Joint VA / DoD DICOM Conformance Requirements for Digital Acquisition Modalities

Version 3.0

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SIGNATURE PAGE

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PREFACE

The purpose of this Requirements Document is to specify how modalities shall provide the Digital Imaging and Communications in Medicine (DICOM) functionality needed by the Department of Veterans Affairs (VA) and Department of Defense (DoD). This document and its associated annexes contain the minimal requirements for all VA and DoD purchases of radiology, dental, ophthalmology and optometry, cardiology, pathology, endoscopy, dermatology, and all other DICOM-compliant digital acquisition modalities and related equipment. Individual VA/DoD organizations may elect to mandate requirements which are listed as optional or are not present within this document and its associated annexes.

The Veterans Health Administration (VHA) Patient Care Services and the DoD Military Health System (MHS), representing all clinical care programs that use imaging equipment, consider these requirements essential for interoperability between imaging equipment and government hospital information systems (HIS). Other agencies are encouraged to adopt these requirements as the basis for DICOM conformance.

This document is available online at http://vaww.va.gov/imaging/.

Please refer to this website for directions regarding submission of comments, inquiries, and suggestions.

REVISION HISTORY

Date	Revision	Description	Author
11/25/1997	1.0 RFC	Request for Comments	Herman Oosterwijk
07/07/1998	1.0 RFP	Request for Proposal	Herman Oosterwijk
06/18/1999	1.0	Original Document	Herman Oosterwijk
06/22/1999	1.1	Minor Revision	Herman Oosterwijk
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02/15/2002	2.1	Made Storage Commitment and MPPS Optional	Peter Kuzmak
03/27/2002	2.2	Added elements to MWL for clinical specialties	Peter Kuzmak
01/03/2003	2.3	Updated references to external documents and web pages	Dan Carozza
12/31/2003	2.4	Combined DoD and VA Requirements into one document	Donald Van Syckle Herman Oosterwijk
03/31/2004	2.4.8.3	Request for Comments	Donald Van Syckle Herman Oosterwijk
05/11/2004	2.4.8.6	Request for Comments	VA / DoD Imaging Subgroup
01/14/05	2.4.8.10	Require Modalities to support IHE Scheduled Workflow	Donald Van Syckle
1/28/05	2.4.8.11	Modifications due to comments from industry; minor editing and corrections	Peter Kuzmak
8/1/05	2.5.5	Added Section 508 Requirements	Peter Kuzmak
9/1/05	2.5.6	Updated IHE reference.	VA / DoD Imaging Subgroup
9/13/05	2.5.7	Added Signatures of Chief Architects	VA / DoD Imaging Subgroup

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Major changes from Version 2.4 to 2.5.7 include:

1) Added Section 508 Requirements
2) Updated the *Integrating Healthcare Enterprise Technical Framework (IHE)* Scheduled Workflow Requirements
3) Updated the document based on review and recommendations of the Department of Defense, TRICARE Management Activity Technology Management, Integration and Standards and VHA/DoD Health IT Sharing Program Architecture and Standards groups.

Major changes from Version 2.3 to 2.4 include:

1) Combined VA and DoD requirements into one document

2) Update References to the *Integrating the Healthcare Enterprise Technical Framework (IHE), Version 5.5* document

3) Updated Web-sites

4) Updated Acronyms

5) Restructured Figures and Table numbering

6) Updated Figure 1 - *Hierarchical Integrated Data Model*

7) Updated Table 1 - *Scheduled Workflow Integration Profile - Actor and Transactions*

8) Updated Table 2 - *Consistent Presentation of Images Integration Profile - Actors and Transactions*

9) Updated Table 6 - *Modality Worklist (MWL) Keys for Broad Worklist Queries*

10) Added two requirements in Section 4.4.3 - *C-STORE Attribute Requirements*

11) Updated Section 4.4.3 Minimum Attribute Length for Patient Name / Patient ID

12) Updated Table 11 - *Image Storage Attributes*

13) Updated Section 6.4 - *Security of Connections*

14) Added Signature Page

15) Add requirement for modalities supporting IHE Scheduled Workflow

Major changes from Version 2.0 to 2.3 included:

1) The requirements for the DICOM Verification, Modality Worklist and Storage services contained in this document are mandated for all new purchases of Radiology, Dental, and Ophthalmic digital acquisition modality equipment.

2) The requirements for the DICOM Storage Commitment and Modality Performed Procedure Step contained in this document are *optional* and are not mandated for purchases of new equipment.

3) This version of the requirements document introduces Print Management and Presentation Look Up Table (LUT) Service-Object Pair (SOP) classes, which are *optional* and are not mandated for purchase of new equipment.

4) If the equipment does support these optional DICOM services, however, it should be done in a fashion satisfying the requirements in this document. VA will not be using or formally validating optional requirements at this time. This functionality will be phased in over time.

5) A checklist is provided at the end of this document to help vendors and acceptance personnel verify that the stated requirements are properly meet.

6) All new models of Radiology, Dental, and Ophthalmic digital acquisition modality equipment shall have their DICOM capabilities verified by Internet testing with the VA prior to being purchased.

This document also differs from Version 1.2 from a formatting perspective as well as a functional perspective. The format has been changed for vendors to more easily identify the specific individual requirements, which are now highlighted with bullets ("➢") in the text. Furthermore, since there is a strong commitment from the VA and DoD to the **IHE Technical Framework** activity and corresponding technical documentation, this document has been made consistent with the transactions and profiles as described in the latest IHE Technical Framework. An effort has been made to reference the IHE documents wherever possible, instead of duplicating the text here. From a functional perspective, this document incorporates experience with integrating modalities with the VistA system since the initial version, and it accommodates non-radiology applications in clinical specialties.

Some of the requirements in this document are more detailed than what IHE specifies, for example, the IHE does not include any explicit statement for the presence of specific image attributes. On the other hand, some requirements are a subset of those of the IHE, because of the actual workflow environment; for example, support is not required for unscheduled case, group cases, and so forth.

Major changes from Version 1.2 to 2.0 included:

1. Verification, MWL and Storage are <u>mandated</u> requirements. Storage Commitment, Modality Performed Procedure Step, the Print Management and Presentation LUT SOP Classes are *optional* and are not mandated.

2. Each requirement is specifically mentioned in the form of a "bullet" and added as a checklist so that a vendor easily can determine and document its compliance (see Appendix C).

3. The requirements for the various SOP Classes were identical for each modality type. They are changed and now depend on the type of modality.

4. This specification is extended to include non-radiology modalities.

5. The document is made consistent with the profiles as specified in the IHE Technical Framework.

6. Print is added as a requirement for modalities, including support for the Presentation LUT, conformant with the IHE Print Composer profile.

7. MWL query support is extended and specified in more depth, consistent with the keys required by IHE; version 1.2 only specified matching keys for Accession number and Requested Procedure Identifier (ID).

8. Shortcut Matching keys were required for the Accession number; this is extended to the Patient ID as well.

9. Support for some modalities as a Storage Service Class Provider (SCP) is added.

10. UID uniqueness (consistent with DICOM) is clarified.

11. Association errors are clarified (consistent with DICOM).

12. Gigabit/sec is added as a communication profile requirement.

13. Requirement for virus protection is added.

14. Testing of new modalities prior to the procurement with VistA is required.

15. Several new elements have been added to MWL in order to support the clinical specialties.

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1. INTRODUCTION

1.1. Executive Summary

The purpose of this document is to define VA / DoD DICOM conformance requirements for digital acquisition modalities, which generate DICOM objects. Examples of these modalities include those used in radiology, dental, ophthalmology and optometry, cardiology, pathology, endoscopy, dermatology, etc. By adhering to these requirements, modality compatibility and interoperability with VistA Imaging and CHCS II will be greatly enhanced. These requirements consist of a defined set of attributes for all objects that are exchanged. The requirements also include a set of DICOM services (DICOM Modality Worklist Management, Storage, Modality Performed Procedure Step, Storage Commitment and Verification).

DICOM standard issues that are commonly subject to misinterpretation are explicitly stated so vendors can check their implementations against the standard and verify their compliance. Note that these requirements should be redundant because they effectively repeat the DICOM standard.

In March 2003, the Federal Government announced the first eGov health information exchange standards. Benefits from using common health care standards include improved patient safety and a reduction in the cost of health care. As part of this federal partnership, the Veterans Health Administration (VHA) and the DoD Military Health System (MHS) have adopted the DICOM standard to enable images and associated diagnostic information to be retrieved and transferred between various manufacturers' devices as well as provider workstations. This document is also designed to facilitate interoperability between the two organizations.

Department of Veterans Affairs (VA)

VA is one of the pioneers of implementing Picture Archiving and Communications Systems (PACS) in a clinical environment. VA was one of the first organizations to implement DICOM[1] interfaces between commercial PACS, image generating modalities, and the hospital/radiology information system. Today, all VA hospitals are using this technology to increase efficiency, lower cost, and reduce turnaround time for diagnostic exams. This has a positive impact on improving patient care in the VA hospital environment.

Based on these early implementations, it became clear that there was a need to specify uniform and consistent requirements for modality vendors supporting the DICOM standard. The VA found many cases where information that was critical in uniquely identifying a patient or a study (for example the accession number in a radiology study) was often entirely missing from the image header, or was encoded in different fields (for example as Comments). The VA also noted that certain modalities do not accommodate a sufficient number of characters in the patient data entry, causing the Patient Name and/or Patient Identifier (ID) to be truncated. Furthermore, the VA encountered DICOM violations that might have resulted from misinterpretations of the standard, which caused interoperability issues. To resolve this situation, the VA initially developed this requirements document.

Department of Defense (DoD)

CHCS II will manage the medical and dental images of over 9.1 million Department of Defense Health Care Beneficiaries. Images from more than 100 hospitals and 600 clinics worldwide will be managed with the CHCS II Clinical Data Repository (CDR) military health record. To support a mobile force, CHCS II will enable worldwide access to images. Through the CDR, CHCS II will have an Enterprise Master Patient Index (EMPI) that will provide a unique identifier for patients.

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[1] National Electrical Manufacturers Association: Digital Imaging and Communications in Medicine standard PS 3.1 to 3.18 – 2004.

CHCS II will be implemented in blocks of increasing functionality, allowing the MHS to build a system that is easily adapted to meet new user requirements and to incorporate the latest technology available. Block 1 provides a graphical user interface (GUI) for encounter documentation that enables immediate and concurrent retrieval of medical records. Block 2 integrates dental charting and documentation functionality as well as immediate global access to medical and dental records. Block 3 will integrate Commercial off the shelf (COTS) pharmacy, laboratory, and radiology functionality into the electronic patient record.

1.2. Audience

The intended audience of this document is:

- Government Contracting Specialists who need to include this document in every purchase order for imaging modalities to ensure that the equipment provides the necessary capabilities to interoperate properly with the Department of Veterans Affairs (VA) and the Department of Defense (DoD) systems.

- Vendor technical staff planning to interface with the Veterans Health Information System Technology and Architecture (VistA) Imaging and the Composite Health Care System II (CHCS II). This document is intended to clarify the differences to implementers who are well versed in the Digital Imaging and Communications in Medicine (DICOM) standard and the Integrating the Healthcare Enterprise (IHE) Technical Framework.

- Vendor personnel who want to learn what specific requirements VA and DoD environments pose on modalities so they can plan their implementations accordingly.

- VA and DoD technical and functional personnel who want to familiarize themselves with the IHE concepts in context of the VistA Imaging and CHCS II environments.

1.3. Reference Documents

1. Federal Government Announces First Federal eGov Health Information Exchange Standards, March 2003. available at http://www.whitehouse.gov/omb/egov/gtob/health_informatics.htm,
2. Department of Defense/Department of Veterans Affairs Clinical Data Repository –Health Data Repository Working Integrated Product Team Imaging Subgroup Charter, dated April 23, 2003.
3. National Electrical Manufacturers Association (NEMA); Digital Imaging and Communications in Medicine (DICOM) standard, available at http://medical.nema.org/dicom/2004.html
4. HIMSS/RSNA Integrating the Healthcare Enterprise (IHE) Technical Framework, rev 6.0, 2005. Available at http://www.ihe.net/Technical_Framework/
5. Kuzmak PM and Dayhoff RE: Minimizing Digital Imaging and Communications in Medicine (DICOM) Modality Worklist Patient/Study Selection Errors, Journal of Digital Imaging, Vol 14, No 2 Suppl 1 (June), 2001: pp 153-157.
6. Gale ME, Gale DR: DICOM Modality Worklist: An Essential Component in a PACS Environment, Journal of Digital Imaging, Vol 13, No 3 (August) 2000: pp 101-108.
7. DoD Ports and Protocol Policy Available on the Defense Information System Agency (DISA) website. http://www.cert.mil/portsandprotocols/.

1.4. Symbols and Abbreviations

AE	Application Entity
CDR	Clinical Data Repository
CDT	Current Dental Terminology
CHCS II	Composite Health Care System II
COTS	Commercial off the Shelf
CPT	Current Procedural Terminology
CR	Computed Radiography
CT	Computed Tomography
DEERS	Defense Enrollment Eligibility Reporting System
DICOM	Digital Imaging and Communications in Medicine
DISA	Defense Information System Agency
DoD	Department Of Defense
DX	Digital Radiography
EMPI	Enterprise Master Patient Index
EWS	Enterprise Wide Scheduling
FTP	File Transfer Protocol (part of the TCP/IP protocol suite)
GUI	Graphical User Interface
HIMSS	Healthcare Information and Management Systems Society
HIS	Hospital Information System
ID	Identifier
IHE	Integrating the Healthcare Enterprise
IOD	Information Object Definition
ISO	International Standards Organization
LUT	Look Up Table
MHS	Military Health System
MPPS	Modality Performed Procedure Step
MR, MRI	Magnetic Resonance Imaging
MWL	Modality Worklist
N/A	Not Applicable
NM	Nuclear Medicine
PACS	Picture Archiving and Communication System
PDU	Protocol Data Unit
PT, PET	Positron Emission Tomography Scan

RFC	Request For Comments
RIS	Radiology Information System
RSNA	Radiological Society of North America
SCP	Service Class Provider
SCU	Service Class User
SOP	Service-Object Pair
TCP/IP	Transmission Control Protocol/Internet Protocol
UID	Unique Identifier
US	Ultrasound
VA	Department of Veterans Affairs
VHA	Veterans Health Administration
VistA	Veterans Health Information System Technology and Architecture
VL	Visible Light
VOI	Volume of Interest
VPN	Virtual Private Network
VR	Value Representation
XA	X-Ray Angiography

1.5. HIMSS/RSNA IHE Initiative

The Healthcare Information and Management Systems Society (HIMSS) and the Radiological Society of North America (RSNA) are sponsoring the IHE initiative to address similar interoperability issues. This effort has drawn participation from all leading commercial information and imaging systems vendors.

VA and DoD are in full support of the IHE effort and this document can be construed as essentially an interpretation of the IHE framework. The reader is directed to the IHE web site to obtain details on the scope of the project, its mission, and Technical Framework[2]. The endorsement of the largest government-owned healthcare networks adds further momentum to the IHE project and signals the willingness of purchasers, vendors, and government software developers to work together toward interoperability.

This document references the **Scheduled Workflow Integration Profile –Acquisition Modality and Archive Actor** and **Consistent Presentation of Images Integration Profile – Print Composer Actor** as defined in the IHE Technical Framework document. This document is intended to augment the IHE document and provide implementation context. Procedural and definition details covered by IHE are not repeated by this document. This document also specifies several notable differences from the requirements set forth by the IHE Technical Framework; see Appendix B of this document. The reader is expected to be fully familiar with the concepts of the IHE Technical Framework. This document inherits the relationships, definitions and nomenclature established by the IHE Technical Framework.

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[2] For more information, please see the appropriate sections of the IHE Technical Framework rev 6.0, 2005. HIMSS/RSNA Integrating the Healthcare Enterprise Technical Framework, available at /www.ihe.net/Technical_Framework/ web site.

1.6. Hierarchical Integrated Data Model

The Data Consistency Model as defined by the IHE Technical Framework (see Figure 1) is generally followed, although there are a few specializations with regard to the multiplicity of the relationships between the various blocks in the diagram. These are described in detail under the corresponding transaction specifications.

The DoD Data Model will follow the IHE Technical Framework. CHCS II will associate the image order with a number of Requested Procedures that have to be performed to satisfy the order. Each Requested Procedure prescribes a number of actions that have to be performed by Digital Acquisition Modalities.

*** This relationship may not exist "0-1 to n" but "0-n to m" when multiple Scheduled Procedure Steps are satisfied by one Performed Procedure Step.

Legend:
{xxx}   : An Attribute which is a unique identifier (DICOM UID) or an identifier (DICOM ID) or for the entity
yyy   : An Attribute which is used in the entity to reference another entity as show by the associated arrow.
[n]   : The Attribute Type as defined by DICOM for this entity (IHE may strengthen this requirement)
───────► : A relationship between two entities using a unique identifier (DICOM UID)
◄──────► : A bidirectional relationship between two entities using a pair of unique identifiers (DICOM UID)
───────► : A relationship between two entities using a simple identifier (DICOM ID)
n-m   : Cardinality of the relationship between the entities, not the identifiers. (Direction of the arrow is irrelevant to cardinality.)
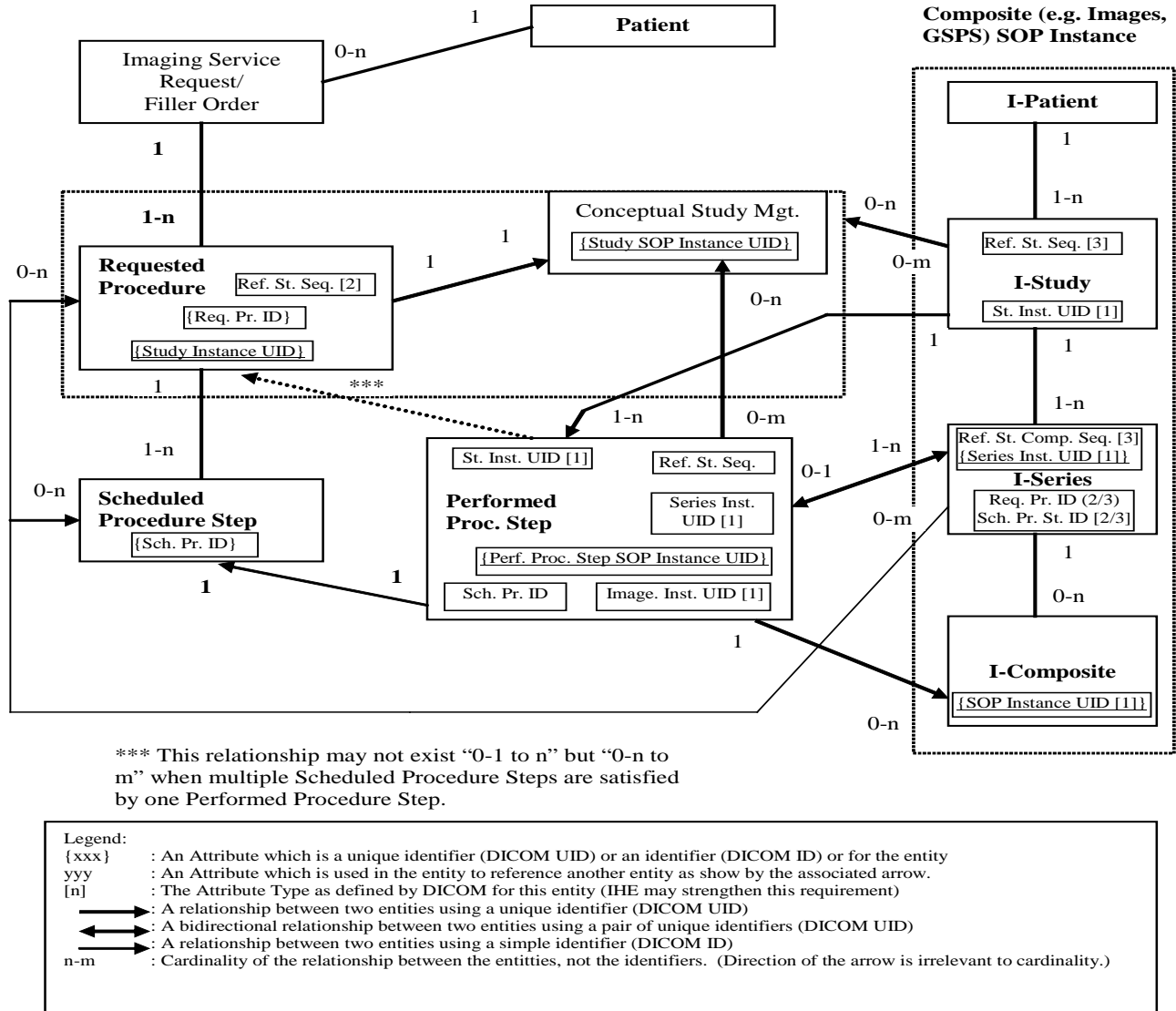
Figure 1 Data Consistency Model [3]

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[3] **REFERENCE: IHE TECHNICAL FRAMEWORK, VOL 2, VER 6.0, FIGURE A-1**. Data Consistency Model: Modality Worklist Information Model, Composite IODs and Modality Performed Procedure Step IOD.

1.7. DICOM Digital Acquisition Modality Interface Architectures

VA currently supports two different architectures with regard to DICOM digital acquisition modality interfaces, depending on whether a commercial PACS system or the VA VistA PACS solution is used. The modalities shall perform the same functions, whether they directly interface with VistA Imaging or interface through a commercial PACS. This document defines the domain of specification strictly as the point of interface between the modality and the PACS.

MHS supports only Architecture A. It is the intent of the MHS to utilize commercial PACS architectures at military medical and dental treatment facilities for image management and distribution. Through an interface with the CHCS II CDR and the Defense Enrollment Eligibility Reporting System (DEERS), CHCS II will provide patient demographic information. Through an interface with the Enterprise Wide Scheduling (EWS) System, CHCS II will provide scheduling information on imaging equipment, rooms, providers, and staff.
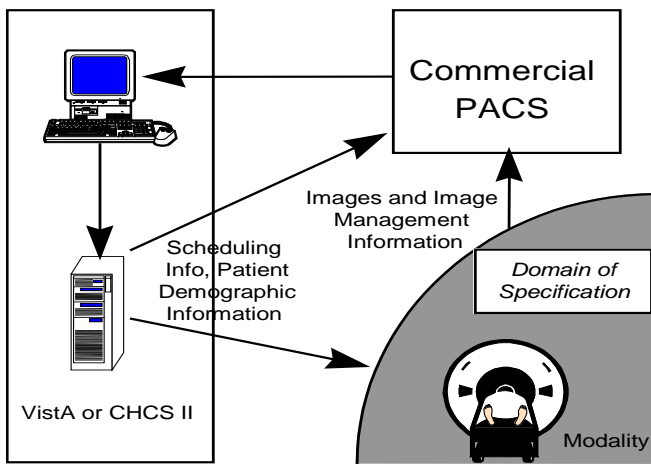
Architecture A has three high level components, the Modality itself, the VistA or CHCS II Information System, and a commercial PACS. In this architecture, the Modality will interface with VistA or CHCS II Information system to obtain patient demographic information and to a Commercial PACS to exchange images and image management information.

Figure 2 Architecture A: Using a commercial PACS
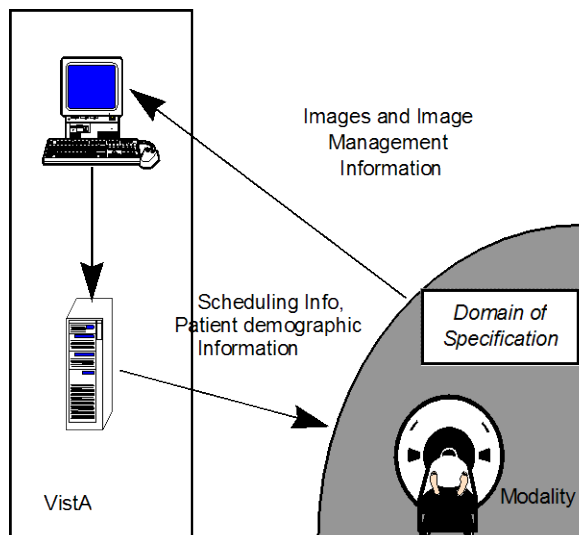
In Architecture B, the PACS is incorporated within the VistA Information system. From a modality functional perspective there is no real difference between Architecture A and Architecture B. The interface from the modality to a commercial PACS is now used between the modality and the VistA Information System.

The domain of this specification (that is, the DICOM interface of the modality) is identified in Figure 2 and Figure 3 by the shaded area.

Figure 3 Architecture B: Using the VistA Imaging System as the PACS

2. REQUIRED AND OPTIONAL IHE PROFILES

2.1. Integration Profile

A modality shall support all of the transactions as defined by the IHE as part of the Scheduled Workflow Integration Profile (see Table 1 below, which is a subset of Table 3.1-1 from the IHE Technical Framework, Vol 1, Ver 6.0). This section describes the minimal required IHE profiles. Individual VA/DoD organizations may elect to mandate requirements which are listed as optional or are not present within this document and its associated annexes.

Note that the Modality Images Stored transaction is supported as two actors, that is, the modality can either send or (optionally) receive the images. The latter might be needed for some modalities when comparing a study with a previous one.

Table 1 Scheduled Workflow Integration Profile - Actor and Transactions

Actors			
Acquisition Modality	Query Modality Worklist	Mandatory *	4.5
	Modality Procedure Step In Progress	Mandatory *	4.6
	Modality Procedure Step Completed	Mandatory	4.7
	Modality Images Stored	Mandatory	4.8
	Storage Commitment	Mandatory	4.10
	Verification	Mandatory	N.A. **
Image Archive	Modality Images Stored	Optional	4.8

    *   The optional features for this transaction are described in the referenced section of the IHE Technical Framework.

    **   The VA's experience is that the Verification Transaction is critical in order to effectively troubleshoot and support these systems.

2.2. Print Profile (Optional)

A modality shall support the transactions as defined by the IHE as part of the Consistent Presentation of Images Integration Profile for the Print Composer Actor (see Table 2, which is a subset of Table 5.1-1 from the IHE Technical Framework, Vol 1, Ver 6.0).

Table 2 Consistent Presentation of Images Integration Profile - Actors and Transactions

Actors	Transactions	Requirement	IHE Section
Print Composer	Print Request with Presentation LUT	Optional	4.23

3.   GENERAL REQUIREMENTS

3.1.   Service-Object Pair (SOP) Class Support to Implement IHE Profiles

To comply with the mandatory profiles specified above, an acquisition modality is required to support the following SOP Classes, with their specified role (Service Class User (SCU)/Service Class Provider (SCP)).

Table 3 Required SOP Classes

SOP CLASS NAME	SOP CLASS UID	USAGE
Modality Worklist Information Model Find	1.2.840.10008.5.1.4.31	SCU
Modality Performed Procedure Step SOP class	1.2.840.10008.3.1.2.3.3	SCU
Storage Commitment Push Model SOP Class	1.2.840.10008.1.20.1	SCU
Modality Storage SOP Class (depends on modality Type, for example, CT, MR, and so forth)	1.2.840.10008.5.x.x.x.x	SCU
Verification SOP Class	1.2.840.10008.1.1	SCU

To further comply with the optional profiles specified above, an acquisition modality may support the following SOP Classes, with their specified role (SCU/SCP).

Table 4 Optional SOP Classes

SOP CLASS NAME	SOP CLASS UID	USAGE
Modality Storage SOP Class (depends on modality Type, for example, CT, MR, and so forth)	1.2.840.10008.5.x.x.x.x	SCP
Verification SOP Class	1.2.840.10008.1.1	SCP
Basic Grayscale Print Management Meta SOP Class	1.2.840.10008.5.1.1.9	SCU
Basic Color Print Management Meta SOP Class	1.2.840.10008.5.1.1.18	SCU
Presentation LUT SOP Class	1.2.840.10008.5.1.1.23	SCU

If equipment does support these optional DICOM services, it should do so in a fashion that satisfies the requirements in this document.

3.2.   Association Behavior

DICOM services may be implemented using multiple Application Entities (AEs). Each AE supports the Verification SOP class (as a SCU/SCP) and one or more additional SOP classes.

  ➢ **Separate AE support:** The modality SCUs utilizing the services of the SCPs shall be prepared to support each service class residing on a separate AE in the VA environment, and be capable of configuring this accordingly.

The configuration of each modality SCU to use a different AE SCP with a different, unique, AE title for each of the SOP Classes (Storage, Modality Worklist, Modality Performed Procedure Step, and Storage Commitment) provides the greatest flexibility for the modality when interfacing to different system configurations. This is consistent with the implicit assumption of the IHE model depicted in the IHE Technical Framework document.

> ➢ **Port numbers:** The modality shall be capable of utilizing the full 16-bit range (1-65535) of port numbers.

> ➢ **Restricted Numbers:** The port numbers allocated by Request for Comments (RFCs) shall not be used for DICOM communications, with the exception of port 104.

4.   SPECIFICATION OF INDIVIDUAL TRANSACTIONS

The following additions and/or specializations of the various transactions are described for the modalities.

4.1.   Modality Worklist Provided (Mandatory)

The DICOM Modality Worklist service allows a modality to query for Patient and Study information (that is, issue a "C-FIND" request).

4.1.1.   Hierarchical Integrated Data Model

The IHE Data Consistency Model (that is, the Modality Worklist Information Model, Image and Standalone Information Object Definitions (IODs) and Modality) Performed Procedure Step IOD is followed with the following specialization:

- The VA mapping from Imaging Service Request to Requested Procedure is 1:1, not 1:n. That is, a study has a single accession number that maps to a single procedure that maps to a single requested procedure step.

- The DoD mapping from Imaging Service Request to Requested Procedure is 1:n, which means that a single Accession number may contain one or more Requested Procedures.

Consistent with IHE, the Scheduled Procedure Step ID is meaningful for requested procedures resulting in multiple performed steps on the same or different modalities. An example would be a composite fluoroscopic study where the same device is used to take a set of supporting CR images.

4.1.2. Query Support

The modality shall initiate a query by supplying one or more matching keys. These can either be manually entered at a keyboard or come from an electronic scanning device (a barcode scanner, for example).
> ➢ **Modality Worklist (MWL) Query support:** The modality shall support BOTH the Patient Based and the Broad Query[4] with the keys that are specified for this transaction (see tables as specified in the IHE below for your reference).

The timing of the Modality Worklist query is important to obtain information on new procedures. In radiology, an "arrival event" is produced when the radiology staff takes responsibility for the study and registers the patient in the department. Because of the way radiology information systems (RISs) work, the "arrival event" is the first notification that a Modality Worklist provider receives about a study. The

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[4] IHE Technical Framework, Vol 2, Ver 6.0: Section 4.5.4.1.2, Examples for the Use of Matching Key Attributes.

most efficient use of Modality Worklist facility is to perform a single query shortly after the patient has been registered. A query prior to the arrival event produces negative results.

4.1.2.1. The Patient Based Query

This is the Query for a Worklist, specific for a particular patient.

> **Query by Patient matching key attributes:** The SCU shall support all 15 combinations of the matching key attributes listed in the Table 5 by including one or more keys.

Table 5   MWL Keys for Query by Patient

Matching Key Attributes	Tag
Patient's Name	(0010,0010)
Patient ID	(0010,0020)
Accession Number	(0008,0050)
Requested Procedure ID	(0040,1001)

Certain types of examinations can only be retrieved with explicit single value accession number queries. An example of this type of query is selecting a previously performed radiology study for scanning on a film digitizer. Fewer selection errors are made when Patient Based Queries are used rather than Broad Queries.

> **Single Value matching:** The Accession Number or Requested Procedure ID shall be retrieved with Single Value Matching (that is, wildcard matching shall not be allowed; an error shall be returned). Note that this is a DICOM specialization.

4.1.2.1.1.   Shortcut Matching Keys in Modality Worklist Patient Based Queries

The VA hospital information system (HIS) and radiology information system (RIS) support "shortcut" representations of patient and study identifiers to minimize the amount of data entered, reducing keystrokes and errors. As an example, the VA uses a "quick-pid" patient identifier shortcut, which consists of the initial of the patient's last name, followed by the last four digits of the social security number (R1234, for instance). This value is a convenient hash on the whole patient list, and usually matches only one or two patients at a time. It is much easier to remember and enter than the nine-digit social security number or the exact spelling of the patient's name. For another example, the VA RIS uses two formats for the accession number, a shortcut called the "case number" which consists of a series of digits (something like 1025), and a "date case number" which consists of the date (in mmddyy format) followed by the case number (something like 102198-1025). The radiology staff only uses the case number when dealing with active studies, and always uses the date case number for referencing historical ones.

To make these shortcuts available at the modality, the VA has implemented them in its MWL SCP. The VA requires the DICOM Modality Worklist user to support this capability. The modality should be able to use a "shortcut" value in a field to do a query and accept results where the "shortcut" value is replaced by a "full" value (in the above examples, the full patient name, patient ID, or study accession number). DoD is developing requirements for "shortcut" representations and supports the VA approach.

> **Ignore matching key checking:** The modality shall accept the results of a query when the returned full key(s) are different than the matching short cut keys specified in the query. The modality shall not indicate an error condition and reject the results when they are different.

4.1.2.2. Broad Modality Worklist Query

This is a Query for a broad Worklist.

➤ **Broad Query matching key attributes:** The SCU shall support all seven combinations of the matching key attributes listed in Table 6 by including one or more keys.

Table 6 MWL Keys for Broad Worklist Queries

Matching Key Attributes	Tag
Scheduled Station AE Title	(0040,0001)
Scheduled Procedure Step Start Date	(0040,0002)
Modality	(0008,0060)

➤ **MWL polling:** Issuing frequent periodic Broad Queries to the Modality Worklist provider (that is, "polling") to retrieve patient data has proven to be inefficient. It is therefore not allowed as the primary method for obtaining such data. Broad Queries initiated by the user on demand are preferred to polling.

4.1.2.3. Selection and Display Requirements for All MWL Queries

A major issue surfaced early in implementations of Modality Worklist within the VA. In some modality implementations, the design of the user interface made it relatively easy to select the wrong patient information to associate with a particular image. The result was a mismatch of the patient demographic data and image(s), with serious effects on data integrity and potentially adverse effects on patient safety. [5]

The selection of the appropriate patient and order information on most modalities is a two-step process. After a MWL query, there is usually a "pick-list" displayed on the screen that clearly identifies the patients and orders so that an unambiguous selection can be made. Upon selecting an entry from this pick-list, more detailed information is displayed and the technologist verifies that the correct patient and order has been selected. The IHE Technical Framework specifies the list of MWL attributes[6] that are required to be displayed, but does not indicate when and under what circumstances these attributes are to be displayed.

➤ **Sufficient data display:** The following minimum list of patient/study data items need to be displayed (in a pick-list) at the modality in order to properly identify scheduled procedure steps to the user:[7]

Table 7 Required Attributes to be Displayed for MWL

Displayed attribute	Tag
Patient's Name	(0010,0010)
Patient ID	(0010,0020)
Accession Number	(0008,0050)
Scheduled Procedure Step Sequence*	(0040,0100)
> Scheduled Procedure Step Description	(0040,0007)
Scheduled Procedure Step Start Date	(0040,0002)

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[5] Kuzmak PM and Dayhoff RE: Minimizing Digital Imaging and Communications in Medicine (DICOM) Modality Worklist Patient/Study Selection Errors, Journal of Digital Imaging, Vol 14, No 2 Suppl 1 (June), 2001: pp 153-157.

[6] IHE Technical Framework, Vol 2, Rev 6.0: Section 4.5.4.1.2.2 Matching Keys and Return Keys for Display.

[7] Gale ME, Gale DR: DICOM Modality Worklist: An Essential Component in a PACS Environment, Journal of Digital Imaging, Vol 13, No 3 (August) 2000: pp 101-108.

Displayed attribute	Tag
Requested Procedure ID	(0040,1001)

*(0040,0100) is the "sequence container", and is obviously not to be displayed.

➢ **MWL data verification:** After the user query, it is <u>mandatory</u> that the user interface requires a second patient/study identification verification step to ensure that the images are matched to the correct patient.

➢ **Support for multiple Studies for a patient:** The modality shall be able to handle multiple studies for the same patient, where each study may have a different Accession Number.

➢ **MWL Attribute support:** The vendor shall support the keys as specified in IHE[8]. This particular table summarizes the matching key requirements and lists the optional and required attributes that shall be requested and shall be returned in order to make these available to the user at the Acquisition Modality.

➢ **Display of Attributes:** The modality shall conform to the display requirements for all attributes listed in IHE[9], which are an addition to the DICOM Standard requirements for the Modality Worklist SOP Class.

➢ **Requiring "Other Patient IDs":** The Other Patient IDs (0010,1000) may be used to store the VA Master Patient Index for the patient. In the near future, this element may be required to be obtained from the Modality Worklist Provider and stored in every image.

➢ **Additional Attributes:** Table 8 lists additional attributes that are available as non-matching return keys. These attributes may be necessary for some digital acquisition modalities.

Table 8 Additional MWL Attributes (Optional)

Additional Attributes	Tag
Patient's Address	(0010,1040)

Scheduled Procedure Step Status – Defined Terms:
     CREATED – order placed but not yet scheduled
     SCHEDULED – scheduled but not yet started
     ARRIVED – patient arrived but study not started
     STARTED – study started but not yet finished
     COMPLETED – completed
     VERIFIED – completed and image quality verified
	(0040,0020)

Scheduled Procedure Step Sequence	(0040,0100)
> Scheduled Procedure Step Location	(0040,0011)
Requested Procedure Priority	(0040,1003)
Intended Recipients of Results	(0040,1010)

The complete mapping of VistA and CHCS II database elements to the DICOM Modality Worklist is specified in Appendix A of this document.

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[7] IHE Technical Framework, Vol 2, Rev 6.0: Table 4.5-3 Return and Matching Keys For Modality Worklist.

[9] IHE Technical Framework Vol 2, Rev 6.0: Section 4.5.4.1.2.2 Matching Keys and Return Keys for Display.

4.2.   Modality Procedure Step In Progress (Mandatory)

The Modality Performed Procedure Step messages shall indicate the authoritative start of the procedure step (start of digital acquisition) and the completion or cancellation of the procedure step (end of digital acquisition), consistent with the IHE generic use case[10]. The Modality Performed Procedure Step N—CREATE event can be used by the Modality Worklist SCP to prevent other modalities from starting the same procedure step.

4.3.   Modality Procedure Step Completed (Mandatory)

The Modality Performed Procedure Step (MPPS) Complete N-SET message can be used to indicate that the Scheduled Procedure Step is eligible for removal from the Worklist.

4.4.   Modality Images Stored – Acquisition Actor (Mandatory)

The primary function of a Modality is to acquire images. The DICOM Storage service is required in order to send image objects to specific destinations.

4.4.1.   Specific SOP Class requirements

4.4.1.1. General Storage Requirements

The following general requirements apply for the Storage SOP Class support:

> **True SOP Class support:** A modality may optionally support the Secondary Capture SOP class in addition to its "true" SOP class such as Digital Radiology (DX), X-Ray Angiography (XA), Visible Light (VL), CT, MR, and Positron Emission Tomography (PET) Scan. Support of Secondary Capture ONLY is not sufficient (except for Film Digitizer modalities).
> **Support of retired SOP Classes:** Support of the retired NM and US Image Storage SOP classes is optional; support of the new NM and US SOP classes is required.

> **Support of Multiframe for Ultrasound:** Ultrasound devices should also support the US Multiframe Storage SOP Class in addition to the regular US SOP Classes.

> **DX support:** Computed Radiography modalities are required to support the DX SOP Classes in addition to the CR SOP Class.

CR modalities can send the images either with a look up table (LUT) or apply the LUT to the image data and send an image that is presentable "as is". For a CR viewing station, which is capable of generating different LUTs, and accommodating these accordingly, it makes sense to receive the images with the LUT. For general-purpose workstations, accommodating this LUT might be an unnecessary burden.

> **Applied LUT support for CR :** If a CR/DX device is capable of sending images with one or more modality and/or Value of Interest (VOI) LUTs as part of the object, they shall be configurable to also send the images with the LUT already applied to the pixel data and omit the transmission of the LUT.

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[10] IHE Technical Framework, Vol 1, Rev 6.0: Figure 3.3-2. Procedure Performance Process Flow.

> **Processed data for CR objects:** If a CR/DX device is capable of sending unprocessed (also known as "raw") data in its CR object, it shall also be configurable to send processed data, that is, apply all pixel transformations so that the data is viewable without any addition processing at a workstation.

Note that the latter requirement only applies for CR objects, this is solved for modalities that support DX, because these are required to support the For Presentation SOP Class as a baseline anyway.

4.4.1.2. Modality Modes of Operation

When sending the images, the Modality shall support all of the following modes of operation:

> **Send images to multiple destinations:** The modality shall be able to send images to different destinations, which shall be operator selectable.

> **Select image subset:** The operator shall be able to select a study or a subset of clinically significant images to be sent to a specific destination. This is especially important for Angiography, Cardiology, and Ultrasound.

The modality shall support the following capabilities:

> **Auto-send:** The modality shall send images automatically without any operator interaction to its destinations during the acquisition (send as you go).

> **Manual-send:** The modality shall send images to its destination initiated by an operator at the modality (manual mode).

> **Time-out send:** The modality shall be capable of sending images automatically after a pre-determined period of time if the images were not sent manually prior to the expiration of the interval timer. This capability shall be configurable so that it can be selectively enabled and overridden when the user does not want to send the images.

> **Retry send:** The modality shall retry failed transmission either automatically or initiated by the operator. The modality shall log all transmission failures and notify the operator of the events.

4.4.1.3. Study Instance Unique Identifier (UID), Series Instance UID, and SOP Instance UID

The Modality Worklist provider shall use the Study Instance UID that is supplied by the HIS/RIS, and the Modality shall use the Study Instance UID that is supplied by the Modality Worklist provider. This Study Instance UID is assumed to be unique. These requirements allow the images to be properly related to the Study within the HIS/RIS and/or PACS.

> **Study Instance UID uniqueness:** When the Modality Worklist provider is not available, the Study Instance UID shall be generated at the modality, and the modality shall guarantee that this value is unique for the particular object it generates.

> **Study Instance UID integrity:** If a particular SOP Instance is sent again later from a particular modality, the same Study Instance UID shall be used to identify the Study.

The Series Instance UID and SOP Instance UID are assigned by the modality and permanently identify the Series and instance objects. By definition, they must be unique for each Series and instance object respectively. Because it cannot provide uniqueness, the modality shall not use a Study Instance UID obtained from Modality Worklist as the root UID for the generation of the Series Instance UID and SOP Instance UID. Rather, the modality shall use its own UID root to generate these values, so that uniqueness can be ensured.

➢ **Series Instance UID integrity:** If a particular SOP Instance is sent again later from a particular modality, the same Series Instance UID shall be used to identify the Series.

➢ **SOP Instance UID integrity:** The SOP Instance UID is not allowed to be subsequently changed, for example, when the same image is re-sent from the modality.

➢ **New SOP Instance UID generation:** When the image object is modified and clinically significant changes are made, the modality shall create a new instantiation (that is, a new image object with a new SOP Instance UID). Additional instantiations received with the same UID will be ignored by the VistA system.

4.4.1.4. Presentation Context

Table 9 Proposed Presentation Context for all Storage SOP classes

Presentation Context Table					
Abstract Syntax		Transfer Syntax		Role	Extended
Name	UID	Name List	UID List		Negotiation
See Note 1	See Note 1	Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None
See Note 1	See Note 1	Explicit VR Little Endian	1.2.840.10008.1.2.1	SCU	None

Note 1: Applicable for all Storage SOP classes

The preferred Transfer Syntax that will be accepted by the SCP will be the Explicit Value Representation (VR) Little Endian (the Explicit VR Transfer Syntax is preferred over the default, implicit VR, because it gives more complete information about the attribute).

➢ **Explicit VR support:** A device shall support the Explicit VR Transfer Syntax for the Storage SOP Classes.

A modality, at its option, could propose additional Transfer Syntaxes, such as Big Endian or JPEG compressed. These will be accepted or rejected on a SOP class basis at the discretion of the Storage SCP.

4.4.2. Storage Service Association Policies for Low Disk Space

An Association might be rejected because of a disk-full situation. In order to distinguish this specific case from the case that the Presentation Context is not supported, specific status information shall be provided as specified below:

Storage Service Association Policies in the Event of a Disk Full Situation[11]

1. If an Association for the DICOM Verification SOP Class is made by the SCU, the VistA and CHCS II Storage SCPs will accept the Association and properly handle the request.

2. If a SCU proposes both the DICOM Verification and DICOM Storage presentation contexts, then the association and DICOM Verification presentation context will be accepted, but the DICOM Storage presentation context(s) will be rejected.

3. If a DICOM Association request is made by the SCU for a Storage SOP Class, the VistA and CHCS II Storage SCPs will reject the association with the following parameters:

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[11] Follows PS 3.8, Section 9.3.4, A-ASSOCIATE-RJ PDU Structure, Table 9-21.

Table 10 Status Information Provided for Disk Full

PDU bytes	Field name	Value and Description of field
Byte 8	Result	2: rejected-transient
Byte 9	Source	3: DICOM UL service provider (Presentation related function)
Byte 10	Reason	1: temporary-congestion

4.4.3. C-STORE Attribute Requirements

The attributes that shall be sent as part of the composite objects shall adhere to the DICOM specification with regard to their Type and Syntax. It is required that some Type 2 and Type 3 attributes always be sent with non-null values:

- ➢ **Type 2 and Type 3 attributes:** Although certain attributes might not have to be provided according to their Type definition in the DICOM standard, attributes specified in Table 11 as "Required" must always sent with a length greater than 0 bytes.

- ➢ **Manual data entry:** The Modality shall be equipped with overrides to allow the technologist to manually enter patient and study data into the system in the event that such data is not available automatically from the Modality Worklist SCP.

- ➢ **Send to more than one storage SCP:** The Modality shall have the capability to be configured to send composite objects to more than one storage SCP. An example where this capability may be used is to send CT or MR images to a PACS and a 3-D reconstruction workstation.

- ➢ **Provide information to allow measurement**: In adherence to the DICOM standard, the Modality shall provide all the necessary attributes to permit anatomical measurements of the image.

- ➢ **Private Elements:** (a) The vendor shall document in the DICOM Conformance Statement the use of Private Elements. This specifically shall include the Private Creator Data Element, and for each private element, the Attribute Name, Attribute Tag, Value Representation, Value Multiplicity and Attribute Description. (b) It is highly recommended that vendors use Explicit VR when using Private Elements.

If a Modality Worklist is unavailable, we understand that the information might not necessarily be unique or correct. The technologist will do a "best effort" to enter this data correctly. In no circumstances shall the modality have "built-in" default values for patient and/or study data.

The following Table 11 specifies the attributes that must be stored in the image header by the modality in three operational scenarios:

1. When no Modality Worklist service is available (it could be temporarily unavailable) the attribute is required (indicated in Table 11 with the "No MWL" column)

2. When Modality Worklist is available, the patient and study attribute values must come from the Modality Worklist and no other values can be used (indicated in Table 11 with the "With MWL" column)

3. When Modality Performed Procedure Step is supported and the Modality Worklist is available, the patient and study attribute values must come from the Modality Worklist and no other values can be used and the MPPS attributes must be provided (indicated in Table 11 with the "MWL + MPPS" column)

Table 11   Image Storage Attributes

Tag	Description	No MWL	With MWL	MWL+MPPS
(0008,0020)	Study Date	Required	Required	Required
(0008,0030)	Study Time	Required	Required	Required
(0008,0050)	Accession Number	Required	Required [12]•	Required •
(0008,0060)	Modality	Required	Required	Required
(0008,0070)	Manufacturer	Required	Required	Required
(0008,0080)	Institution Name	Required	Required	Required
(0008,0090)	Referring Physician's Name	Required	Required •	Required •
(0008,1010)	Station Name	Required	Required	Required
(0008,1030)	Study Description			
(0008,103E)	Series Description			
(0008,1048)[13]	Physician(s) of Record		Optional •	Optional •
(0008,1090)	Manufacturer Model Name	Required	Required	Required
(0008,1111)	Referenced Study Component Sequence			Required •
(0008,1150)	>Referenced SOP Class UID			Required
(0008,1155)	>Referenced SOP Instance UID			Required
(0010,0010)	Patient Name	Required	Required •	Required •
(0010,0020)	Patient ID	Required	Required •	Required •
(0010,0030)	Patient's Birth Date		Required •	Required •
(0010,0040)	Patient's Sex	Required	Required •	Required •
(0010,1000)	Other Patient IDs (unique internal patient id)		Required•	Required•
(0010,2160)	Ethnic Group		Optional •	Optional •
(0010,21B0)	Additional Patient History		Optional •	Optional •
(0010,4000)	Patient Comments		Optional •	Optional •
(0018,1020)	Software Version	Required	Required	Required
(0018,1030)	Protocol Name			Required
(0020,000D)	Study Instance UID	Required	Required •	Required •
(0020,0010)	Study ID		Optional	Optional
(0028,0030) (0018,1164)	Pixel Spacing or Imager Pixel Spacing or other [14]	Required	Required	Required
(0040,0275)	Request Attributes Sequence			
>(0040,0008)	Scheduled Protocol Code Sequence			
(0040,0244)	Performed Procedure Step Start date			Required
(0040,0245)	Performed Procedure Step Start time			Required
(0040,0253)	Performed Procedure Step ID			Required
(0040,0254)	Performed Procedure Step Description			Required
(0040,0275)	Requested Attributes Sequence		Required	Required

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[12] Attributes identified with a • must be obtained from the Modality Worklist Provider and inserted into the image header (that is, copied).

[13] Physician(s) of Record (0008,1048) shall be values from the Requesting Physician (0032,1032) and Names of Intended Recipients of Results (0040,1010) supplied by the Modality Worklist Provider.

[14] The modality shall provide the equivalent SOP-specific anatomical measurement information.

Tag	Description	No MWL	With MWL	MWL+MPPS
(0040,1001)	>Requested Procedure ID		Required	Required •
(0040,0007)	>Scheduled Procedure Step Description			Required •
(0040,0009)	>Scheduled Procedure Step ID			Required •

> ➢ **Required Type 2 and Type 3 Attributes:** There are several Type 2 and Type 3 attributes that are required to be present in the image header with non-null values. There are several reasons for this:
>
> > o **Accession Number (0008,0050), Patient Name (0010,0010), Patient ID (0010,0020), Patient's Birth Date (0010,0030), Patient's Sex (0010,0040), and Other Patient IDs (0010,1000)** – these are required to properly identify the patient and study with which the images are associated.
> >
> > o **Study Date (0008,0020), Study Time (0008,0030), Manufacturer (0008,0070), Institution Name (0008,0080), Station Name (0008,1010), Manufacturer Model Name (0008,1090), and Software Version (0018,1030)** – these are necessary to identify when, where, and what device produced the image.
> >
> > o **Referring Physician's Name (0008,0090)** – this is the medical contact for the patient
> >
> > o **Pixel Spacing (0028,0030), Imager Pixel Spacing (0018,1164) or other** – this information is required to support measurement calculations.
>
> ➢ **Minimum Attribute length:** The modality shall support at least the number of characters specified for the following Attributes:

Patient Name	64
Patient ID	32
Other Patient ID	32
Accession Number	16

4.4.4.   Pixel Representation Issues

DICOM images contain the attribute Photometric Interpretation (0028,0004). For monochromatic X-ray images, this attribute specifies whether the minimum pixel value is intended to be displayed or printed as black or white. The concept of how a pixel value is intended to be displayed is different from the concept of how a pixel value is related to incident X-ray intensity (or inversely, how a pixel value is related to X-ray attenuation). This is not specified at all in any existing DICOM objects. Thus, regardless of whether the minimum pixel value is intended to be displayed as black (MONOCHROME2) or white (MONOCHROME1), and whether it corresponds to air or bone/lead/contrast is unspecified in DICOM.

The most common expectation of a radiologist is that air be displayed as black, and bone/lead/contrast be displayed as white. An exception is for subtracted images, in which the radiologist's preference varies, and it is sometimes desired to show the contrast as black on a white background.

There is also an interaction with the area outside the display shutter, which should usually be shown as black. Display workstations should not invert the area outside the shuttered area when the image is inverted.

Photometric Interpretation: If images are sent with a Photometric Interpretation of MONOCHROME2 either:

- air will always be sent as the minimum acquired pixel value15, or
- the system may be configured such that air will always be sent as the minimum acquired pixel value, or
- the operator can follow a procedure such that air will be sent as the minimum acquired pixel value and the area outside the display shutter will be black.

If images are sent with a Photometric Interpretation of MONOCHROME1 either:

- air will always be sent as the maximum acquired pixel value, or
- the system may be configured such that air will always be sent as the maximum acquired pixel value, or
- the operator can follow a procedure such that air will be sent as the maximum acquired pixel value and the area outside the display shutter will be black.

The Pixel Intensity Relationship Sign (0028,1041) of the DX Module, which defines the relationship of pixel value to X-ray intensity, is used to allow workstations, displays and printers to exercise the radiologist's preference as to whether or not air is displayed as black or white.

> **Eight bits pixel fields**: It is highly recommended that eight-bit pixels be sent in eight-bit fields. That is, if the Smallest Image Pixel Value (0028,0106) is 0 and Largest Image Pixel Value (0028,0107) is 255, the Bits Allocated (0028,0100) should be 8, and not 16.

4.5. Modality Images Stored – Archive Actor (Optional)

The modality optionally could also function as an Archive Actor, that is, it can also receive images, typically for comparison purposes.

4.5.1. Specific SOP Class Requirements

The following general requirements apply for the Storage SOP Class SCP support.

> **Receiver SOP Class support:** Certain modalities shall optionally support the Storage Class as a SCP of its own modality type, for example, MR Store for an MRI modality. Other Storage SOP classes might be supported as well.

4.6. Storage Commitment (Mandatory)

Storage Commitment SOP Class Push Model implementation are specified in order to guarantee the safe storage and integrity of imaging information generated by the modalities. VistA and CHCS II imaging systems interpret Storage Commitment as a request from a modality to guarantee safe storage of the IOD instances.

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[15] In this context, acquired pixel value is the resulting value of the digitized X-ray energy at the detector. The minimum or maximum acquired pixel value is not necessarily the minimum or maximum pixel value in the image. The pixel representation usually allows for pixel values outside of the range of the acquired pixel values (for example: if an image is using 12 bit signed data representation and the ADCs convert to 10 bits; air may be represented as –512, but the minimum pixel value may be as low –2048).

➢ **Auto retry:** The modality shall retry failed storage commitments with a configurable interval for a configurable number of times.

Under most circumstances, it is preferable to commit all images of a study at one time. Usually the practice of individually committing SOP instances is discouraged. However, there are some situations (for example, ship-to-shore Teleradiology applications) where it may be desirable to commit image instances one at a time as they are sent.

➢ **Storage Commitment image by image**: The modality must be configurable to operate in both modes, that is, image-by-image and as a batch.

VistA and CHCS II systems always return the N-EVENT-REPORTs on a separate association. This association is opened with reverse role negotiation, that is, the Calling AE is the SCP and the Called AE is the SCU[16].
After an N-ACTION request the Storage Commitment N-EVENT-REPORT message is returned upon one of several triggering events:

1. An N-EVENT-REPORT message with status of success will be returned if all image objects have already been received, linked into the database, and safely stored.

2. An N-EVENT-REPORT message with the status of failure will be returned if a sufficiently long period of time has elapsed and the image objects have not been safely stored and inserted into the image database (if image objects have been received and the imaging systems cannot be linked properly to the corresponding patient and study, safe storage cannot be achieved). The error conditions for Storage Commitment are returned in the Failed SOP sequence.

➢ **Transaction UID:** The requesting systems shall generate a new transaction UID for each N-ACTION request, regardless of the receipt of the corresponding N-EVENT-REPORT.

4.7. Verification (Mandatory)

When supporting DICOM Verification as a SCU, the modality shall establish an Association with another DICOM device and issue a C-ECHO request. When the modality optionally supports Verification as a SCP, it shall accept an association and respond to a C-ECHO request.

It is a DICOM requirement that a modality that accepts association requests must also support the Verification SOP Class as an SCP[17]. Consequently, if a modality supports the Storage Commitment Push Model SOP Class and accepts associations to support the reverse role negotiation requirement, it must also support the Verification SOP Class as an SCP.

➢ **Verification support:** The modality shall fully support the DICOM Verification SOP Class as a SCU and optionally as a SCP.

Some modality vendors implement a verification service using a non-DICOM mechanism such as File Transfer Protocol (FTP) or PING. There is no guarantee that these will work and it is unacceptable if they are implemented in lieu of the true DICOM Verification service. The vendor must provide the capability to disable these non-DICOM features.

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[16] DICOM PS 3.4-2004 Annex J.2.1

[17] PS 3.2, Section 7.1: An implementation claiming DICOM network conformance shall accept a Presentation Context for the Verification SOP Class as an SCP if the implementation accepts any DICOM association requests.

4.8. Print Composer (Optional)

➢ **True size printing:** CR and DX modalities shall support true size printing, that is, allow the Request Image Size attribute to be used on the film box level. This is an optional requirement for other modalities.

It is highly recommended that modalities be able to compose images on a sheet according to common hanging protocols and current practice. This requirement is not only for modalities such as CT and MR, but especially for dental and other applications.

5. SERVICE AND SUPPORT REQUIREMENTS

Configuring systems and troubleshooting connectivity is often hampered by a lack of accessible documentation. This information is required to be readily accessible and available.

➢ **Service documentation:** All normally supplied documentation, (that is installation, user, service manuals as well as conformance statements) shall also be provided in a softcopy format (typically as PDF files).

Modality systems connected to the VA and DOD networks are susceptible to malicious software attacks. Such attacks can be mitigated or arrested through the provision of comprehensive protection solutions for vulnerabilities and viruses. Vendors agree to comply with VHA/DoD security requirements. Those requirements may include use of antiviral software, periodic operating system upgrades, and use of VLAN. Links to the VA and DoD current security policy documents are available online at http://vaww.va.gov/imaging/

The VA has had several instances where modalities have gone out of service due to exceeding a vendor license time period. This has caused several serious disruptions in patient care. This kind of event must be prevented from occurring in the future. The following paragraph is to be included in contract language to ensure there are no Vendor Induced Inhibiting Code (VIIC) vulnerabilities present in software applications, upgrades, patches, etc.

➢ **VIIC Prohibition:** To assure continuity of patient care and to maximize access to patient care data, the vendor shall not include any Vendor Induced Inhibiting Code (VIIC) or any other inhibitor data or software as part of their product. VIIC is defined as any deliberately-included application or system code that will degrade performance, result in inaccurate data, deny accessibility, or adversely effect, in any way, programs or data or use of the system. The vendor represents, warrants, covenants, and shall certify that the licensed software and all software upgrades shall not contain any computer code that would disable the licensed software or impair in any way its operation based on the elapsing of a period of time, exceeding an authorized number of copies, advancement to a particular date or numbers or other similar self-destruct mechanisms (sometimes referred to as "time bombs," "time locks," or "drop dead" devices) or that would permit the vendor to access the licensed software to cause such disablement or impairment (sometimes referred to as a "trap door" device). The vendor shall further certify that all third-party software toolkits and utilities incorporated into the product and upgrades to such toolkits and utilities shall not contain any computer code that would disable the licensed software or impair in any way its operation.

6. COMMUNICATION PROFILES

6.1. Transmission Control Protocol / Internet Protocol (TCP/IP) Stack

The TCI/IP stack shall be the only supported protocol.

6.2. Datalink and Physical Media

Ethernet support: Modalities shall support 10mb/s Switched Ethernet, 100mb/s Fast Ethernet and Gigabit Ethernet (ISO/IEC 8802-3:2000), over either copper or fiber.

6.3. Configurable Parameters

➢ **Configuration parameters:** All parameters that are required to be configurable including their range shall be specified by the modality. This includes, but is not limited to:

- o Number of simultaneous associations
- o Max PDU sizes
- o Time out values
- o Local IP address and network mask
- o Gateway address
- o Port Numbers
- o Station Name
- o Local AE Title(s)
- o Remote AE Title(s)

6.4. Security of Remote Access for Vendor Service of Imaging Modalities

All vendor access to modalities shall be accomplished using the current implementation of the respective VA and DoD secure Virtual Private Network (VPN). All vendor's access into the DoD modalities will also be compliant with the current DoD Ports and Protocol Policy (available on the Defense Information System Agency (DISA) public website. http://www.cert.mil/portsandprotocols/).

The use of dial-in modems will require a special written exemption from the VA Office of Cyber Security and the DoD Office of Cyber Security. Such exemptions will be considered only when the operating system of the modality does not permit VPN connectivity, or when secure remote access can be accomplished via the modem connection.

7. SECTION 508 REQUIREMENTS

Section 508, effective June 21, 2001, requires Federal departments and agencies that develop, procure, maintain, or use electronic and information technology to assure that these technologies provide access to information and data for people with disabilities.

The Section 508 technical requirements apply to purchased operating systems and application software programs. These requirements also apply to electronic and information technology products that contain software as an integral part of their functionality. Such application software is bundled or sold with the

product, and typically executes on an attached network connected personal computer or server. This includes information technology and any equipment or interconnected system or subsystem of equipment that is used in the creation, conversion or duplication of data or information.

Sources of information about Section 508 include:

- Access Board (http://www.access-board.gov/508.htm)
- Federal Acquisition Regulations (http://www.arnet.gov/far)
- Center for Information Technology Accommodation (http://www.section508.gov)
- Accessibility Forum (http://accessibilityforum.org)
- Information Technology Technical Assistance and Training Center (http://www.ittatc.org)

8.   SUPPORT FOR FUTURE ENHANCEMENTS

Several extensions and modifications to the DICOM standard are being considered. A vendor is obviously free to implement any of the new services as they are being specified. However, some of them are critical to resolve difficulties that have been experienced; others are necessary extensions to the current operation.

➢ **Upgrade commitment:** The VA/DoD will announce what DICOM extensions need to be supported and the vendors will have 18 months to implement them.

9.   TESTING PRIOR TO PROCUREMENT

All new modalities to be purchased by the VA (including different models or software versions) must be tested remotely over Internet in conjunction with the VA VistA Imaging Project prior to their procurement. Appendix C can be used by a vendor to specify the level of conformance with this specification. It lists the major requirements in tabular format.

The VA procedure involves exercising the DICOM capabilities of the instrument with a validation test system over the Internet. The instrument is required to perform several modality worklist queries to verify that the various query-options operate correctly. The instrument is required to store images containing data from the modality worklist query. The data in the images is examined for completeness, correctness, and conformance with the DICOM Standard. See Table 15 below for a complete list of the steps of the validation test.

Testing procedures for the DoD have not yet been established.

APPENDIX A: MAPPING BETWEEN DICOM MWL SCP ATTRIBUTES AND FIELD NAMES IN VISTA AND CHCS II

Table 12 Mapping Between DICOM MWL SCP Attributes and field names in VISTA and CHCS II

Tag	Description	VistA Field Name	CHCSII Field Name
(0008,0005)	Specific Character Set (ISO_IR 100)	N/A	N/A
(0008,0050)	Accession Number (MMDDYY-NNNNN or other format, like AAAA-NNNNN)	Date-case number for radiology, accession number for clinical specialties	Order ID
(0008,0090)	Referring Physician's Name	Primary Care Provider (or requesting physician, for outpatient)	Referring Provider Name
(0008,1030)	Study Description	VA Procedure Description	Study Description
(0008,1050)	Performing Physician's Name	Attending physician	Performing Provider Name
(0008,1110)	Referenced Study Sequence		
(0008,1150)	>Referenced SOP Class UID		
(0008,1155)	>Referenced SOP Instance UID	Study UID	Study UID
(0008,1120)	Referenced Patient Sequence		
(0008,1150)	>Referenced SOP Class UID		
(0008,1155)	>Referenced SOP Instance UID	Patient UID	
(0010,0010)	Patient's Name	Patient Name	Patient Name
(0010,0020)	Patient ID	Patient ID	EMPI (Patient ID)
(0010,0030)	Patients Birth Date	Patient Date of Birth	Patient Birth Date
(0010,0040)	Patient's Sex	Patient Sex	Patient Sex
(0010,1000)	Other Patient IDs	Other Patient ID (master patient index)	Patient SSN
(0010,1040)	Patient's Address	Patient Address	Patient Address
(0010,2000)	Medical Alerts	General Allergies (food, medication, etc.)	Patient Alerts
(0010,2160)	Ethnic Group	Patient Race	Patient Race
(0010,21B0)	Additional Patient History*	Reason for Study and Clinical Warnings	Patient Allergies
(0010,21C0)	Pregnancy Status	Pregnancy Status	Patient Pregnancy
(0010,4000)	Patient Comment	Patient Comment	
(0020,0010)	Study ID	Case Number	Study ID
(0020,000D)	Study Instance UID	Study SOP Instance UID	Study UID
(0032,1030)	Reason for Study	Reason for the study	Reason for Study
(0032,1032)	Requesting Physician	Requesting Physician	Requested By
(0032,1033)	Requesting Service	Requesting Service	
(0032,1060)	Requested Procedure Description	Procedure Description	CDT / CPT Common Procedure Name
(0032,1064)	Requested Procedure Code Sequence	CPT Procedure	
(0008,0100)	>Code Value	CPT Code	CDT / CPT Code
(0008,0102)	>Coding Scheme Designator	CPT Coding Scheme (C4)	CDT / CPT Coding Scheme

Tag	Description	VistA Field Name	CHCSII Field Name
(0008,0104)	>Code Meaning	CPT Procedure Description	CDT / CPT Description
(0038,0300)	Current Patient Location	Patient Location	
(0040,0100)	Scheduled Procedure Step Sequence		
(0008,0060)	>Modality	Modality	DX, IO, SC (determined by Radiograph Type)
(0040,0001)	>Scheduled Station AE Title	Station AE Title	Scheduled Stations AE Title
(0040,0002)	>Scheduled Procedure Step Start Date	Scheduled Date	Appointment Date/Time
(0040,0003)	>Scheduled Procedure Step Start Time	Scheduled Time	Appointment Date/Time
(0040,0006)	>Scheduled Performing Physician's Name	Unknown	
(0040,0007)	>Scheduled Procedure Step Description	Scheduled Procedure Description	Radiograph Type: Bitewing, PA, PANO
(0040,0008)	>Scheduled Protocol Code Sequence	VA Procedure**	
(0008,0100)	>>Code Value	VA Procedure Code (dictionary number)	
(0008,0102)	>>Coding Scheme Designator	VA Coding Scheme ("L" for "local")	
(0008,0104)	>>Code Meaning	VA Procedure Description	
(0040,0009)	>Scheduled Procedure Step ID		
(0040,0010)	>Scheduled Station Name		Scheduled Station Names
(0040,0011)	> Scheduled Procedure Step Location	Clinic, ward, or room location for study	
(0040,0020)	> Scheduled Procedure Step Status	Study Status	
(0040,1001)	Requested Procedure ID	Case Number or clinical specialty accession number	Requested Procedure ID
(0040,1003)	Requested Procedure Priority	Priority	
(0040,1010)	Names of Intended recipients of results	Intended Recipient of Results	
(0040,1400)	Requested Procedure Comments	*To be used as needed*	Special Instructions (Procedure)
(0040,2400)	Imaging Service Request Comments	*To be used as needed*	Special Instructions (Image)

* In the VA HIS/RIS the "reason for the study" is often a short patient history summarizing the condition of the patient and giving background information for the reason for the study. It usually exceeds the 64 character Long String Value Representation provided by the DICOM standard attributes Reason for the Study (0032,1030), Reason for the Request Procedure (0040,1002), and Reason of the Imaging Service Request (0040,2001). In order to faithfully communicate this essential field, the VA has chosen to map it to the Additional Patient History (0010,21B0) attribute.

** Starting in Version 1.1, the Scheduled Protocol Code Sequence contained the VA (local) procedure codes, in order to be compatible with the IHE.

APPENDIX B: DIFFERENCE BETWEEN THE VA / DOD AND IHE REQUIREMENTS

Table 13 VA / DoD and IHE* Differences

#	VA/DoD requirement	Section	IHE Section
1	A Verification transaction is added to the Integration Profile. Verification is not explicitly required as a SCU by IHE.	2.1	N/A
2	Specific requirements for multiple AEs as well as the port number range.	3.2	N/A
3	MWL Patient based queries: The VA requires a short-cut matching key mechanism.	4.1.2.1.1	N/A
4	Specific selection and display requirements for MWL.	4.1.2.3	4.5.4.1.2.2
5	Modality modes of operation (capable of sending to multiple destinations, and other features) for Storage are required by VA and DoD, but not by IHE	4.4.1.2	N/A
6	Explicit VR Transfer Syntax is required by VA and DoD, but not by IHE.	4.4.1.4	N/A
7	Certain Type 2 attributes (Accession Number, Referring Physician Name, Patient Name, ID, Sex, and Manufacturer) are not allowed to be sent with length "0" but rather shall contain actual values. See IHE for exceptions related to MPPS rules in Scheduled Workflow).	4.4.3	4.6
8	Certain Type 3 attributes are required to be sent (Institution Name, Station Name, Manufacturer Model Name, Software Version).	4.4.3	N/A
9	Minimum lengths for Patient Name, ID and Accession number are specified.	4.4.3	N/A
10	Send to more than one storage SCP.	4.4.3	N/A
11	True size printing is required for CR modalities.	4.8	N/A

* IHE Technical Framework rev 5.5, 2003.

APPENDIX C: CONFORMANCE CHECKLIST

This Table 14 can be filled in and sent to the proper VA contact. No DoD contact has been established. This can be used by a vendor to specify the level of conformance with this specification. It lists the major requirements in tabular format. See the appropriate section for the complete requirement definition.

Specify the following information:

- Date
- Vendor
- Modality Type
- Product Name
- Software Version

DoD testing procedures have not yet been established.

Table 14   VA / DoD Requirements Compliance Checklist

Section	Requirement	Compliance (Y/N, Optional, or N/A)	If not compliant, specify date
3	GENERAL REQUIREMENTS		
3.1	SOP Class Support to Implement IHE Profiles		
3.1.1	Required SOP Classes		
	Modality Worklist Information Model Find (SCU)		
	Modality Performed Procedure Step (SCU)		
	Storage Commitment Push Model (SCU)		
	Modality Storage (SCU)		
	Verification (SCU)		
3.1.2	Optional SOP Classes		
	Modality Storage (SCP)		
	Verification (SCP)		
	Basic Grayscale Print Management Meta (SCU)		
	Basic Color Print Management Meta (SCU)		
	Presentation LUT (SCU)		
3.2	Association Behavior		
	Separate AE Support		
	Port numbers (1-65535)		
4	SPECIFICATIONS OF INDIVIDUAL TRANSACTIONS		
4.1	Modality Worklist Provided (Mandatory)		
4.1.2	MWL Query support		
4.1.2.1	Query by Patient matching key attributes		
4.1.2.1	Single value matching		
4.1.2.1.1	Ignore matching key checking		
4.1.2.2	Broad Query matching key attributes		
	MWL polling		
4.1.2.3	Sufficient data display		

Section	Requirement	Compliance (Y/N, Optional, or N/A)	If not compliant, specify date
	MWL data verification		
	Support for multiple studies for a patient		
	MWL attribute support		
	Display of attributes		
	Additional Attributes		
	Requiring "Other Patient IDs"		
4.2	Modality Procedure Step in Progress (Mandatory)		
4.3	Modality Procedure Step Completed (Mandatory)		
4.4	Modality Images Stored – Acquisition Actor (Mandatory)		
4.4.1	Specific SOP Class requirements		
4.4.1.1	General Storage Requirements		
	True SOP Class support		
	Support of retired SOP Classes		
	Support of multiframe for Ultrasound		
	DX support		
	Applied LUT support for CR		
	Processed data for CR objects		
4.4.1.2	Modality Modes of Operation		
	Send images to multiple destinations		
	Select image subset		
	Auto-send		
	Manual-send		
	Time-out send		
	Retry send		
4.4.1.3	Study Instance UID, Series Instance UID, and SOP Instance UID		
	Study Instance UID uniqueness		
	Study Instance UID integrity		
	Series Instance UID integrity		
	SOP Instance UID integrity		
	New SOP Instance UID generation		
4.4.1.4	Presentation Context		
	Explicit VR support		
4.4.3	C-STORE Attribute Requirements		
	Type 2 and 3 attributes		
	Manual data entry		
	Table 4.4.3.1 Image Storage Attributes		
	MWL Attributes to copy		
	Minimum Attribute length		
4.4.4	Pixel Representation Issues		
	Photometric interpretation		
	Eight bit pixel fields		
4.5	Modality Images Stored – Archive Actor (Optional)		
4.5.1	Receiver SOP Class support		
4.6	Storage Commitment (Mandatory)		
	Auto retry		

Section	Requirement	Compliance (Y/N, Optional, or N/A)	If not compliant, specify date
	Storage Commitment image by image		
	Transaction UID		
4.7	Verification (Mandatory)		
	Verification support		
	True Verification support		
4.8	Print Composer (Optional)		
	True size printing		
5	SERVICE AND SUPPORT REQUIREMENTS		
	Service documentation		
	Virus protection		
6	COMMUNICATIONS PROFILES		
6.2	Ethernet support		
6.3	Configurable parameters		
6.4	Secure dial-in modem		
7	SUPPORT FOR FUTURE ENHANCEMENTS		
	Upgrade commitment		
8	TESTING WITH VA OVER INTERNET PRIOR TO PROCUREMENT		
	VA validation status		

Table 15 VA / DoD Internet Test Checklist

Section	Test	Requirement	Pass /Fail
3.2	Support SCP Port Number greater than 60000	SCP port numbers greater that 60000 will be used in the testing over Internet	
4.1.2.2	Modality Worklist Broad Query	Modality shall be able to receive multiple patients and examinations; a patient may have more than one study	
4.1.2.1	Modality Worklist Patient Name Query	Modality shall be able to retrieve patients using a patient name; modality shall also be able to use a quick-pid and retrieve one (or) more matching patients; a patient may have more than one study	
4.1.2.1	Modality Worklist Patient ID Query	Modality shall be able to retrieve patients using a patient id; modality shall also be able to use a quick-pid and retrieve one (or) more matching patients; a patient may have more than one study	
4.1.2.1.1	Modality Worklist Accession Number Query	Modality shall be able to retrieve study using an accession number; modality shall also be able to use a case number to retrieve the study	
4.1.2.1.1	Modality Worklist Requested Procedure ID Query	Modality shall be able to retrieve study using an accession number for the requested procedure id; modality shall also be able to use a case number for the requested procedure id to retrieve the study	
4.4	Stored Images	All DICOM images shall be properly constructed according to the current version of the standard (PS 3-2001)	
4.4.3	Store images with attributes from Modality Worklist	The following DICOM attributes shall be obtained from the modality worklist query and stored in the image header: (0008,0050) Accession Number (0008,0090) Referring Physician (0010,0010) Patient's Name (0010,0020) Patient ID (0010,0030) Patient's Birth Date† (0010,0040) Patient's Sex (0020,000D) Study Instance UID † Note that the Patient's Birth Date may contain an imprecise date value, like 19390000, if the actual date is unknown.	
4.4.3	Additional required attributes of stored images	(0008,0070) Manufacturer (0008,0080) Institution Name (0008,1010) Station Name (0008,1090) Manufacturer's Model Name (0018,1020) Software Version	
4.4.1.3	SOP Instance UID	The SOP Instance UID (0008,0018) shall be constructed using the manufacturer's root UID, and not from the VA's Study Instance UID	

Section	Test	Requirement	Pass /Fail
4.4.1.3	Series Instance UID	The Series Instance UID (0020,000E) shall be constructed using the manufacturer's root UID, and not from the VA's Study Instance UID	
PS 3.3-2001	Conformance with the Information Object Definition	All attributes shall properly conform to the applicable Information Object Definition. All Type 1 and Type 2 attributes shall present, and all the Type 1 attributes shall have valid values.	
4.4.4	Image Presentation	The image(s) shall be displayable using verified DICOM viewers	

Table 16   VA / DoD Acceptance Testing Checklist

Section	Test	Requirement	Pass /Fail
3.2	Support Separate IP address for Modality Worklist and Storage	The modality shall be able to be configured to support separate SCP AE titles, IP address, and port number for the Modality Worklist and Storage providers	
8	Repeat Internet test with local Modality Worklist and Storage SCP	The Internet test will be repeated on site, if the site is operational.	
4.1.2.3	Modality Worklist Verification of selected Study	The tester will verify that the modality supports a patient/study identification selection verification step	
4.1.2.3	Adequate Display of Modality Worklist Data on Pick-list	The tester will verify that at least the following fields are displayed on the Modality Worklist Pick-list: Patient Name, Patient ID, Accession Number, Procedure Name, and Start Date	
4.4.1.2	Modality supports required modes of operation	The tester will verify that the modality can perform the following modes of operations: 1. Send images to multiple destinations 2. Send a subset of clinically significant images to a specific destination 3. Auto-send images without operator interaction 4. Manual-send images with operator interaction 5. Time-out send images after a configurable period of time 6. Retry sending images that failed because of transmission problems	