Supplement 217

NEUROPHYSIOLOGY WAVEFORMS

DICOM WORKING GROUP 32

LETTER BALLOT

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Working Group 32 Neurophysiology Data

ORGANIZATION AND PURPOSE

Working Group 32

Chaired by:

- Jonathan Halford
  Medical University of South Carolina (MUSC)
- vacant

Secretary:

- The International Federation of Clinical Neurophysiology (IFCN)
  Catherine Lamoureux

Working Group 32

Ultimate goal is

- a comprehensive, standard-based digital platform for neurophysiology in the patient care setting

New specification should

- Leverage the existing and growing ecosystem of DICOM-capable systems in use in healthcare institutions
- Leverage standards already in use in the neurophysiology industry

Working Group 32

Short-term objectives:

- New IOD(s) for storing neurophysiology data in PACS or VNA
  - Direct association with the patient
  - Together with related objects such as video or ECG
  - Keeping data synchronized
- Gap analysis of existing DICOM Standard with respect to potential neurophysiology requirements (e.g. waveform compression)
- Identify and establish relationship to other DICOM Working Groups currently responsible for related features
- Priorities for the identified gaps

Working Group 32

Milestones so far:

- In Vienna 2016 some research projects were initiated:
  - Using DICOM Waveforms for EEG and Sleep Studies
  - proofed EHR integration, EEG analysis algorithms running on DICOM Waveforms
- IFCN Task Force in 2018
  - "Common Standard Format for Neurophysiology Data Exchange"
  - Clear vote of the IFCN Task Force for DICOM
- Kickoff for Working Group 32 in 12/2018
- First Read of Sup217 in 06/2019
- Public Comment ended in 01/2020

Neurophysiology Waveforms

EXTENDING DICOM WAVEFORMS TO NEW DOMAINS

Supplement 217 addresses

Exchange and storage of neurophysiology data like

- Electroencephalography (EEG)
- Electromyography (EMG)
- Electrooculography (EOG)
- Polysomnography (PSG)

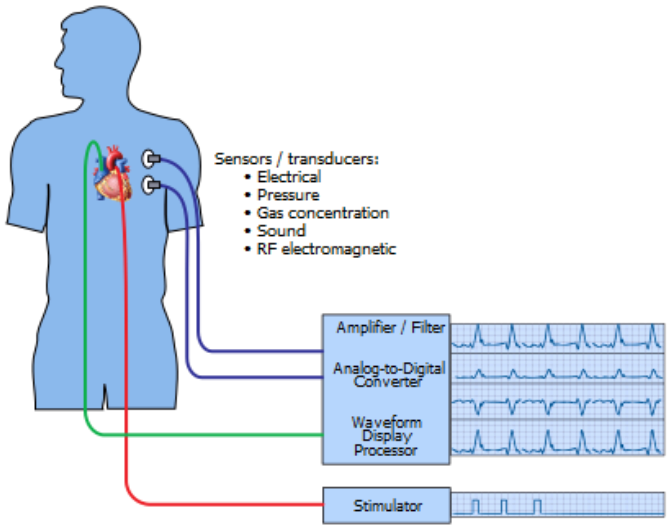
and

- Continuous recording of the patient‘s position

DICOM Waveforms

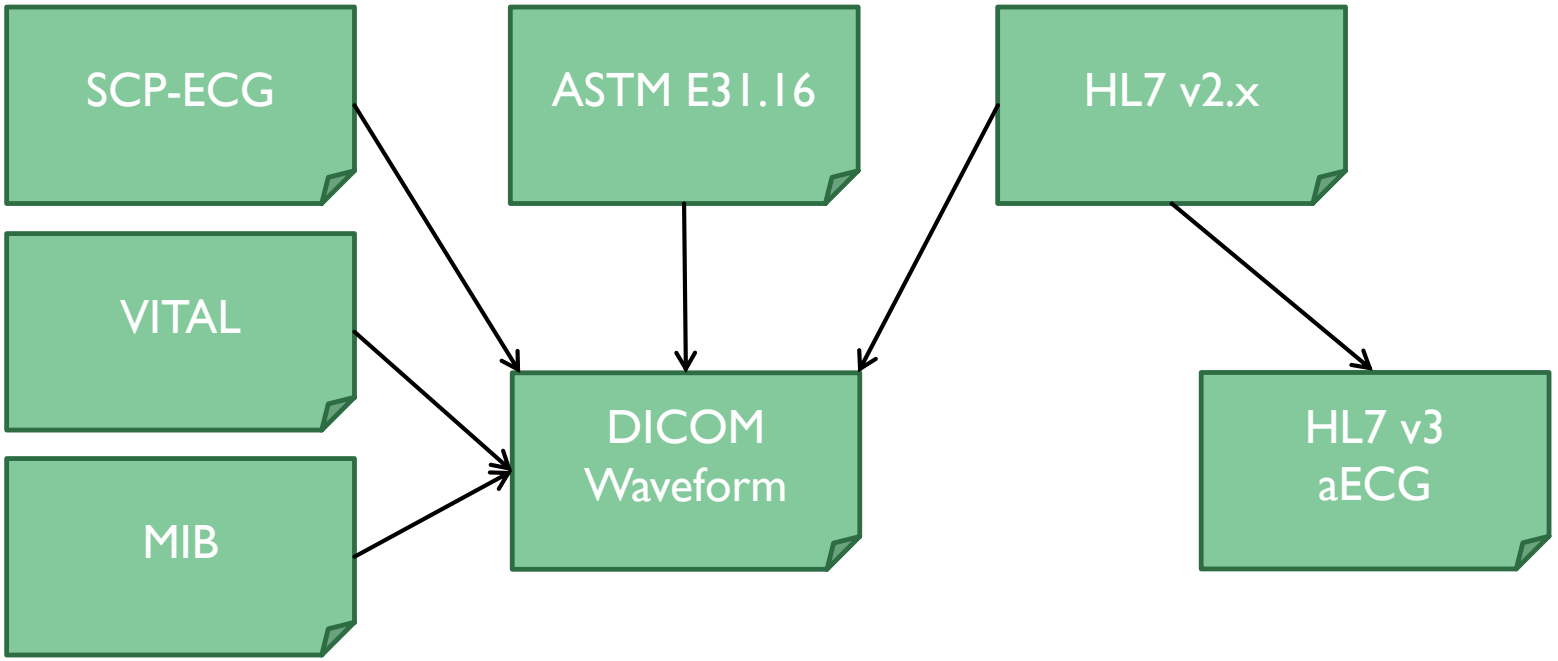
DICOM Support since 2000

- Audio: 2 SOP Classes
- ECG: 3 SOP Classes
  - 12-lead, General ECG, Ambulatory
- Arterial Pulse Waveform
- Respiratory Waveform
- Basic Cardiac Electrophysiology
- Hemodynamic



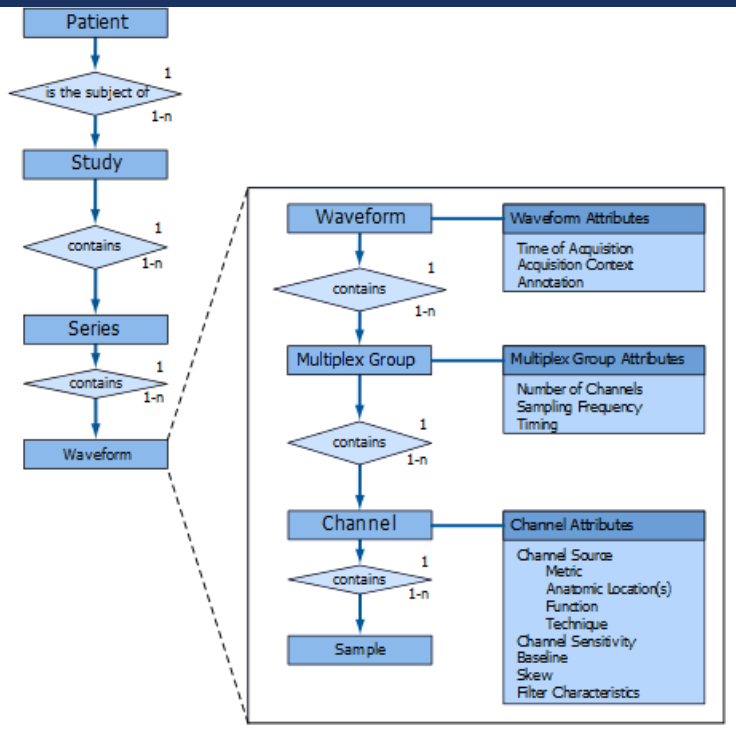
DICOM PS3.17 Fig. C.4-1.

DICOM Waveforms



DICOM Waveforms

- Waveform Attributes
  - Acquisition Time
  - Acquisition Context
  - Annotations
- Channel Multiplexing
- Channel Attributes
  - Channel Source
  - Scaling
  - Callibration
  - Filter
- Sample Values



DICOM Waveform Information Model PS3.17 Fig. C.5-1

DICOM
Digital Imaging and Communications in Medicine

Clinical Scenarios

Scenario	Recording	Indication
Routine EEG	Scalp EEG	Encephalography, epilepsy
EEG-Video-Monitoring	Scalp EEG	Seizure characterization, presurgical epilepsy evaluation
EEG-Video Monitoring – intracranial	Implanted electrodes	presurgical epilepsy evaluation
Longterm EEG Monitoring	Scalp EEG	Encephalograpyh, epilepsy, ICU
Polysomnography	Scalp EEG, EMG, EOG + additional	Sleep disorders
High-density EEG	More Electrodes, req. 3D localization	
EEG-fMRI	Sync. Acquisition of EEG and MRI	

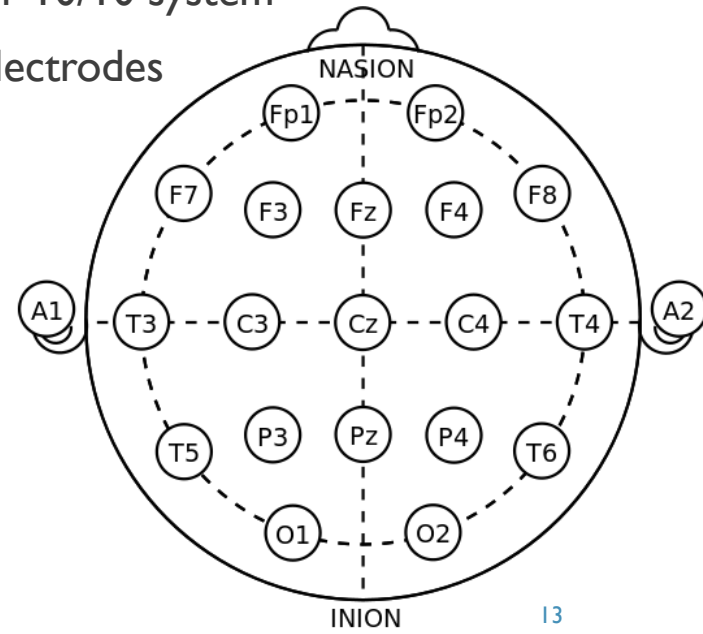
Routine Scalp EEG

Properties

- Electrode positions according the international 10/20 or 10/10 system
- Maybe alternative setting using a cap instead of single electrodes
- Up to 32 channels, sampling frequency up to 1024 Hz
- Additionally recorded: single ECG channel

Nomenclature: ISO IEEE 11073 10101

- Leads
  A.8.4 Sites for EEG-electrode placement on the head
- Annotations



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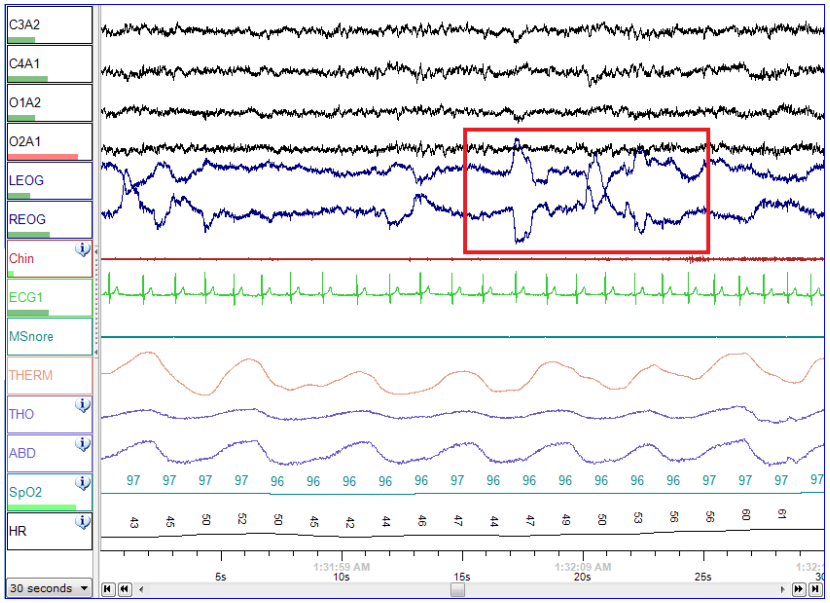
Polysomnography

Multimodal recording:

- EEG is essential, additionally required:
  - EMG (activity of skeletal muscles)
  - EOG (eye activity)
- Reuse of existing DICOM objects:
  - ECG
  - Pulse oximetry
  - Sound recordings
  - Video



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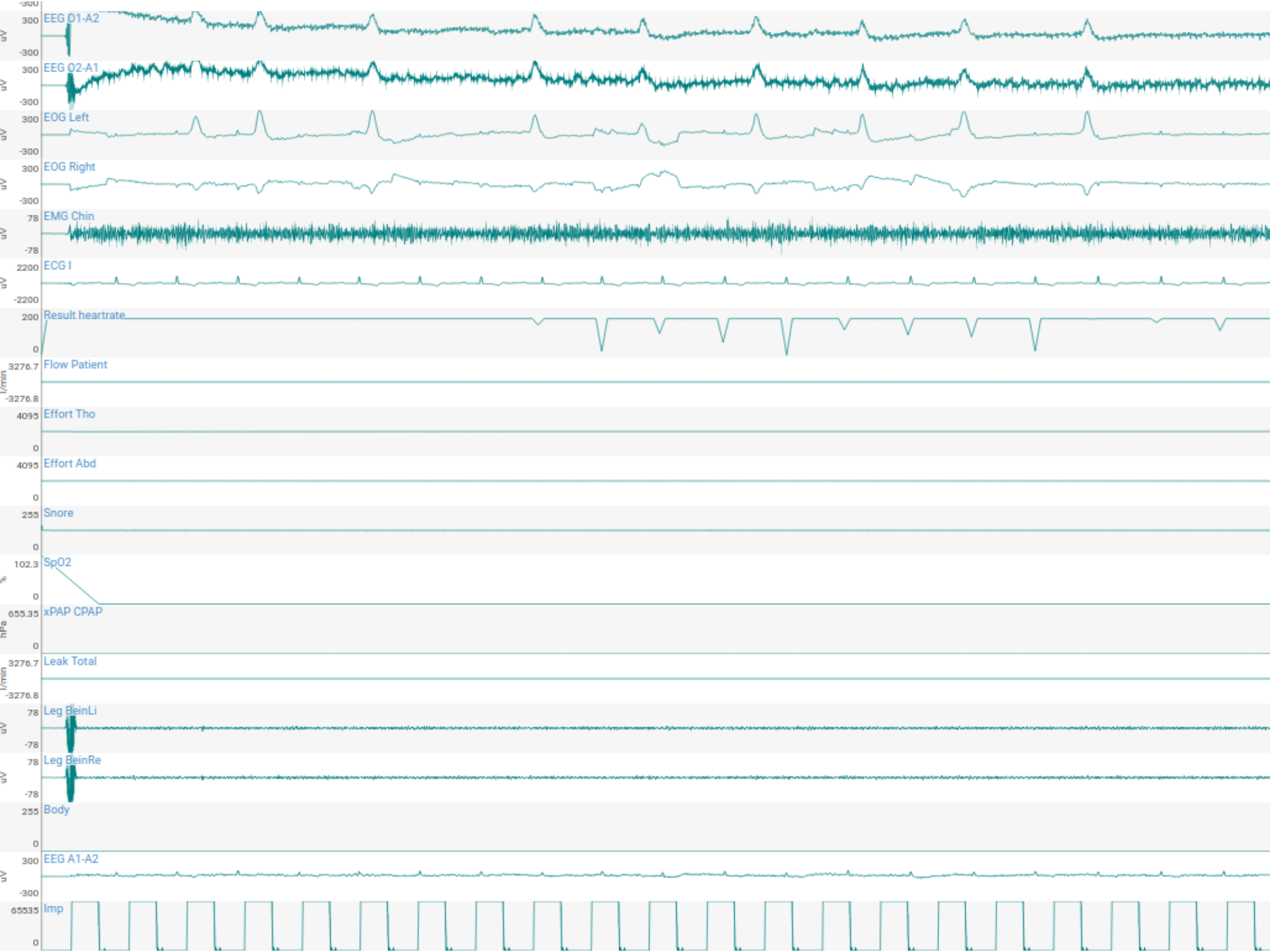

EEG O1-A2
300
-300
uV
EEG O2-A1
300
-300
uV
EOG Left
300
-300
uV
EOG Right
300
-300
uV
EMG Chin
78
-78
uV
ECG I
2200
-2200
uV
Result heartrate
200
0
Flow Patient
3276.7
l/min
-3276.8
Effort Tho
4095
0
Effort Abd
4095
0
Snore
255
0
SpO2
102.3
%
0
xPAP CPAP
655.35
hPa
0
Leak Total
3276.7
l/min
-3276.8
Leg BeinLi
78
-78
uV
Leg BeinRe
78
-78
uV
Body
255
0
EEG A1-A2
300
-300
uV
Imp
65535
0

Multi-channel Respiratory Waveform

- Existing IOD is limited to a single channel
- Existing Context Group for respiratory channel sources (CID 3005) contains only a single value
- PSG respiration monitoring needs more channels and distinguishable channel sources

Body Position

- DICOM has no IOD to monitor the patient‘s position continuously
- [WG-07 Sup.160 – worked on patient position monitoring]

- Tracking the patient‘s movement is essential for PSG
  - Video
  - Sensor(s) applied to the patient‘s body
    >> Patient Position IOD

Body Position cont.

Proprietary PSG systems often store 5 discrete values:

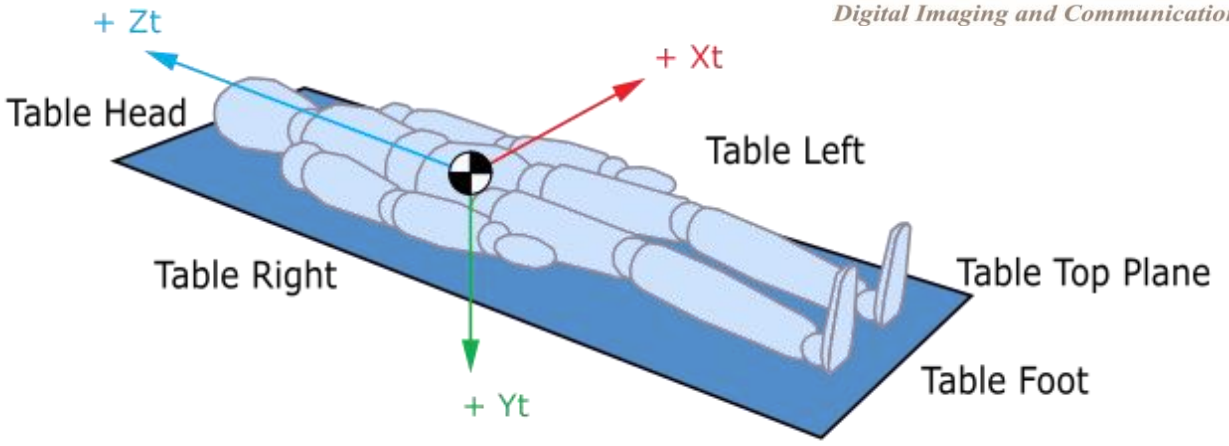
- supine (the patient's face being in an upward direction)
- lateral decubitus left (patient's left side being in downward direction)
- prone (the patient‘s face being in a downward direction)
- lateral decubitus right (patient's right side being in downward direction)
- upright (the patient‘s chest is elevated from the bed)

Body Position cont.

To meet this requirement an IOD was defined as follows:

- A single multiplex group
- not limiting the number of channels
- A defined CID with different types of channel sources
  - Single channel monitoring just storing 5 discrete values
  - Two channel monitoring storing two rotation angles:
    - Channel I (head-feet-axis rotation: supine, lat. decubitus left, prone, lat. decubitus right)
    - Channel II (laying down versus sitting/standing upright)

By amending CID 30ww further position monitoring methods can be added easily.



Position Value	Channel I	Channel II
supine	0	0
lateral decubitus left	90	0
prone	180	0
lateral decubitus right	270	0
head up (sitting or standing)	0	90
feet up	0	-90

Work Items Defered to Later

- Waveform compression
- Long term monitoring
- High density EEG Intracranial EEG
- Evoked Potentials
- Magnetoencephalography (MEG)
- Amend body position to sensor data