



Certified DICOM Integration Professional  
(CDIP)  
Requirements

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## **Certified DICOM Integration Professional (CDIP) requirements:**

This document contains the detailed requirements for the certification of a CDIP, or Certified DICOM Integration Professional.

Target audience for this certification: PACS system administrators, integration specialists, purchasing and specification agents, technical imaging professionals, informaticians, service engineers, software analysts and developers, advanced system administrators/managers.

Certification Objective: To support and evaluate DICOM connectivity, troubleshoot, perform system integration, and develop software and applications.

### **1. DICOM introduction and negotiation**

1.1 DICOM architecture and background: DICOM has several “layers” or “dimensions” with regard to functionality, has been defined based on the ACR-NEMA standard, has implicit version control through its negotiation mechanism. – Know to distinguish the DICOM functionality layers, relationship with ACR-NEMA and occurrence of “retired” attributes and services, as well as meaning of DICOM version 3.0.

1.2 Common issues: “DICOM is not always DICOM”, it deals with interconnectivity, not interoperability. Many vendors use proprietary data elements in the objects defined as so-called Classes, there are issues with missing attributes, as well as the use of interface boxes, and the many optional features in the standard. – Know the limitations and issues with the DICOM standard, most frequent problems and misconceptions and value of conformance.

1.3 Importance of Information model: The DICOM standard has a comprehensive information model: for example, for most images the major constituents of the model are Patient, Study, Series, and Image, for requests it is Image Service Request, Requested Procedure and Scheduled Procedure Steps. – Know the importance and limitations of the DICOM information model, especially with regard to the image and request-related model.

1.4 AE, SCU/SCP, FSR/FSC/FSU: DICOM Application Entities have different roles for the different DICOM services, both communication and media. – Know meaning of the roles and how to specify the roles depending on the required functionality.

1.5 Negotiation; Presentation Context ID, Abstract Syntax, Transfer Syntax and Association Management: Part of the negotiation between two AE’s is the exchange of the Presentation Context. – Know meaning and contents of the Presentation ID, Abstract and Transfer Syntax and potential issues with Association lengths and meaning.

### **2. DICOM Messages and basic conformance:**

2.1 SOP Class concept: DICOM functionality is defined as SOP Classes, while the exchange is in the form of SOP Instances. – Know definition of SOP Class and Instances and SOP Class and Instance UID identification.

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2.2 Composite (Image) Message Structure: Images are structured as IE's, Modules and Attributes. – Know the basic structure of the composite DICOM objects, relationship to the information model, how to distinguish Composite and Normalized services and objects, and rules for creating a new persistent object.

2.3 Data Elements: The basic building blocks of DICOM messages consist of a Tag-Length-VR-Data Value string. - Know how to identify these elements in a DICOM dump, the importance of “group-element” numbers, as well as private groups, LE and BE byte ordering, TYPE definitions, Sequences, Macro's and Coded data elements.

2.4 Comparing conformance statements: In order to determine whether there are any compatibility issues between two devices, there are certain key area's to compare these. – Know the critical areas to compare conformance statements against.

2.5 UML diagrams: A critical component of a conformance statement is the UML diagram showing the sequence of each DICOM transaction. – Know how to interpret and create a UML diagram.

### **3. DICOM Storage and image management Services:**

3.1 Storage Service Class: The Storage Service Class contains the SOP Classes for exchanging image and other composite objects, identified by UID's. – Know the limitations and options of Storage SOP Classes.

3.2 Important Storage Service Classes: There are single and multi-frame Storage SOP Classes. Images can be identified by being Primary or secondary - Secondary Capture (SC) or “derived”, and as being the “native” single frame modality and multiframe. – Know characteristics of SC, single and multiframe.

3.3 STC: Storage Commitment provides a “hands-off” from a modality to the PACS, and can be used either with a single or separate Association for the request and response. – Know the information that is exchanged and potential issues with error information and Association implementation as well as PACS workflow impact.

3.4 MPPS and IA: Modality Performed Procedure Step exchanges five important pieces of information to the MPPS manager, forwarding this to the RIS and PACS. Image Availability is a service that allows devices to communicate that images are available for interpretation. - Know to identify the five critical information pieces of the MPPS and impact on PACS workflow. Also know use case scenarios, actors and protocol used for Image Availability.

3.5 MWL: Modality Worklist is critical from an efficiency and data integrity perspective. Its information model needs to match the RIS orders and results. It uses a client-server model and can be used for real time query and polling. – Know how to identify the single value and broad query matching attributes and how to relate the attributes to the information model, potential issues with RIS order mapping. Also, issues with polling and the need to map the order/request form to allow an institution to go paperless.

#### **4. DICOM Print, Query/Retrieve and Compression:**

4.1 Print: DICOM Print is used to make hardcopies (paper or film), typically for referring physicians or specialists. It is critical to match the image quality between the image on the monitor and hardcopy, and, in some cases, to make a “true size” print. – Know the normalized service elements used for creating a Print Session and the mechanisms to change the image quality (CI and Presentation LUT), and true image size attributes.

4.2 Print extensions: Additional print services might be used to provide text on the films and to check the printer status. – Know the function and how to use Annotation Box as well as Print Job.

4.3 Query/Retrieve-FIND: Queries to an AE can be performed using three different Information models with Unique, Required or Optional Keys. Different type of matching can be performed (exact, range, etc.). – Know the difference between the three information models, examples of matching, the importance of matching the keys of the SCU and SCP and why we need a Cancel.

4.4 Query/Retrieve-MOVE-GET: Information can be retrieved using either MOVE or GET which results in either a separate or same Association for the responses.- Know mechanism of MOVE/GET, function of the Response and Cancel.

4.5 Compression: Compression is used for archiving and communication. There are several compression algorithms, that are negotiated, JPEG, MPEG, RLE, Wavelet, some of them either lossless or lossy. – Know the most common compression ratios for lossless and lossy, characteristics of RLE, Lossy and Lossless in JPEG Wavelet, and MPEG, and how compression is negotiated by AE's.

#### **5. DICOM Media**

5.1 Media specifications: DICOM media specifications include the physical media, file structure, DICOMDIR and Application profiles. – Know importance of media specifications for compatibility, structure of the DICOMDIR, and why Application profiles are critical.

5.2 DICOM Part 10 files: The logical file structure or encapsulation of the DICOM objects is defined in Part 10 of the DICOM standard. – Know importance of Group 2, and structure as well as contents of Metafile header.

5.3 Application Profiles: Application profiles are used to constrain the options for information exchange. – Know the constraints for the General Purpose Application and other Profiles.

5.4 CD interchange issues: CD's are increasingly being used to exchange patient files between institutions, however, their compatibility track record is somewhat poor. – Know of the most common compatibility issues with exchange CD's.

5.5 DICOM media services: One could instruct other devices over the network to create and manage exchange media using the appropriate DICOM protocol services. – Know which DICOM services to use to manage exchange media remotely.

## **6. DICOM Image Quality and SR**

6.1 Pixel representation: Pixel data is stored with a certain pixel range (number of bits) in specific manner in the DICOM images representing grayscale or color. – Know how to identify the pixel attributes (Allocated, Stored, High bit), the representation (monochrome, color) as well as signed/unsigned identification.

6.2 Image pixel pipeline: Pixels undergo a series of conversions and/or mappings prior to be sent to a display subsystem, which includes the optional Mask, Modality LUT, optional Mask, VOI LUT, and potentially Presentation LUT. – Know meaning and function of these transformations, as well as potential issues and configuration impact.

6.3 GSDF: To achieve a consistent presentation of the images among different displays and hardcopy, a standard mapping from digital values to density or luminance is defined. Devices require calibration to comply with this mapping. – Know importance of calibration, and popular commercial calibration methods.

6.4 Presentation State and overlays: Overlays can be exchanged in different manners, i.e. in the pixel data, as an overlay plane in the image, or as separate DICOM objects in the form of a Presentation State. The DICOM Presentation State allows the annotations, manipulations, etc. to be preserved. - Know different encodings of overlays (embedded, group 6000, stand-alone), the function of DICOM presentation state and importance for the preservation of presentation information in a standard (non-proprietary) manner both for greyscale and color.

6.5 SR: DICOM Structured Reports are typically used for measurements, observations or special applications such as Key Images. They use templates to pre-define the object structure in a greater detail. – Know the three different generic SR SOP Classes, the Key Object Note structure and how SR is used for applications such as cardiology, OB/GYN CAD, Ultrasound measurements and Dose reporting.

## **7. DICOM VR's and detailed conformance.**

7.1 Value Representations: Value Representations define the encoding rules for DICOM attributes, they can be included in the DICOM messages (explicit VR). – Know how to decode most common VR's, importance of VM, maximum/fixed length restrictions, control characters, including padding requirements to make even length data elements.

7.2 Specialization and privatization: Information can be added to DICOM objects that is not defined as part of the SOP Class definition. – Know how to detect Standard Extended SOP Classes and how private groups are allocated and identified and the importance of specialization.

7.3 Attribute matching: Attributes in the image header, and information exchanged with the Query and Modality Worklist need to match between the SCU and SCP. - Know how to evaluate these attributes and look for potential interoperability issues.

7.4 Gap Analysis: An institution has specific requirements regarding SOP Class support, transfer syntaxes. – Be able to perform a proper gap analysis using a spreadsheet to show whether there are any conformance gaps.

7.5 SOP Specific behavior: Specific behavior, including error handling, specifies how the details are implemented of the various DICOM services. – Know where to find these behavior sections and what to look for to determine potential interoperability issues.

## **8. DICOM networking**

8.1 Message structure in detail: DICOM messages are broken down in packets (PDU, PDV) while the “command” is contained in a special group 0. – Know importance of PDU, how to configure this and potential performance impact, to recognize group “0” information and how the break down its content from the object to the TCP/IP packets, i.e. how it references to the ISO OSI communication model.

8.2 Set up and configure DICOM devices: DICOM AE’s communicate with each other using certain addresses, port numbers, etc. – Know how to configure AE titles, port numbers, and IP addresses and importance of uniqueness.

8.3 Sniffers and active test software: There are several tools available to troubleshoot DICOM connections, both active and passive. – Know function and how to use active and passive DICOM test tools.

8.4 Interpret logs and DICOM dumps: DICOM dumps showing the Association set-up and image header information that is sent/received are critical in order to determine whether an issue is related to an incorrect interpretation of a message or due to an issue with the message itself. – Know how to interpret DICOM dumps and logs.

8.5 Network Sniffer logs: To diagnose semi-random connectivity problems and in case regular logs don’t provide sufficient information, the investigation of sniffer logs, which shows the actual information that is being exchanged is critical. – Know how to configure a network sniffer to show the connectivity information and be able to interpret the information.

## **9. DICOM Troubleshooting**

9.1 Send/receive TCP/IP Ping: The first step to verify connectivity issues is to issue a ping to a potential receiving device. – Know how to ping a device.

9.2 DICOM Verification (Echo): Verification (DICOM Ping) is the second step to verify connectivity. – Know how to issue a DICOM Echo and how to receive it.

9.3 Send/receive test messages: Prior to connecting a new device to a PACS system, one might send images from the new device to a well-known node, such as a workstation, to see whether there are any issues with the images. – Know how to send an image to a specific DICOM receiver and how to receive one.

9.4 Send/receive images with different SOP Classes and Transfer Syntaxes: Some issues are related to sending specific SOP classes and/or transfer syntaxes to a device. – Know how to change and/or select different SOP Classes and transfer syntaxes (implicit, explicit, LE, BE, compression) and to send/receive them.

9.5 Modify image headers and anonymization: An issue might be caused by specific header information being missing, incorrect, or being incorrectly interpreted. Changing

the header and re-sending it could assist in troubleshooting. Anonymizing data is required when sharing images with a “non-trusted” node and/or to create files for teaching or other public use. – Know how to modify a header and to anonymize it.

### 10. New DICOM developments

10.1 For Processing and Presentation Images: Digital Radiography images can be identified by new versions such as DX, IO or MG, with each having a For Processing and For Presentation SOP Class. – Know differences between CR, DX, for Processing, Presentation.

10.2 Enhanced CT, MR, XA, RF, ophthalmology (OCT) and Digital Breast Tomosynthesis group of SOP Classes: The traditional SOP Classes do not lend themselves to encode the many different dimensions of the acquisition, hence the definition of the new, enhanced SOP Classes which are Multiframe - Know how the new enhanced SOP Classes are defined and the structure of dimensions, stacks and header structure which impacts hanging protocols.

10.3 Unified Worklist and Procedure Step definition (UPS): To facilitate a standard interface between one or more PACS workflow manager and workstations, a worklist is defined with its synchronization. - Know the SOP Classes and transactions defined for the UPS and what are typical use cases.

10.4 Pathology: Pathology images require a new definition because of their size and requirement to move through the data in a top-down fashion. – Know the structure of the data and header definition of pathology SOP Class.

10.5 DICOM protocol over the internet (DICOMWeb): The DICOM protocol is optimized for Local Area Network connections and not for Internet communication. – Know the extensions to the DICOM protocol to address internet communication such as email, WADO-URI, WADO-WS, WADO-RS and QIDO, STOW, UPS and Option services defined for DICOMWeb.