Medical Imaging Working Group

School of Graphic Communications Management
Heidelberg Centre (HEI Building)
Ryerson University
125 Bond Street
Toronto, Canada
11 November 2017

Craig Revie, MIWG chair, opened the meeting at 15:15 and introduced the agenda as follows:

1. Introductions
2. Electro-Optical Requirements for Medical Display
3. Activities in IEC 62B/MT51 and AAPM WGMD
4. DICOM camera raw support and EXIF tags
5. Tolerances for DICOM in Professional Color Displays
6. Identification of possible future projects for MIWG
7. Action items review

1. Introductions

Mr Revie performed a sound check and participants introduced themselves. He reminded the participants of the ICC MIWG web site http://www.color.org/groups/medical/medical_imaging_wg.xalter, which contains pages for all the activity areas as well as minutes, presentations and recordings of the meetings.

2. Electro-Optical Requirements for Medical Display

Wonseon Song of LG Display presented a proposed set of measurements for medical displays [see attached]. She stated that the proposed standard was aimed at medical physicists (rather than manufacturers), but that the manufacturers should make the measurements. Tom Lianza, as a contributor to the Information Display Measurements Standard, suggested that all the proposed measurements are straightforward (apart from the temporal measurements), and the question is what target values should be in the standard ï these would need user testing to define. He also noted that the current trend was for manufacturers to make basically the same display for different vertical markets, and differentiate them by the marketing. SID have templates for display measurements.

The meeting discussed whether the goal of the activity was certification of performance or measurement methods. Certification would require independent body to perform if for diagnostics, and Chris Bai suggested that requirements could be divided into acceptance and certification. Ms Song clarified that the priority was measurement methods rather than certification tests.

3. Activities in IEC 62B/MT51 and AAPM WGMD

Aldo Badano of the FDA presented a summary of current activities in IEC and AAPM related to colour displays [see attached]. AAPM Task Group TG18 had developed the recommendations for primary and secondary grayscale displays, and all approved displays can now be cleared by bench testing if there are no significant new features. TG18 has been disbanded and TG270 is planning to update the recommendations to include colour. Four categories have been defined: modality monitors, radiology workstations, clinical spreadsheets and workstations for accessing Electronic Health Records.

AAPM TG 196 has published a report on gray tracking, and is working on a new report on mRGB and CSDF.

TG260 is working on an extension to hand-held devices. The intention is not to produce a specification but to alert the radiologist to the possibility of differences in appearance compared to a desktop display.

IEC TC 62/SC 62B/MT 51 has generated a document for medical physicists rather than the manufacturer. This requires a lower level of instrumentation for measurement, costing a maximum of $5000. Following the proposal made at the previous meeting, Mr Revie will act as liaison with this group.

Dr Badano emphasised that AAPM was more focused on end users, while IEC defines standards for manufacturers. Since international standards carry more weight, IEC is preferred as a forum for developing standards.

The meeting discussed how ICC could help. Dr Badano noted that the Digital Pathology Association and DICOM organise occasional connect-a-thons, where at previous events ICC profiles have successfully been used to connect different devices. Some issues had been encountered at these events and ICC input was needed.

Mr Revie described some of the issues in display of pathology images. There was no agreement on how to present specular highlights and what reference white should be used in the case of a pathology slide. The goal was that a slide scanned and displayed on different devices should always have the same appearance.

Dr Badano asked whether ICC could contribute on compliance. It was agreed that this was not in scope for ICC.

4. DICOM camera raw support and EXIF tags

Mr Revie reported that Dr David Clunie had submitted a DICOM specification amendment to handle camera RAW data. The meeting discussed whether this was an issue for ICC, and it was agreed to circulate the draft amendment [see attached].

5. Tolerances for DICOM in Professional Color Displays

Mr Chris Bai of BenQ presented a report on tolerances for DICOM, using a BenQ graphics display [see attached]. He had found that it was possible to get within the 10% JND tolerance for all luminance levels within a calibration process time-limited to 30 minutes. However, a panel calibrated to a 6500 Kelvin white point goes out of tolerance. Colour temperature in neutrals is reasonably stable, but drifts at low digital counts (below about 30 in an 8-bit image). BenQ had performed tests with a user group of physicians, who recommended a 15% JND tolerance with a colour temperature varying by +/- 0.01 in CIE x,y chromaticity, and a luminance greater than 170 cd/m^2.

6. Identification of possible future projects for MIWG

There was no update on the projects discussed at the previous meeting [see attached], with the exception of the LG medical display assessment which had been discussed at this meeting. Regarding the proposed work on viewing conditions for pathology, Aldo Badano suggested that CAP (College of Americal Pathologists) may have some recommendations and Craig Revie agreed to contact CAP for details.

7. Action item review

The meeting discussed open action items [see attached] as follows:

MIWG-16-01: Closed.
MIWG-15-30: Dr Green undertook to remind Dr Kimpe about the calibration targets.
MIWG-16-12: An ICS for GSDF profiles had been completed. Dr Derhak agreed to provide a report on this at the next MIWG meeting. Mr Bai undertook to test the profile on a GSDF calibrated display, with ambient luminance passed in as an environment variable.

There being no other business, the meeting closed at 17:30.

Action items

The following action item was agreed at the meeting:

MIWG 2017-07 Invite ICC members to participate in DICOM Connectathon (Revie)

MIWG 2017-08 Circulate DICOM specification amendment on support for camera RAW to MIWG members for comment (Revie)

MIWG 2017-09 Remind Tom Kimpe about providing calibration targets (Green)

MIWG 2017-10 Report on iccMAX GSDF profiles at next MIWG meeting (Derhak)

MIWG 2017-11 Test iccMAX GSDF profile on GSDF calibrated display with ambient illuminance passed in as environmental variable (Bai)

MIWG 2017-12 Circulate DICOM amendment on camera RAW to MIWG members (Revie)

MIWG 2017-13 Contact CAP for details of their recommendations for viewing conditions for pathology images (Revie)

International Color Consortium

ICC Medical Imaging Working Group

Ryerson University Toronto

11 October 2017 (15:15-17:30)

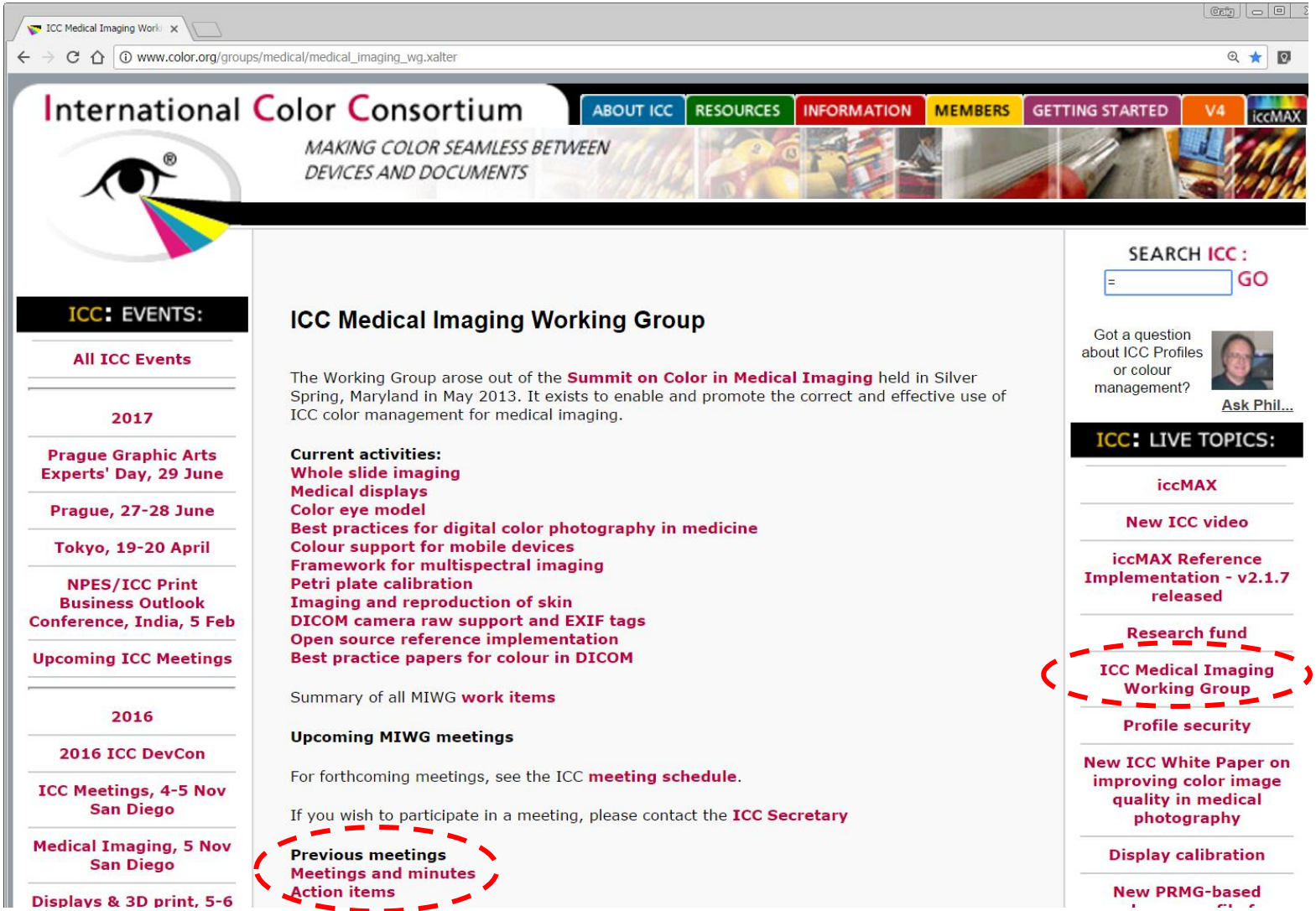
See colour in a new light

Experience 100% colour volume*

Check the small, small print!

*Measured to DCI-P3 standard, certified by VDE.

ICC MIWG web page at www.color.org

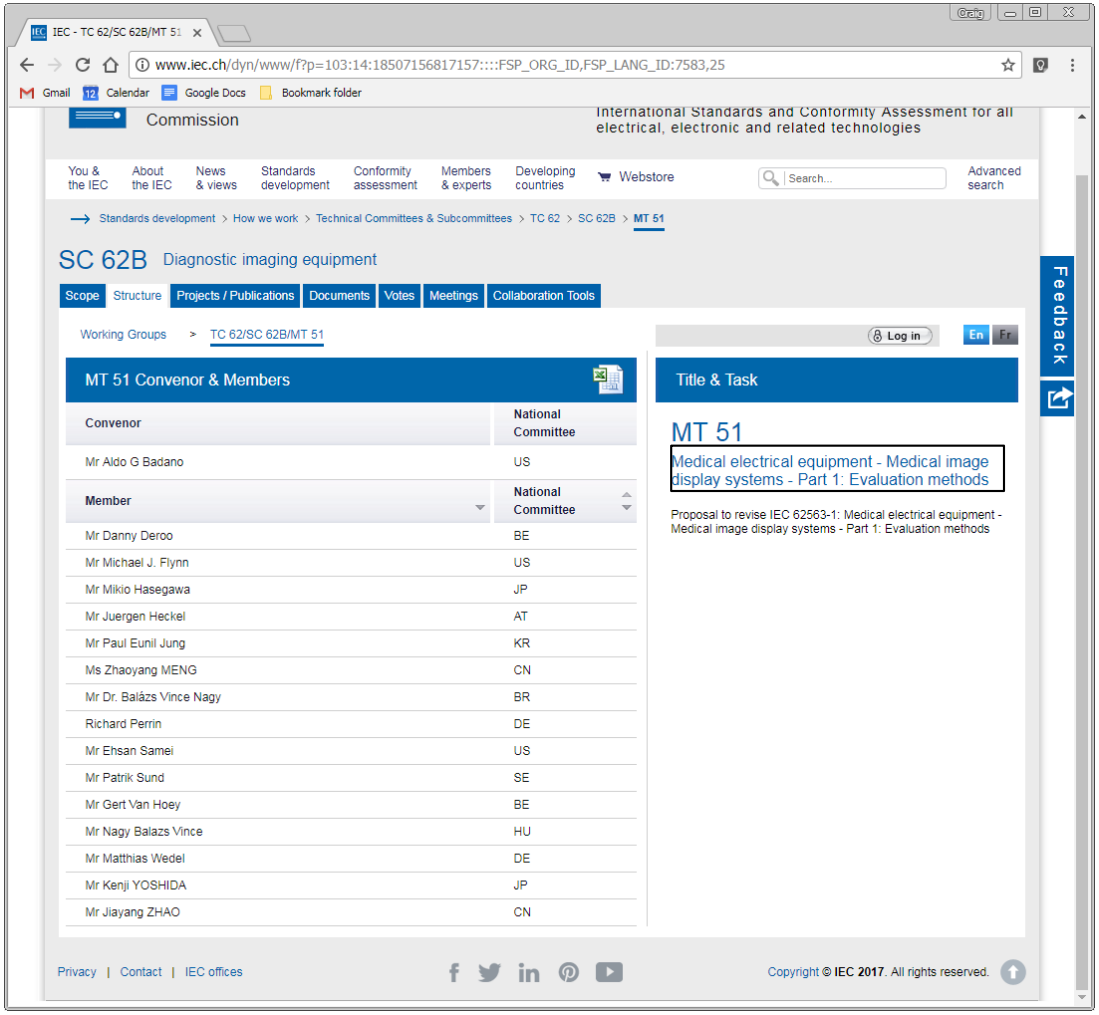


ICC MIWG Working group meeting

October 2017

• Introductions	
• Electro-Optical Requirements for Medical Display	Wonseon Song
• Activities in IEC 62B/MT51 and AAPM WGMD	Aldo Badano
• DICOM camera raw support and EXIF tags	David Clunie
• Tolerances for DICOM in Professional Color Displays	Chris Bai
• Identification of possible future projects for MIWG	Craig Revie
• Action items review	Craig Revie

Possible liaison with IEC 62B/MT51



MT 51 Convenor & Members

Convenor

Mr Aldo G Badano

Member

Mr Danny Deroo

Mr Michael J. Flynn

Mr Mikio Hasegawa

New work item proposal (IEC 62B/MT51)

WORKING DOCUMENT FOR NEW TASK IN AAPM TG196

version 0.0

Chair:

Wednesday, June 28, 2017

AAPM TG196 has a very close liaison with IEC 62B/MT51

Possible future projects for MIWG

- Guidelines for digital pathology viewing environment (check telemedicine guidelines)
- Recommendation for colour vision testing and development of tools to aid practitioners with colour deficiency
  - Daltonisation to improve diagnostic ability
- Algorithms for analysis of medical images (we need to determine what the ICC could do to help this)
- LG medical display/application assessment
- Others? Call to MIWG + Honorary Members [CR]

Action items review

MIWG-15-30	Displays	Make assessment targets available to group	13-10-2015	Kimpe	Open
MIWG-16-01	Petri plate	Send Petri plate imaging guidelines for review by MIWG	16-02-2016	Pescatore	Close
MIWG-16-12	Displays	Discuss ICS for GSDF and report back to MIWG	04-05-2016	Bai, Derhak, Nagashima-san, Kimpe	Open
MIWG-16-20	Petri plate calibration	Distribute draft primer on Petri plate system calibration by December 2016	05-11-2016	Pescatore	Close
MIWG-17-03	General	Develop activity proposals on Viewing Environment in Pathology Imaging; Automation of Detecting Anomalous Features; and Electro-Optical Requirements for Medical Displays	20-05-2017	Revie; Lianza; Wonseon	Open

ICC MIWG, Toronto, Canada, October 11

IPS

Electro-Optical Requirements for Medical Display

Wonseon Song

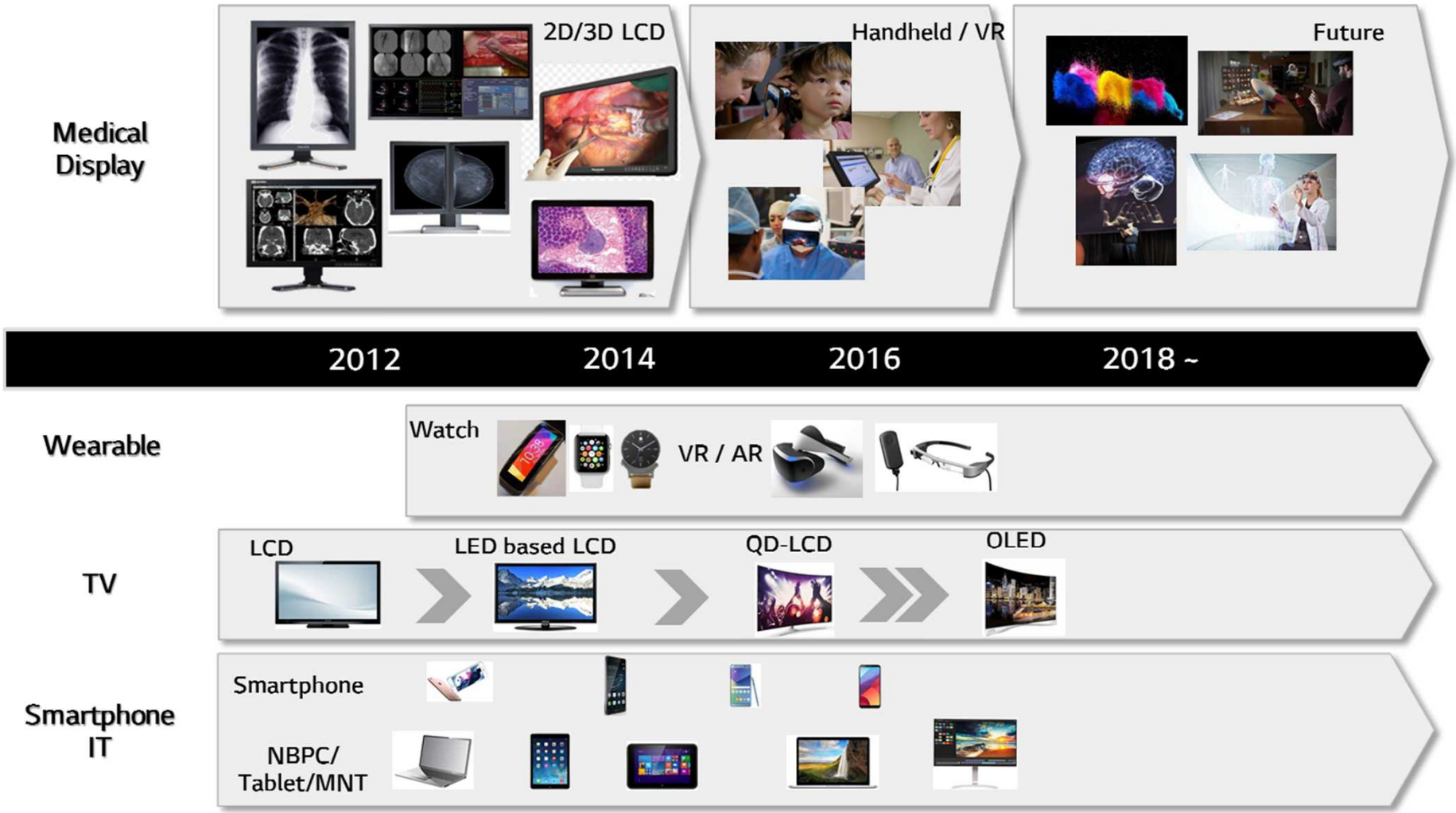
LG Display

Contents

LG Display

1. Medical Display Trends

Display technology has found its way into various consumer electronics, and now medical industry needs to innovate in medical display.



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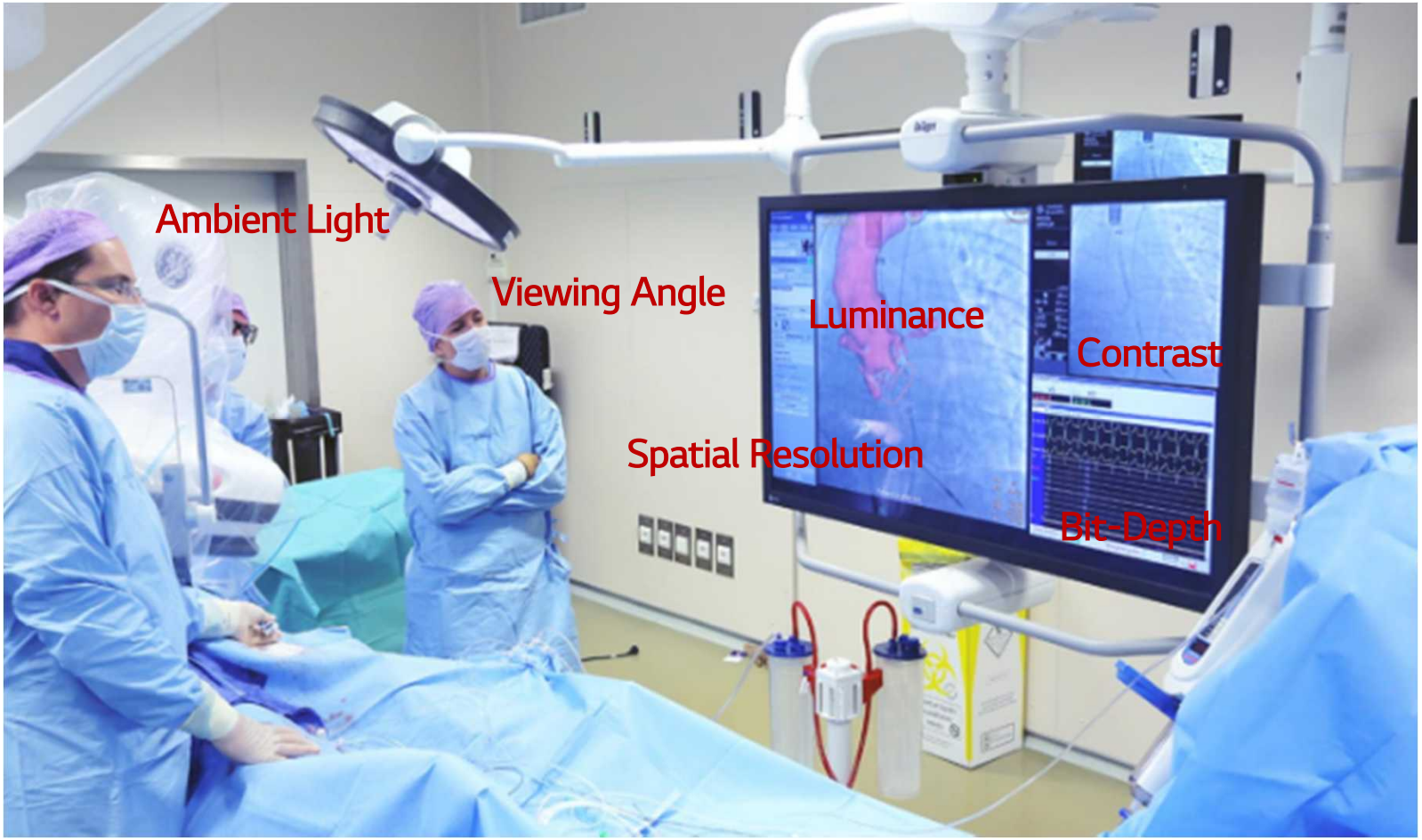
2. Requirements for Medical Display

- Medical Displays require more accurate Electro-Optical Properties



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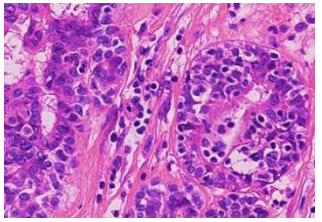
3. Structure of the Suggested Standard for Medical Display

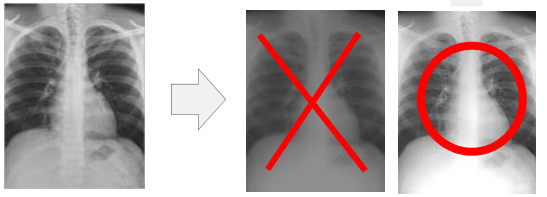
1. Purpose & Scope
   - The Integrated evaluation for medical display helps users make better judgment and guide them to medical standards.
   - The scope of this proposal is to cover measurement methods, conditions, and metrics for medical display in terms of electro-optical performance.
2. Characteristics and Methods of Measurement

Contrast/Luminance

✓ Luminance Contrast Ratio ✓ Color Contrast Ratio

Gray Scale Characteristics



✓ Tone characteristics

Gradation Representation

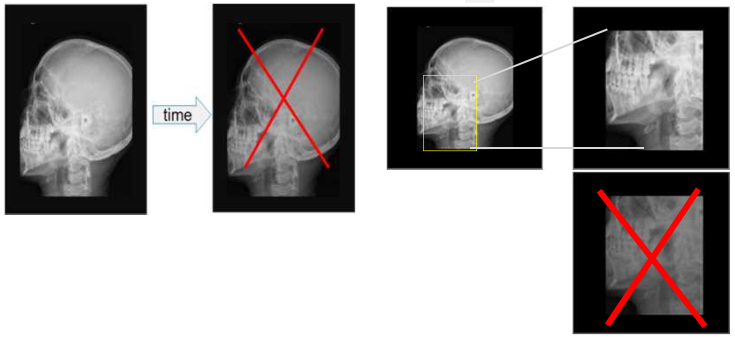
Visual Assessment

Electro-Optical Assessment

Viewing Angles

✓ Directional Luminance Contrast Ratio
✓ Directional Color Contrast Ratio
✓ Directional Gamma Distortion Ratio

Luminance Maintenance



✓ Time ✓ APL (Average Pixel Lum)

Temporal Properties

✓ Response Time
✓ Flicker

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4. Summary

- We introduced the electro-optical requirements for medical display.

- To measure the performance of medical display,
  1) Contrast : Luminance and Color Contrast
  2) Viewing Angles
     - Directional Luminance /Color Contrast
     - Directional Gamma
  3) Gray Scale Characteristics
  4) Luminance Maintenance
  5) Temporal Properties : Response Time, Flicker
  6) Gradation Representation

- The Integrated Measurement Method for medical display is needed because it can guide more accurate judgment and standards.

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Appendix. Contrast

- **In Medical Display, Contrast is an important measurement factor since lesion observation should be easy**
- **Measure the center luminance and optionally the chromaticity coordinates and CCT of full-screen white.**

Display A

Display B

Fig. 1. Example for Luminance CR

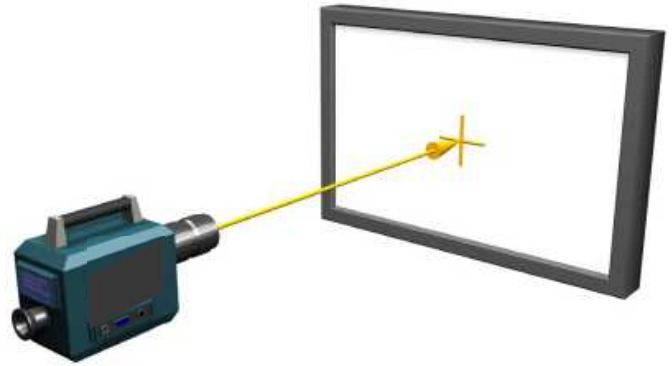

Fig. 2. Measurement Method (ref. IDMS 1.03b)

CR=Lw/Lk (for example)

Fig. 3. Test Pattern

*Ref. image : http://cancer.snuh.org/2011www/cdoctor/center/CIC/sub05/sub05/index.jsp?cat_id=CAT_20110610161196

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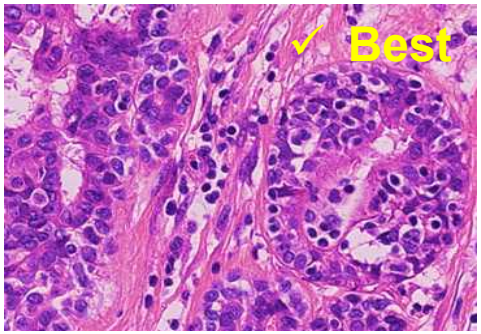
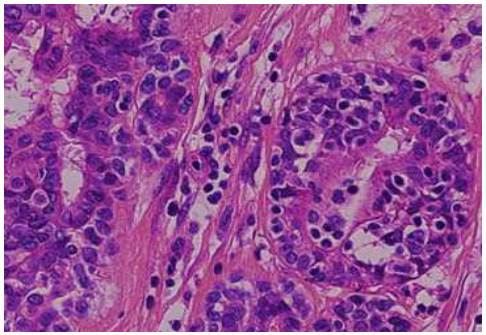
Appendix. Contrast

- **In Medical Display, Color Contrast is an important measurement factor since lesion observation should be easy**
- **Many color coordinates definitions have been standardized and can be used to define the color variation with respect to the measurement direction.**

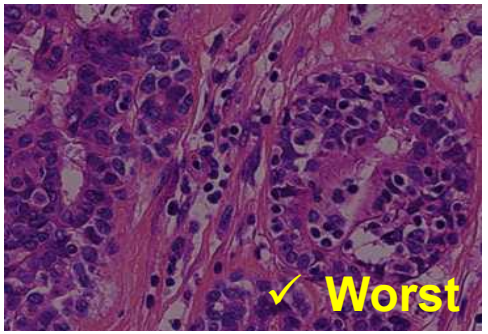


Display A

→ Easy to find objects



Display B



Display C

Fig. 1. Comparison of Color Contrast

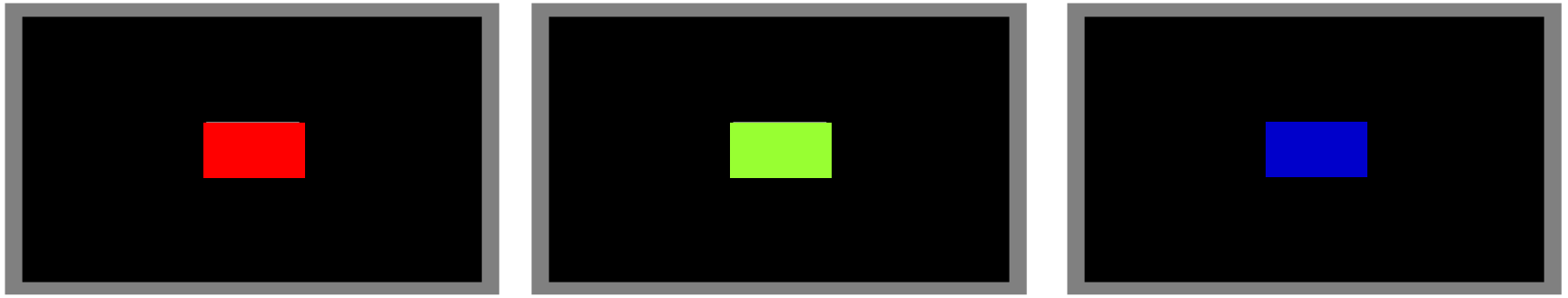


Fig. 2. Center measurement is made on 20% linear box (ref. IDMS 1.03b)

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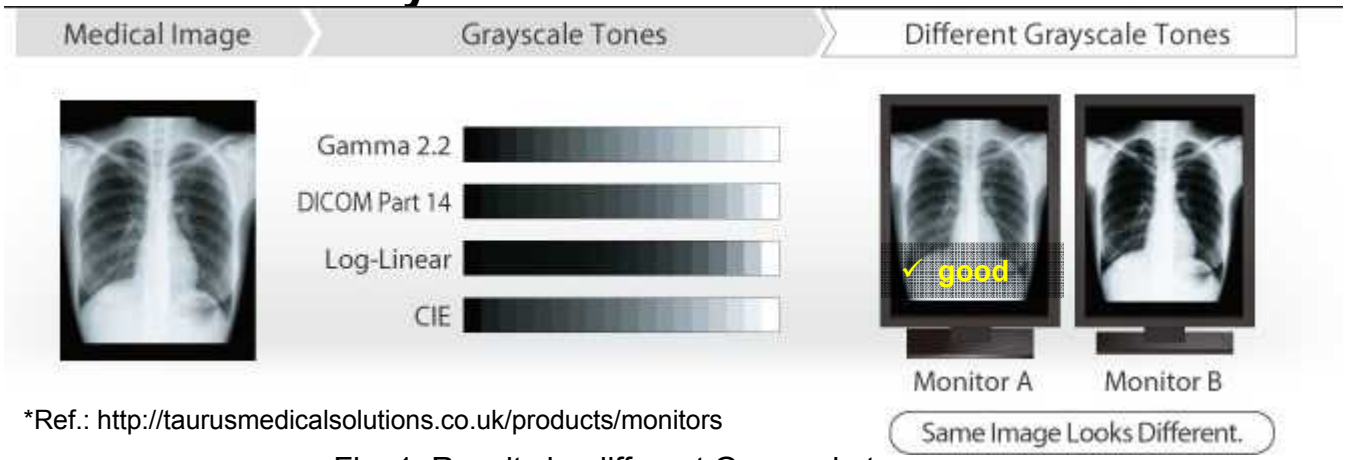
Appendix. Gray Scale Characteristics

- **Gray scale characteristics are important for original image reproduction in medical display.**
- **Evaluation method can be used to measure the target, which can be a medical standard, DICOM Part 14 Gray Scale.**



*Ref.: http://taurusmedicalsolutions.co.uk/products/monitors

Fig. 1. Results by different Grayscale tones

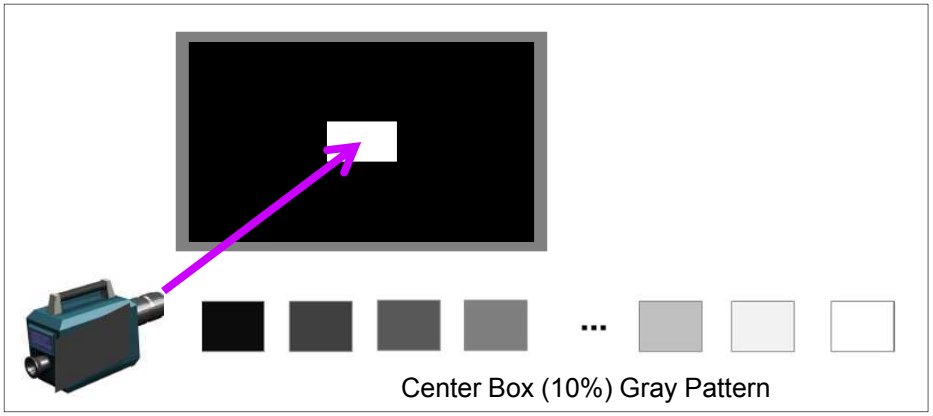


Fig. 2. Measurement Method

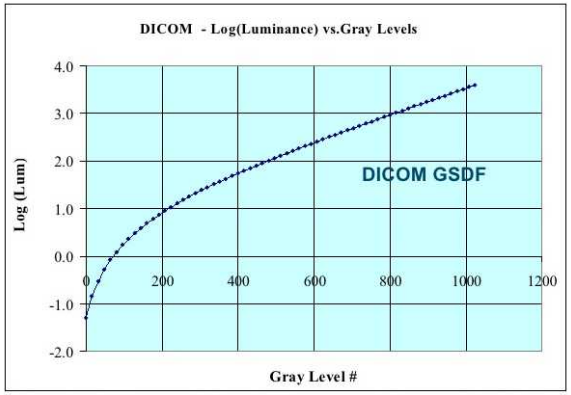


Fig. 3. DICOM function (Reference gamma)

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Appendix. Viewing Angles

- **All users should be able to observe the same medical image regardless of their position.**
- **Measure the directional contrast of 1/5 size white box compared to four 1/10 size boxes placed in each corner.**

Display A

Display B

Fig. 1. Example Image for Luminance CR

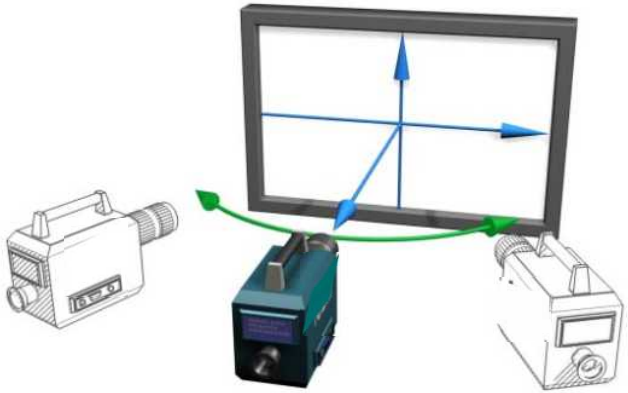
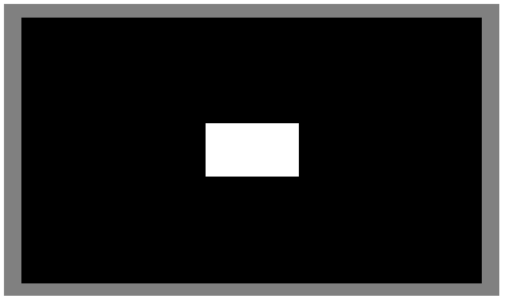


Fig. 2. Measurement Method



(a) White center measurement is made on 20% linear box

(b) Black center measurement is made with 10% linear boxes in corners

Fig. 3. Test Pattern

*Ref. image : http://cancer.snuh.org/2011www/cdoctor/center/CIC/sub05/sub05/index.j?cat_id=CAT_20110610161196

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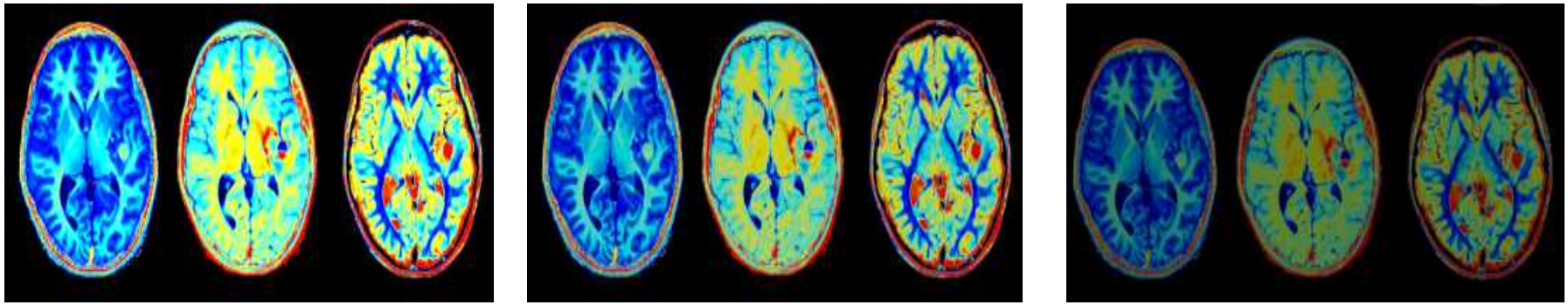
Appendix. Viewing Angles

- **Many color coordinates definitions have been standardized and can be used to define the color variation with respect to the measurement direction.**
- **All users should be able to observe the same medical image regardless of their position.**



Display A　　Display B　　Display C

Fig. 1. Comparison of Color Contrast

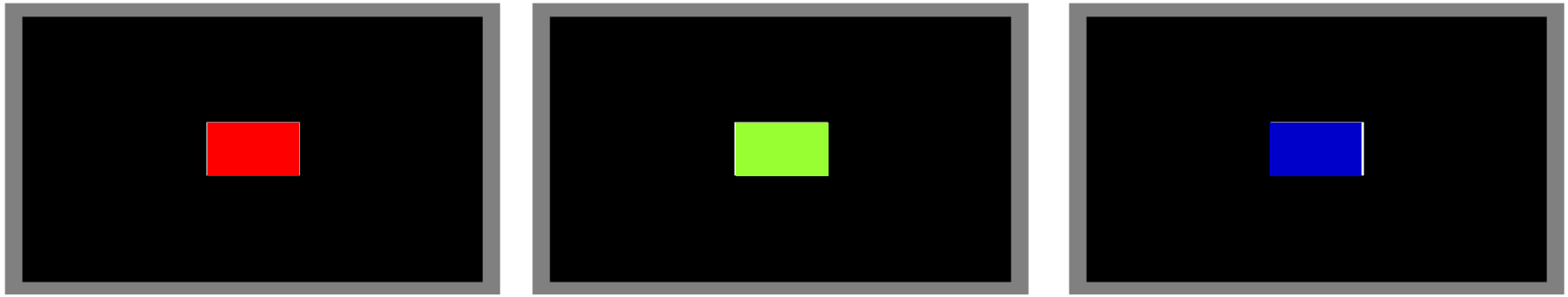


Fig. 2. Center measurement is made on 20% linear box

*Ref. image : jkna.org/journal/view.php?number=6235

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Appendix. Viewing Angles

- **Measure the gray scale at center screen and at four angles about the screen normal- up, down, left, right- as need.**
- **The ideal display device has a characteristic that the gamma values are constant in any viewing directions.**
- **This method measures how the gamma values change from the usually viewing direction.**

Fig. 1. Example of DICOM Images

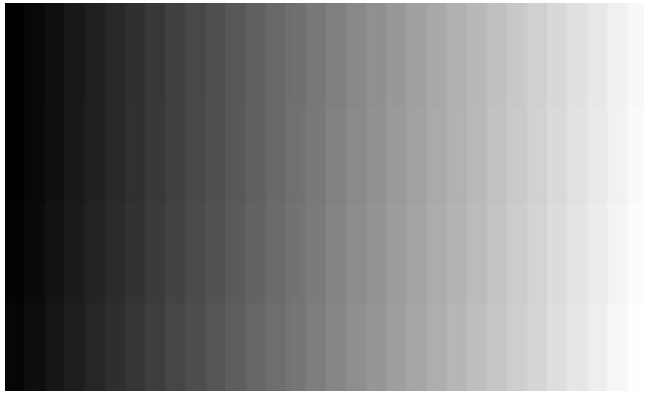

Fig. 2. Gray-Scale Gamma

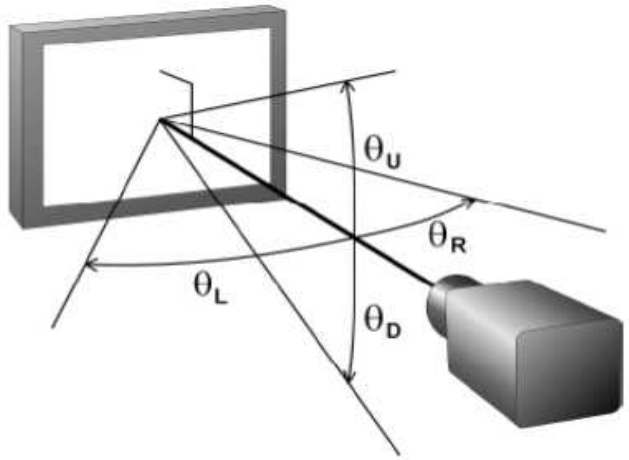

Fig. 3. Measurement Method

*Ref. image : http://weresite1.weebly.com/skeletal-diagrams.html

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- **Luminance color scales of the primary colors are measured at 9, 17, or more color levels for each primary color.**

Fig. 1. Example Image for Color-scale Gamma

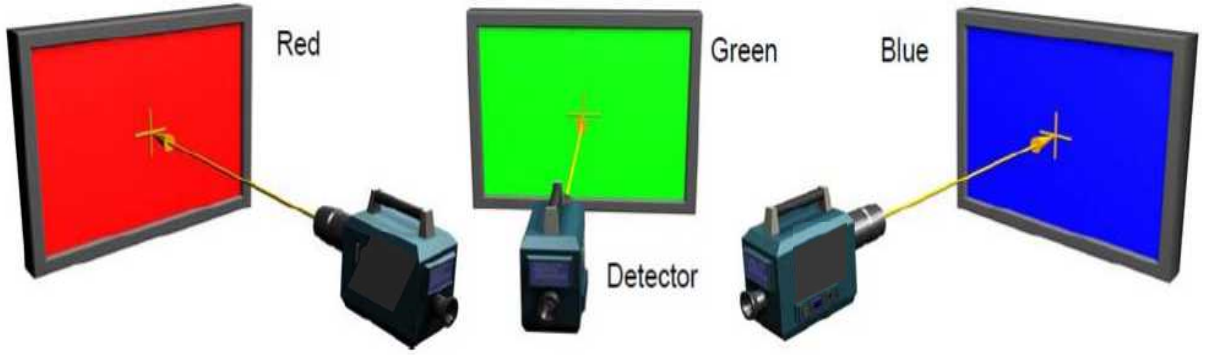

Fig. 2. Full screen patterns of primary colors are shown here, but other patterns may be more suitable depending upon the display technology.

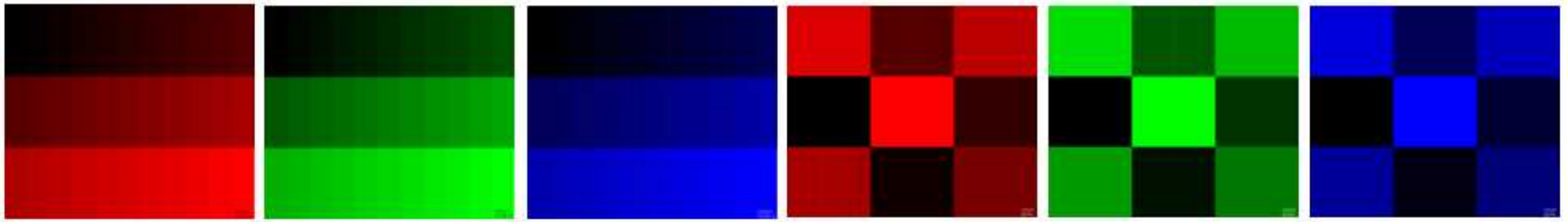

Fig. 3. Constant-picture-level patterns that cycle the various color levels at the center

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Appendix. Luminance Maintenance

- **Measured that the luminance is maintained even when the APL (Average Pixel Luminance) is changed.**
- **By maintaining the luminance, we can identify the correct medical image.**

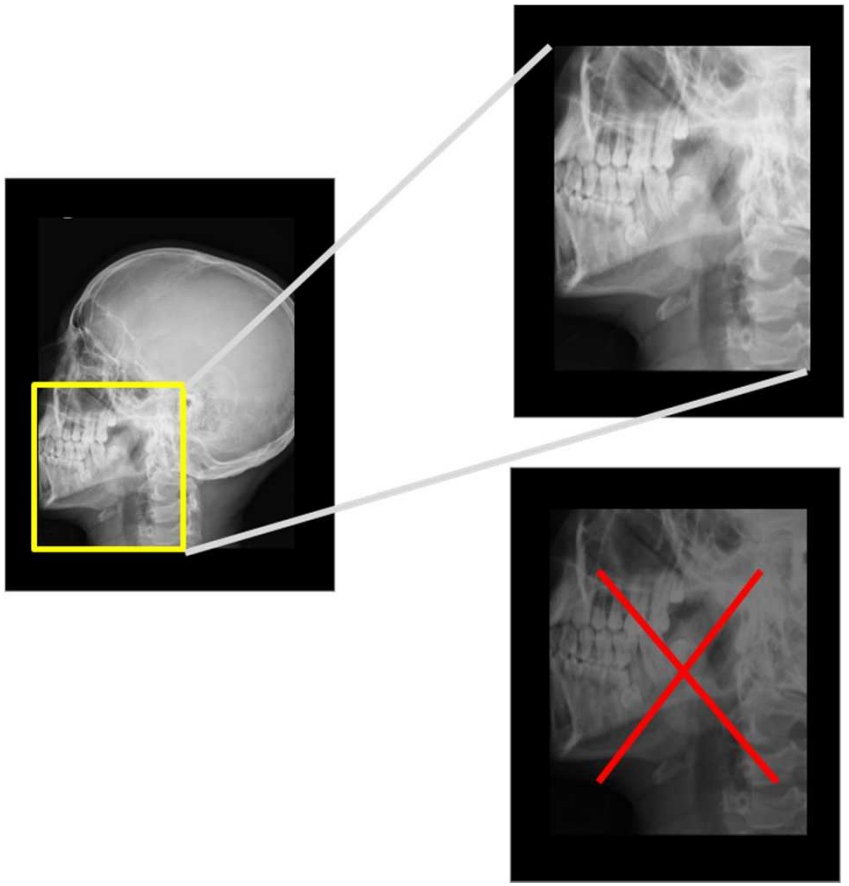

Fig. 1. Example Image for Luminance maintenance

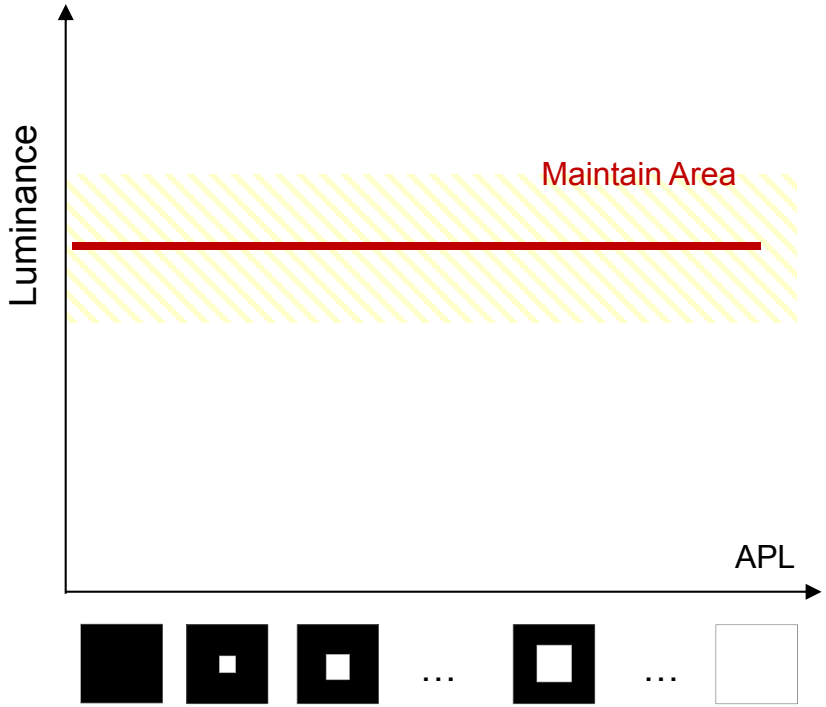

Fig. 2. Expected Results according to APL

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Appendix. Luminance Maintenance

- **Measured that the luminance is maintained even when the time is changed.**
- **By maintaining the luminance, accurate medical images with no change over time can be confirmed.**

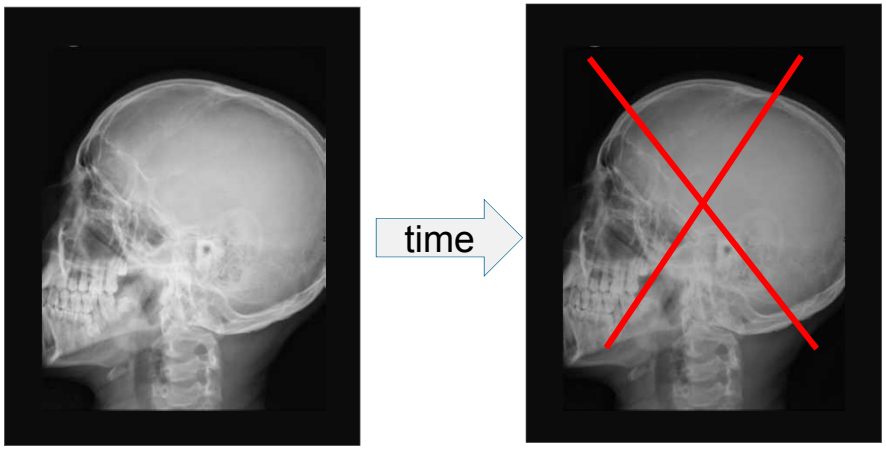

Fig. 1. Example Image for Luminance maintenance

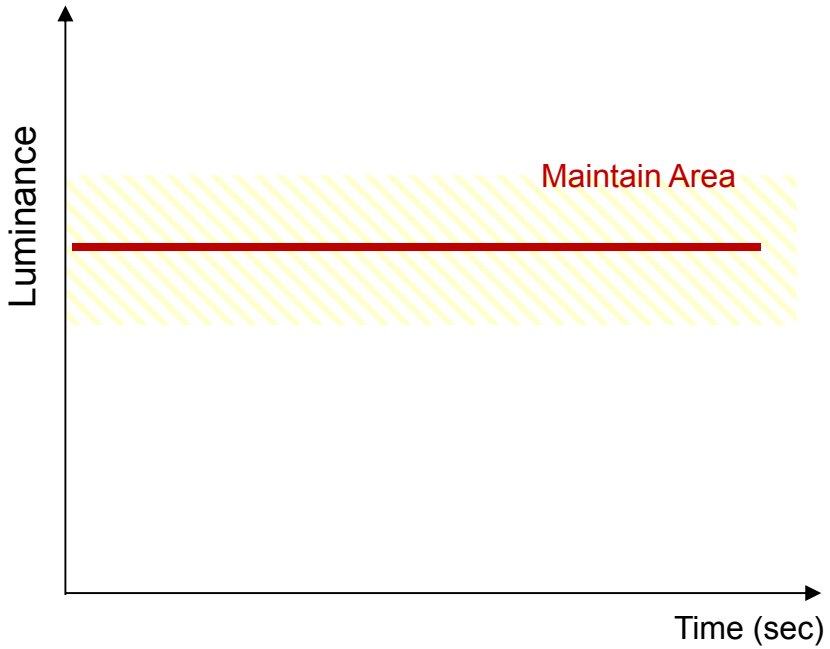

Fig. 2. Expected Results according to time

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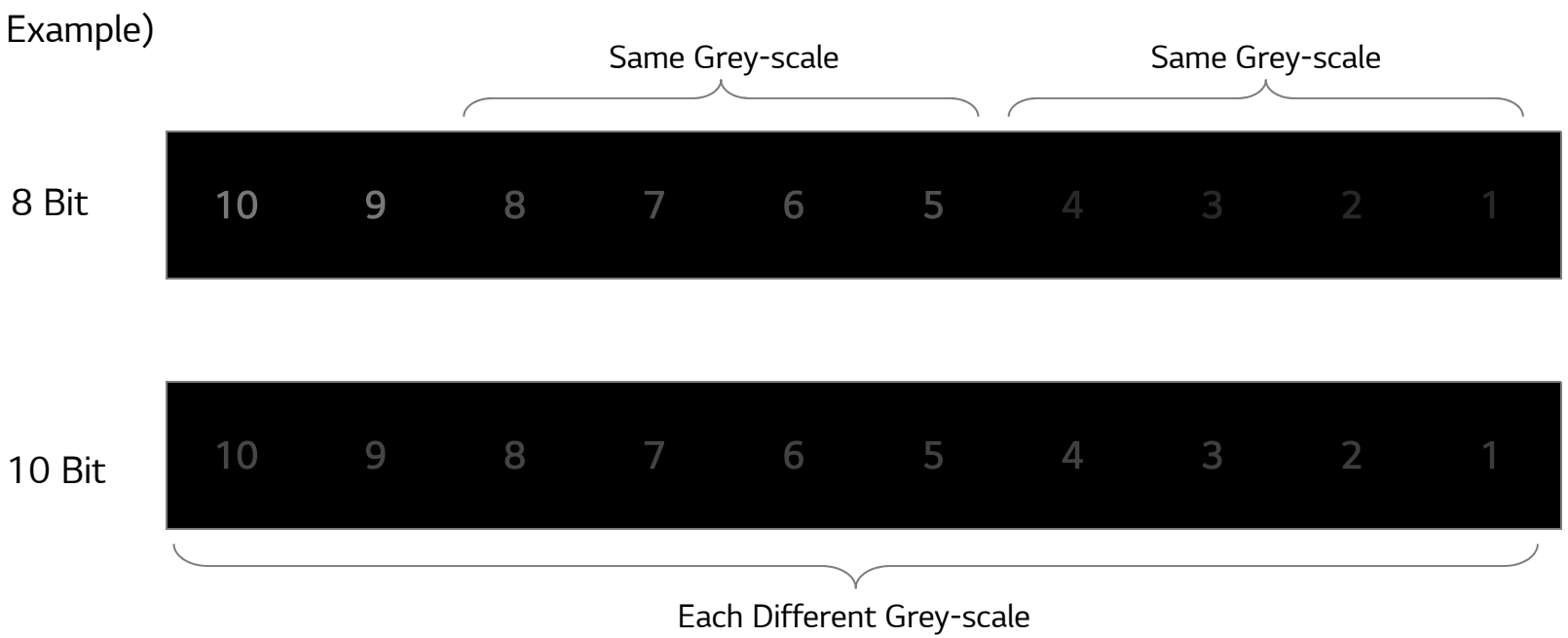
Appendix. Gradation Representation

□ **Visual Assessment**

- Bit-depth is recognized only by specification by D-IC manufacturer

- Representation of 8- and 10-bit display for 10bit pattern are different



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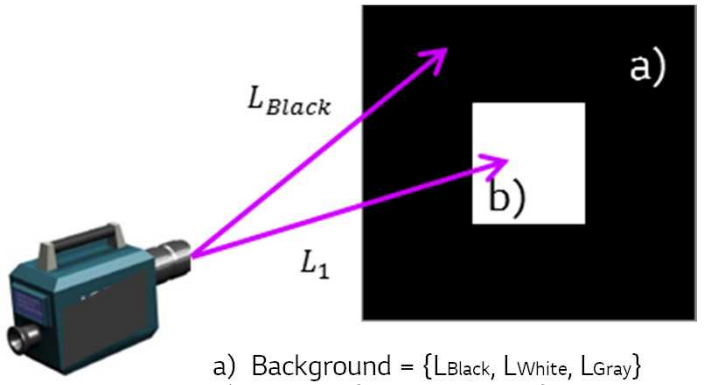
Appendix. Gradation Representation

□ **Electro-Optical Assessment**

- Using the differential value of the background and the pattern, the part where the sign changes is detected to determine the recognition degree of the bit-depth.

Pattern)

Measurement Method)



a) Background = {L_{Black}, L_{White}, L_{Gray}}
b) Patch = {L_1, L_2, L_3, ..., L_{10}}

Example) 10bit-value

Target (Ti)		(B-Ti)'	(B-Ti)"
PTN	Luminance		
1	0.0001	0	0
2	0.0004	-0.602059991	0.60206
3	0.0216	-1.73239376	1.130334
4	0.0803	-0.570261794	-1.16213
⋮		⋮	⋮
127	0.5718	-0.075988391	-0.01943
⋮		⋮	⋮
254	2.516945	-0.003154952	0.003567
255	2.521465	-0.004519972	0.001365
256	2.52674	-0.005274791	0.000755
257	2.530084	-0.003344602	-0.00193
⋮	⋮	⋮	⋮
1023			

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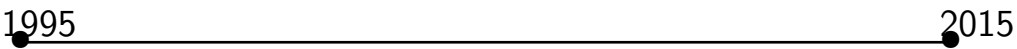
Display Standard Activities in IEC and AAPM

Update to the MIWG, Toronto, October 11, 2017

Aldo Badano

Division of Imaging, Diagnostics, and Software Reliability
Office of Science and Engineering Laboratories
Center for Devices and Radiological Health
U.S. Food and Drug Administration

Medical display timeline from a regulatory perspective

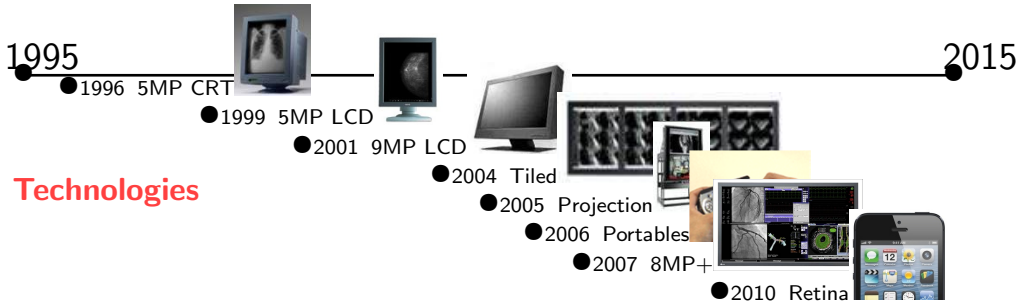


Technologies

Standards

Regulatory

Medical display timeline from a regulatory perspective

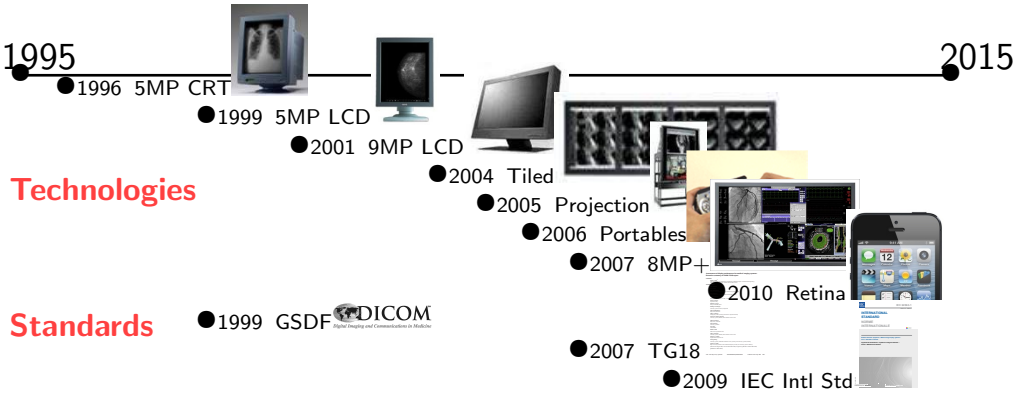


Technologies

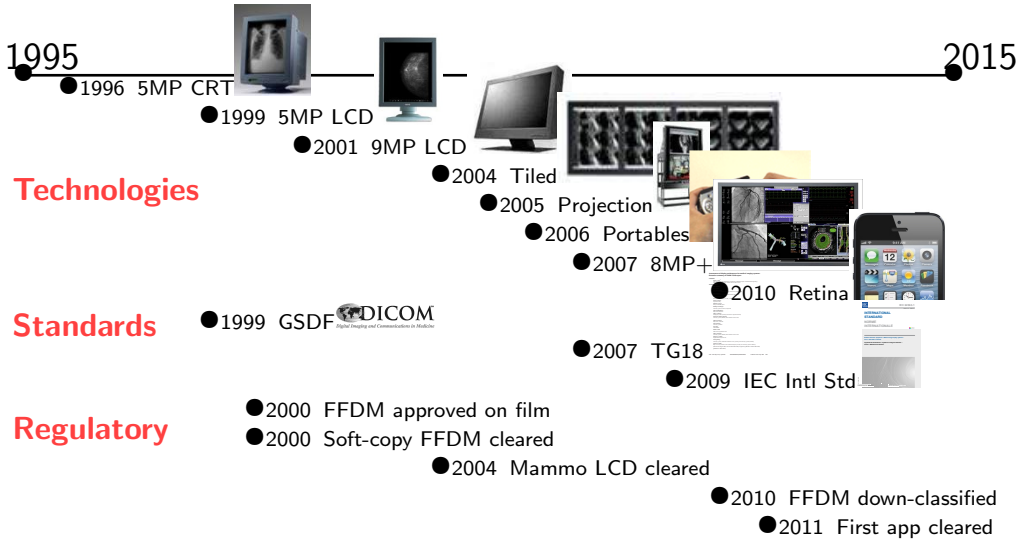
Standards

Regulatory

Medical display timeline from a regulatory perspective



Medical display timeline from a regulatory perspective



Medical display timeline from a regulatory perspective

2000 FFDM approved on film with large clinical study (P990066).

2000 Electronic reading approved as Supplement (P990066/S001).

2004 LCD cleared with small image comparison (K040443).

- Since then, 80+ clearances.
- Today, displays (and detectors)[1] are Class II cleared exclusively with bench testing.

Display Devices for Diagnostic Radiology. Guidance for Industry and FDA
Issued September 29, 2017

[1] . . . which do not raise any significant new questions for safety and effectiveness.

Role of standards in regulatory evaluations

- CDRH actively supports international and national standards
- CDRH liaisons to 29+ IEC/ISO TCs
- CDRH participates in 400+ WGs in 20+ organizations
- 1997 FDA Modernization Act: Declaration of Conformity
- CDRH has 1000+ recognized standards
- Standards + recommendations and guidelines
- Uses: conformity (all or in part), referenced

Relevant documents

- AAPM TG18 - image display (grayscale)
- AAPM TG196 - image display (color)
- AAPM TG270 - display QC
- AAPM TG260 - handheld display
- IEC 62B/MT51 - 62653-1 “Medical Displays” (2^{nd} harmonized edition in preparation)
- IEC TC110 - non-medical, . . . but near-eye (AR/VR/RR, mixed-reality devices)

the end

Tolerances for DICOM in Professional Color Displays

Chris Bai
Color Technology Lab
BenQ Corporation
2017/10/11

Overview

- Scenario / Background
- Differences between Medical Display and Professional Color Display
  - Panel Optical Performance
- AAPM Target
- Results
- Recommendations

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Scenario / Background

- More hospitals / clinics are adopting digital imaging workflow.
- Clinical reviewing displays are increasingly needed.
- Many of the hospitals / clinics are not able to acquire adequate numbers of medical graded displays.
- Space in clinic room is limited, and may not be able to house 2 displays for every physician.
- High demand for asking using **one** color display for reviewing color and grayscale medical images.

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Differences in Panel Optical Performance

Panel Native	Medical Display	Professional Display
		
Luminance (Typical, cd/m^2)	400 ~ 1000	350
Color Temperature (K)	9300 ~ 11000	6500 ~ 7500
Gamma Curve	DICOM	2.2
Black Point (Typical, cd/m^2)	1.0 ~ 2.0	0.3 ~ 0.5
Size	22 ~ 26”	24 ~ 32”

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AAPM Targets

Table 3. Typical ambient lighting levels.

Area	Illumination (lux)
Operating rooms	300–400
Emergency medicine	150–300
Hospital clinical viewing stations	200–250
Staff offices	50–180
Diagnostic reading stations (CT/MR/NM)	15–60
Diagnostic reading stations (x-rays)	2–10

Table 7. Tests, tools, and acceptance criteria for acceptance testing of electronic display systems.

Test	Major Required Tools		Procedure	Acceptance Criteria (for two classes of displays)		Suggested Action (if unacceptable)
	Equipment	Patterns		Primary	Secondary	
Geometric distortions	Flexible ruler or transparent template	TG18-QC	See section 4.1.4	Deviation ≤ 2%	Deviation ≤ 5%	Readjustment, repair or replacement for repeated failures
Reflection[a]	Measuring ruler, light sources, luminance and illuminance meters, illuminator	TG18-AD	See sections 4.2.3 and 4.2.4	$L_{min} \geq 1.5\ L_{amb}$ (ideally $\geq 4\ L_{amb}$)	$L_{min} \geq 1.5\ L_{amb}$ (ideally $\geq 4\ L_{amb}$)	Results are used to adjust the level of ambient lighting
Luminance response	Luminance and illuminance meters	TG18-LN TG18-CT TG18-MP	See sections 4.3.4 and 4.3.3	$L'_{max} \geq 170$ cd/m² $LR' \geq 250$ $\Delta L'_{max} \leq 10\%$ $k_\delta \leq 10\%$	$L'_{max} \geq 100$ cd/m² $LR' \geq 100$ $\Delta L'_{max} \leq 10\%$ $k_\delta \leq 20\%$	Readjustment, recalibration, repair or replacement for repeated failures
Luminance dependencies	luminance-meter, Luminance angular response measurement tool	TG18-UNL TG18-LN TG18-CT	See sections 4.4.3 and 4.4.4	Non-unif. ≤30% $LR'_{\delta,\theta} \geq 175$ $k_{\delta,\theta} \leq 30\%$	Non-unif. ≤30% $LR'_{\delta,\theta} \geq 70$ $k_{\delta,\theta} \leq 60\%$	Readjustment, repair or replacement for repeated failures; Angular results used to define acceptable viewing angle cone
Resolution[b]	luminance-meter Magnifier	TG18-QC TG18-CX TG18-PX	See sections 4.5.3 and 4.5.4.1.2	$0 \leq Cx \leq 4$ $\Delta L \leq 30\%$ RAR=0.9–1.1 AR ≤ 1.5	$0 \leq Cx \leq 6$ $\Delta L \leq 50\%$	Focus adjustment, repair or replacement for repeated failures
Noise[b]	None	TG18-AFC	See section 4.6.3	All targets visible except the smallest	Two largest sizes visible	Reverification of Luminance response, otherwise replacement
Veiling glare	Baffled funnel, telescopic photometer	TG18-GV TG18-GVN TG18-GQs	See sections 4.7.3 and 4.7.4	≥ 3 targets visible, GR ≥ 400	≥ 1 target visible, GR ≥ 150	Reverification of Luminance response, otherwise replacement
Chromaticity	Colorimeter	TG18-UNL80	See section 4.8.4	$\Delta(u',v')$ ≤ 0.01	None	Replacement

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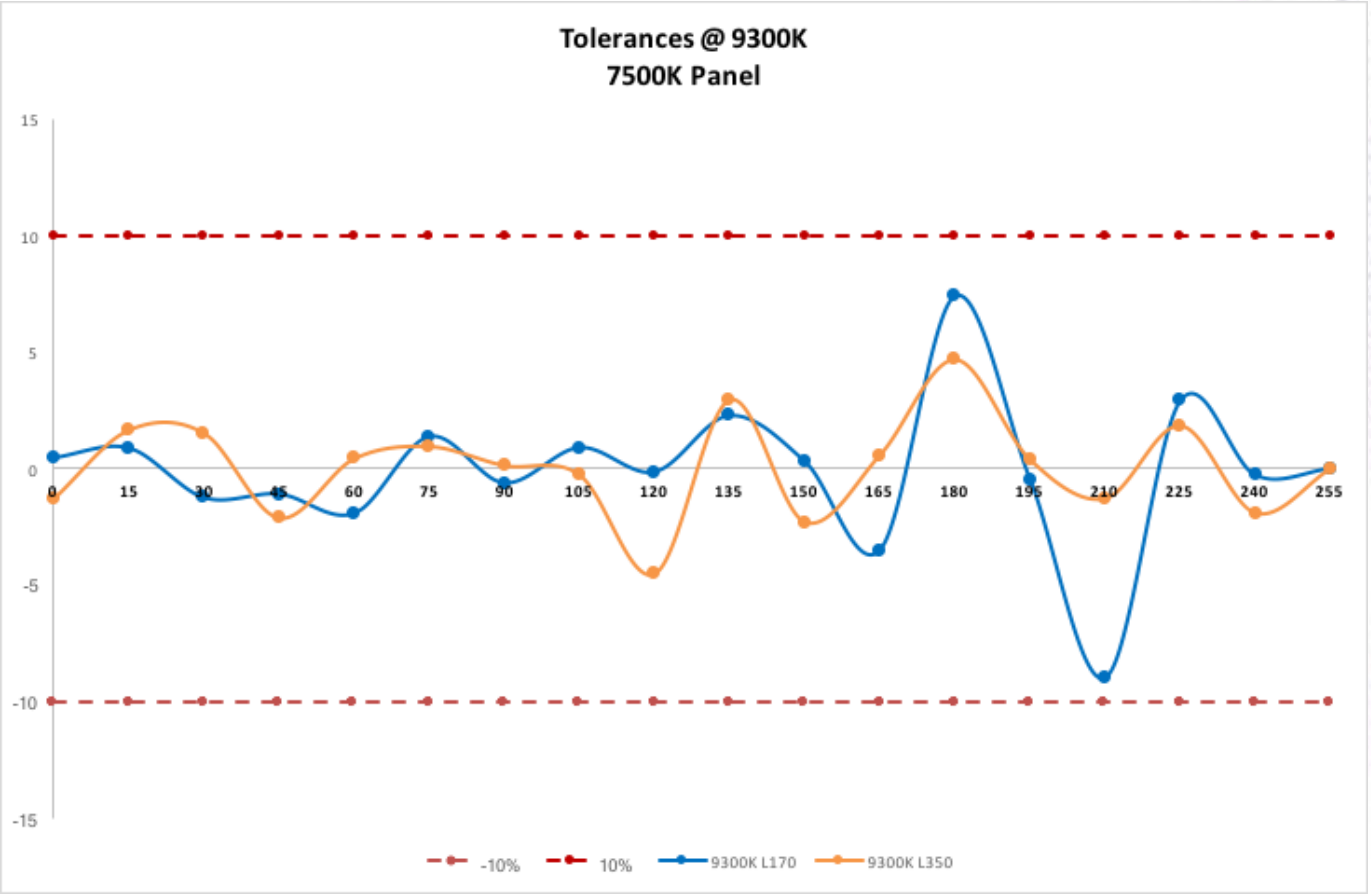
Results – Gamma Curve



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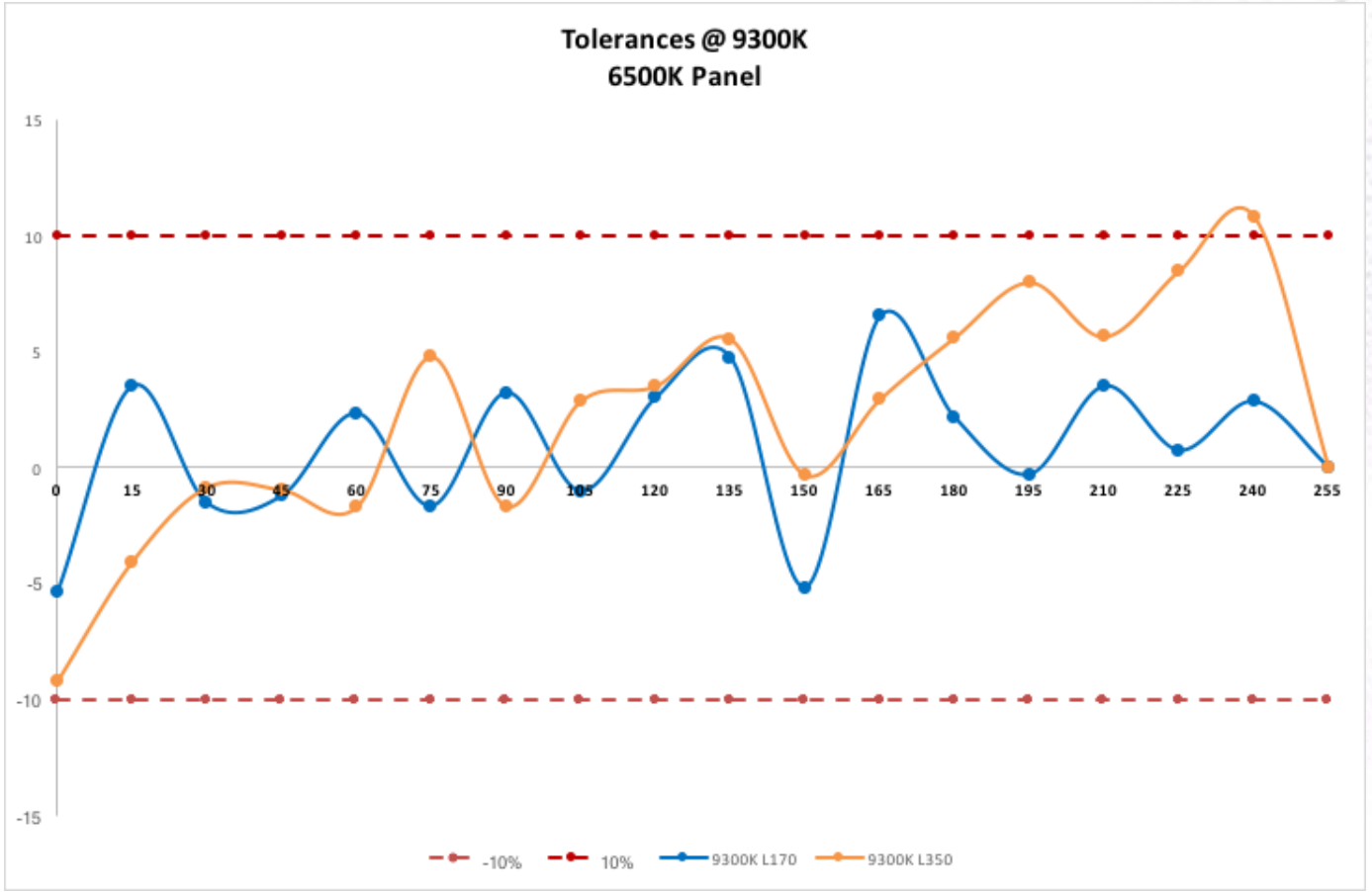
Results – Gamma Curve



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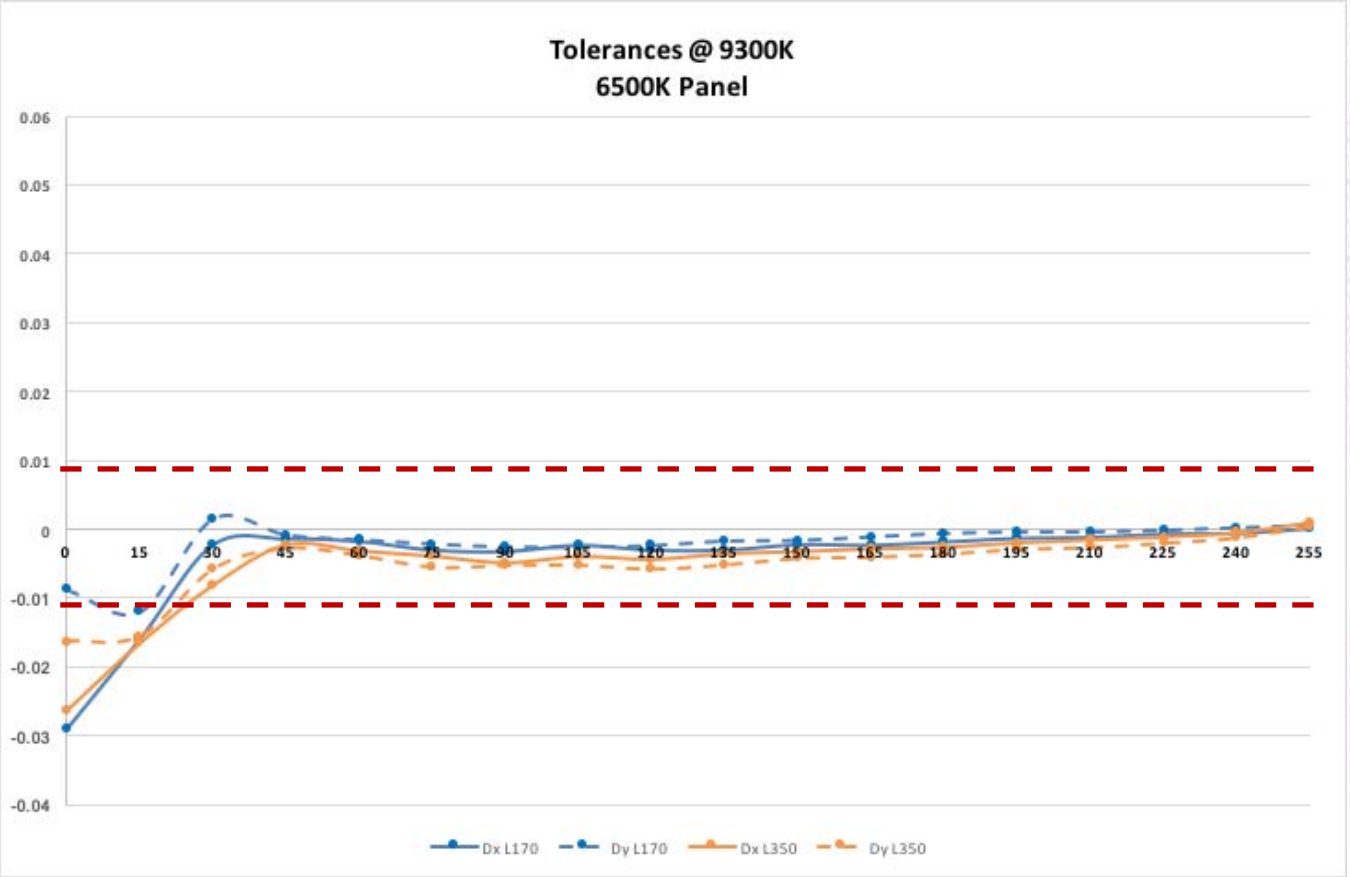
Results – Color Temperature



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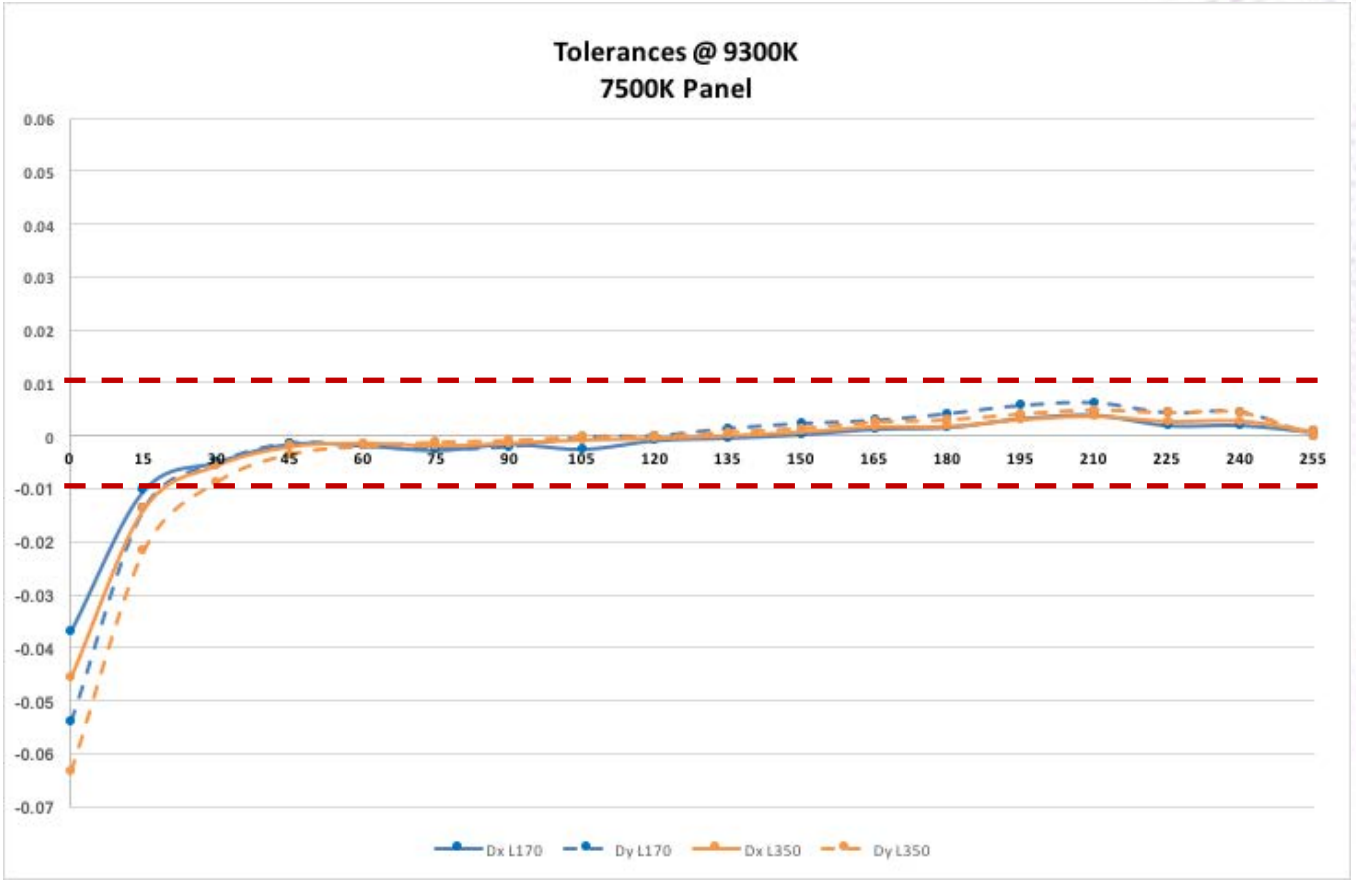
Results – Color Temperature



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Recommendations

- The majority of the panel optical characteristic for Professional Displays are:
  - Luminance: 350 cd/m^2
  - Color Temperature: 6500K
  - Gamma: 2.2
- Recommended Tolerances:
  - Gamma Curve: ±15% in JND
  - CT: ±0.01 in Dx, Dy (@9300K)
  - Luminance: ≧170 cd/m^2

Calibration Time
≦ 30 mins

Field Testing Now

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BenQ
Because it matters

Status	Submitted
Date of Last Update	2017/09/06
Person Assigned	David Clunie mailto:dclunie@dclunie.com
Submitter Name	ICC MIWG
Submission Date	2017/07/24

Correction Number CP-1736
Log Summary: Add Visible Light Photography Attributes corresponding to EXIF 2.31
Name of Standard PS3.3, PS3.6, PS3.17
Rationale for Correction: The Attributes describing the acquisition of visible light photographic images are currently lacking detail related to the characteristics and identification of the camera and lens and the parameters of the acquisition process such as sensitivity. These have been standardized by consumer and professional grade camera manufacturers and reused in many mobile phone devices in the EXIF standard, the most recent version of which is 2.31. This information needs to be made available at the DICOM Attribute level so that they can be accessed and indexed in the normal manner, rather than requiring extraction from the compressed bit stream (e.g., the JPEG APP1 marker segment, which may contain TIFF-encoded EXIF data). *[Ed.Note.: What other IODs, if any, should these Attributes be added to? E.g., Video Photographic Image IOD?* *[Ed.Note.: Should we include an explanation of the APEX values for aperture, shutter speed, etc., e.g., EXIF Annex C and its tables or the APEX article tables, or is a reference sufficient?]* *[Ed.Note.: What do we need to say about TIFF/EP (ISO 12234-2:2001), if anything, esp. regarding different tag numbers for the same thing like ExposureIndex? https://www.loc.gov/preservation/digital/formats/fdd/fdd000073.shtml and https://en.wikipedia.org/wiki/TIFF/EP#Differences_from_TIFF_and_Exif.]* *[Ed.Note.: DNG tags are outside the scope of this CP and will be handled in a Supplement about photographic raw data, and so 50xxx tags should be removed from Annex XXXX.]* *[Ed.Note.: ? See .]*
Correction Wording:

*Amend DICOM PS3.3 as follows (changes to existing text are bold and **underlined** for additions and **~~struckthrough~~** for removals):*

2 Normative References

2.1 International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC)

[ISO 12232] ISO. 2006. *Photography - Digital still cameras - Determination of exposure index, ISO speed ratings, standard output sensitivity, and recommended exposure index*. http://www.iso.org/standard/37777.html .

[ISO 14524] ISO. 2009. *Photography - Electronic still-picture cameras - Methods for measuring opto-electronic conversion functions (OECFs)*. http://www.iso.org/standard/43527.html .

2.6 Other References

[EXIF 2.31] Camera and Imaging Products Association (CIPA). July 2016. 2.31. *Exchangeable Image File Format for Digital Still Cameras - CIPA DC-008, JEITA CP-3451C Translation*. http://cipa.jp/std/documents/e/DC-008-Translation-2016-E.pdf .

[EXIF 2.31] Douglas A. Kerr. August 4, 2007. *APEX — The Additive System of Photographic Exposure*. http://dougkerr.net/Pumpkin/articles/APEX.pdf .

A.32.4.2 VL Photographic Image IOD Entity-Relationship Model

Table A.32.4-1. VL Photographic Image IOD Modules

IE	Module	Reference	Usage
Patient	Patient	???	M
	Clinical Trial Subject	???	U
Study	General Study	???	M
	Patient Study	???	U
	Clinical Trial Study	???	U
Series	General Series	???	M
	Clinical Trial Series	???	U
Equipment	General Equipment	C.7.5.1	M
	VL Photographic Equipment	C.8.12.n1	**U**
Image	General Image	???	M
	General Reference	???	U
	Image Pixel	???	M
	Acquisition Context	???	M
	Device	???	U
	Specimen	???	C - Required if Imaging Subject is a specimen
	VL Image	C.8.12.1	M
	VL Photographic Acquisition	C.8.12.n2	**U**
	VL Photographic Geolocation	C.8.12.n3	**U**
	Overlay Plane	???	U
	ICC Profile	???	U
	SOP Common	???	M
	Common Instance Reference	???	U

C.7.5 Common Equipment IE Modules

C.7.5.1 General Equipment Module

Table C.7-8. General Equipment Module Attributes

Attribute Name	Tag	Type	Attribute Description
Manufacturer	(0008,0070)	2	Manufacturer of the equipment that produced the composite instances.
Institution Name	(0008,0080)	3	Institution where the equipment that produced the composite instances is located.
Institution Address	(0008,0081)	3	Mailing address of the institution where the equipment that produced the composite instances is located.
Station Name	(0008,1010)	3	User defined name identifying the machine that produced the composite instances.
Institutional Department Name	(0008,1040)	3	Department in the institution where the equipment that produced the composite instances is located.
Manufacturer's Model Name	(0008,1090)	3	Manufacturer's model name of the equipment that produced the composite instances.
Device Serial Number	(0018,1000)	3	Manufacturer's serial number of the equipment that produced the composite instances. **Note** This identifier corresponds to the device that actually created the images, such as a CR plate reader or a CT console, and may not be sufficient to identify all of the equipment in the imaging chain, such as the generator or gantry or plate.
Software Versions	(0018,1020)	3	Manufacturer's designation of software version of the equipment that produced the composite instances. See Section C.7.5.1.1.3.
Gantry ID	(0018,1008)	3	Identifier of the gantry or positioner.
UDI Sequence	(0018,100A)	3	Unique Device Identifier (UDI) of the entire equipment. For example, the entire CT Scanner. **Note** 1. Multiple items may be present if the entire equipment has UDIs issued by different Issuing Authorities. 2. Multiple items may be present if multiple pieces of equipment were involved in the creation of this instance, e.g., the DR plate and the DR reader. 3. his is not intended to contain the UDIs of the components of the equipment, such as the x-ray tube of the CT scanner. Such information is stored elsewhere and accessible using the UDI of the entire equipment and a date. One or more Items are permitted in this Sequence.
>Include ???			
Spatial Resolution	(0018,1050)	3	The inherent limiting resolution in mm of the acquisition equipment for high contrast objects for the data gathering and reconstruction technique chosen. If variable across the images of the series, the value at the image center.
Date of Last Calibration	(0018,1200)	3	Date when the image acquisition device calibration was last changed in any way. Multiple entries may be used for additional calibrations at other times. See Section C.7.5.1.1.1 for further explanation.

Attribute Name	Tag	Type	Attribute Description
Time of Last Calibration	(0018,1201)	3	Time when the image acquisition device calibration was last changed in any way. Multiple entries may be used. See Section C.7.5.1.1.1 for further explanation.
Pixel Padding Value	(0028,0120)	1C	Single pixel value or one limit (inclusive) of a range of pixel values used in an image to pad to rectangular format or to signal background that may be suppressed. See Section C.7.5.1.1.2 for further explanation. Required if Pixel Padding Range Limit (0028,0121) is present and either Pixel Data (7FE0,0010) or Pixel Data Provider URL (0028,7FE0) is present. May be present otherwise only if Pixel Data (7FE0,0010) or Pixel Data Provider URL (0028,7FE0) is present. **Note** 1. The Value Representation of this Attribute is determined by the value of Pixel Representation (0028,0103). 2. This Attribute is not used in Presentation State Instances; there is no means in a Presentation State to "override" any Pixel Padding Value specified in the referenced images. 3. This Attribute does apply to RT Dose and Segmentation instances, since they include Pixel Data. 4. This Attribute does not apply when Float Pixel Data (7FE0,0008) or Double Float Pixel Data (7FE0,0009) are used instead of Pixel Data (7FE0,0010); Float Pixel Padding Value (0028,0122) or Double Float Pixel Padding Value (0028,0123), respectively, are used instead, and defined at the Image, not the Equipment, level.

C.7.5.1.1 General Equipment Attribute Descriptions

Note

The attributes Manufacturer (0008,0070), Manufacturer's Model Name (0008,1090) and Device Serial Number (0018,1000) are intended to be a primary identification of the system that produces the data (e.g., modality or workstation application providing the content of the SOP Instance) and not the identification of the component that encodes the SOP Instance (e.g., a commonly used DICOM encoding toolkit).

C.7.5.1.1.1 Date of Last Calibration, Time of Last Calibration

Date of Last Calibration (0018,1200) and Time of Last Calibration (0018,1201) are used to convey the date and time of calibration. The Attribute Date of Last Calibration (0018,1200) may be supported alone, however, Time of Last Calibration (0018,1201) Attribute has no meaning unless Attribute Date of Last Calibration (0018,1200) is also supported. The order for each Attribute shall be from the oldest date/time to the most recent date/time. When the Attributes are both supported they shall be provided as pairs.

C.7.5.1.1.2 Pixel Padding Value and Pixel Padding Range Limit

C.7.5.1.1.3 Software Versions

Software Versions (0018,1020) is a multi-valued attribute. For equipment that is composed of several components, it may be used to identify the name and version for each of those components. This may also include the identifier and version of libraries or configuration files that significantly affect the production of the SOP Instance.

C.7.5.2 Enhanced General Equipment Module

Table C.7-8b specifies the Attributes that identify and describe the piece of equipment that produced a Series of Composite Instances.

Note

1. This table contains a subset of the attributes of General Equipment Module (Table C.7-8) but the Type Designation is changed into Type 1. Including this module in an IOD overwrites the Type Designation of the General Equipment Module.

2. The attributes are intended to be a primary identification of the system that produces the data (e.g., modality or workstation application providing the content of the SOP Instance) and not the identification of the component that encodes the SOP Instance (e.g., a commonly used DICOM encoding toolkit).

Table C.7-8b. Enhanced General Equipment Module Attributes

Attribute Name	Tag	Type	Attribute Description
Manufacturer	(0008,0070)	1	Manufacturer of the equipment that produced the composite instances.
Manufacturer's Model Name	(0008,1090)	1	Manufacturer's model name of the equipment that produced the composite instances.
Device Serial Number	(0018,1000)	1	Manufacturer's serial number of the equipment that produced the composite instances.
Software Versions	(0018,1020)	1	Manufacturer's designation of software version of the equipment that produced the composite instances. See Section C.7.5.1.1.3.

C.8.12 VL Modules and Functional Group Macros

C.8.12.1 VL Image Module

Table C.8-77 specifies the Attributes that describe a VL Image produced by Endoscopy (ES), General Microscopy (GM), Automated-Stage Microscopy (SM), External-camera Photography (XC), or other VL imaging Modalities.

Table C.8-77. VL Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Image Type	(0008,0008)	1	Image identification characteristics. See Section C.8.12.1.1.6 for specialization.
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the pixel data. See Section C.8.12.1.1.1 for specialization of this Attribute.
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. Each sample shall have the same number of bits allocated. See Section C.8.12.1.1.2 for specialization of this Attribute. See ???? for further explanation.
Bits Stored	(0028,0101)	1	Number of bits stored for each pixel sample. Each sample shall have the same number of bits stored. See Section C.8.12.1.1.2 for specialization of this Attribute. See ???? for further explanation.
High Bit	(0028,0102)	1	Most significant bit for pixel sample data. Each sample shall have the same high bit. See Section C.8.12.1.1.2 for specialization of this Attribute. See ???? for further explanation.
Pixel Representation	(0028,0103)	1	Data representation of the pixel samples. Each sample shall have the same pixel representation. See Section C.8.12.1.1.3 for specialization of this Attribute.

Attribute Name	Tag	Type	Attribute Description
Samples per Pixel	(0028,0002)	1	Number of samples (planes) per image. See Section C.8.12.1.1.4 for specialization of this Attribute.
Planar Configuration	(0028,0006)	1C	Indicates whether the pixel data are encoded color-by-plane or color-by-pixel. Required if Samples per Pixel (0028,0002) has a value greater than 1. See Section C.8.12.1.1.5 for specialization of this Attribute.
Content Time	(0008,0033)	1C	The time the image pixel data creation started. Required if the Image is part of a series in which the images are temporally related. **Note** This Attribute was formerly known as Image Time.
Lossy Image Compression	(0028,2110)	2	Specifies whether an Image has undergone lossy compression (at a point in its lifetime). **Enumerated Values:** **00** Image has NOT been subjected to lossy compression. **01** Image has been subjected to lossy compression. Once this value has been set to 01 it shall not be reset. See ???
Referenced Image Sequence	(0008,1140)	1C	A Sequence that references other images significantly related to this image. One or more Items are permitted in this Sequence. Required if Image Type (0008,0008) Value 3 is present and has a value of "STEREO L" or "STEREO R". May also be present otherwise. See Section C.8.12.1.1.7.
>Include ???			
>Purpose of Reference Code Sequence	(0040,A170)	2	Describes the purpose for which the reference is made. Zero or one Item shall be included in this Sequence.
>>Include ???			*Defined ????.*
Window Center	(0028,1050)	3	Window Center for display. See ??? for further explanation. Meaningful only if Photometric Interpretation (0028,0004) is MONOCHROME2.
Window Width	(0028,1051)	1C	Window Width for display. See ??? for further explanation. Required if Window Center (0028,1050) is present.
Anatomic Region Sequence	(0008,2218)	1C	Sequence that identifies the anatomic region of interest in this image (i.e., external anatomy, surface anatomy, or general region of the body). Only a single Item shall be included in this Sequence. Required if Number of Frames (0028,0008) is present and Specimen Description Sequence (0040,0560) is absent. May be present otherwise.
>Include ???			Defined ???? is defined for the Video Endoscopic IOD. For other IODs, no Context ID is defined.

Attribute Name	Tag	Type	Attribute Description
>Anatomic Region Modifier Sequence	(0008,2220)	3	Sequence of Items that modifies the anatomic region of interest of this image One or more Items are permitted in this Sequence.
>>Include ???			*Baseline ????.*
Include ???			No Context ID is defined. These Type 3 Attributes are not appropriate when Specimen Description Sequence (0040,0560) is present, as it includes the Primary Anatomic Structure Macro for each specimen in the image.
Channel Description Code Sequence	(0022,001A)	3	Describes the light color used for each channel to generate the image. If Photometric Interpretation (0028,0004) has one of the YBR values, the meaning is for pixel data in an equivalent RGB encoding. **Note** Interpretation and representation of RGB images rely on the assumption that the red channel really contains the red wavelength range of illumination light, the blue channel the blue wavelength range, etc. Some modalities use the RGB Photometric Interpretation as a container representing 3 channels of any illumination wavelength. Shall have the same number of items as the value of Samples per Pixel (0028,0002). The channels shall be described in the order in which the channels are encoded.
>Include ???			*Baseline ????.*
Pixel Spacing	(0028,0030)	3	Physical distance in the imaging target (patient or specimen) between the center of each pixel, specified as a numeric pair - adjacent row spacing \ adjacent column spacing, in mm. See ???.

C.8.12.1.1 VL Image Module Attribute Descriptions

C.8.12.1.1.1 Photometric Interpretation

Enumerated Values:

MONOCHROME2
RGB
YBR_FULL_422
YBR_PARTIAL_420
YBR_RCT
YBR_ICT

Photometric Interpretation (0028,0004) shall be RGB for uncompressed or lossless compressed Transfer Syntaxes that do not have defined color space transformations, YBR_ICT for irreversible JPEG 2000 Transfer Syntaxes, YBR_RCT for reversible JPEG 2000 Transfer Syntaxes, YBR_PARTIAL_420 for MPEG2, MPEG-4 AVC/H.264 and HEVC/H.265 Transfer Syntaxes and YBR_FULL_422 for JPEG lossy compressed Transfer Syntaxes.

Note

1. The YBR_FULL Photometric Interpretation (0028,0004), such as might be used with the RLE Transfer Syntax, is not permitted.

2. There is no formal color space defined, hence "false" color applications that encode near-visible light images may be encoded, for example, as RGB.

C.8.12.1.1.2 Bits Allocated, Bits Stored, and High Bit

Enumerated Values of Bits Allocated (0028,0100):

8

Enumerated Values of Bits Stored (0028,0101):

8

Enumerated Values of High Bit (0028,0102):

7

C.8.12.1.1.3 Pixel Representation

Enumerated Values:

0

C.8.12.1.1.4 Samples Per Pixel

Enumerated Values when Photometric Interpretation (0028,0004) is MONOCHROME2:

1

Enumerated Values when Photometric Interpretation (0028,0004) is RGB or YBR_FULL_422 or YBR_PARTIAL_420 or YBR_RCT or YBR_ICT:

3

C.8.12.1.1.5 Planar Configuration

This value shall be present if Samples per Pixel (0028,0002) has a value greater than 1.

Enumerated Values:

0

Note

The prohibition of a value of 1 for Planar Configuration (0028,0006) prevents the use of the RLE Transfer Syntax.

C.8.12.1.1.6 Image Type

The Image Type attribute identifies important image characteristics in a multiple valued data element. For Visible Light, Image Type is specialized as follows:

- Value 1 shall identify the Pixel Data Characteristics in accordance with ???.

Enumerated Values:

ORIGINAL
DERIVED

- Value 2 shall identify the Patient Examination Characteristics in accordance with ???.

Enumerated Values:

PRIMARY

SECONDARY

- Value 3 may be absent, but if present shall identify the members of a stereo pair, in which case Referenced Image Sequence (0008,1140) is used to identify the other member of the pair.

Enumerated Values:

STEREO L Image is the left image (relative to the observer's left) of a stereo pair acquisition
STEREO R Image is the right image (relative to the observer's right) of a stereo pair acquisition

- Other Values are implementation specific (optional).

C.8.12.1.1.7 Referenced Image Sequence

When Image Type (0008,0008) Value 3 is STEREO L or STEREO R, Referenced Image Sequence (0008,1140) shall be used to identify the corresponding SOP Instance of the Stereoscopic acquisition. In this case, either:

- only a single item shall be present, or
- multiple items may be present, each with the Purpose of Reference Code Sequence (0040,A170) present, and only the first item having the Purpose of Reference value (121315, DCM, "Other image of stereoscopic pair").

...

C.8.12.n1 VL Photographic Equipment Module

Table C.8.12.n1-1 specifies the Attributes that identify and describe a photographic device such as a camera.

Table C.8.12.n1-1. VL Photographic Equipment Module Attributes

Attribute Name	Tag	Type	Attribute Description
...	...	...	...

TBD: Copy from Annex XXXX when completed.

C.8.12.n2 VL Photographic Acquisition Module

Table C.8.12.n2-1 specifies the Attributes that describe the process of acquisition of a photographic image.

Table C.8.12.n2-1. VL Photographic Acquisition Module Attributes

Attribute Name	Tag	Type	Attribute Description
...	...	...	...

TBD: Copy from Annex XXXX when completed.

C.8.12.n3 VL Photographic Geolocation Module

Table C.8.12.n3-1 specifies the Attributes that describe the geographic location during acquisition of a photographic image.

Table C.8.12.n3-1. VL Photographic Geolocation Module Attributes

Attribute Name	Tag	Type	Attribute Description
...	...	...	...

TBD: Copy from Annex XXXX when completed.

Amend DICOM PS3.6 to add new Data Elements as follows:

TBD: Copy from Annex XXXX when completed.

Amend DICOM PS3.17 to add new Annex as follows:

XXXX Mapping of Visible Light Photography Related Attributes to EXIF Tags (Informative)

Table XXXX-1 describes the mapping of Visible Light Photography related Attributes to EXIF Tags as defined in [EXIF 2.31]. The list of EXIF and associated TIFF tags was derived from the table at http://www.exiv2.org/tags.html updated to remove redundancies and resolve differences between EXIF 2.3 and 2.31.

Table XXXX-1. Mapping of Visible Light Photography Related Attributes to EXIF Tags

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(0008,0201)	Timezone Offset From UTC	SOP Common	0x9010	36880	Photo 231	OffsetTime	Ascii	A tag used to record the offset from UTC (the time difference from Universal Time Coordinated including daylight saving time) of the time of DateTime tag. The format when recording the offset is "±HH:MM". The part of "±" shall be recorded as "+" or "-". When the offset are unknown, all the character spaces except colons (":") should be filled with blank characters, or else the Interoperability field should be filled with blank characters. The character string length is 7 Bytes including NULL for termination. When the field is left blank, it is treated as unknown.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(0008,0201)	Timezone Offset From UTC	SOP Common	0x9011	36881	Photo 231	OffsetTimeOriginal	Ascii	A tag used to record the offset from UTC (the time difference from Universal Time Coordinated including daylight saving time) of the time of DateTimeOriginal tag. The format when recording the offset is "±HH:MM". The part of "±" shall be recorded as "+" or "-". When the offset are unknown, all the character spaces except colons (":") should be filled with blank characters, or else the Interoperability field should be filled with blank characters. The character string length is 7 Bytes including NULL for termination. When the field is left blank, it is treated as unknown.
(0008,0201)	Timezone Offset From UTC	SOP Common	0x9012	36882	Photo 231	OffsetTimeDigitized	Ascii	A tag used to record the offset from UTC (the time difference from Universal Time Coordinated including daylight saving time) of the time of DateTimeDigitized tag. The format when recording the offset is "±HH:MM". The part of "±" shall be recorded as "+" or "-". When the offset are unknown, all the character spaces except colons (":") should be filled with blank characters, or else the Interoperability field should be filled with blank characters. The character string length is 7 Bytes including NULL for termination. When the field is left blank, it is treated as unknown.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggpa,9400)	Temperature	VL Photographic Acquisition	0x9400	37888	Photo 231	Temperature	SRational	Temperature as the ambient situation at the shot, for example the room temperature where the photographer was holding the camera. The unit is °C. If the denominator of the recorded value is FFFFFFFF.H, unknown shall be indicated. Obtaining method or accuracy is not stipulated. Therefore methods like that the photographer manually input the numeric, as an example, are usable.
(ggpa,9401)	Humidity	VL Photographic Acquisition	0x9401	37889	Photo 231	Humidity	Rational	Humidity as the ambient situation at the shot, for example the room humidity where the photographer was holding the camera. The unit is %. If the denominator of the recorded value is FFFFFFFF.H, unknown shall be indicated. Obtaining method or accuracy is not stipulated. Therefore methods like that the photographer manually input the numeric, as an example, are usable.
(ggpa,9402)	Pressure	VL Photographic Acquisition	0x9402	37890	Photo 231	Pressure	Rational	Pressure as the ambient situation at the shot, for example the room atmospfere where the photographer was holding the camera or the water pressure under the sea. The unit is hPa. If the denominator of the recorded value is FFFFFFFF.H, unknown shall be indicated. Obtaining method or accuracy is not stipulated. Therefore methods like that the photographer manually input the numeric, as an example, are usable.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggpa,9403)	Water Depth	VL Photographic Acquisition	0x9403	37891	Photo 231	WaterDepth	SRational	Water depth as the ambient situation at the shot, for example the water depth of the camera at underwater photography. The unit is m. When the value is negative, the absolute value of it indicates the height (elevation) above the water level. If the denominator of the recorded value is FFFFFFFF.H, unknown shall be indicated. Obtaining method or accuracy is not stipulated. Therefore methods like that the photographer manually input the numeric, as an example, are usable.
(ggpa,9404)	Acceleration	VL Photographic Acquisition	0x9404	37892	Photo 231	Acceleration	Rational	Acceleration (a scalar regardless of direction) as the ambient situation at the shot, for example the driving acceleration of the vehicle which the photographer rode on at the shot. The unit is mGal (10-5 m/s2). If the denominator of the recorded value is FFFFFFFF.H, unknown shall be indicated. Obtaining method or accuracy is not stipulated. Therefore methods like that the photographer manually input the numeric, as an example, are usable.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggpa,9405)	Camera Elevation Angle	VL Photographic Acquisition	0x9405	37893	Photo 231	Camera ElevationAngle	SRational	Elevation/depression. angle of the orientation of the camera(imaging optical axis) as the ambient situation at the shot. The unit is degree(°). The range of the value is from -180 to less than 180. If the denominator of the recorded value is FFFFFFFF.H, unknown shall be indicated. Obtaining method or accuracy is not stipulated. Therefore methods like that the photographer manually input the numeric, as an example, are usable.
(ggpa,829a)	Exposure Time	VL Photographic Acquisition	0x829a	33434	Photo	ExposureTime	Rational	Exposure time, given in seconds (sec).
(ggpa,829d)	FNumber	VL Photographic Acquisition	0x829d	33437	Photo	FNumber	Rational	The F number.
(ggpa,8822)	Exposure Program	VL Photographic Acquisition	0x8822	34850	Photo	ExposureProgram	Short	The class of the program used by the camera to set exposure when the picture is taken.
(ggpa,8824)	Spectral Sensitivity	VL Photographic Acquisition	0x8824	34852	Photo	SpectralSensitivity	Ascii	Indicates the spectral sensitivity of each channel of the camera used. The tag value is an ASCII string compatible with the standard developed by the ASTM Technical Committee.
(ggpa,8827)	ISOSpeedRatings	VL Photographic Acquisition	0x8827	34855	Photo	ISOSpeedRatings	Short	Indicates the ISO Speed and ISO Latitude of the camera or input device as specified in [ISO 12232].
(ggpa,8828)	OECF	VL Photographic Acquisition	0x8828	34856	Photo	OECF	Undefined	Indicates the Opto-Electoric Conversion Function (OECF) specified in [ISO 14524]. <OECF> is the relationship between the camera optical input and the image values.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggpa,8830)	Sensitivity Type	VL Photographic Acquisition	0x8830	34864	Photo	SensitivityType	Short	The SensitivityType tag indicates which one of the parameters of ISO12232 is the PhotographicSensitivity tag. Although it is an optional tag, it should be recorded when a PhotographicSensitivity tag is recorded. Value = 4, 5, 6, or 7 may be used in case that the values of plural parameters are the same.
(ggpa,8831)	Standard Output Sensitivity	VL Photographic Acquisition	0x8831	34865	Photo	Standard OutputSensitivity	Long	This tag indicates the standard output sensitivity value of a camera or input device defined in [ISO 12232]. When recording this tag, the Photographic Sensitivity and Sensitivity Type tags shall also be recorded.
(ggpa,8832)	Recommended Exposure Index	VL Photographic Acquisition	0x8832	34866	Photo	Recommended ExposureIndex	Long	This tag indicates the recommended exposure index value of a camera or input device defined in [ISO 12232]. When recording this tag, the Photographic Sensitivity and Sensitivity Type tags shall also be recorded.
(ggpa,8833)	ISOSpeed	VL Photographic Acquisition	0x8833	34867	Photo	ISOSpeed	Long	This tag indicates the ISO speed value of a camera or input device that is defined in [ISO 12232]. When recording this tag, the PhotographicSensitivity and SensitivityType tags shall also be recorded.
(ggpa,8834)	ISOSpeed Latitudeyyy	VL Photographic Acquisition	0x8834	34868	Photo	ISOSpeedLatitudeyyy	Long	This tag indicates the ISO speed latitude yyy value of a camera or input device that is defined in [ISO 12232]. However, this tag shall not be recorded without ISOSpeed and ISOSpeedLatitudezzz.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggpa,8835)	ISOSpeed Latitudezzz	VL Photographic Acquisition	0x8835	34869	Photo	ISOSpeedLatitudezzz	Long	This tag indicates the ISO speed latitude zzz value of a camera or input device that is defined in [ISO 12232]. However, this tag shall not be recorded without ISOSpeed and ISOSpeedLatitudeyyy.
(ggpa,9000)	Exif Version	VL Photographic Acquisition	0x9000	36864	Photo	ExifVersion	Undefined	The version of this standard supported. Nonexistence of this field is taken to mean nonconformance to the standard.
(0008,002A)	Acquisition Date Time	General Image	0x9003	36867	Photo	DateTimeOriginal	Ascii	The date and time when the original image data was generated. For a digital still camera the date and time the picture was taken are recorded.
	Content Date, Content Time	General Image	0x9004	36868	Photo	DateTimeDigitized	Ascii	The date and time when the image was stored as digital data.
-	-	-	0x9101	37121	Photo	Components Configuration	Undefined	Information specific to compressed data. The channels of each component are arranged in order from the 1st component to the 4th. For uncompressed data the data arrangement is given in the <Photometric Interpretation> tag. However, since <Photometric Interpretation> can only express the order of Y, Cb and Cr, this tag is provided for cases when compressed data uses components other than Y, Cb, and Cr and to enable support of other sequences.
-	-	-	0x9102	37122	Photo	CompressedBitsPerPixel	Rational	Information specific to compressed data. The compression mode used for a compressed image is indicated in unit bits per pixel.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggpa,9201)	Shutter Speed Value	VL Photographic Acquisition	0x9201	37377	Photo	ShutterSpeedValue	SRational	Shutter speed. The unit is the APEX (Additive System of Photographic Exposure) setting.
(ggpa,9202)	Aperture Value	VL Photographic Acquisition	0x9202	37378	Photo	ApertureValue	Rational	The lens aperture. The unit is the APEX value.
(ggpa,9203)	Brightness Value	VL Photographic Acquisition	0x9203	37379	Photo	BrightnessValue	SRational	The value of brightness. The unit is the APEX value. Ordinarily it is given in the range of -99.99 to 99.99.
(ggpa,9204)	Exposure Bias Value	VL Photographic Acquisition	0x9204	37380	Photo	ExposureBiasValue	SRational	The exposure bias. The units is the APEX value. Ordinarily it is given in the range of -99.99 to 99.99.
(ggpa,9205)	Max Aperture Value	VL Photographic Acquisition	0x9205	37381	Photo	MaxApertureValue	Rational	The smallest F number of the lens. The unit is the APEX value. Ordinarily it is given in the range of 00.00 to 99.99, but it is not limited to this range.
(ggpa,9206)	Subject Distance	VL Photographic Acquisition	0x9206	37382	Photo	SubjectDistance	Rational	The distance to the subject, given in meters.
(ggpa,9207)	Metering Mode	VL Photographic Acquisition	0x9207	37383	Photo	MeteringMode	Short	The metering mode.
(ggpa,9208)	Light Source	VL Photographic Acquisition	0x9208	37384	Photo	LightSource	Short	The kind of light source.
(ggpa,9209)	Flash	VL Photographic Acquisition	0x9209	37385	Photo	Flash	Short	This tag is recorded when an image is taken using a strobe light (flash).
(ggpa,920a)	Focal Length	VL Photographic Acquisition	0x920a	37386	Photo	FocalLength	Rational	The actual focal length of the lens, in mm. Conversion is not made to the focal length of a 35 mm film camera.
(ggpa,9214)	Subject Area	VL Photographic Acquisition	0x9214	37396	Photo	SubjectArea	Short	This tag indicates the location and area of the main subject in the overall scene.
(ggpa,927c)	Maker Note	VL Photographic Acquisition	0x927c	37500	Photo	MakerNote	Undefined	A tag for manufacturers of Exif writers to record any desired information. The contents are up to the manufacturer.
	Image Comments	General Image	0x9286	37510	Photo	UserComment	Comment	A tag for Exif users to write keywords or comments on the image besides those in <ImageDescription>, and without the character code limitations of the <Image Description> tag.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggpa,9290)	Sub Sec Time	VL Photographic Acquisition	0x9290	37520	Photo	SubSecTime	Ascii	A tag used to record fractions of seconds for the <DateTime> tag.
(0008,002A)	Acquisition Date Time	General Image	0x9291	37521	Photo	SubSecTimeOriginal	Ascii	A tag used to record fractions of seconds for the <DateTimeOriginal> tag.
	Content Time	General Image	0x9292	37522	Photo	SubSecTimeDigitized	Ascii	A tag used to record fractions of seconds for the <DateTimeDigitized> tag.
-	-	-	0xa000	40960	Photo	FlashpixVersion	Undefined	The FlashPix format version supported by a FPXR file.
	Color Space	Image Pixel	0xa001	40961	Photo	ColorSpace	Short	The color space information tag is always recorded as the color space specifier. Normally sRGB is used to define the color space based on the PC monitor conditions and environment. If a color space other than sRGB is used, Uncalibrated is set. Image data recorded as Uncalibrated can be treated as sRGB when it is converted to FlashPix.
-	-	-	0xa002	40962	Photo	PixelXDimension	Long	Information specific to compressed data. When a compressed file is recorded, the valid width of the meaningful image must be recorded in this tag, whether or not there is padding data or a restart marker. This tag should not exist in an uncompressed file.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
-	-	-	0xa003	40963	Photo	PixelYDimension	Long	Information specific to compressed data. When a compressed file is recorded, the valid height of the meaningful image must be recorded in this tag, whether or not there is padding data or a restart marker. This tag should not exist in an uncompressed file. Since data padding is unnecessary in the vertical direction, the number of lines recorded in this valid image height tag will in fact be the same as that recorded in the SOF.
-	-	-	0xa004	40964	Photo	RelatedSoundFile	Ascii	This tag is used to record the name of an audio file related to the image data. The only relational information recorded here is the Exif audio file name and extension (an ASCII string consisting of 8 characters + '.' + 3 characters). The path is not recorded.
-	-	-	0xa005	40965	Photo	InteroperabilityTag	Long	Interoperability IFD is composed of tags which stores the information to ensure the Interoperability and pointed by the following tag located in Exif IFD. The Interoperability structure of Interoperability IFD is the same as TIFF defined IFD structure but does not contain the image data characteristically compared with normal TIFF IFD.
(ggpa,a20b)	Flash Energy	VL Photographic Acquisition	0xa20b	41483	Photo	FlashEnergy	Rational	Indicates the strobe energy at the time the image is captured, as measured in Beam Candle Power Seconds (BCPS).

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggpa,a20c)	Spatial Frequency Response	VL Photographic Acquisition	0xa20c	41484	Photo	Spatial FrequencyResponse	Undefined	This tag records the camera or input device spatial frequency table and SFR values in the direction of image width, image height, and diagonal direction, as specified in ISO 12233.
(ggpa,a20e)	Focal PlaneXResolution	VL Photographic Acquisition	0xa20e	41486	Photo	Focal PlaneXResolution	Rational	Indicates the number of pixels in the image width (X) direction per <Focal PlaneResolutionUnit> on the camera focal plane.
(ggpa,a20f)	Focal PlaneYResolution	VL Photographic Acquisition	0xa20f	41487	Photo	Focal PlaneYResolution	Rational	Indicates the number of pixels in the image height (V) direction per <Focal PlaneResolutionUnit> on the camera focal plane.
(ggpa,a210)	Focal Plane Resolution Unit	VL Photographic Acquisition	0xa210	41488	Photo	Focal PlaneResolutionUnit	Short	Indicates the unit for measuring <Focal PlaneXResolution> and <FocalPlaneYResolution>. This value is the same as the <ResolutionUnit>.
(ggpa,a214)	Subject Location	VL Photographic Acquisition	0xa214	41492	Photo	SubjectLocation	Short	Indicates the location of the main subject in the scene. The value of this tag represents the pixel at the center of the main subject relative to the left edge, prior to rotation processing as per the <Rotation> tag. The first value indicates the X column number and second indicates the Y row number.
(ggpa,a215)	Exposure Index	VL Photographic Acquisition	0xa215	41493	Photo	ExposureIndex	Rational	Indicates the exposure index selected on the camera or input device at the time the image is captured.
(ggpa,a217)	Sensing Method	VL Photographic Acquisition	0xa217	41495	Photo	SensingMethod	Short	Indicates the image sensor type on the camera or input device.
(ggpa,a300)	File Source	VL Photographic Acquisition	0xa300	41728	Photo	FileSource	Undefined	Indicates the image source. If a DSC recorded the image, this tag value of this tag always be set to 3, indicating that the image was recorded on a DSC.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggpa,a301)	Scene Type	VL Photographic Acquisition	0xa301	41729	Photo	SceneType	Undefined	Indicates the type of scene. If a DSC recorded the image, this tag value must always be set to 1, indicating that the image was directly photographed.
(ggpa,a302)	CFAPattern	VL Photographic Acquisition	0xa302	41730	Photo	CFAPattern	Undefined	Indicates the color filter array (CFA) geometric pattern of the image sensor when a one-chip color area sensor is used. It does not apply to all sensing methods.
(ggpa,a401)	Custom Rendered	VL Photographic Acquisition	0xa401	41985	Photo	CustomRendered	Short	This tag indicates the use of special processing on image data, such as rendering geared to output. When special processing is performed, the reader is expected to disable or minimize any further processing.
(ggpa,a402)	Exposure Mode	VL Photographic Acquisition	0xa402	41986	Photo	ExposureMode	Short	This tag indicates the exposure mode set when the image was shot. In auto-bracketing mode, the camera shoots a series of frames of the same scene at different exposure settings.
(ggpa,a403)	White Balance	VL Photographic Acquisition	0xa403	41987	Photo	WhiteBalance	Short	This tag indicates the white balance mode set when the image was shot.
(ggpa,a404)	Digital Zoom Ratio	VL Photographic Acquisition	0xa404	41988	Photo	DigitalZoomRatio	Rational	This tag indicates the digital zoom ratio when the image was shot. If the numerator of the recorded value is 0, this indicates that digital zoom was not used.
(ggpa,a405)	Focal Length In35mm Film	VL Photographic Acquisition	0xa405	41989	Photo	FocalLengthIn35mm Film	Short	This tag indicates the equivalent focal length assuming a 35mm film camera, in mm. A value of 0 means the focal length is unknown. Note that this tag differs from the <Focal Length> tag.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggpa,a406)	Scene Capture Type	VL Photographic Acquisition	0xa406	41990	Photo	SceneCaptureType	Short	This tag indicates the type of scene that was shot. It can also be used to record the mode in which the image was shot. Note that this differs from the <Scene Type> tag.
(ggpa,a407)	Gain Control	VL Photographic Acquisition	0xa407	41991	Photo	GainControl	Short	This tag indicates the degree of overall image gain adjustment.
(ggpa,a408)	Contrast	VL Photographic Acquisition	0xa408	41992	Photo	Contrast	Short	This tag indicates the direction of contrast processing applied by the camera when the image was shot.
(ggpa,a409)	Saturation	VL Photographic Acquisition	0xa409	41993	Photo	Saturation	Short	This tag indicates the direction of saturation processing applied by the camera when the image was shot.
(ggpa,a40a)	Sharpness	VL Photographic Acquisition	0xa40a	41994	Photo	Sharpness	Short	This tag indicates the direction of sharpness processing applied by the camera when the image was shot.
(ggpa,a40b)	Device Setting Description	VL Photographic Acquisition	0xa40b	41995	Photo	Device SettingDescription	Undefined	This tag indicates information on the picture-taking conditions of a particular camera model. The tag is used only to indicate the picture-taking conditions in the reader.
(ggpa,a40c)	Subject Distance Range	VL Photographic Acquisition	0xa40c	41996	Photo	Subject DistanceRange	Short	This tag indicates the distance to the subject.
	SOP Instance UID	SOP Common	0xa420	42016	Photo	ImageUniqueID	Ascii	This tag indicates an identifier assigned uniquely to each image. It is recorded as an ASCII string equivalent to hexadecimal notation and 128-bit fixed length.
(ggpa,a430)	Camera Owner Name	VL Photographic Acquisition	0xa430	42032	Photo	CameraOwnerName	Ascii	This tag records the owner of a camera used in photography as an ASCII string.
	Device Serial Number	General Equipment	0xa431	42033	Photo	BodySerialNumber	Ascii	This tag records the serial number of the body of the camera that was used in photography as an ASCII string.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggpa,a432)	Lens Specification	VL Photographic Acquisition	0xa432	42034	Photo	LensSpecification	Rational	This tag notes minimum focal length, maximum focal length, minimum F number in the minimum focal length, and minimum F number in the maximum focal length, which are specification information for the lens that was used in photography. When the minimum F number is unknown, the notation is 0/0
(ggpa,a433)	Lens Make	VL Photographic Acquisition	0xa433	42035	Photo	LensMake	Ascii	This tag records the lens manufactor as an ASCII string.
(ggpa,a434)	Lens Model	VL Photographic Acquisition	0xa434	42036	Photo	LensModel	Ascii	This tag records the lens's model name and model number as an ASCII string.
(ggpa,a435)	Lens Serial Number	VL Photographic Acquisition	0xa435	42037	Photo	LensSerialNumber	Ascii	This tag records the serial number of the interchangeable lens that was used in photography as an ASCII string.
			0x0001	1	Iop	InteroperabilityIndex	Ascii	Indicates the identification of the Interoperability rule. Use "R98" for stating Exif R98 Rules. Four bytes used including the termination code (NULL). see the separate volume of Recommended Exif Interoperability Rules (Exif R98) for other tags used for ExifR98.
			0x0002	2	Iop	Interoperability Version	Undefined	Interoperability version
-	-	-	0x1000	4096	Iop	RelatedImageFile Format	Ascii	File format of image file
-	-	-	0x1001	4097	Iop	RelatedImageWidth	Long	Image width
-	-	-	0x1002	4098	Iop	RelatedImageLength	Long	Image height
			0x000b	11	Image	ProcessingSoftware	Ascii	The name and version of the software used to post-process the picture.
-	-	-	0x00fe	254	Image	NewSubfileType	Long	A general indication of the kind of data contained in this subfile.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
-	-	-	0x00ff	255	Image	SubfileType	Short	A general indication of the kind of data contained in this subfile. This field is deprecated. The New SubfileType field should be used instead.
	Columns	Image Pixel	0x0100	256	Image	ImageWidth	Long	The number of columns of image data, equal to the number of pixels per row. In JPEG compressed data a JPEG marker is used instead of this tag.
	Rows	Image Pixel	0x0101	257	Image	ImageLength	Long	The number of rows of image data. In JPEG compressed data a JPEG marker is used instead of this tag.
			0x0102	258	Image	BitsPerSample	Short	The number of bits per image component. In this standard each component of the image is 8 bits, so the value for this tag is 8. See also <Samples PerPixel>. In JPEG compressed data a JPEG marker is used instead of this tag.
	Transfer Syntax UID	File Metainformation	0x0103	259	Image	Compression	Short	The compression scheme used for the image data. When a primary image is JPEG compressed, this designation is not necessary and is omitted. When thumbnails use JPEG compression, this tag value is set to 6.
	Photometric Interpretation	Image Pixel	0x0106	262	Image	Photometric Interpretation	Short	The pixel composition. In JPEG compressed data a JPEG marker is used instead of this tag.
-	-	-	0x0107	263	Image	Thresholding	Short	For black and white TIFF files that represent shades of gray, the technique used to convert from gray to black and white pixels.
-	-	-	0x0108	264	Image	CellWidth	Short	The width of the dithering or halftoning matrix used to create a dithered or halftoned bilevel file.
-	-	-	0x0109	265	Image	CellLength	Short	The length of the dithering or halftoning matrix used to create a dithered or halftoned bilevel file.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
-	-	-	0x010a	266	Image	FillOrder	Short	The logical order of bits within a byte
(0042,0010)	Document Title	(Encapsulated Document), add to General Image?	0x010d	269	Image	DocumentName	Ascii	The name of the document from which this image was scanned
	Image Comments	General Image	0x010e	270	Image	ImageDescription	Ascii	A character string giving the title of the image. It may be a comment such as "1988 company picnic" or the like. Two-bytes character codes cannot be used. When a 2-bytes code is necessary, the Exif Private tag <User Comment> is to be used.
	Manufacturer	General Equipment	0x010f	271	Image	Make	Ascii	The manufacturer of the recording equipment. This is the manufacturer of the DSC, scanner, video digitizer or other equipment that generated the image. When the field is left blank, it is treated as unknown.
	Manufacturer's Model Name	General Equipment	0x0110	272	Image	Model	Ascii	The model name or model number of the equipment. This is the model name or number of the DSC, scanner, video digitizer or other equipment that generated the image. When the field is left blank, it is treated as unknown.
-	-	-	0x0111	273	Image	StripOffsets	Long	For each strip, the byte offset of that strip. It is recommended that this be selected so the number of strip bytes does not exceed 64 Kbytes. With JPEG compressed data this designation is not needed and is omitted. See also <RowsPerStrip> and <Strip ByteCounts>.
			0x0112	274	Image	Orientation	Short	The image orientation viewed in terms of rows and columns.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
	Samples Per Pixel	Image Pixel	0x0115	277	Image	SamplesPerPixel	Short	The number of components per pixel. Since this standard applies to RGB and YCbCr images, the value set for this tag is 3. In JPEG compressed data a JPEG marker is used instead of this tag.
-	-	-	0x0116	278	Image	RowsPerStrip	Long	The number of rows per strip. This is the number of rows in the image of one strip when an image is divided into strips. With JPEG compressed data this designation is not needed and is omitted. See also <StripOffsets> and <StripByteCounts>.
-	-	-	0x0117	279	Image	StripByteCounts	Long	The total number of bytes in each strip. With JPEG compressed data this designation is not needed and is omitted.
	Pixel Spacing	VL Image	0x011a	282	Image	XResolution	Rational	The number of pixels per <ResolutionUnit> in the <ImageWidth> direction. When the image resolution is unknown, 72 [dpi] is designated.
	Pixel Spacing	VL Image	0x011b	283	Image	YResolution	Rational	The number of pixels per <ResolutionUnit> in the <ImageLength> direction. The same value as <XResolution> is designated.
	Planar Configuration	Image Pixel	0x011c	284	Image	PlanarConfiguration	Short	Indicates whether pixel components are recorded in a chunky or planar format. In JPEG compressed files a JPEG marker is used instead of this tag. If this field does not exist, the TIFF default of 1 (chunky) is assumed.
			0x0122	290	Image	GrayResponseUnit	Short	The precision of the information contained in the GrayResponseCurve.
			0x0123	291	Image	GrayResponseCurve	Short	For grayscale data, the optical density of each possible pixel value.
-	-	-	0x0124	292	Image	T4Options	Long	T.4-encoding options.
-	-	-	0x0125	293	Image	T6Options	Long	T.6-encoding options.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
-	-	-	0x0128	296	Image	ResolutionUnit	Short	The unit for measuring <XResolution> and <YResolution>. The same unit is used for both <XResolution> and <YResolution>. If the image resolution is unknown, 2 (inches) is designated.
			0x0129	297	Image	PageNumber	Short	The page number of the page from which this image was scanned.
			0x012d	301	Image	TransferFunction	Short	A transfer function for the image, described in tabular style. Normally this tag is not necessary, since color space is specified in the color space information tag (<ColorSpace>).
(0018,1020)	Software Versions	General Equipment	0x0131	305	Image	Software	Ascii	This tag records the name and version of the software or firmware of the camera or image input device used to generate the image. The detailed format is not specified, but it is recommended that the example shown below be followed. When the field is left blank, it is treated as unknown.
	Content Date, Content Time	General Image	0x0132	306	Image	DateTime	Ascii	The date and time of image creation. In Exif standard, it is the date and time the file was changed.
			0x013b	315	Image	Artist	Ascii	This tag records the name of the camera owner, photographer or image creator. The detailed format is not specified, but it is recommended that the information be written as in the example below for ease of Interoperability. When the field is left blank, it is treated as unknown. Ex.) "Camera owner, John Smith; Photographer, Michael Brown; Image creator, Ken James"

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0x013c	316	Image	HostComputer	Ascii	This tag records information about the host computer used to generate the image.
			0x013d	317	Image	Predictor	Short	A predictor is a mathematical operator that is applied to the image data before an encoding scheme is applied.
			0x013e	318	Image	WhitePoint	Rational	The chromaticity of the white point of the image. Normally this tag is not necessary, since color space is specified in the colorspace information tag (<ColorSpace>).
			0x013f	319	Image	Primary Chromaticities	Rational	The chromaticity of the three primary colors of the image. Normally this tag is not necessary, since colorspace is specified in the colorspace information tag (<ColorSpace>).
-	-	??? map to Palette Color Module ???	0x0140	320	Image	ColorMap	Short	A color map for palette color images. This field defines a Red-Green-Blue color map (often called a lookup table) for palette-color images. In a palette-color image, a pixel value is used to index into an RGB lookup table.
			0x0141	321	Image	HalftoneHints	Short	The purpose of the HalftoneHints field is to convey to the halftone function the range of gray levels within a colorimetrically-specified image that should retain tonal detail.
-	-	-	0x0142	322	Image	TileWidth	Short	The tile width in pixels. This is the number of columns in each tile.
-	-	-	0x0143	323	Image	TileLength	Short	The tile length (height) in pixels. This is the number of rows in each tile.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
-	-	-	0x0144	324	Image	TileOffsets	Short	For each tile, the byte offset of that tile, as compressed and stored on disk. The offset is specified with respect to the beginning of the TIFF file. Note that this implies that each tile has a location independent of the locations of other tiles.
-	-	-	0x0145	325	Image	TileByteCounts	Short	For each tile, the number of (compressed) bytes in that tile. See TileOffsets for a description of how the byte counts are ordered.
-	-	-	0x014a	330	Image	SubIFDs	Long	Defined by Adobe Corporation to enable TIFF Trees within a TIFF file.
-	-	-	0x014c	332	Image	InkSet	Short	The set of inks used in a separated (Photometric Interpretation=5) image.
-	-	-	0x014d	333	Image	InkNames	Ascii	The name of each ink used in a separated (Photometric Interpretation=5) image.
			0x014e	334	Image	NumberOfInks	Short	The number of inks. Usually equal to Samples PerPixel, unless there are extra samples.
			0x0150	336	Image	DotRange	Byte	The component values that correspond to a 0% dot and 100% dot.
			0x0151	337	Image	TargetPrinter	Ascii	A description of the printing environment for which this separation is intended.
			0x0152	338	Image	ExtraSamples	Short	Specifies that each pixel has m extra components whose interpretation is defined by one of the values listed below.
			0x0153	339	Image	SampleFormat	Short	This field specifies how to interpret each data sample in a pixel.
			0x0154	340	Image	SMinSampleValue	Short	This field specifies the minimum sample value.
			0x0155	341	Image	SMaxSampleValue	Short	This field specifies the maximum sample value.
			0x0156	342	Image	TransferRange	Short	Expands the range of the TransferFunction

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0x0157	343	Image	ClipPath	Byte	A TIFF ClipPath is intended to mirror the essentials of PostScript's path creation functionality.
			0x0158	344	Image	XClipPathUnits	SShort	The number of units that span the width of the image, in terms of integer ClipPath coordinates.
			0x0159	345	Image	YClipPathUnits	SShort	The number of units that span the height of the image, in terms of integer ClipPath coordinates.
-	-	-	0x015a	346	Image	Indexed	Short	Indexed images are images where the 'pixels' do not represent color values, but rather an index (usually 8-bit) into a separate color table, the ColorMap.
-	-	-	0x015b	347	Image	JPEGTables	Undefined	This optional tag may be used to encode the JPEG quantization and Huffman tables for subsequent use by the JPEG decompression process.
			0x015f	351	Image	OPIProxy	Short	OPIProxy gives information concerning whether this image is a low-resolution proxy of a high-resolution image (Adobe OPI).
-	-	-	0x0200	512	Image	JPEGProc	Long	This field indicates the process used to produce the compressed data
-	-	-	0x0201	513	Image	JPEGInterchange Format	Long	The offset to the start byte (SOI) of JPEG compressed thumbnail data. This is not used for primary image JPEG data.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
-	-	-	0x0202	514	Image	JPEGInterchange FormatLength	Long	The number of bytes of JPEG compressed thumbnail data. This is not used for primary image JPEG data. JPEG thumbnails are not divided but are recorded as a continuous JPEG bitstream from SOI to EOI. Appn and COM markers should not be recorded. Compressed thumbnails must be recorded in no more than 64 Kbytes, including all other data to be recorded in APP1.
-	-	-	0x0203	515	Image	JPEGRestartInterval	Short	This Field indicates the length of the restart interval used in the compressed image data.
-	-	-	0x0205	517	Image	JPEGLossless Predictors	Short	This Field points to a list of lossless predictor-selection values, one per component.
-	-	-	0x0206	518	Image	JPEGPoint Transforms	Short	This Field points to a list of point transform values, one per component.
-	-	-	0x0207	519	Image	JPEGQTables	Long	This Field points to a list of offsets to the quantization tables, one per component.
-	-	-	0x0208	520	Image	JPEGDCTables	Long	This Field points to a list of offsets to the DC Huffman tables or the lossless Huffman tables, one per component.
-	-	-	0x0209	521	Image	JPEGACTables	Long	This Field points to a list of offsets to the Huffman AC tables, one per component.
-	-	-	0x0211	529	Image	YCbCrCoefficients	Rational	The matrix coefficients for transformation from RGB to YCbCr image data. No default is given in TIFF; but here the value given in Appendix E, "Color Space Guidelines", is used as the default. The color space is declared in a color space information tag, with the default being the value that gives the optimal image characteristics Interoperability this condition.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
-	-	-	0x0212	530	Image	YCbCrSubSampling	Short	The sampling ratio of chrominance components in relation to the luminance component. In JPEG compressed data a JPEG marker is used instead of this tag.
-	-	-	0x0213	531	Image	YCbCrPositioning	Short	The position of chrominance components in relation to the luminance component. This field is designated only for JPEG compressed data or uncompressed YCbCr data. The TIFF default is 1 (centered); but when Y:Cb:Cr = 4:2:2 it is recommended in this standard that 2 (co-sited) be used to record data, in order to improve the image quality when viewed on TV systems. When this field does not exist, the reader shall assume the TIFF default. In the case of Y:Cb:Cr = 4:2:0, the TIFF default (centered) is recommended. If the reader does not have the capability of supporting both kinds of <YCb CrPositioning>, it shall follow the TIFF default regardless of the value in this field. It is preferable that readers be able to support both centered and co-sited positioning.
			0x0214	532	Image	ReferenceBlackWhite	Rational	The reference black point value and reference white point value. No defaults are given in TIFF, but the values below are given as defaults here. The color space is declared in a color space information tag, with the default being the value that gives the optimal image characteristics Interoperability these conditions.
-	-	-	0x02bc	700	Image	XMLPacket	Byte	XMP Metadata (Adobe technote 9-14-02)

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
-	-	-	0x4746	18246	Image	Rating	Short	Rating tag used by Windows
-	-	-	0x4749	18249	Image	RatingPercent	Short	Rating tag used by Windows, value in percent
-	-	-	0x800d	32781	Image	ImageID	Ascii	ImageID is the full pathname of the original, high-resolution image, or any other identifying string that uniquely identifies the original image (Adobe OPI).
			0x828d	33421	Image	CFARepeat PatternDim	Short	Contains two values representing the minimum rows and columns to define the repeating patterns of the color filter array
			0x828e	33422	Image	CFAPattern	Byte	Indicates the color filter array (CFA) geometric pattern of the image sensor when a one-chip color area sensor is used. It does not apply to all sensing methods. [Not EXIF but TIFF/EP]
			0x828f	33423	Image	BatteryLevel	Rational	Contains a value of the battery level as a fraction or string

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0x8298	33432	Image	Copyright	Ascii	Copyright information. In this standard the tag is used to indicate both the photographer and editor copyrights. It is the copyright notice of the person or organization claiming rights to the image. The Interoperability copyright statement including date and rights should be written in this field; e.g., "Copyright, John Smith, 19xx. All rights reserved.". In this standard the field records both the photographer and editor copyrights, with each recorded in a separate part of the statement. When there is a clear distinction between the photographer and editor copyrights, these are to be written in the order of photographer followed by editor copyright, separated by NULL (in this case since the statement also ends with a NULL, there are two NULL codes). When only the photographer copyright is given, it is terminated by one NULL code. When only the editor copyright is given, the photographer copyright part consists of one space followed by a terminating NULL code, then the editor copyright is given. When the field is left blank, it is treated as unknown.
-	-	-	0x83bb	33723	Image	IPTCNAA	Long	Contains an IPTC/NAA record
-	-	-	0x8649	34377	Image	ImageResources	Byte	Contains information embedded by the Adobe Photoshop application

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
-	-	-	0x8769	34665	Image	ExifTag	Long	A pointer to the Exif IFD. Interoperability, Exif IFD has the same structure as that of the IFD specified in TIFF. ordinarily, however, it does not contain image data as in the case of TIFF.
	ICC Profile	Image Pixel, ICC Profile	0x8773	34675	Image	InterColorProfile	Undefined	Contains an InterColor Consortium (ICC) format color space characterization/profile
-	-	-	0x8825	34853	Image	GPSTag	Long	A pointer to the GPS Info IFD. The Interoperability structure of the GPS Info IFD, like that of Exif IFD, has no image data.
-	-	-	0x8829	34857	Image	Interlace	Short	Indicates the field number of multifield images.
		SOP Common	0x882a	34858	Image	TimeZoneOffset	SShort	This optional tag encodes the time zone of the camera clock (relativeto Greenwich Mean Time) used to create the Data TimeOriginal tag-valuewhen the picture was taken. It may also contain the time zone offsetof the clock used to create the DateTime tag-value when the image was modified. [Not EXIF but TIFF/EP]
			0x882b	34859	Image	SelfTimerMode	Short	Number of seconds image capture was delayed from button press.
			0x920b	37387	Image	FlashEnergy	Rational	Amount of flash energy (BCPS). [Not EXIF but TIFF/EP]
			0x920c	37388	Image	Spatial FrequencyResponse	Undefined	SFR of the camera. [Not EXIF but TIFF/EP]
			0x920d	37389	Image	Noise	Undefined	Noise measurement values.
			0x920e	37390	Image	Focal PlaneXResolution	Rational	Number of pixels per Focal PlaneResolutionUnit (37392) in ImageWidth direction for main image. [Not EXIF but TIFF/EP]
			0x920f	37391	Image	Focal PlaneYResolution	Rational	Number of pixels per Focal PlaneResolutionUnit (37392) in ImageLength direction for main image. [Not EXIF but TIFF/EP]

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0x9210	37392	Image	Focal PlaneResolutionUnit	Short	Unit of measurement for Focal PlaneXResolution(37390) and Focal PlaneYResolution(37391). [Not EXIF but TIFF/EP]
(0020,0013)	Instance Number	General Image	0x9211	37393	Image	ImageNumber	Long	Number assigned to an image, e.g., in a chained image burst.
			0x9212	37394	Image	SecurityClassification	Ascii	Security classification assigned to the image.
			0x9213	37395	Image	ImageHistory	Ascii	Record of what has been done to the image.
			0x9214	37396	Image	SubjectLocation	Short	Indicates the location and area of the main subject in the overall scene. [Not EXIF but TIFF/EP]
			0x9215	37397	Image	ExposureIndex	Rational	Encodes the camera exposure index setting when image was captured. [Not EXIF but TIFF/EP]
-	-	-	0x9216	37398	Image	TIFFEPStandardID	Byte	Contains four ASCII characters representing the TIFF/EP standard version of a TIFF/EP file, eg '1', '0', '0', '0'
			0x9217	37399	Image	SensingMethod	Short	Type of image sensor. [Not EXIF but TIFF/EP]
-	-	-	0x9c9b	40091	Image	XPTitle	Byte	Title tag used by Windows, encoded in UCS2
-	-	-	0x9c9c	40092	Image	XPComment	Byte	Comment tag used by Windows, encoded in UCS2
-	-	-	0x9c9d	40093	Image	XPAuthor	Byte	Author tag used by Windows, encoded in UCS2
-	-	-	0x9c9e	40094	Image	XPKeywords	Byte	Keywords tag used by Windows, encoded in UCS2
-	-	-	0x9c9f	40095	Image	XPSubject	Byte	Subject tag used by Windows, encoded in UCS2
			0xc4a5	50341	Image	PrintImageMatching	Undefined	Print Image Matching, description needed.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc612	50706	Image	DNGVersion	Byte	This tag encodes the DNG four-tier version number. For files compliant with version 1.1.0.0 of the DNG specification, this tag should contain the bytes: 1, 1, 0, 0.
			0xc613	50707	Image	DNGBackward Version	Byte	This tag specifies the oldest version of the Digital Negative specification for which a file is compatible. Readers shouldnot attempt to read a file if this tag specifies a version number that is higher than the version number of the specification the reader was based on. In addition to checking the version tags, readers should, for all tags, check the types, counts, and values, to verify it is able to correctly read the file.
			0xc614	50708	Image	UniqueCameraModel	Ascii	Defines a unique, non-localized name for the camera model that created the image in the raw file. This name should include the manufacturer's name to avoid conflicts, and should not be localized, even if the camera name itself is localized for different markets (see LocalizedCameraModel). This string may be used by reader software to index into per-model preferences and replacement profiles.
	Manufacturer's Model Name	General Equipment	0xc615	50709	Image	Localized CameraModel	Byte	Similar to the Unique CameraModel field, except the name can be localized for different markets to match the localization of the camera name.
			0xc616	50710	Image	CFAPlaneColor	Byte	Provides a mapping between the values in the CFAPattern tag and the plane numbers in Linear Raw space. This is a required tag for non-RGB CFA images.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc617	50711	Image	CFALayout	Short	Describes the spatial layout of the CFA.
			0xc618	50712	Image	LinearizationTable	Short	Describes a lookup table that maps stored values into linear values. This tag is typically used to increase compression ratios by storing the raw data in a non-linear, more visually uniform space with fewer total encoding levels. If SamplesPerPixel is not equal to one, this single table applies to all the samples for each pixel.
			0xc619	50713	Image	BlackLevelRepeatDim	Short	Specifies repeat pattern size for the BlackLevel tag.
			0xc61a	50714	Image	BlackLevel	Rational	Specifies the zero light (a.k.a. thermal black or black current) encoding level, as a repeating pattern. The origin of this pattern is the top-left corner of the ActiveArea rectangle. The values are stored in row-column-sample scan order.
			0xc61b	50715	Image	BlackLevelDeltaH	SRational	If the zero light encoding level is a function of the image column, BlackLevelDeltaH specifies the difference between the zero light encoding level for each column and the baseline zero light encoding level. If SamplesPerPixel is not equal to one, this single table applies to all the samples for each pixel.
			0xc61c	50716	Image	BlackLevelDeltaV	SRational	If the zero light encoding level is a function of the image row, this tag specifies the difference between the zero light encoding level for each row and the baseline zero light encoding level. If SamplesPerPixel is not equal to one, this single table applies to all the samples for each pixel.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc61d	50717	Image	WhiteLevel	Short	This tag specifies the fully saturated encoding level for the raw sample values. Saturation is caused either by the sensor itself becoming highly non-linear in response, or by the camera's analog to digital converter clipping.
			0xc61e	50718	Image	DefaultScale	Rational	DefaultScale is required for cameras with non-square pixels. It specifies the default scale factors for each direction to convert the image to square pixels. Typically these factors are selected to approximately preserve total pixel count. For CFA images that use CFALayout equal to 2, 3, 4, or 5, such as the Fujifilm SuperCCD, these two values should usually differ by a factor of 2.0.
			0xc61f	50719	Image	DefaultCropOrigin	Short	Raw images often store extra pixels around the edges of the final image. These extra pixels help prevent interpolation artifacts near the edges of the final image. Default CropOrigin specifies the origin of the final image area, in raw image coordinates (i.e., before the DefaultScale has been applied), relative to the top-left corner of the Active Area rectangle.
			0xc620	50720	Image	DefaultCropSize	Short	Raw images often store extra pixels around the edges of the final image. These extra pixels help prevent interpolation artifacts near the edges of the final image. Default CropSize specifies the size of the final image area, in raw image coordinates (i.e., before the Default Scale has been applied).

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc621	50721	Image	ColorMatrix1	SRational	ColorMatrix1 defines a transformation matrix that converts XYZ values to reference camera native color space values, under the first calibration illuminant. The matrix values are stored in row scan order. The Color Matrix1 tag is required for all non-monochrome DNG files.
			0xc622	50722	Image	ColorMatrix2	SRational	ColorMatrix2 defines a transformation matrix that converts XYZ values to reference camera native color space values, under the second calibration illuminant. The matrix values are stored in row scan order.
			0xc623	50723	Image	CameraCalibration1	SRational	CameraCalibration1 defines a calibration matrix that transforms reference camera native space values to individual camera native space values under the first calibration illuminant. The matrix is stored in row scan order. This matrix is stored separately from the matrix specified by the Color Matrix1 tag to allow raw converters to swap in replacement color matrices based on Unique CameraModel tag, while still taking advantage of any per-individual camera calibration performed by the camera manufacturer.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc624	50724	Image	CameraCalibration2	SRational	CameraCalibration2 defines a calibration matrix that transforms reference camera native space values to individual camera native space values under the second calibration illuminant. The matrix is stored in row scan order. This matrix is stored separately from the matrix specified by the Color Matrix2 tag to allow raw converters to swap in replacement color matrices based on Unique CameraModel tag, while still taking advantage of any per-individual camera calibration performed by the camera manufacturer.
			0xc625	50725	Image	ReductionMatrix1	SRational	ReductionMatrix1 defines a dimensionality reduction matrix for use as the first stage in converting color camera native space values to XYZ values, under the first calibration illuminant. This tag may only be used if ColorPlanes is greater than 3. The matrix is stored in row scan order.
			0xc626	50726	Image	ReductionMatrix2	SRational	ReductionMatrix2 defines a dimensionality reduction matrix for use as the first stage in converting color camera native space values to XYZ values, under the second calibration illuminant. This tag may only be used if ColorPlanes is greater than 3. The matrix is stored in row scan order.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc627	50727	Image	AnalogBalance	Rational	Normally the stored raw values are not white balanced, since any digital white balancing will reduce the dynamic range of the final image if the user decides to later adjust the white balance; however, if camera hardware is capable of white balancing the color channels before the signal is digitized, it can improve the dynamic range of the final image. Analog Balance defines the gain, either analog (recommended) or digital (not recommended) that has been applied the stored raw values.
			0xc628	50728	Image	AsShotNeutral	Short	Specifies the selected white balance at time of capture, encoded as the coordinates of a perfectly neutral color in linear reference space values. The inclusion of this tag precludes the inclusion of the AsShotWhiteXY tag.
			0xc629	50729	Image	AsShotWhiteXY	Rational	Specifies the selected white balance at time of capture, encoded as x-y chromaticity coordinates. The inclusion of this tag precludes the inclusion of the AsShotNeutral tag.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc62a	50730	Image	BaselineExposure	SRational	Camera models vary in the trade-off they make between highlight headroom and shadow noise. Some leave a significant amount of highlight headroom during a normal exposure. This allows significant negative exposure compensation to be applied during raw conversion, but also means normal exposures will contain more shadow noise. Other models leave less headroom during normal exposures. This allows for less negative exposure compensation, but results in lower shadow noise for normal exposures. Because of these differences, a raw converter needs to vary the zero point of its exposure compensation control from model to model. Baseline Exposure specifies by how much (in EV units) to move the zero point. Positive values result in brighter default results, while negative values result in darker default results.
			0xc62b	50731	Image	BaselineNoise	Rational	Specifies the relative noise level of the camera model at a baseline ISO value of 100, compared to a reference camera model. Since noise levels tend to vary approximately with the square root of the ISO value, a raw converter can use this value, combined with the current ISO, to estimate the relative noise level of the current image.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc62c	50732	Image	BaselineSharpness	Rational	Specifies the relative amount of sharpening required for this camera model, compared to a reference camera model. Camera models vary in the strengths of their anti-aliasing filters. Cameras with weak or no filters require less sharpening than cameras with strong anti-aliasing filters.
			0xc62d	50733	Image	BayerGreenSplit	Long	Only applies to CFA images using a Bayer pattern filter array. This tag specifies, in arbitrary units, how closely the values of the green pixels in the blue/green rows track the values of the green pixels in the red/green rows. A value of zero means the two kinds of green pixels track closely, while a non-zero value means they sometimes diverge. The useful range for this tag is from 0 (no divergence) to about 5000 (quite large divergence).
			0xc62e	50734	Image	LinearResponseLimit	Rational	Some sensors have an unpredictable non-linearity in their response as they near the upper limit of their encoding range. This non-linearity results in color shifts in the highlight areas of the resulting image unless the raw converter compensates for this effect. LinearResponseLimit specifies the fraction of the encoding range above which the response may become significantly non-linear.
			0xc62f	50735	Image	CameraSerialNumber	Ascii	CameraSerialNumber contains the serial number of the camera or camera body that captured the image.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc630	50736	Image	LensInfo	Rational	Contains information about the lens that captured the image. If the minimum f-stops are unknown, they should be encoded as 0/0.
			0xc631	50737	Image	ChromaBlurRadius	Rational	ChromaBlurRadius provides a hint to the DNG reader about how much chroma blur should be applied to the image. If this tag is omitted, the reader will use its default amount of chroma blurring. Normally this tag is only included for non-CFA images, since the amount of chroma blur required for mosaic images is highly dependent on the de-mosaic algorithm, in which case the DNG reader's default value is likely optimized for its particular de-mosaic algorithm.
			0xc632	50738	Image	AntiAliasStrength	Rational	Provides a hint to the DNG reader about how strong the camera's anti-alias filter is. A value of 0.0 means no anti-alias filter (i.e., the camera is prone to aliasing artifacts with some subjects), while a value of 1.0 means a strong anti-alias filter (i.e., the camera almost never has aliasing artifacts).
			0xc633	50739	Image	ShadowScale	SRational	This tag is used by Adobe Camera Raw to control the sensitivity of its 'Shadows' slider.
			0xc634	50740	Image	DNGPrivateData	Byte	Provides a way for camera manufacturers to store private data in the DNG file for use by their own raw converters, and to have that data preserved by programs that edit DNG files.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
-	-	-	0xc635	50741	Image	MakerNoteSafety	Short	MakerNoteSafety lets the DNG reader know whether the EXIF MakerNote tag is safe to preserve along with the rest of the EXIF data. File browsers and other image management software processing an image with a preserved MakerNote should be aware that any thumbnail image embedded in the MakerNote may be stale, and may not reflect the current state of the full size image.
			0xc65a	50778	Image	CalibrationIlluminant1	Short	The illuminant used for the first set of color calibration tags (ColorMatrix1, CameraCalibration1, ReductionMatrix1). The legal values for this tag are the same as the legal values for the LightSource EXIF tag.
			0xc65b	50779	Image	CalibrationIlluminant2	Short	The illuminant used for an optional second set of color calibration tags (Color Matrix2, Camera Calibration2, Reduction Matrix2). The legal values for this tag are the same as the legal values for the CalibrationIlluminant1 tag; however, if both are included, neither is allowed to have a value of 0 (unknown).
			0xc65c	50780	Image	BestQualityScale	Rational	For some cameras, the best possible image quality is not achieved by preserving the total pixel count during conversion. For example, Fujifilm SuperCCD images have maximum detail when their total pixel count is doubled. This tag specifies the amount by which the values of the DefaultScale tag need to be multiplied to achieve the best quality image size.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc65d	50781	Image	RawDataUniqueID	Byte	This tag contains a 16-byte unique identifier for the raw image data in the DNG file. DNG readers can use this tag to recognize a particular raw image, even if the file's name or the metadata contained in the file has been changed. If a DNG writer creates such an identifier, it should do so using an algorithm that will ensure that it is very unlikely two different images will end up having the same identifier.
-	-	-	0xc68b	50827	Image	OriginalRawFile Name	Byte	If the DNG file was converted from a non-DNG raw file, then this tag contains the file name of that original raw file.
-	-	-	0xc68c	50828	Image	OriginalRawFileData	Undefined	If the DNG file was converted from a non-DNG raw file, then this tag contains the compressed contents of that original raw file. The contents of this tag always use the big-endian byte order. The tag contains a sequence of data blocks. Future versions of the DNG specification may define additional data blocks, so DNG readers should ignore extra bytes when parsing this tag. DNG readers should also detect the case where data blocks are missing from the end of the sequence, and should assume a default value for all the missing blocks. There are no padding or alignment bytes between data blocks.
			0xc68d	50829	Image	ActiveArea	Short	This rectangle defines the active (non-masked) pixels of the sensor. The order of the rectangle coordinates is: top, left, bottom, right.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc68e	50830	Image	MaskedAreas	Short	This tag contains a list of non-overlapping rectangle coordinates of fully masked pixels, which can be optionally used by DNG readers to measure the black encoding level. The order of each rectangle's coordinates is: top, left, bottom, right. If the raw image data has already had its black encoding level subtracted, then this tag should not be used, since the masked pixels are no longer useful.
			0xc68f	50831	Image	AsShotICCProfile	Undefined	This tag contains an ICC profile that, in conjunction with the AsShotPre ProfileMatrix tag, provides the camera manufacturer with a way to specify a default color rendering from camera color space coordinates (linear reference values) into the ICC profile connection space. The ICC profile connection space is an output referred colorimetric space, whereas the other color calibration tags in DNG specify a conversion into a scene referred colorimetric space. This means that the rendering in this profile should include any desired tone and gamut mapping needed to convert between scene referred values and output referred values.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc690	50832	Image	AsShotPre ProfileMatrix	SRational	This tag is used in conjunction with the As ShotICCProfile tag. It specifies a matrix that should be applied to the camera color space coordinates before processing the values through the ICC profile specified in the As ShotICCProfile tag. The matrix is stored in the row scan order. If ColorPlanes is greater than three, then this matrix can (but is not required to) reduce the dimensionality of the color data down to three components, in which case the AsShotICCProfile should have three rather than ColorPlanes input components.
			0xc691	50833	Image	CurrentICCProfile	Undefined	This tag is used in conjunction with the CurrentPreProfileMatrix tag. The CurrentICCProfile and CurrentPreProfile Matrix tags have the same purpose and usage as the AsShotICCProfile and As ShotPreProfileMatrix tag pair, except they are for use by raw file editors rather than camera manufacturers.
			0xc692	50834	Image	CurrentPreProfile Matrix	SRational	This tag is used in conjunction with the CurrentICCProfile tag. The CurrentICCProfile and CurrentPreProfileMatrix tags have the same purpose and usage as the AsShotICCProfile and As ShotPreProfileMatrix tag pair, except they are for use by raw file editors rather than camera manufacturers.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc6bf	50879	Image	Colorimetric Reference	Short	The DNG color model documents a transform between camera colors and CIE XYZ values. This tag describes the colorimetric reference for the CIE XYZ values. 0 = The XYZ values are scene-referred. 1 = The XYZ values are output-referred, using the ICC profile perceptual dynamic range. This tag allows output-referred data to be stored in DNG files and still processed correctly by DNG readers.
			0xc6f3	50931	Image	Camera CalibrationSignature	Byte	A UTF-8 encoded string associated with the CameraCalibration1 and CameraCalibration2 tags. The CameraCalibration1 and CameraCalibration2 tags should only be used in the DNG color transform if the string stored in the Camera CalibrationSignature tag exactly matches the string stored in the Profile CalibrationSignature tag for the selected camera profile.
			0xc6f4	50932	Image	Profile CalibrationSignature	Byte	A UTF-8 encoded string associated with the camera profile tags. The Camera Calibration1 and Camera Calibration2 tags should only be used in the DNG color transfer if the string stored in the Camera CalibrationSignature tag exactly matches the string stored in the Profile CalibrationSignature tag for the selected camera profile.
			0xc6f6	50934	Image	AsShotProfileName	Byte	A UTF-8 encoded string containing the name of the "as shot" camera profile, if any.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc6f7	50935	Image	Noise ReductionApplied	Rational	This tag indicates how much noise reduction has been applied to the raw data on a scale of 0.0 to 1.0. A 0.0 value indicates that no noise reduction has been applied. A 1.0 value indicates that the "ideal" amount of noise reduction has been applied, i.e. that the DNG reader should not apply additional noise reduction by default. A value of 0/0 indicates that this parameter is unknown.
			0xc6f8	50936	Image	ProfileName	Byte	A UTF-8 encoded string containing the name of the camera profile. This tag is optional if there is only a single camera profile stored in the file but is required for all camera profiles if there is more than one camera profile stored in the file.
			0xc6f9	50937	Image	ProfileHueSat MapDims	Long	This tag specifies the number of input samples in each dimension of the hue/saturation/value mapping tables. The data for these tables are stored in ProfileHueSatMapData1 and ProfileHueSat MapData2 tags. The most common case has Value Divisions equal to 1, so only hue and saturation are used as inputs to the mapping table.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc6fa	50938	Image	ProfileHueSat MapData1	Float	This tag contains the data for the first hue/saturation/value mapping table. Each entry of the table contains three 32-bit IEEE floating-point values. The first entry is hue shift in degrees; the second entry is saturation scale factor; and the third entry is a value scale factor. The table entries are stored in the tag in nested loop order, with the value divisions in the outer loop, the hue divisions in the middle loop, and the saturation divisions in the inner loop. All zero input saturation entries are required to have a value scale factor of 1.0.
			0xc6fb	50939	Image	ProfileHueSat MapData2	Float	This tag contains the data for the second hue/saturation/value mapping table. Each entry of the table contains three 32-bit IEEE floating-point values. The first entry is hue shift in degrees; the second entry is a saturation scale factor; and the third entry is a value scale factor. The table entries are stored in the tag in nested loop order, with the value divisions in the outer loop, the hue divisions in the middle loop, and the saturation divisions in the inner loop. All zero input saturation entries are required to have a value scale factor of 1.0.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc6fc	50940	Image	ProfileToneCurve	Float	This tag contains a default tone curve that can be applied while processing the image as a starting point for user adjustments. The curve is specified as a list of 32-bit IEEE floating-point value pairs in linear gamma. Each sample has an input value in the range of 0.0 to 1.0, and an output value in the range of 0.0 to 1.0. The first sample is required to be (0.0, 0.0), and the last sample is required to be (1.0, 1.0). Interpolated the curve using a cubic spline.
			0xc6fd	50941	Image	ProfileEmbedPolicy	Long	This tag contains information about the usage rules for the associated camera profile.
			0xc6fe	50942	Image	ProfileCopyright	Byte	A UTF-8 encoded string containing the copyright information for the camera profile. This string always should be preserved along with the other camera profile tags.
			0xc714	50964	Image	ForwardMatrix1	SRational	This tag defines a matrix that maps white balanced camera colors to XYZ D50 colors.
			0xc715	50965	Image	ForwardMatrix2	SRational	This tag defines a matrix that maps white balanced camera colors to XYZ D50 colors.
-	-	-	0xc716	50966	Image	Preview ApplicationName	Byte	A UTF-8 encoded string containing the name of the application that created the preview stored in the IFD.
-	-	-	0xc717	50967	Image	Preview ApplicationVersion	Byte	A UTF-8 encoded string containing the version number of the application that created the preview stored in the IFD.
-	-	-	0xc718	50968	Image	Preview SettingsName	Byte	A UTF-8 encoded string containing the name of the conversion settings (for example, snapshot name) used for the preview stored in the IFD.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
-	-	-	0xc719	50969	Image	Preview SettingsDigest	Byte	A unique ID of the conversion settings (for example, MD5 digest) used to render the preview stored in the IFD.
-	-	-	0xc71a	50970	Image	PreviewColorSpace	Long	This tag specifies the color space in which the rendered preview in this IFD is stored. The default value for this tag is sRGB for color previews and Gray Gamma 2.2 for monochrome previews.
-	-	-	0xc71b	50971	Image	PreviewDateTime	Ascii	This tag is an ASCII string containing the name of the date/time at which the preview stored in the IFD was rendered. The date/time is encoded using ISO 8601 format.
-	-	-	0xc71c	50972	Image	RawImageDigest	Undefined	This tag is an MD5 digest of the raw image data. All pixels in the image are processed in row-scan order. Each pixel is zero padded to 16 or 32 bits deep (16-bit for data less than or equal to 16 bits deep, 32-bit otherwise). The data for each pixel is processed in little-endian byte order.
-	-	-	0xc71d	50973	Image	OriginalRawFile Digest	Undefined	This tag is an MD5 digest of the data stored in the OriginalRawFileData tag.
			0xc71e	50974	Image	SubTileBlockSize	Long	Normally, the pixels within a tile are stored in simple row-scan order. This tag specifies that the pixels within a tile should be grouped first into rectangular blocks of the specified size. These blocks are stored in row-scan order. Within each block, the pixels are stored in row-scan order. The use of a non-default value for this tag requires setting the DNGBackward Version tag to at least 1.2.0.0.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc71f	50975	Image	RowInterleaveFactor	Long	This tag specifies that rows of the image are stored in interleaved order. The value of the tag specifies the number of interleaved fields. The use of a non-default value for this tag requires setting the DNGBackwardVersion tag to at least 1.2.0.0.
			0xc725	50981	Image	ProfileLookTable Dims	Long	This tag specifies the number of input samples in each dimension of a default "look" table. The data for this table is stored in the ProfileLookTableData tag.
			0xc726	50982	Image	ProfileLookTableData	Float	This tag contains a default "look" table that can be applied while processing the image as a starting point for user adjustment. This table uses the same format as the tables stored in the ProfileHueSat MapData1 and Profile HueSatMapData2 tags, and is applied in the same color space. However, it should be applied later in the processing pipe, after any exposure compensation and/or fill light stages, but before any tone curve stage. Each entry of the table contains three 32-bit IEEE floating-point values. The first entry is hue shift in degrees, the second entry is a saturation scale factor, and the third entry is a value scale factor. The table entries are stored in the tag in nested loop order, with the value divisions in the outer loop, the hue divisions in the middle loop, and the saturation divisions in the inner loop. All zero input saturation entries are required to have a value scale factor of 1.0.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
			0xc740	51008	Image	OpcodeList1	Undefined	Specifies the list of opcodes that should be applied to the raw image, as read directly from the file.
			0xc741	51009	Image	OpcodeList2	Undefined	Specifies the list of opcodes that should be applied to the raw image, just after it has been mapped to linear reference values.
			0xc74e	51022	Image	OpcodeList3	Undefined	Specifies the list of opcodes that should be applied to the raw image, just after it has been demosaiced.
			0xc761	51041	Image	NoiseProfile	Double	NoiseProfile describes the amount of noise in a raw image. Specifically, this tag models the amount of signal-dependent photon (shot) noise and signal-independent sensor readout noise, two common sources of noise in raw images. The model assumes that the noise is white and spatially independent, ignoring fixed pattern effects and other sources of noise (e.g., pixel response non-uniformity, spatially-dependent thermal effects, etc.).
(ggps,0000)	GPSVersionID	VL Photographic Geolocation	0x0000	0	GPSInfo	GPSVersionID	Byte	Indicates the version of <GPSInfoIFD>. The version is given as 2.0.0.0. This tag is mandatory when <GPSInfo> tag is present. (Note: The <GPSVersionID> tag is given in bytes, unlike the <ExifVersion> tag. When the version is 2.0.0.0, the tag value is 02000000.H).
(ggps,0001)	GPSLatitudeRef	VL Photographic Geolocation	0x0001	1	GPSInfo	GPSLatitudeRef	Ascii	Indicates whether the latitude is north or south latitude. The ASCII value 'N' indicates north latitude, and 'S' is south latitude.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggps,0002)	GPSLatitude	VL Photographic Geolocation	0x0002	2	GPSInfo	GPSLatitude	Rational	Indicates the latitude. The latitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. When degrees, minutes and seconds are expressed, the format is dd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format is dd/1,mmmm/100,0/1.
(ggps,0003)	GPSLongitudeRef	VL Photographic Geolocation	0x0003	3	GPSInfo	GPSLongitudeRef	Ascii	Indicates whether the longitude is east or west longitude. ASCII 'E' indicates east longitude, and 'W' is west longitude.
(ggps,0004)	GPSLongitude	VL Photographic Geolocation	0x0004	4	GPSInfo	GPSLongitude	Rational	Indicates the longitude. The longitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. When degrees, minutes and seconds are expressed, the format is ddd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format is ddd/1,mmmm/100,0/1.
(ggps,0005)	GPSAltitudeRef	VL Photographic Geolocation	0x0005	5	GPSInfo	GPSAltitudeRef	Byte	Indicates the altitude used as the reference altitude. If the reference is sea level and the altitude is above sea level, 0 is given. If the altitude is below sea level, a value of 1 is given and the altitude is indicated as an absolute value in the GSPAltitude tag. The reference unit is meters. Note that this tag is BYTE type, unlike other reference tags.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggps,0006)	GPSAltitude	VL Photographic Geolocation	0x0006	6	GPSInfo	GPSAltitude	Rational	Indicates the altitude based on the reference in GPSAltitudeRef. Altitude is expressed as one RATIONAL value. The reference unit is meters.
(ggps,0007)	GPSTimeStamp	VL Photographic Geolocation	0x0007	7	GPSInfo	GPSTimeStamp	Rational	Indicates the time as UTC (Coordinated Universal Time). <TimeStamp> is expressed as three RATIONAL values giving the hour, minute, and second (atomic clock).
(ggps,0008)	GPSSatellites	VL Photographic Geolocation	0x0008	8	GPSInfo	GPSSatellites	Ascii	Indicates the GPS satellites used for measurements. This tag can be used to describe the number of satellites, their ID number, angle of elevation, azimuth, SNR and other information in ASCII notation. The format is not specified. If the GPS receiver is incapable of taking measurements, value of the tag is set to NULL.
(ggps,0009)	GPSStatus	VL Photographic Geolocation	0x0009	9	GPSInfo	GPSStatus	Ascii	Indicates the status of the GPS receiver when the image is recorded. "A" means measurement is in progress, and "V" means the measurement is Interoperability.
(ggps,000a)	GPSMeasure Mode	VL Photographic Geolocation	0x000a	10	GPSInfo	GPSMeasureMode	Ascii	Indicates the GPS measurement mode. "2" means two-dimensional measurement and "3" means three-dimensional measurement is in progress.
(ggps,000b)	GPSDOP	VL Photographic Geolocation	0x000b	11	GPSInfo	GPSDOP	Rational	Indicates the GPS DOP (data degree of precision). An HDOP value is written during two-dimensional measurement, and PDOP during three-dimensional measurement.
(ggps,000c)	GPSSpeedRef	VL Photographic Geolocation	0x000c	12	GPSInfo	GPSSpeedRef	Ascii	Indicates the unit used to express the GPS receiver speed of movement. "K" "M" and "N" represents kilometers per hour, miles per hour, and knots.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggps,000d)	GPSSpeed	VL Photographic Geolocation	0x000d	13	GPSInfo	GPSSpeed	Rational	Indicates the speed of GPS receiver movement.
(ggps,000e)	GPSTrackRef	VL Photographic Geolocation	0x000e	14	GPSInfo	GPSTrackRef	Ascii	Indicates the reference for giving the direction of GPS receiver movement. "T" denotes true direction and "M" is magnetic direction.
(ggps,000f)	GPSTrack	VL Photographic Geolocation	0x000f	15	GPSInfo	GPSTrack	Rational	Indicates the direction of GPS receiver movement. The range of values is from 0.00 to 359.99.
(ggps,0010)	GPSImg DirectionRef	VL Photographic Geolocation	0x0010	16	GPSInfo	GPSImgDirectionRef	Ascii	Indicates the reference for giving the direction of the image when it is captured. "T" denotes true direction and "M" is magnetic direction.
(ggps,0011)	GPSImgDirection	VL Photographic Geolocation	0x0011	17	GPSInfo	GPSImgDirection	Rational	Indicates the direction of the image when it was captured. The range of values is from 0.00 to 359.99.
(ggps,0012)	GPSMapDatum	VL Photographic Geolocation	0x0012	18	GPSInfo	GPSMapDatum	Ascii	Indicates the geodetic survey data used by the GPS receiver. If the survey data is restricted to Japan, the value of this tag is "TOKYO" or "WGS-84".
(ggps,0013)	GPSDest LatitudeRef	VL Photographic Geolocation	0x0013	19	GPSInfo	GPSDestLatitudeRef	Ascii	Indicates whether the latitude of the destination point is north or south latitude. The ASCII value "N" indicates north latitude, and "S" is south latitude.
(ggps,0014)	GPSDestLatitude	VL Photographic Geolocation	0x0014	20	GPSInfo	GPSDestLatitude	Rational	Indicates the latitude of the destination point. The latitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. If latitude is expressed as degrees, minutes and seconds, a typical format would be dd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format would be dd/1,mmmm/100,0/1.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggps,0015)	GPSDest LongitudeRef	VL Photographic Geolocation	0x0015	21	GPSInfo	GPSDest LongitudeRef	Ascii	Indicates whether the longitude of the destination point is east or west longitude. ASCII "E" indicates east longitude, and "W" is west longitude.
(ggps,0016)	GPSDest Longitude	VL Photographic Geolocation	0x0016	22	GPSInfo	GPSDestLongitude	Rational	Indicates the longitude of the destination point. The longitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. If longitude is expressed as degrees, minutes and seconds, a typical format would be ddd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format would be ddd/1,mmmm/100,0/1.
(ggps,0017)	GPSDest BearingRef	VL Photographic Geolocation	0x0017	23	GPSInfo	GPSDestBearingRef	Ascii	Indicates the reference used for giving the bearing to the destination point. "T" denotes true direction and "M" is magnetic direction.
(ggps,0018)	GPSDestBearing	VL Photographic Geolocation	0x0018	24	GPSInfo	GPSDestBearing	Rational	Indicates the bearing to the destination point. The range of values is from 0.00 to 359.99.
(ggps,0019)	GPSDest DistanceRef	VL Photographic Geolocation	0x0019	25	GPSInfo	GPSDestDistanceRef	Ascii	Indicates the unit used to express the distance to the destination point. "K", "M" and "N" represent kilometers, miles and knots.
(ggps,001a)	GPSDestDistance	VL Photographic Geolocation	0x001a	26	GPSInfo	GPSDestDistance	Rational	Indicates the distance to the destination point.
(ggps,001b)	GPSProcessing Method	VL Photographic Geolocation	0x001b	27	GPSInfo	GPSProcessing Method	Undefined	A character string recording the name of the method used for location finding. The first byte indicates the character code used, and this is followed by the name of the method.

Attribute Name	DICOM Tag	DICOM Module	EXIF Tag (hex)	EXIF Tag (dec)	EXIF IFD	EXIF Key	EXIF Type	EXIF Tag description
(ggps,001c)	GPSArea Information	VL Photographic Geolocation	0x001c	28	GPSInfo	GPSAreaInformation	Undefined	A character string recording the name of the GPS area. The first byte indicates the character code used, and this is followed by the name of the GPS area.
(ggps,001d)	GPSDateStamp	VL Photographic Geolocation	0x001d	29	GPSInfo	GPSDateStamp	Ascii	A character string recording date and time information relative to UTC (Coordinated Universal Time). The format is "YYYY:MM:DD.".
(ggps,001e)	GPSDifferential	VL Photographic Geolocation	0x001e	30	GPSInfo	GPSDifferential	Short	Indicates whether differential correction is applied to the GPS receiver.