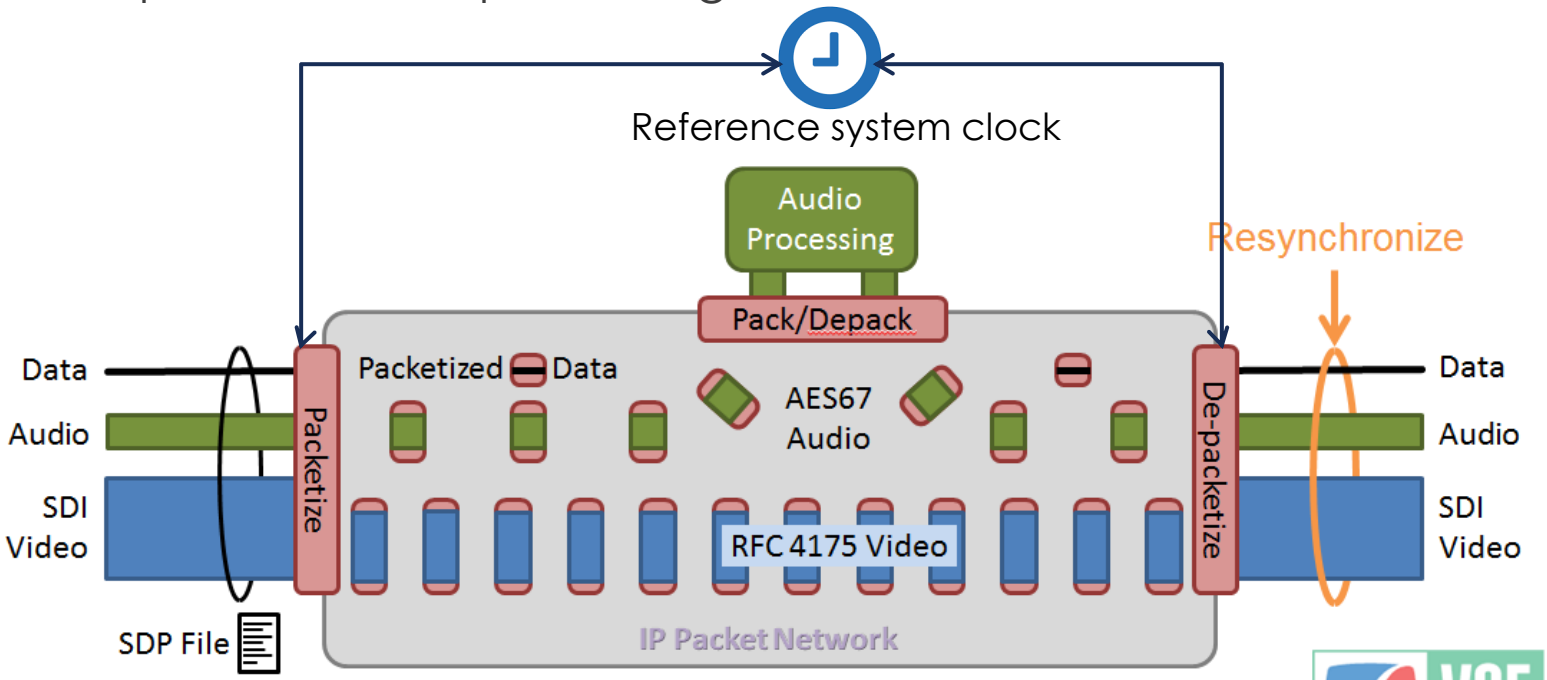
- 2013-2017: *« There is more to be done with IP than merely replacing a cable with another »*
  - Using SDN technologies for open control of networking gear along the path of AV streams.
  - Re-visiting the essence exchange and transport model.
- Focus of the Joint Task Force for New [illegible] VSF TR03 & TR04



TR03 resulting standards: SMPTE ST 2110-*

VSF-TR03/ST 2110-10 (audio) in a nutshell

- Example: live audio processing



SDP: Session Description Protocol

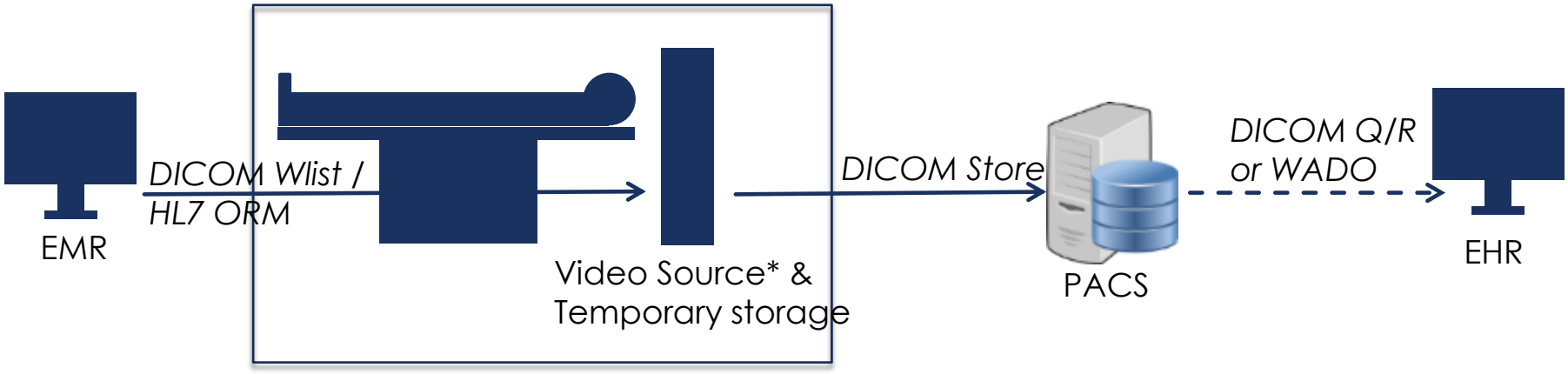
Video in DICOM

FROM VIDEO STUDY STORAGE TO … REAL-TIME VIDEO (SUP202)

Existing DICOM Video Storage

For example, Operating Room to EHR via PACS

- Not real-time
- Patient information in video metadata



Operating Room

*over head camera, endoscope, microscope …

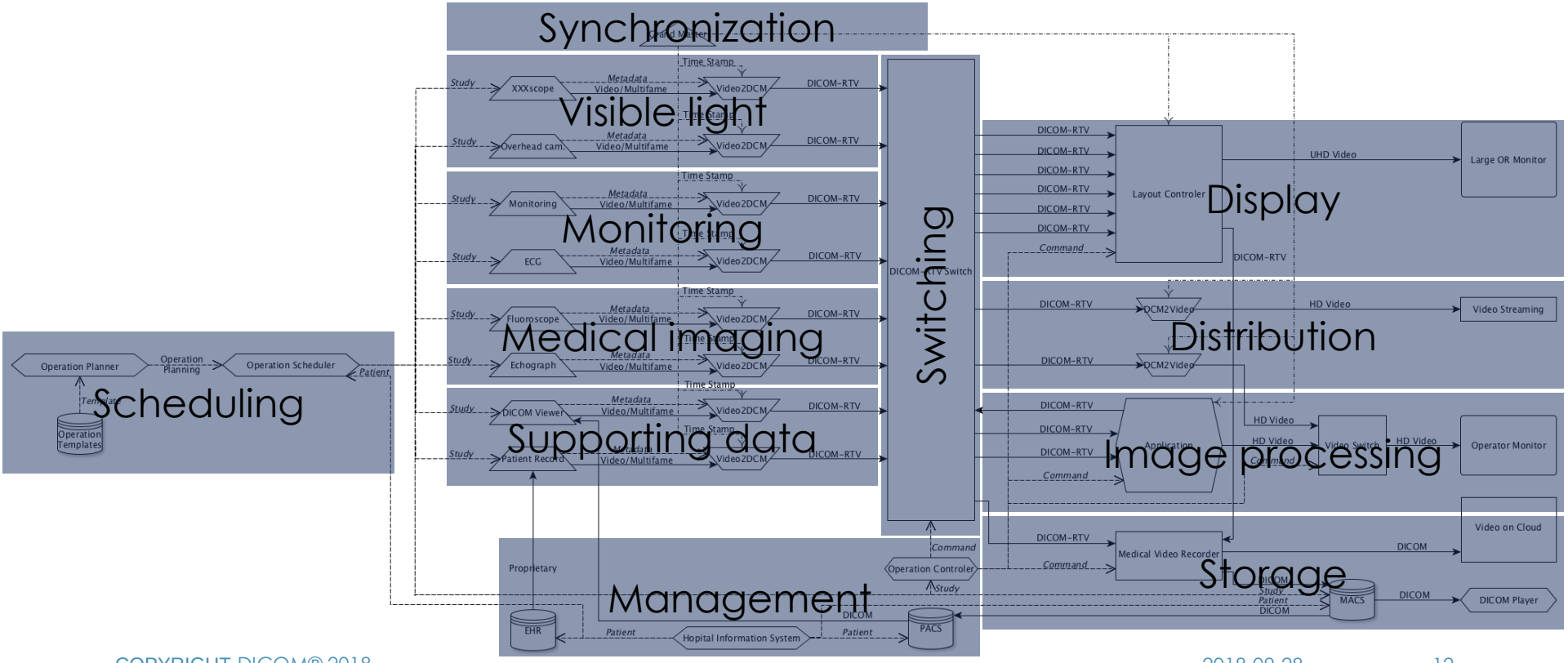
Video Interoperability in Operating Room(s)

- The OR is core to health businesses
  - 20% of hospital expenditures, 6% of health costs
  - 50 million procedures per year (U.S.)
- Important risks
  - 300,000 preventable severe adverse events / year (U.S.)
  - only ¼ of which are related to surgeon gesture itself
- Need to improve
  - OR infrastructure mainly based on proprietary solutions
  - prohibitive purchase & operation
  - no shared resources among room

Users of Real-Time Video

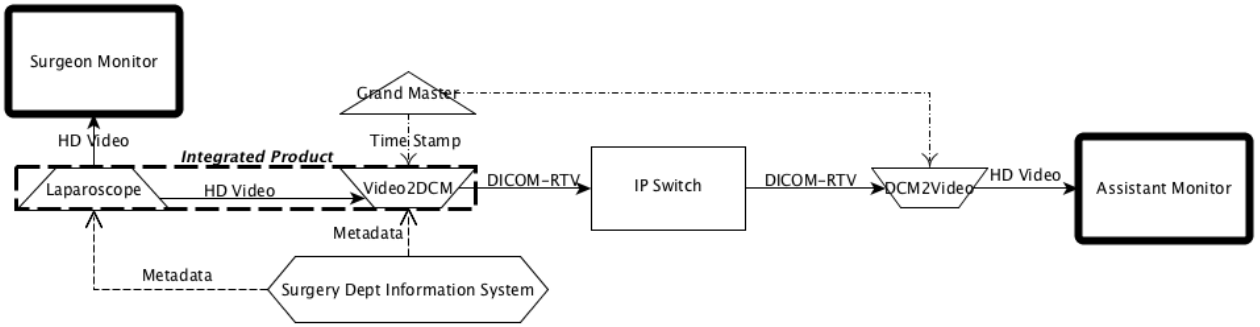
- Varied video sources (not just visible light)
  - Endoscopy (gastroenterology, orthopedic surgery, ENT)
  - Laparoscopy
  - Microscopy
  - Fluoroscopy
  - Ultrasound
  - Angiography
  - Ophthalmology
  - General surgery: overhead camera
  - Dental surgery
  - HIT displays (patient vital monitors, chart…)

Use Cases: Global Picture



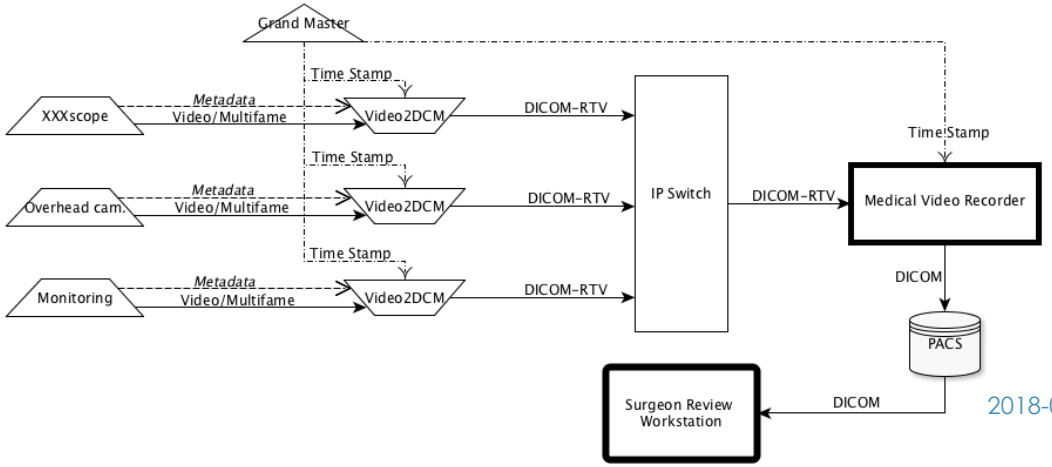
Duplicate video on multiple monitors

- Two operators contributing to a procedure
  - a surgeon performing the operation
  - an assistant controlling the imaging system
- Latency between monitors should be compatible with collaborative activity on surgery
- Implementation either in the device or as a converter



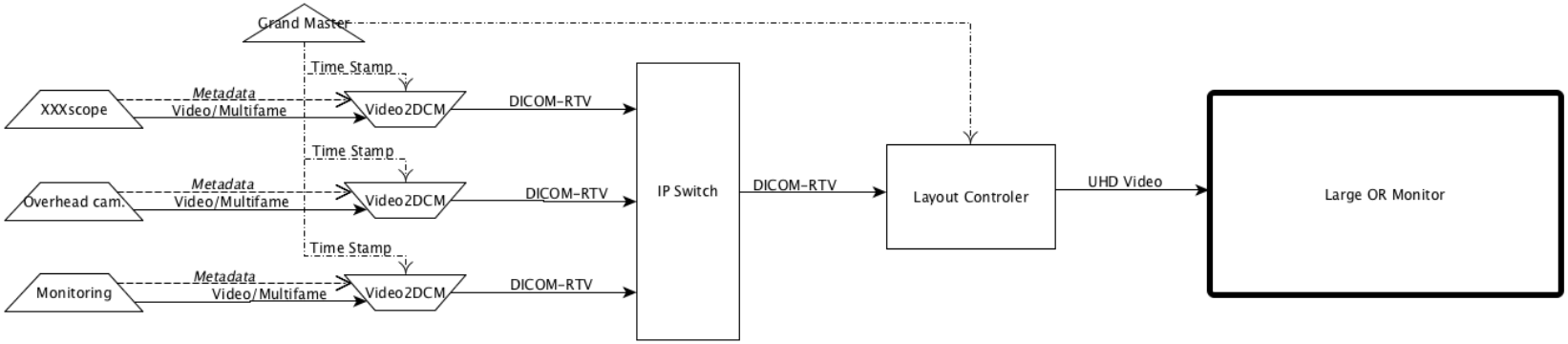
Post-procedure Review

- Senior surgeon watches a recorded procedure
  - Reviews to understand what happened
  - Decides if the procedure is a success or need to re-operate
- Need good quality recording of all video (endoscopy, monitors, …) and associated metadata
- Need accurate time synchronization between channels



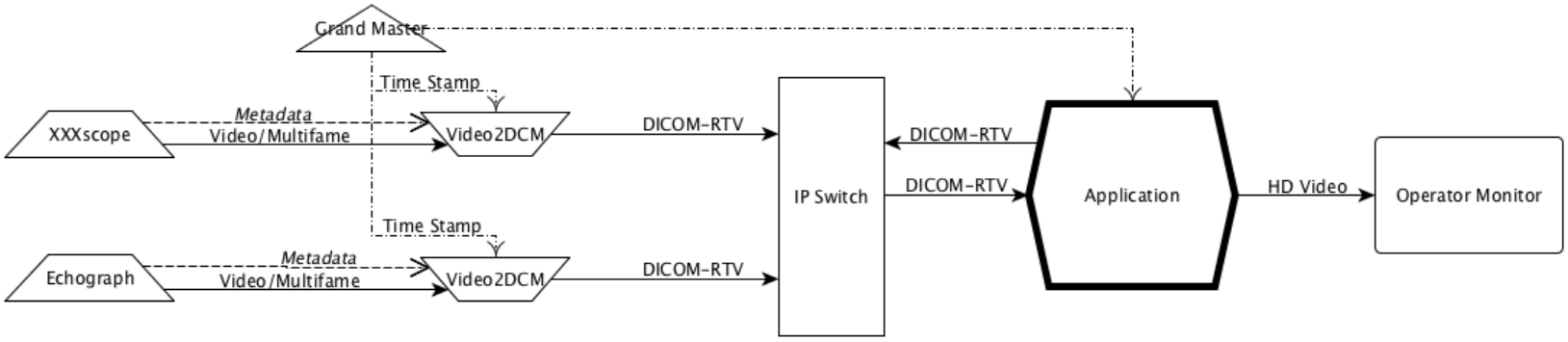
Automated OR Displays

- "Multi-displays" tile multiple videos on one monitor
- Tiling/Layout depends on the procedure step
- Need automated layout set-up ("hanging protocol")
- Metadata drives layout automation



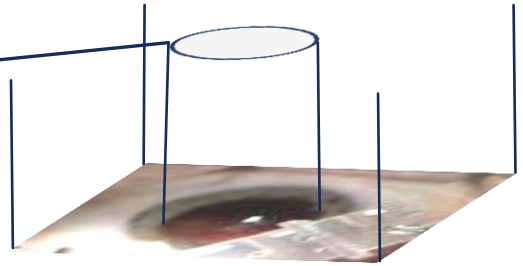
Augmented Reality

- Image-guidance improves interventional procedures
- Real-time display may be current feed(s), or combined with reference imaging (e.g., PET tumor location)
- Need real-time video, metadata, and good synch
- Minimizing latency improves safety and efficacy



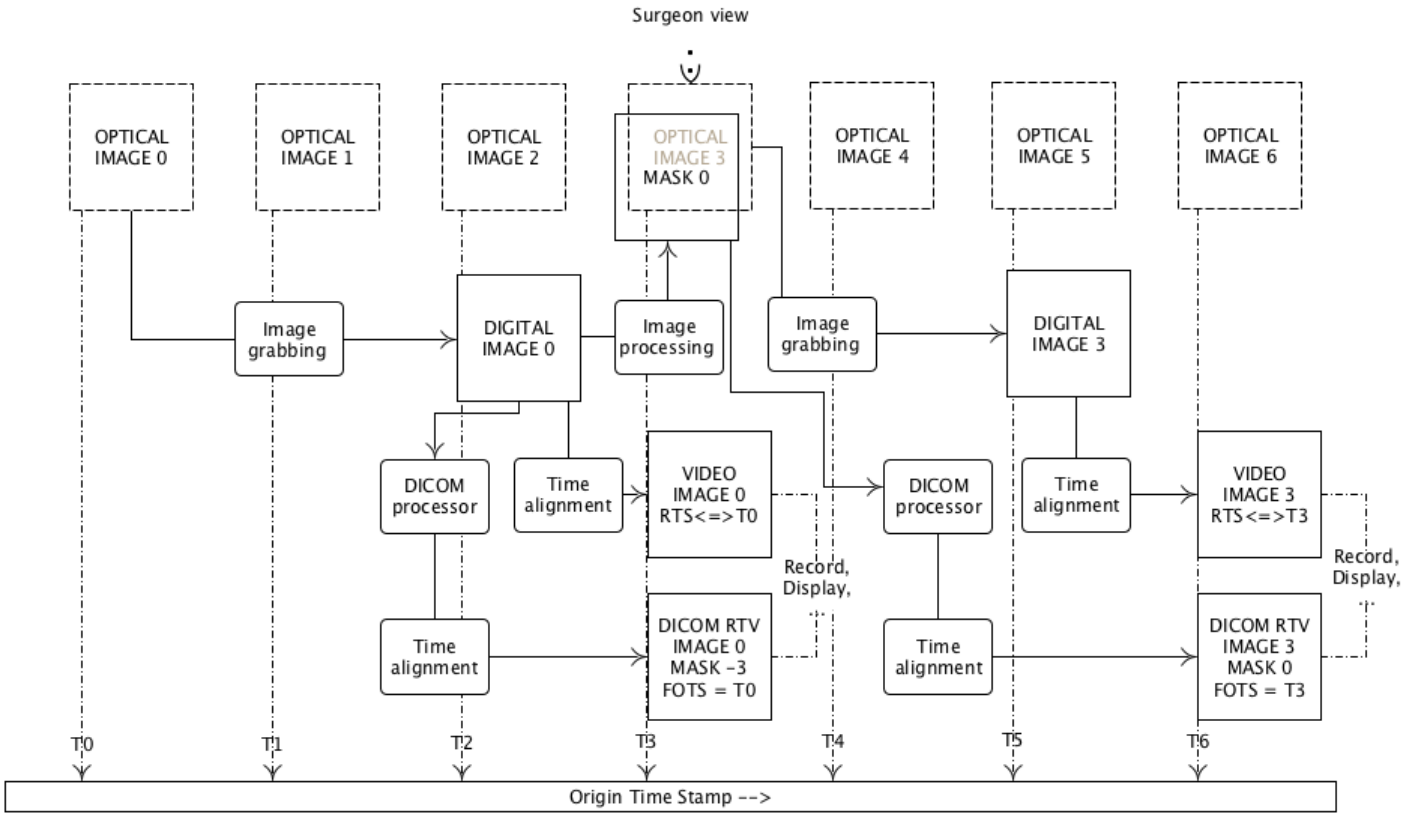
Example: Cataract surgery

- Overlay plane



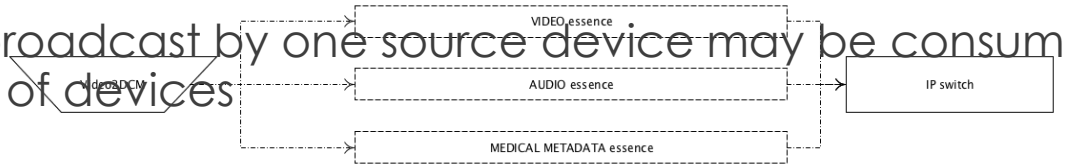
- Surgeon view

Example: Implementation

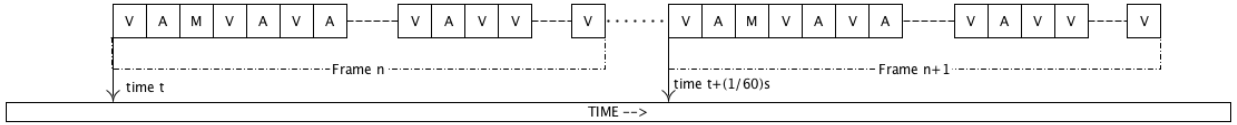


Real-Time Video Principles

- Real-time data is comprised of video, audio and associated metadata essences
- Each essence is carried as a flow over a multicast IP-based infrastructure
- A flow broadcast by one source device may be consumed by any number of devices

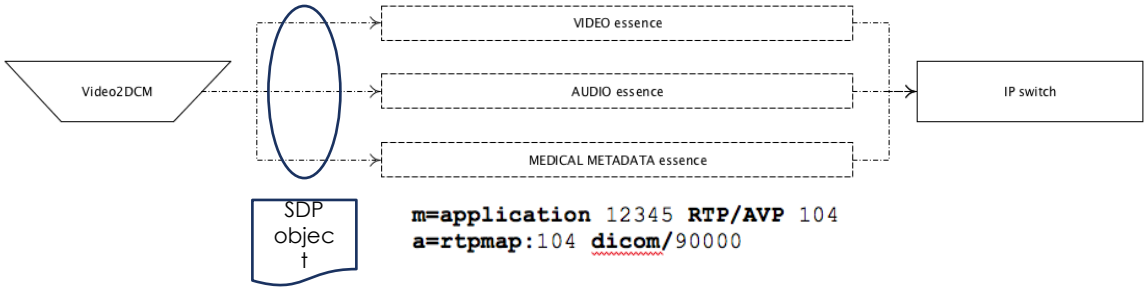


  - A Flow is transmitted as a sequence of Grains (each may be one or more packets)
  - Grains (frames) are synchronized/"aligned" via PTP (Precision Time Protocol)
  - Pac met



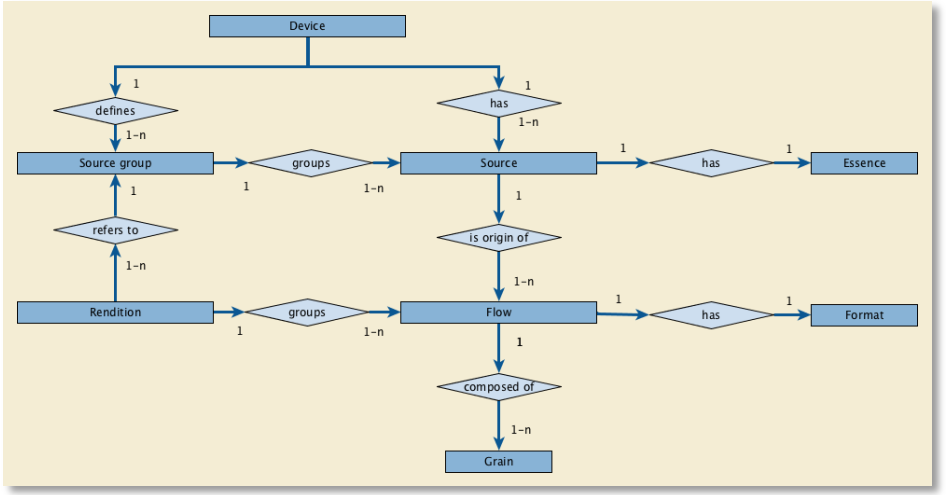
Real-Time Session Description

- SMPTE ST 2110-10 requires an SDP object describing a set of flows
  - Nature of the flow (video, audio, DICOM-RTV metadata…)
  - one IP port per flow
  - Video characteristics
  - Source identification
  - …
- DICOM metadata also incorporates the main SDP content
- DICOM Conformance Statements describe how SDP objects are accessed



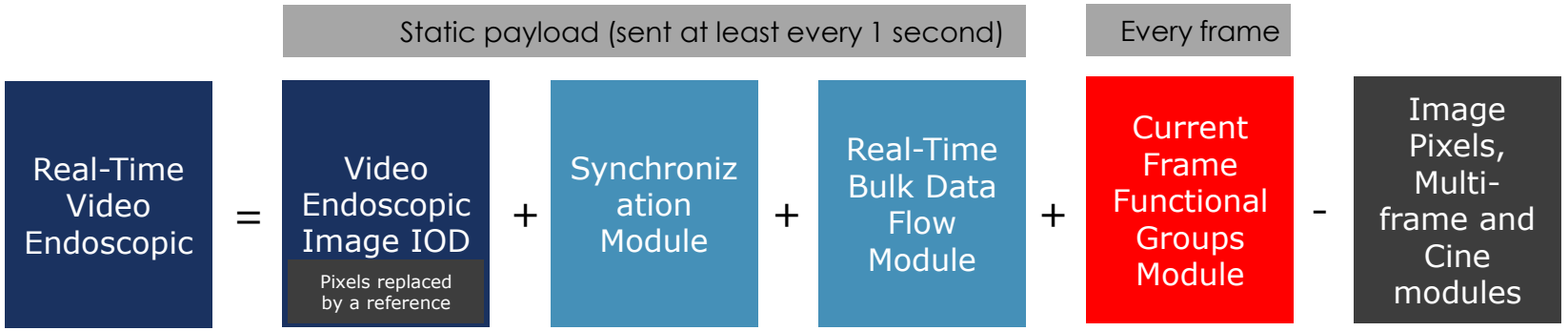
Real World Model

- A Device can provide and/or consume content
- A producing Device has one or more Sources
- A Source is the origin of one or more Flows (same content)
- A Flow corresponds to a SOP Instance (with a UID & transfer syntax)
- A Rendition links multiple Flows (e.g., video and audio)



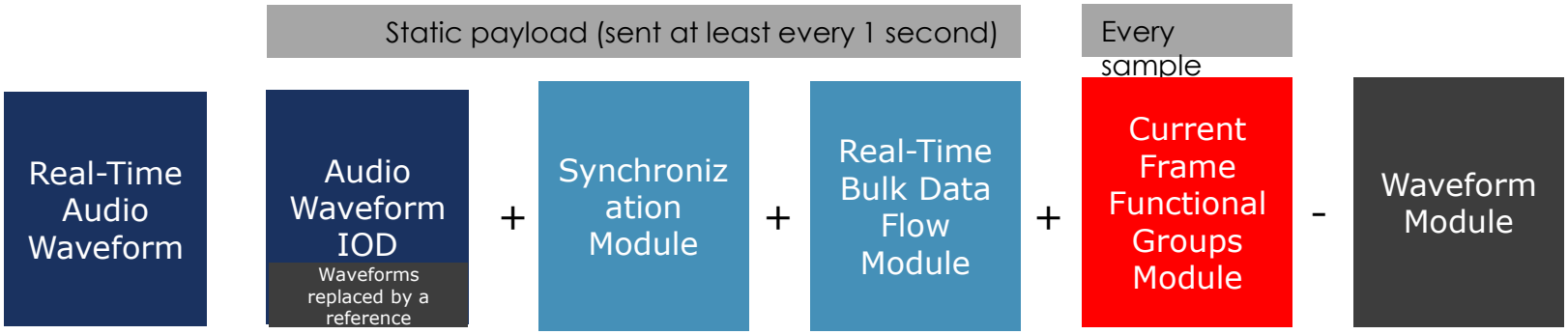
Metadata Flow (for video)

- Video Flow contains only Bulk Data (no metadata)
- Metadata Flow references the Video Flow (similar to JPIP) but contains no Pixel data
- Metadata Flow describes the Video Flow using (modified) modules from existing video IODs

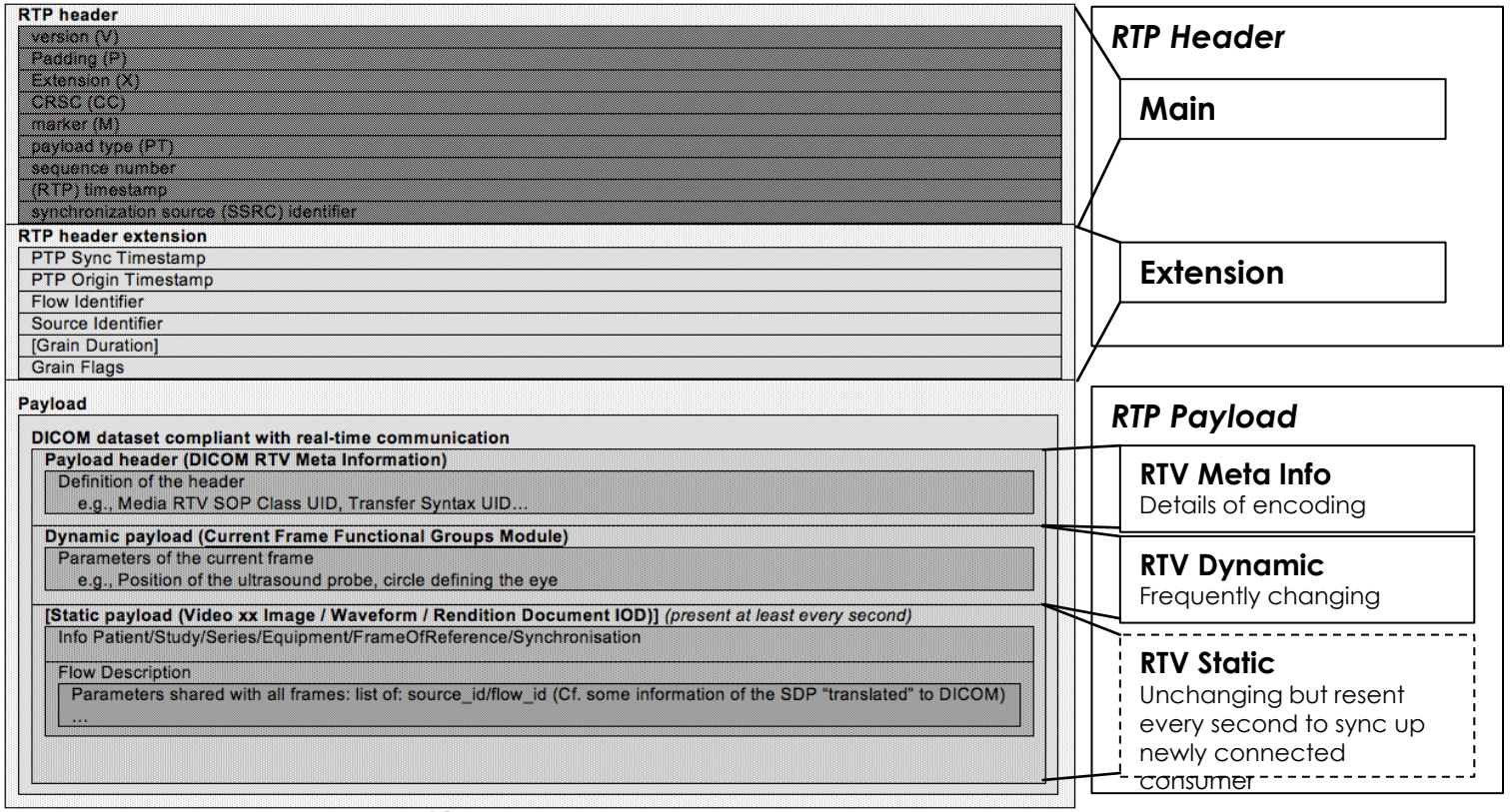


Metadata Flow (for audio)

- Audio Flow contains only Bulk Data (no metadata)
- Metadata Flow references the Audio Flow but contains no waveform samples
- Metadata Flow describes the Audio Flow using (modified) modules from existing audio IODs



Metadata Packet Structure



IOD Modules

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
Equipment	General Equipment	C.7.5.1	M
Frame of Reference	Frame of Reference	C.7.4.1	U
	Synchronization	C.7.6.X1	M *Reference to PTP (vs. NTP)*
Image	General Image	C.7.6.1	M
	General Reference	C.12.4	U
	Real-Time Bulk Data Flow	C.7.6.X1	M
	Acquisition Context	C.7.6.14	M
	Device	C.7.6.12	U
	Specimen	C.7.6.22	C - Required if the Imaging Subject is a Specimen
	VL Image	C.8.12.1	M
	ICC Profile	C.11.15	U
	SOP Common	C.12.1	M
	Common Instance Reference	C.12.2	U
	Stereoscopic Acquisition	C.X.X	C - Required if this flow contains a stereoscopic pair
	Current Frame Functional Groups	C.7.6.X2	M **--RTV Dynamic Payload--**

--RTV Static Payload--

Current Frame Functional Groups Module

- This Module is placed in every frame, in the RTV Dynamic Payload

Attribute Name	Tag	Type	Attribute Description
Current Frame Functional Groups Sequence	(hhhh,ee14)	1	Sequence that contains the Functional Group Sequence Attributes corresponding to the current frame or audio sample. Only one Item shall be included in this Sequence.
Frame Origin Timestamp	(hhhh,ee15)	1	This timestamp contains the capture time of the payload content for this frame or audio sample. It is relative to Time Distribution Standard (gggg,ee13).
>Include one or more Functional Group Macros.			For each IOD that includes this module, a table is defined in which the permitted Functional Group Macros and their usage is specified.

Example of Functional Group Macro

- Real-Time Video Microscopic Image Functional Group Macro

Attribute Name	Tag	Type	Attribute Description
Light Brightness Ratio	(gggg,ee19)	3	The light brightness ratio, expressed in percentage. See Section C.7.6.X4.1.1 for further explanation.
Focal Distance	(0018,1182)	3	Focal distance of the lens, in mm. See Section C.7.6.X4.1.2 for further specialization.
Zoom Factor	(0028,0031)	3	The amount of magnification applied to each pixel in the image, specified by a numeric pair: row value (delimiter) column value. See Section C.7.6.X4.1.3 for further explanation.

New IODs and SOP Classes

Information Object Definition	Type	Part
Real-Time Video Endoscopic Image IOD	Composite	PS3.3
Real-Time Video Microscopic Image IOD	Composite	PS3.3
Real-Time Video Photographic Image IOD	Composite	PS3.3
Real-Time Audio Waveform IOD	Composite	PS3.3
Rendition Document IOD	Composite	PS3.3

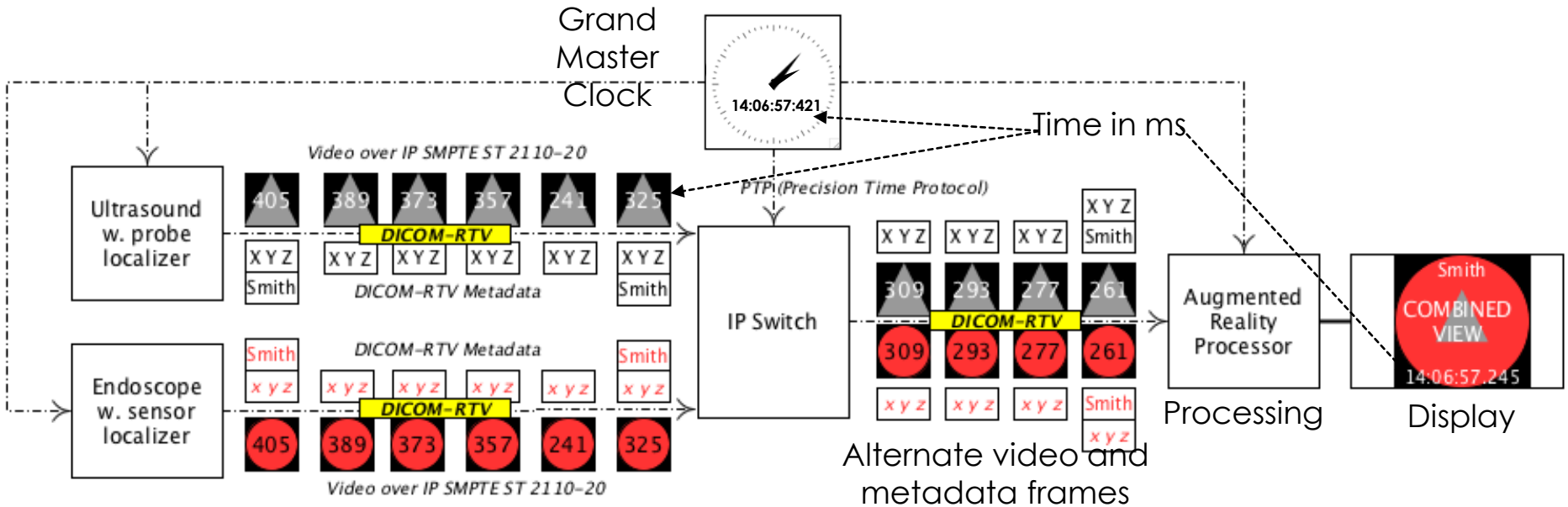
UID Value	UID Name	UID Type	Part
xxxxxxx	Video Endoscopic Image Real-Time Communication	SOP Class	PS3.X
xxxxxxx	Video Microscopic Image Real-Time Communication	SOP Class	PS3.X
xxxxxxx	Video Photographic Image Real-Time Communication	SOP Class	PS3.X
xxxxxxx	Audio Waveform Real-Time Communication	SOP Class	PS3.X
xxxxxxx	Rendition Document Real-Time Communication	SOP Class	PS3.X

Transfer Syntaxes

- Transfer Syntax describes the encoding of the bulk data (video or audio) conveyed in the ST 2110-xx Flow referenced in the DICOM RTV Metadata Flow
- Initially, only uncompressed video is supported
- Will consider compression as ST 2110-xx evolves
- ST 2110-22 (Compressed Video Formats) is in the process of

UID Value	UID Name	UID Type	Part
xxxxxxx	SMPTE ST 2110-20 Uncompressed Progressive Active Video	Transfer Syntax	PS3.5
xxxxxxx	SMPTE ST 2110-20 Uncompressed Interlaced Active Video	Transfer Syntax	PS3.5
xxxxxxx	SMPTE ST 2110-30 PCM Digital Audio	Transfer Syntax	PS3.5
xxxxxxx	SMPTE ST 2110-30 Digital Waveform	Transfer Syntax	PS3.5

Summary: Example of Endoscopy/Ultrasound AR



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Thank you for your attention!