Integrating the Healthcare Enterprise

IHE Radiology User's Handbook

2005 Edition

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Executive Summary

Integrating the Healthcare Enterprise (IHE) is an initiative by care providers (including ACC, HIMSS and RSNA) and vendors to improve the way information systems communicate to support patient care. IHE defines *Integration Profiles* that use established data standards to integrate systems for effective interoperability and efficient workflow. IHE makes it possible to achieve the level of integration required in the era of the electronic health record.

What is an Integration Profile?

Each IHE Integration Profile describes a clinical requirement for systems integration and a solution to address it. It defines functional components, called *IHE Actors*, by specifying in careful detail the transactions, based on standards such as Digital Imaging and Communication in Medicine (DICOM) and Health Level 7 (HL7), each Actor must perform.

How do you get IHE Integration Profiles?

You specify IHE capabilities as requirements on the information systems (such as PACS, RIS, modalities, and workstations) you are purchasing or upgrading. Simply state in the RFP which IHE Actors and Integration Profiles you want.

What do IHE Integration Profiles cost?

In some cases Integration Profiles cost nothing—they are integral to a product's capabilities. In other cases, vendors may package IHE Integration Profiles at an added cost with new systems or offer them as upgrades to installed systems. IHE Integration Profiles should represent only a small fraction of the total cost of most systems.

What is the business case for implementing Integration Profiles?

Integration Profiles enable you to efficiently manage the array of integrated information systems necessary to support effective healthcare. The alternative—building site-specific interfaces—is more expensive and requires maintaining these custom interfaces for the life of the system involved. Integration via IHE is less costly at the start and makes future acquisitions easier to plan and execute, as well as more productive in delivering valuable functionality. Integration Profiles give clear definitions, based on widely accepted standards, of how the pieces fit together.

What other benefits does IHE provide?

IHE makes it practical for healthcare providers to use advanced information technology to improve the quality and efficiency of care. By ensuring the integrity of medical information, IHE enhances patient safety. By reducing the time spent in solving data problems such as lost and mismatched studies, IHE allows the most efficient use of staff time. By providing care providers comprehensive patient information, IHE enables better-informed medical decisions.

What should you do next?

Learn about the IHE Integration Profiles available for Radiology and other parts of the Enterprise and consider how they meet your organization's goals. Read this IHE Radiology User's Handbook to learn how to require these capabilities in an RFP and how to implement them in your setting. These resources and more are available at *www.ihe.net.*

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How to Use this Handbook

Assembled by the IHE Radiology Planning and Technical committees with input from healthcare professionals who have implemented IHE capabilities at their sites, the IHE Radiology Deployment Handbook describes how and why to acquire and implement systems with IHE capabilities.

IHE was designed to make the complex, intricate and time-consuming task of integrating healthcare systems easier, faster and more reliable. This Handbook describes how you can use IHE to improve the way the integration capabilities of your systems are selected, specified, purchased and deployed. Each chapter presents a typical scenario: buying and deploying a new modality, buying and deploying a picture archiving and communication system (PACS) and upgrading a radiology information system (RIS). The principles outlined in each scenario can be applied to any systems acquisition and deployment project that involves integration of systems with IHE-defined transactions.

Each scenario includes advice for those selecting and purchasing new systems and for the technical staff who will handle the installation and configuration of the new system. A series of appendices provide advice and information applicable to each scenario—or any other deployment project linking systems via IHE transactions.

Each Chapter/Scenario includes the following sections:

Sections X.1.1 and X.1.2: Selecting IHE Integration Profiles by mapping goals and needs to the benefits provided by each profile

Section X.1.3: Writing RFPs to obtain the desired profiles (sample text for some recommended profiles is included).

Sections X.1.4 and X.1.5: Identifying and evaluating relevant products

Section X.2.1: Workflow changes that maximize the benefit of the IHE Profiles

Section X.2.2: Installation testing to confirm that IHE capabilities are functioning properly.

Section X.2.3: Issues to consider when installing and configuring IHE-compliant system

Section X.2.4: Identifying and addressing potential problems in order to maximize your benefit despite existing "legacy" systems

This Handbook provides direction on how to make use of the tools developed by the IHE initiative to deploy radiology systems that exchange information effectively, using standards-based transactions to meet critical clinical needs. It does not attempt to take account of the many other factors that determine the efficiency and suitability of an application for clinical use. The tools provided by IHE are thus only part—albeit an essential one—of the full set of resources required to select, purchase, deploy and upgrade IHE systems.

Note: This is the first edition of the IHE Radiology User's Handbook. Future editions will be expanded and enhanced. The newest edition will always be available at www.ihe.net.

The Handbook is intended to meet the needs of the healthcare community. Comments and suggestions are welcome. Send them by email to ihe@rsna.org or submit them online at http://forums.rsna.org.

Contents

Glossary

Actor [IHE]: A system or application responsible for certain information or tasks—e.g., the Order Placer Actor. Each Actor supports a specific set of IHE transactions to communicate with other Actors. A vendor product may include one or more Actors.

Admission, Discharge and Transfer (ADT) message [HL7]: Provides for transmitting new or updated demographics and patient visit information. Generally, information will be entered into a Patient Administration system and passed on to nursing, ancillary and financial systems either in the form of an unsolicited update or in response to a record-oriented query.[1]

Broker: A device or application that addresses legacy issues by interfacing between the rest of the world and a system that does not comply with a particular specification. Messages to and/or from the system are instead sent to the broker, which translates between the required specification and what the system can understand.

Connectathon [IHE]: An annual event where participating vendors test their implementations of IHE capabilities with other vendors in a supervised environment.

Digital Imaging and Communication in Medicine (DICOM): The established standard for the exchange of digital information between medical imaging equipment and other systems.

DICOM Service: See Service Class.

Domain [IHE]: A working group in IHE that addresses a particular clinical area—e.g., Radiology, Cardiology, Laboratory or IT Infrastructure. Each domain publishes a Technical Framework (TF).

General order message (ORM) [HL7]: The function of this message is to initiate the transmission of information about an order. This includes placing new orders, cancellation of existing orders, discontinuation, holding, etc. ORM messages can originate also with a placer, filler or interested third party.[2]

Health Level 7 (HL7): The established standard for the exchange, management and integration of data that support clinical patient care and the management, delivery and evaluation of healthcare services.

Integrating the Healthcare Enterprise (IHE): An initiative by healthcare professionals and industry to improve the way computer systems in healthcare share information.

Integration Profile [IHE]: A precise description of how standards are to be implemented to address a specific clinical integration need. Each Integration Profile includes definitions of the clinical use case, the clinical information and workflow involved and the set of actors and transactions that address that need. Integration profiles reference the fully detailed integration specifications defined in the IHE TF in a form that is convenient to use in requests for proposals (RFPs) and product descriptions.

Integration Statement [IHE]: A document prepared and published by a vendor to describe the IHE Integration Profiles, Actors and options supported by a specific version of a product.

Interface engine: See Broker

Lost study: A study that has been deleted or cannot be located (often due to having been incorrectly indexed because of errors or mismatches in demographics or tracking information).

[1] Definition taken from HL7 Version 2.3.1
[2] Definition taken from HL7 Version 2.3.1

Profile [IHE]: See Integration Profile

Registration System: The system used for patient registration under normal workflow; usually the owner/source of patient demographics.

Service Class [DICOM]: A function, such as storage or printing, specified by DICOM and implemented by a device, which may provide or use the service.

Service Class Provider (SCP) [DICOM]: A system or application that provides a DICOM Service (often viewed as the "server" of a service).

Service Class User (SCU) [DICOM]: A system or application that uses a DICOM Service (often viewed as the "client" of a service).

Supplement [IHE]: A proposed addition to the TF. After public comment, review, trial implementation and testing, it is generally merged into the TF.

Technical Framework (TF) [IHE]: The document that defines Integration Profiles, the problems and use cases they address, and the Actors and Transactions involved. It provides detailed implementation instructions for each transaction (primarily used as a guide for vendors).

Transaction [IHE]: An exchange of information between Actors. For each Transaction, the TF describes how to use an established standard (such as HL7, DICOM or W3C) to exchange information.

Worklist: A list of work items, such as image acquisitions, to be performed. Generally, it is retrieved electronically and contains details about the task, such as patient name and identification (ID) number, Accession Number, and relevant input data. May or may not dictate a specific schedule or piece of equipment.

Additional Abbreviations
AE Title = Application-Entity Title
CPI = Consistent Presentation of Images
DCS = DICOM Conformance Statement
GSPS = Grayscale Presentation State
HIS = hospital information system
MPPS = Modality Performed Procedure Step
MWL = Modality Worklist
PACS = picture archiving and communication system
PGP = Presentation of Grouped Procedures
PIR = Patient Information Reconciliation
PPS = Performed Procedure Step
RFI = request for information
RFP = request for proposals
RIS = radiology information system
SWF = Scheduled Workflow

1. SCENARIO: BUYING A MODALITY

When buying and implementing a new modality in a typical hospital or clinic, depending on the systems (radiology information system [RIS], picture archiving and communication system [PACS], workstations) and capabilities (Digital Imaging and Communication in Medicine [DICOM] Modality Worklist [MWL], soft-copy review) already in place, implementing a modality with IHE integration capabilities can provide many benefits.

1.1. The Planning and Purchasing Process

Intended for administrators who make purchasing decisions, this section lists organizational goals to consider when specifying requirements for a modality system, how to select the IHE Integration Profile that will address those goals, how to clearly state IHE requirements in a request for proposals (RFP) and how to interpret vendor responses.

1.1.1. Organizational Goals and Integration Profiles

Clearly identifying organizational goals is a important for defining the requirements for equipment acquisition. Each IHE Integration Profile is designed to meet a specific set of organizational goals. Below is a list of goals an institution might have in acquiring a new modality system and the contributions that each relevant Integration Profile makes in supporting these goals.

Reduce Errors and Enhance Patient Care

Scheduled Workflow (SWF) on the Modality:

- Prevents manual data entry errors at the modality console by downloading patient and study information from the RIS in the MWL
- Prevents stale data by downloading current accurate information from the RIS to the modality in the Worklist
- Prevents complications from patient allergies or pregnancy status—modality obtains these details in the Worklist, which may be displayed to the operator
- Prevents delays in patient care by transmitting images and completion status notification electronically and by reducing number of manual steps
- Prevents lost or "broken"[3] studies in ways described below in the throughput section
- Reduces missing or irrelevant priors—modality stores studies with accurate, detailed patient demographics and procedure descriptions downloaded from the RIS, allowing accurate location and retrieval

Consistent Presentation of Images (CPI) on the modality:

- Prevents confusion about patient orientation by attaching a presentation state at the modality console to define patient orientation for unusual imaging geometries

Presentation of Grouped Procedures (PGP) on the modality:

- Reduces patient discomfort from multiple acquisitions by allowing procedures to be grouped into a single acquisition

[3] A "broken" study occurs when there is a mismatch between key demographic or tracking information between the patient record, the order and the images.

Key Image Notes (KIN) on the modality:

- Allows significant observations during acquisition, such as patient state or motion, to be recorded for the radiologist as a "digital sticky note" by the technologist

Evidence Documents on the modality:

- Provides additional clinical detail to the radiologist, including relevant measurements
- Prevents lost measurements by electronically storing modality measurements, such as fetus length, vessel stenosis or ejection fraction, with the images in human- and machine-readable format

Assisted Protocol Setting Option (in SWF) on the modality:

- Reduces inconsistent or incorrect protocol usage, adjusting initial protocol settings based on procedure codes provided in the Worklist entry

Performed Procedure Step (PPS) Exception Management Option (in SWF) on the modality:

- Reduces incorrect patient studies resulting from incorrectly selected Worklist entries—the modality electronically signals the problem to the RIS and PACS

Improve Throughput

Scheduled Workflow (SWF) on the modality:

- Saves manual data entry time by using Worklists to download patient demographics and study details
- Prevents time wasted searching for or redoing lost studies—modality downloads patient demographics to prevent filing of studies under misspelled patient names and electronically confirms PACS receipt of images to avoid accidental deletion
- Saves time wasted manually confirming image transfer to the PACS—modality automatically confirms PACS receipt of images
- Reduces delays in the review/reporting process—modality specifically reports exams in progress and completed exams to the RIS, allowing faster initial and final reads
- Prevents misperformed studies from misread paper orders—the modality downloads the order Worklist from the RIS
- Prevents time wasted manually fixing demographics for emergency or John Doe studies—the PACS updates the studies to the modality based on patient demographics feeds from the RIS

Assisted Protocol Setting Option (in SWF) on the modality:

- Reduces protocol setup time—modality sets initial protocol parameters based on procedure codes provided in the Worklist entry

PPS Exception Management Option (in SWF) on the modality:

- Improves rescheduling of aborted studies—modality provides detailed reasoning to the RIS (e.g., equipment failure, patient condition, patient death)

Consistent Presentation of Images (CPI) on the modality:

- Reduces radiologist time spent preparing images—the technologist prepares the images and saves the presentation state

Presentation of Grouped Procedures (PGP) on the modality:

- Reduces acquisition time for multiple orders in a single patient by grouping procedures into one acquisition
- Reduces the time a radiologist spends matching anatomic regions between comparison studies by providing presentation states that point directly to relevant images with the right windowing applied.

Evidence Documents on the modality:

- Reduces dictation, transcription and proofing time—modality provides measurements digitally to the reporting system

Improve Billing Process

Scheduled Workflow (SWF) on the modality:

- Recovers lost revenue for additional procedures performed that are not entered into the RIS—modality updates the RIS with procedures actually performed
- Prevents payer claim rejection of reported procedures not matching the order—modality reports procedures actually performed and flags when they differ so they can be reconciled
- Prevents time spent doing "paperwork" for procedures already cancelled by the modality by informing the RIS about cancelled procedures and the reason for cancellation

Charge Posting on the modality:

- Accurately bills film and other consumables for each procedure—modality reports such details to the RIS

Presentation of Grouped Procedures (PGP) on the modality:

- Prevents lost revenue when multiple procedures are grouped at the modality—modality maintains each separate Accession Number and report

PPS Exception Management Option (in SWF) on the modality:

- Reduces time spent billing for incomplete studies—modality provides detailed "incompletion" codes to the RIS

Reduce Patient Radiation Dose

Scheduled Workflow (SWF) on the modality:

- Prevents dose increase from repeating lost studies by avoiding lost studies
- Prevents dose increase from repeating "late" studies by improving turnaround time

Presentation of Grouped Procedures (PGP) on the modality:

- Reduces dose from multiple orders in a patient by performing a single combination scan

Assisted Protocol Setting Option (in SWF) on the modality:

- Prevents dose increase from repeating misperformed studies—modality sets initial protocol parameters based on procedure codes provided in the Worklist entry instead of setting protocols manually from paper orders

- Prevents dose increase from using adult protocols in pediatric patients—modality sets initial protocol parameters based on procedure codes provided in the Worklist entry

Reduce Operational Costs

Scheduled Workflow (SWF), Consistent Presentation of Images (CPI) and Presentation of Grouped Procedures (PGP) on the modality:

- Prevents extra head count with the efficiencies and improvements in throughput described above

Portable Data for Imaging (PDI) on the modality:

- Reduces unnecessary films for surgery, referrals to other sites or referring physicians—modality creates Portable Data for Imaging CDs to be sent to those users

Improve Image Quality

Consistent Presentation of Images (CPI) on the modality:

- Reduces ineffective display settings because the technologist selects appropriate display settings on the modality and stores the presentation state on the PACS
- Reduces ineffective display settings by allowing modality display stations to be properly calibrated

Key Image Notes (KIN) on the modality:

- Reports patient motion or contrast material leakage and other acquisition issues—the technologist can create digital "sticky notes" on the modality for the radiologist
- Flags poor technique and other acquisition issues—the radiologist can use the same tool for communication with the technologist

Reduce Deployment Cost/Time

All IHE Profiles on the modality:

- Prevents custom interface specification time and expense—IHE TF provides a detailed specification for a powerful interface, supported and tested by many vendors
- Prevents custom interface implementation time and expense—many IHE Integration Profiles are already supported by many vendor products
- Reduces interface compliance testing time and expense—many implementation variations have been refined in systems tested at IHE Connectathons
- Reduces intersystem testing time and expense—many combinations of systems have already been directly tested together at IHE Connectathons
- Reduces custom interface maintenance time and expense by maintaining a single interface (IHE) instead of multiple custom interfaces

It is not always possible to address all organizational goals by making a single equipment purchase. Achieving the full benefit of an IHE Integration Profile requires that the systems interacting with the modality also play their roles as defined in the Profile. Frequently, partial benefits can be achieved by implementing an Integration Profile on a single Actor, such as the acquisition modality, in an environment where the interacting systems have some but not all of the functionality described in the Profile. Appendix A provides a general discussion of sequencing requirements and planning individual purchases as part of a long-range plan.

To track progress toward organizational goals and determine return on investment, a well-defined set of performance metrics is needed—see Appendix I.

1.1.2. Selecting IHE Integration Profiles and Actors

Specifying integration requirements for the system you are purchasing is a simple matter of selecting which IHE Integration Profiles and which IHE Actors you want supported. Note that some Profiles include options that provide additional functionality you may also decide to select. The Integration Profiles relevant to the purchase of a modality and the functionality each provides are given below.

Scheduled Workflow is the cornerstone of IHE integration for the acquisition process. It establishes a seamless flow of information that supports efficient patient care in a typical imaging encounter by specifying transactions that maintain the consistency of patient information from registration through ordering, scheduling, imaging acquisition, storage and viewing. It is strongly recommended that you start with this Profile.

Consistent Presentation of Images allows the technologist to set up initial presentation settings on the modality instead of requiring the radiologist to do so at the time of interpretation.

Presentation of Grouped Procedures enables the modality to perform grouped procedures (for example, chest-abdomen-pelvis) without disrupting the reporting and billing chain.

Portable Data for Imaging enables creating DICOM-compliant image CDs on the modality.

Evidence Documents enables image measurements (e.g., ejection fraction, fetus length) to be acquired with the modality and stored on the PACS.

Assisted protocol setting option (in the SWF Profile) enables adjusting the initial protocol on the modality automatically, based on the Worklist entry.

Exception management option (in the SWF Profile) enables the modality to provide detailed feedback to the RIS about why studies were halted or may need to be "fixed."

The *Acquisition Modality Actor* is the key role played by a modality system. Additional IHE Actors a modality can perform include: *Print Composer* to send print requests to DICOM printers, *Media Creator* to create image CDs, *Image Display* to retrieve and display images from the PACS and *Evidence Creator* to store measurements in the PACS.

The benefits provided by each Profile and Actor are outlined in the previous section. For further information, see Appendix B.

1.1.3. Putting Integration Requirements in Your RFP

Requiring IHE support in your RFP is as simple as stating which IHE Integration Profiles (and options) you want the system to support and which IHE Actor roles the system should play in each Profile.

The following are sample statements to specify the Profiles and Actors for a full-featured acquisition modality:

- *"The modality system shall support the IHE **Scheduled Workflow** Integration Profile as the **Acquisition Modality** and **Image Display** Actors."*
- *"The modality system shall support the **Assisted Protocol Setting Option** and the **Exception Management Option** in IHE Scheduled Workflow as the **Acquisition Modality** Actor."*

- *"The modality system shall support the IHE **Consistent Presentation of Images** Integration Profile as the **Acquisition Modality** and **Print Composer** Actors."*
- *"The modality system shall support the IHE **Presentation of Grouped Procedures** Integration Profile as the **Acquisition Modality** Actor."*
- *"The modality system shall support the IHE **Portable Data for Imaging** Integration Profile as the **Media Creator** Actor."*
- *"The modality system shall support the IHE **Evidence Documents** Integration Profile as the **Acquisition Modality** Actor."*

For further discussion of the RFP process, see Appendix C.

1.1.4. Identifying Suitable Products

While you may choose to proceed directly to sending your RFP to a broad group of potential vendors, find out which vendors have products with relevant IHE integration capabilities by referring to public sources. For a description of these sources, see Appendix D.

1.1.5. Reading Integration Statements from Vendors

Vendors may respond to your RFP by providing an IHE Integration Statement document. IHE Integration Statements are also available for many products at *www.ihe.net/Resources/ihe_integration_statements.cfm.*

An Integration Statements is a direct statement of which IHE Profiles, Actors and options are supported by a particular product from a particular vendor. For the contents of an Integration Statement, see Appendix E.

1.2. The Configuration and Implementation Process

The following sections are intended for the implementation team. They cover important clinical and IT considerations when deploying a modality system with IHE capabilities, including dealing with "legacy" issues when connecting a modality to systems that do not support IHE Profiles.

1.2.1. Considering Changes to Your Workflow

IHE Profiles are designed to implement digital imaging in a streamlined clinical workflow. For instance, they eliminate the need to enter patient information at the modality, searching for lost film folders or reconciling cases in the unmatched study folder on the PACS. They also allow images to be immediately available for viewing. To gain the full benefit of these changes, there are several tasks that need to be performed in the correct manner.

1.2.1.1. Scheduled Workflow (SWF) and Patient Information Reconciliation (PIR)

The SWF and PIR Profiles ensure that patient demographics and order and procedural information are correct and consistent. They allow images to be available for review in a timely fashion. Modality operators use the MWL to query and retrieve the relevant patient demographics and scheduled procedure information from the RIS. Patient name changes should not be made on the modality. The RIS is the primary information source and is capable of managing name updates, as long as the modality does not introduce additional unexpected changes. To ensure the most timely and correct patient information, the Worklist should be re-queried just before starting a new exam in case patient or order details have changed. The modality operator should verify that the right patient is selected for each examination.

In unscheduled cases (e.g., emergency patients), patient names and identification (ID) numbers may be unknown. As these are required to commence the procedure, they will need to be selected from a predefined list of temporary patient and names and IDs and entered at the modality. In such unscheduled cases, the AN, a key identifier for the imaging order, must be left blank. Later, when the correct patient ID, name and Accession Number are known, the RIS and the PACS will reconcile the image information with the correct values.

1.2.1.2. Consistent Presentation of Images (CPI)

The CPI Profile ensures that image views are consistent throughout the enterprise, regardless of the monitor or printer used. Technologists will be using image-processing functions to create an appropriate view (or perhaps several), including contrast and brightness settings, flips, zooms, shutters, rotations and annotations for the acquired images. Well-understood identifying descriptions should be used for the presentation states, so the radiologist knows which one to select—e.g., when the as-last-seen view is required at the PACS workstation.

Radiologists need to be aware of the existence and meaning of these presentation state objects, in addition to the images. They may choose to store their own modified view of the images as a presentation state for future reference.

IT personnel should regularly calibrate monitors and printers, according to the Grayscale Display Function Standard (DICOM PS 3.14), to preserve the consistency of the presentation on all monitors and film printers used.

1.2.2. Confirming that it's Working

The following sections provide guidance on how to confirm that the modality is operating according to each IHE Profile implemented. Each section provides elements for testing an individual Profile as it relates to the modality. Often, there are other ways than the ones described to confirm the data and the transactions—see Appendix H.

1.2.2.1. Scheduled Workflow (SWF)

For modalities, it is important that patient demographics and order and procedural information be available to the modality through the MWLs and be preserved in the images created by the modality. Verify that the critical information is available for reviewing on the modality. Confirm that the correct information is maintained by checking information associated with studies on the PACS at the completion of a study and making sure it matches with the RIS Worklist. The following is an example of the high-level list of tests that may need to be run on a new modality with SWF:

1) Schedule a procedure through the hospital information system (HIS)/RIS and review the MWL information on the modality using its Worklist features. (MWL*)

   *This designator is a Transaction code, located in the IHE TF at www.ihe.net/Technical_Framework/index.cfm.

   Confirming the scenario: Verify that the patient demographics and the procedural information on the modality matches what was scheduled through the RIS. Comparing the RIS scheduled procedures with the MWL on the modality may do this. See Table 4.5-3 of the IHE TF Vol. 2 for specific information available on the MWL (e.g., patient name, patient ID, AN, modality, requested procedure ID, protocol name, protocol codes).

2) Run a scheduled procedure on the modality and review the procedure information/status updates on the RIS during the procedure. *(MPPS In Progress)*

Confirming the scenario: Verify that the procedure status on the RIS (or PACS) has been updated based on the procedure being performed on the modality. NOTE: Many modalities do not provide intermediate procedure status. See Appendix A of the IHE TF Vol. 2 for specific information that will be updated based on what is being performed. See Section 4.6 of the IHE TF Vol. 2 for the use cases of how the modality may perform the procedure.

3) Complete a scheduled procedure on the modality and review the procedure/information status information/ status (complete) on the RIS *(MPPS Complete)*. Also, perform an unscheduled procedure on the modality where the patient demographics and procedural information will need to be entered (it may be from a bar code or manually), append a new procedure to a scheduled procedure after the radiologist reviews the resulting images and abandon the procedure on the modality before it is completed.

   Confirming the scenario: Verify that the procedure status on the RIS (or PACS) has been updated based on the procedure being performed on the modality. See Appendix A of the IHE TF Vol. 2 for specific information that will be updated based on what is being performed. See Section 4.6 of the IHE TF Vol. 2 for the use cases of how the modality may perform the procedure. Some of the parameters of particular interest based on the scenario being tested are the AN, requested procedure ID and comparison of the scheduled procedure versus the performed procedure information.

4) Archive images from the modality to the image archival system (either through auto-store or manual storage of images). *(Modality Image Stored)*

   Confirming the scenario: Verify that the images created on the modality are stored on the PACS system.

5) Attempt to delete the images from the modality prior to the image archive claiming possession of the images. *(Storage Commitment)*

   Confirming the scenario: Verify that the images on the modality cannot be deleted because they have not been permanently stored through the PACS system.

6) Attempt to delete the images from the modality after the image archive claims possession of the images. *(Storage Commitment)*

   Confirming the scenario: Verify that the images on the modality can be deleted because they have been permanently stored through the PACS system.

For each of these areas, detailed test sets need to be developed with the appropriate data sets. For example, when a modality retrieves the MWL from the RIS, the following types of items must be taken into account:

1) What type of MWL queries can the modality perform?

   Develop tests that ask for the relevant fields (e.g., all of the scheduled procedures for today for this modality).

2) What information can this modality display, and what information is stored in the resulting image sets?

   Develop tests to review all of the MWL information and determine which can be displayed on the modality. Verify the ability to review each of the MWL fields returned and displayed on the modality (patient name, patient ID, AN, etc.). Develop tests to review all of the resulting information, which was generated out of the MWL and used in the resulting DICOM images.

1.2.2.2. Assisted Protocol Setting Option (in SWF)

Some modalities have the ability to support Procedure Plans based on Protocol Sequence Codes conveyed to the modality through the MWL from the RIS and conveyed back to the RIS at completion of the procedure. The Protocol Sequences are used to drive all steps within a procedure. For example, a protocol sequence for an MRI might call for a "T-1 axial-weighted fat sat sequence of the brain." That protocol sequence can be given a numeric value and each modality can be configured to respond to that value by performing the appropriate machine protocol.

For enterprises capable of supporting this option, this should be tested on modalities capable of supporting this option. This may be accomplished by adding additional tests to the SWF and modalities tests.

1) Schedule a procedure using protocol codes through the RIS and review the information through the MWL feature on the modality.

   Confirming the scenario: Verify that the protocol codes on the modality match what was scheduled through the RIS. See Table 4.5-3 of the IHE TF Vol. 2 for specific information regarding the Protocol Code Sequences in the MWL. Verify that the modality uses the protocol codes to control the procedure being performed. See Section 4.6.4.1.2.4.2 for additional information on the Assisted Protocol Option.

2) Run the scheduled procedure using the protocol codes specified by the RIS.

   Confirming the scenario: Verify that the modality uses the protocol codes to control the procedure being performed. See Section 4.6.4.1.2.4.2 for additional information on the Assisted Protocol Option.

3) Alternatively run the scheduled procedure with altered protocol codes.

   Confirming the scenario: Verify that the RIS has been updated with the procedures performed by the modality. See Section 4.6.4.1.2.4.2 for additional information on the Assisted Protocol Option.

Detailed tests sets should be developed with the data sets. A representative set of procedures should be used to test the specific modality.

1.2.2.3. PPS Exception Management Option (in SWF)

Some modalities have the ability to support the provision of an appropriate reason code in case a started procedure needs to be abandoned. For enterprises capable of supporting this option, this should be tested on the modalities. See Section 4.7.4.1.2.2 of the IHE Radiology TF Vol. 2 for specific requirements. This may be accomplished by adding additional tests to the SWF and modalities tests.

1) Schedule a requested procedure through the RIS and review the information through the MWL feature on the modality.

2) Run the scheduled procedure. Acquire a number of images and send to the PACS.

3) Abandon the procedure and fill in the discontinuation reason code.

4) Check that a PPS is created with the discontinuation reason code, which has references to the acquired images sent to the PACS.

   Confirming the scenario: Verify that the procedure status on the RIS (or PACS) has been updated based on the procedure being performed on the modality. See Table 4.7-1 of the IHE TF Vol. 2 for details on the Exception Management Codes.

Detailed test sets should be developed with the data sets. A representative set of procedures should be used to test the specific modality.

1.2.2.4. Consistent Presentation of Images (CPI)

Efficiency and accuracy of image review can be improved through the use of CPI. The modality plays a critical role in creating the Presentation States associated with CPI. The following is an example of the high-level list of tests that may need to be run on a new modality system with CPI:

1) Calibrate all workstations and printers to be used in association with CPI. (Refer to Vendor's Documentation)

2) Create images that have been window/leveled, magnified, rotated, etc., on the modality (either directly through the image acquisition process or in postprocessing of acquired images) and store them to the PACS. *(Modality Presentation State Stored)*

3) Retrieve images from the PACS and display them on another workstation *(Retrieve Images)*

   Confirming the scenario: Verify that displayed images are identical to original postprocessed images. See DICOM 2003 PS 3.4: GSPS [Grayscale Presentation State] Storage for a full list of display attributes that can be saved.

4) Print the processed images from the modality to a printer. *(Print Request with Presentation LUT)*

   Confirming the scenario: Verify that images are identical to original postprocessed images. See DICOM 2003 PS 3.4: Presentation LUT SOP Class for a full list of print attributes.

For each of these areas, detailed sets of tests need to be developed with the appropriate data sets. These data will need to include representative images that can be processed and a list of image manipulations/transforms to apply (to verify the modality is correctly setting the appropriate attributes in the GSPS it creates).

1.2.3. Considering Installation Issues

Even with IHE, installation is not "plug & play"—the systems are not self-configuring. For the modality, you will likely need to do the following:

1.2.3.1. Scheduled Workflow (SWF) and Patient Information Reconciliation (PIR)

1) Configure the AE Title, IP address, and port for your modality's DICOM MWL. This information needs to be shared with the RIS vendor so the RIS can be configured to provide your MWL.

2) Configure the AE Title, IP address, and port for your modality's DICOM Modality Performed Procedure Step (MPPS). This information needs to be shared with the PACS vendor (if it is the configured MPPS manager) so they can forward MPPS messages from your modality to the RIS. Otherwise, if the RIS is acting as the MPPS manager, it will be receiving MPPS messages and forwarding them to the PACS, and the RIS would need your modality's MPPS configuration information.

3) Configure the AE Title, IP address, and port for your modality's DICOM Storage and Storage Commitment. This information needs to be shared with the PACS vendor so the PACS can be configured to provide your storage services.

4) Configure the AE Title, IP address, and port for your modality's DICOM print services. This information needs to be shared with the printer vendor so the printer can be configured to

provide your print-on-film services. In addition, in Print Composer, configure the printer properties supported for the specific printer, such as medium type, minimum and maximum density, film orientation, film size ID, magnification type, trim, configuration information and polarity.

A significant amount of time goes into creating and keeping various codes in sync between different systems. Codes will need to be established for many parts of your system—as simple as a set of protocol codes to a much larger set of data, like procedure codes. These codes are typically kept in sync manually, and if they are out of sync, the receiver may not accept data, as it may not be aware of a coded value.

1.2.3.2. Consistent Presentation of Images (CPI)

Regular calibration of monitors and printers is required, according to the Grayscale Display Function Standard (DICOM PS 3.14). Naming conventions will be needed for the Presentation States created.

1.2.4. Identifying and Addressing "Legacy" Problems

IHE Integration Profiles are built assuming that all relevant systems support these Profiles. If some systems do not support the Profiles you have selected but do support the standards the Profile is built on, some benefit is still possible. If you have deficient systems, consider how to work around the deficiencies in the short term and when you plan to replace or upgrade those systems.

1.2.4.1. Connecting the Modality to a Non-IHE PACS

Interoperability between the modality and the PACS enables the patient demographics and order and procedural information to be preserved and updated (in the case of PIR) when new or updated information is provided through the HIS or RIS. Image status can be provided to ensure that images are made available as quickly as possible. Some or all of these capabilities may be available based on the capabilities of the non-IHE PACS. The following are some guidelines to consider when determining how to integrate the modality with a non-IHE PACS.

Request a DICOM Conformance Statement (DCS) from your PACS vendor for the current product release installed at your site. See Appendix F.

1.2.4.1.1 Scheduled Workflow (SWF)

In the SWF Profile, the modality expects the PACS to support several DICOM services, using specific attributes and responding to messages in specific ways (refer to the TF). The critical DICOM services are:

- DICOM Storage as an SCP
- DICOM Storage Commitment as an SCP
- DICOM MPPS as an SCP
- DICOM Query/Retrieve as an SCP

If your PACS has all of these services, the next step is to confirm that critical DICOM attributes provided in the DICOM images (and any other DICOM objects) by the modality are acted on in the PACS. A summary of the key identifying attributes defined by IHE to ensure information consistency throughout the acquisition workflow is:

- Patient name (0010,0010)
- Patient ID (0010,0020)

- Study Instance Unique Identifier (0020,000D)
- Accession Number (0008,0050)
- Requested procedure ID (0040,1001)
- Scheduled Procedure Step ID (0040,0009)

For a complete mapping of the key attributes, see the radiology TF, Vol. 2, Appendix A. If your PACS does not act on any of these key attributes, your vendor may have an option or upgrade to provide proper support for these attributes.

Support for MPPS on a PACS is useful to "close the acquisition loop" by enabling automated procedure status tracking and billing. Though workflow may be hampered by absence of the MPPS service, data consistency between systems is not endangered in the absence of this service. If your PACS does not have DICOM MPPS, it will not be able to receive study status to from the modality (or the RIS). In this case, reducing the workflow problems this causes in terms of "closing the acquisition loop," tracking procedure status and performing fast and accurate billing can often be accomplished by one of the following means: *(a)* Your PACS may have a "fallback mode" that allows it to guess study status based on heuristics by using Storage and Storage Commitment or other events or triggers from the modality or the RIS; *(b)* you may also track work status by using a RIS client on or near the PACS to view the status of the acquisition task.

Support for DICOM Storage Commitment on the PACS enables automatic removal of images from the modality once the PACS has accepted "commitment" of them. If your PACS does not have DICOM Storage Commitment, it will not be able to confirm that the PACS has received and taken ownership of the imaging data. To reduce the problems this causes: *(a)* Manually confirm all images for each study have been received on the PACS and "committed" to permanent, long-term storage before deleting those images from the modality system; and *(b)* keep copies of all images on the modality until the reports have been generated and the images archived.

If your PACS does not support DICOM Storage, IHE integration is not really possible, as DICOM Storage is really the bare minimum. Consider upgrading or replacing your PACS.

1.2.4.1.2 Consistent Presentation of Images (CPI)

In the CPI Profile, the modality expects the PACS to support several DICOM services by using specific attributes and responding to messages in specific ways (refer to the TF). The critical DICOM services are:

- DICOM Storage as an SCP (for GSPSs),
- DICOM Query/Retrieve as an SCP (for GSPSs)
- DICOM Storage Commitment as an SCP

If your PACS does not support these services, your vendor may have an option or upgrade to provide them.

One of the foundations of the CPI Integration Profile is the creation, storage and use of DICOM GSPS objects to convey all grayscale processing operations and all spatial and graphic transformations necessary to present or print associated images in an "as-last-seen" view. If your PACS cannot receive and process GSPS objects, it will not be possible to view the image "as-last-seen" on the PACS workstation, nor to print this "as-last-seen" view of the image on film. To reduce the problems this causes, *(a)* Your PACS may be able to store and query/retrieve GSPS objects. Consider adding a third-party workstation to your PACS that supports CPI for viewing and as a print composer. *(b)* The modality may have the option to support CPI as a print composer, which enables image printing with a consistent appearance to a CPI-capable print

server. *(c)* The modality may be able to fall back to creating graphic overlays for the images and generate a copy of the images for each specific grayscale setting the technologist at the modality wants to convey. However, this will increase enormously the amount of images that need to be sent to the PACS and will prevent future processing of these images.

For discussion of the issues and possible "workarounds" associated with a PACS that does not support DICOM Storage Commitment, refer to the section on Storage Commitment in the SWF above.

1.2.4.2. Connecting the Modality to a Non-IHE RIS

Request a DCS from your RIS vendor for the currently installed system at your site. See Appendix F.

1.2.4.2.1 Scheduled Workflow (SWF)

In the SWF Profile, the modality expects the RIS to support several DICOM services, using specific attributes and responding to messages in specific ways (refer to the TF). The critical DICOM services are:

- DICOM MWL as an SCP and
- DICOM MPPS as an SCP.

A RIS should use DICOM MWL to convey patient and order information to the modalities. Check the conformance statement to see what kind of attributes it supports for Worklist query and return values, in particular for the extra attributes for which IHE requires support in addition to what is required in the DICOM Standard:

- Requested Procedure ID (0040,1001) as Matching Key,
- Accession Number (0008,0050) as Matching Key,
- Code Meaning (0080, 0104) as Return Key for the Scheduled Procedure Code Sequence (0040,0008)
- Requested Procedure Code Sequence (0032,1064)

If these attributes are not supported, your workflow will be affected because the modality operator may not be able to search for the required Worklist entry efficiently.

In the absence of the DICOM MWL capabilities on the RIS, some possible workarounds for getting patient and exam information on the modality are *(a)* using bar-codes (an alternative way of accessing at least essential identification data), and *(b)* manually entering data at the modality by reading at a RIS terminal or on hard copy. Critical information the modality needs includes basic patient demographics, the RIS-assigned AN, and if possible the RIS-assigned Study Instance Unique Identifier (to ensure consistent data throughout the enterprise).

To close the acquisition workflow loop, modalities issue a DICOM MPPS to the relevant system to track the acquisition status (in progress, completed, discontinued), to notify the occurrence of the single-acquisition group case and to provide additional data on the work done for billing purposes. This is an additional feature that a site can decide to implement in a later phase and negotiate accordingly with suppliers of the registration system. The need of this service also depends on whether the institution intends to integrate/automate the billing process into the overall workflow or continue with its unintegrated billing procedures.

IHE requires a modality to send MPPS messages to RIS or PACS. If your RIS lacks support for DICOM MPPS, it will not be able to receive study status updates. To reduce problems this causes in terms of being able to close the acquisition loop, track procedure status and perform fast and

accurate billing, the MPPS message could be sent to a broker, which could then send an HL7-based update message to the RIS and forward the MPPS to the PACS. A RIS terminal may be available close to the modality console to manually enter exam updates.

2. SCENARIO: UPGRADING A RIS

A radiology department is planning to upgrade/replace their existing RIS. The department is experiencing an increasing volume of radiology procedures, yet not all revenue is realized. There are problems closing orders, and sometimes studies go missing in the reporting and result delivery process.

The institution has an existing source of patient demographics and order management. The department has a PACS, which archives all studies produced by the modalities. There are a number of existing DICOM-capable modalities and some new modalities will be added after the RIS upgrade is complete.

The primary function of the RIS will be to process orders, schedule exams and generate reports, as well as capture charges for procedures performed and interpreted in the radiology department. The RIS will send copies of diagnostic reports to an enterprise report repository.

2.1. The Planning and Purchasing Process

Intended for administrators in charge of making purchasing decisions, this section lists organizational goals to consider when specifying requirements for a RIS system, how to select IHE Integration Profiles that will address those goals, how to clearly state IHE requirements in an RFP and interpret vendor responses.

2.1.1. Achieving Organizational Goals

Clearly identifying organizational goals is an important first step in defining the requirements for any equipment acquisition. Each IHE Integration Profile is designed to meet a specific set of organizational goals. Below is a list of goals an institution might have in acquiring a new RIS and the contributions each relevant IHE Integration Profile makes in supporting these goals.

Reduce Errors and Enhance Patient Care

Scheduled Worklfow (SWF) on the RIS:

- Decreases lost data due to inconsistently identified data because the RIS receives patient demographics from the HIS or registration system and provides it to the PACS and modalities
- Prevents manual data entry errors because the RIS receives patient demographics and updates from the registration system and radiology order details from the order entry system electronically
- Prevents manual data entry errors because the RIS transmits patient and order information to the modality using MWL
- Prevents performing incorrect or cancelled procedures because the RIS makes up-to-the-minute Worklists, including recent procedure and schedule changes, available to the modality
- Prevents complications from allergies or pregnancy status because the RIS includes details about patient allergies and pregnancy status in the MWL
- Minimizes patient waiting time because the RIS introduces efficiencies in the exam process, as described in the Improve Throughput section below

Patient Information Reconciliation (PIR) on the RIS:

- Prevents misidentified patients and incorrect patient demographicss because the RIS receives updates from the registration system (from discovering entry errors, identifying John Does, migrating records to a married name, etc.), updates the Worklist and passes the updates to other integrated systems, like the PACS and the Report Manager

Improve Throughput

Scheduled Workflow (SWF) and Patient Information Reconcilation (PIR) on the RIS:

- Eliminates staff time wasted manually entering patient demographicss because the RIS receives the information electronically from the registration system and provides it to the modalities
- Reduces staff time wasted waiting or searching for paper orders because the RIS receives the ordered exams electronically from the order placing system and provides them to the modalities
- Reduces staff time wasted identifying and correcting errors (in a coordinated fashion) among the HIS, RIS, PACS and modality because the RIS handles many of the corrections automatically
- Eliminates staff time wasted manually reconciling unscheduled orders because the RIS automatically backfills orders and informs the order placer systems when unscheduled acquisitions are reported by the modalities

Increase Revenue/Improve Billing

Scheduled Workflow (SWF) and Patient Information Reconcilation (PIR) on the RIS:

- Prevents loss of revenue for exams performed as ordered that were subsequently either canceled or modified because the RIS provides up-to-date details to the modality via Worklists.
- Reduces delays in billing because the RIS receives timely procedure completion information from the modality in the PPS messages
- Reduces inaccurate billing because the RIS receives accurate details on procedures cancelled or changed at the modality
- IHE Charge Posting on the RIS:
- Reduces billing delays because the RIS captures billable events from all systems as they happen, makes the charges quickly and accurately and makes the results centrally available to the billing system

IHE Presentation of Grouped Procedures (PGP) on the RIS:

- Reduces unclosed orders for grouped acquisitions because the RIS receives completion messages from the modality for the single scan and also for each Accession Number of each of the grouped orders

Reduce Operational Costs

Scheduled Workflow (SWF), Patient Information Reconcilation (PIR), Charge Posting and Presentation of Grouped Procedures (PGP) on the RIS:

- Prevents extra head count due to the efficiencies and improvements in throughput and the billing process, as described above

Reduce Deployment Cost and Time

All IHE Profiles on the RIS:

- Eliminates custom interface specification time and cost, since the IHE TF provides a detailed specification for a powerful interface, supported and tested by many vendors
- Prevents custom interface implementation time and cost, since many IHE Integration Profiles are already supported by many vendor products
- Reduces interface compliance testing time and cost because many implementation variations have been ironed out in systems tested at the IHE Connectathon
- Reduces intersystem testing time and cost because many combinations of systems have already been directly tested together at the IHE Connectathon
- Reduces custom interface maintenance time and cost by maintaining a single IHE interface instead of multiple custom interfaces

It is not always possible to address all organizational goals by making a single equipment purchase. Achieving the full benefit of an IHE Integration Profile requires that the systems interacting with the RIS also play their roles as defined in the Profile. Frequently, partial benefits can be achieved by implementing an Integration Profile on a single Actor, such as the RIS, in an environment where the interacting systems have some but not all of the functionality described in the Profile. Appendix A provides a general discussion of sequencing requirements and planning individual purchases as part of a long-range plan.

To track progress toward organizational goals and determine return on investment, a well-defined set of performance metrics is needed—see Appendix I.

2.1.2. Selecting IHE Integration Profiles and Actors

Specifying integration requirements for the system you are purchasing is a simple matter of selecting which IHE Integration Profiles and which IHE Actors you want supported. Note that some Profiles include options that provide additional functionality you may also decide to select. The Integration Profiles relevant to the purchase of a RIS and the functionality each provides at the modality are given below:

The SWF and the PIR Profiles form the cornerstone of integrating a RIS with other systems in the institution. They establish a seamless flow of information that supports efficient patient care in a typical imaging encounter and certain exception cases by specifying transactions that maintain the consistency of patient information from registration through ordering, scheduling, imaging acquisition, storage and viewing. It is strongly recommended that you start with these Profiles.

Charge Posting enables collecting accurate chargeable event information from departmental systems and making it quickly and centrally available to billing systems.

Presentation of Grouped Procedures provides efficient workflow and accurate order tracking when multiple procedure orders are grouped by the modality at acquisition time.

Assisted Protocol Setting Option (in the SWF Profile) enables sending the initial protocol settings to the modality in the Worklist.

IHE Exception Management Option (in the SWF Profile) allows monitoring of detailed feedback from the modality about why studies were halted or may need to be "fixed."

The DSS/Order Filler Actor is the key role played by a RIS system. Additional IHE Actors the RIS can perform include Report Repository to provide permanent storage for diagnostic reports, Report Creator to create diagnostic reports and optionally retrieve Worklist entries for reporting steps, and Report Reader to query for and review reports.

The benefits provided by each Profile and Actor are outlined in the previous section. For further information on the Profiles, see Appendix B.

2.1.3. Putting Integration Requirements in Your RFP

Requiring IHE support in your RFP is as simple as stating which IHE Integration Profiles (and options) you want the system to support and which IHE Actor roles the system should play in each Profile.

The following are sample statements to specify Profiles and Actors for a full-featured RIS:

- *"The RIS shall support the SWF Profile and the PIR Integration Profile as the DSS/order Filler Actor."*
- *"The RIS shall support the Assisted Protocol Setting Option and the Exception Management Option in the SWF Profile as the DSS/order Filler Actor."*
- *"The Radiology Information System shall support the IHE Charge Posting Profile as the DSS/Order Filler Actor."*

For further discussion of the RFP process, see Appendix C.

2.1.4. Identifying Suitable Products

While you may choose to proceed directly to sending your RFP to a broad group of potential vendors, you can learn which vendors may have products with relevant IHE integration capabilities by referring to public sources. For source descriptions, see Appendix D.

2.1.5. Reading Integration Statements from Vendors

Vendors may respond to your RFP by providing an IHE Integration Statement document. You may also find IHE Integration Statements for many products at *www.ihe.net/Resources/ihe_integration_statements.cfm.*

An Integration Statement is a direct statement of which IHE Profiles, Actors and options are supported by a particular model of a particular system from a particular vendor. For the contents of an Integration Statement, see Appendix E.

2.2. The Configuration and Implementation Process

The following sections are intended for the implementation team. They discuss important clinical and IT considerations when deploying a RIS system with IHE capabilities, including dealing with "legacy" issues when connecting the RIS to systems that do not support IHE Profiles.

2.2.1. Considering Changes to Your Workflow

IHE Profiles are designed to implement digital imaging in a streamlined clinical workflow. For instance, they eliminate the need to enter patient information at the modality, searching for lost film folders or reconciling cases in the unmatched study folder on the PACS. They also allow images to be immediately available for viewing. To gain the full benefit of these changes, there are several tasks that need to be performed in the correct manner.

Scheduled Workflow (SWF) and Patient Information Reconciliation (PIR)

The SWF Profile ensures that patient demographics and order and procedural information are correct and consistent throughout the enterprise—they must consistently be entered from the same system (HIS, RIS, etc.) so the responsible system can maintain and appropriately distribute the information to all interested systems. Clinical and IT personnel will need to identify the owners of certain information elements. The owners distribute the information, while receivers track it. Typically,

- The HIS owns the patient identification. In an emergency case, the HIS is still required to reconcile the patient and update the RIS. Patients should only be registered in the HIS. The IHE workflow will update all other systems below it as needed. There is no IHE workflow to update the HIS if a patient is registered at the RIS.
- The RIS owns the Accession Number and Study Instance Unique Identifier, among other scheduling information. At the modality, do not type in the Accession Number if it is unknown.

As a part of identifying information ownership, clinical and IT personnel may want to further review how information is related. For example, IHE supports an Accession Number associated with multiple ordered procedures. Setting up these types of relationships may resolve current workflow inefficiencies.

2.2.2. Confirming That It's Working

The following sections provide guidance as to how to confirm that the RIS is operating according to each IHE Profile implemented. Each section provides elements for testing an individual Profile as it relates to the RIS. Note that in many cases, there are other possible ways than the ones described to confirm the data and the transactions. For an introduction on testing strategies, see Appendix H.

2.2.2.1. Scheduled Workflow (SWF)

It is important that the patient demographics and order information sent from the HIS are recorded correctly in the RIS. This information, along with additional patient demographics and order and procedural information, must be correctly forwarded to the modality and PACS so that the proper procedures are performed and reported on. Likewise, the status information returned to the RIS from the modality and PACS is critical in providing the enterprise with appropriate status on what procedures have been performed and the availability of information, such as images.

Confirming the RIS interface operation requires checks at several points in the process. Confirm by checking the information of specific patient procedures that have been generated by the HIS and sent to the RIS for scheduling. Confirm the information of specific patient procedures that have been generated by the HIS and the RIS and sent to the modality to perform the procedure. Confirm by checking the status and update information from the modality. Finally, confirm by checking the availability of images on the PACS.

The following are examples of the high-level list of tests that may need to be run on a new RIS with SWF. Some or all may be relevant to a specific enterprise. These test scenarios are based on the use cases identified in Section 4.4 of Vol. 1 of the IHE TF. Along with each scenario is a mechanism to verify that the test scenario is provided. Note that in many cases, there are multiple ways to confirm the data and the transactions.

Patient registration and order fulfillment can occur in a number of ways. This includes:

1) Register the patient and place the orders on the HIS. Fill the through the RIS. (*Patient Registration, Placer Order Management, Filler Order Management)*

   Confirming the scenario: Verify that the critical patient demographics, encounter information (PV-1), etc., entered during patient registration for your operation, appears correctly on the RIS. See Section 4.1.4 of the IHE TF Vol. 2 for specific information sent by the HIS as HL7 messages (e.g., patient name, ID, address, class, consulting physician, allergy type). Then, verify that the critical order information entered for your operation appears correctly on the RIS. Make sure that the order can be filled and scheduled on the RIS. See Section 4.2.4 of the IHE TF Vol. 2 for specific information sent by the HIS as HL7 messages (e.g., order number, order date/time, universal service ID, ordering provider).

2) Register the Patient on the HIS, place the order through the RIS. (Patient Registration, Placer Order Management, Filler Order Management)

   Confirming the scenario: Verify that the critical patient demographics, encounter information (PV-1), etc., entered during patient registration for your operation appears correctly on the RIS through the Patient Management User Interface. See Section 4.1.4 of the IHE TF Vol. 2 for specific information sent by the HIS as HL7 messages (e.g., patient name, ID, address, class, consulting physician, allergy type). Then, verify that the critical order information entered at the RIS for your operation appears correctly on the HIS through the Patient Management User Interface. See Section 4.2.4 of the IHE TF Vol. 2 for specific information sent by the HIS as HL7 messages (e.g., order number, order date/time, universal service ID, ordering provider).

3) Register the patient on the HIS. Prior to placing any orders, update the patient information through the HIS.

   Confirming the scenario: Verify that the critical patient demographics, encounter information (PV-1), etc., reflected on the RIS through the Patient Management User Interface consists only of the updated patient data. See Section 4.1.4 of the IHE TF Vol. 2 for specific information sent by the HIS as HL7 messages (e.g., patient name, ID, address, class, consulting physician, allergy type).

4) Based on the orders created by the HIS or the RIS, procedures are than scheduled by the RIS. *(Procedure Scheduled)*

   Confirming the scenario: Verify that the procedural information for the registered patient is sent to the PACS. View the order information for the scheduled patient by using the Scheduled Procedure User Interface for the PACS. (Alternatively, there may be subsequent scheduling of activities to ensure that the appropriate information is available for reporting on the completion of the procedure. This includes the retrieval of prior image studies and reports). See Section 4.4.4.1.2 of the IHE TF Vol. 2 for specific information sent by the RIS as HL7 messages (e.g., patient name, ID, universal service ID).

5) In some cases, orders will change prior to performing a procedure. In this case, procedural information updates will need to occur on the RIS. *(Procedure Update)*

Confirming the scenario: Verify that the procedural information for the registered patient has been changed on the PACS by viewing the order information for the scheduled patient by using the Scheduled Procedure User Interface for the PACS. See Section 4.13.1.2 of the IHE TF Vol. 2 for specific information sent by the RIS as HL7 messages (e.g., procedure cancelled, procedure changed, procedure discontinued).

Procedures may be scheduled for modalities. The systems performing procedures need to interact with the RIS, as they may need to retrieve scheduled procedures and provide updates. A representative number of systems should be tested to ensure all of the required order and procedural information is transmitted.

6) Modalities may retrieve lists of procedures schedules on the RIS. *(Modality Worklist Provided)*

   Confirming the scenario: Verify that the patient demographics and order and procedural information for the scheduled procedure are displayed correctly on the modality by viewing the MWL. See Table 4.5-3 of the IHE TF Vol. 2 for specific information sent by the RIS as DICOM (e.g., patient name, ID, requested procedure, AN).

7) As the modality performs procedures, status updates are provided to the RIS. *(MPPS In-Progress, MPPS Complete*)

   Confirming the scenario: Verify that the procedure according to the RIS matches what was performed on the modality. The following is a list of outcomes. See Table 4.7-1 of the IHE TF Vol. 2 for specific information sent from the modality in the case of procedure discontinuation and Section 4.6.4.1.2.4 for Assisted Protocol Option.

   Outcomes: Modality/workstations perform single scheduled procedure, modality/workstations abandon procedure, modality/workstations group two scheduled procedures (if *Modality Group Case Option* supported), modality performs procedure different than scheduled, modality performs unscheduled procedures (See PIR section below), modality performs procedures scheduled with protocol codes (if *Assisted Protocol Option* supported).

8) Workstations used to create additional images for reporting (e.g., a CAD workstation) may also be required to notify the RIS of performed procedures. *(Creator Procedure Step In Progress, Creator Procedure Step Complete*)

   Confirming the scenario: Verify that the procedure according to the RIS matches what was performed by the Evidence Creator. Below is a list of outcomes.

   The RIS provides status updates to other components within the enterprise, including the PACS, during the acquisition phase of the procedure.

9) The RIS maintains not only procedural status, but also status on the images associated with the procedure. PACS reporting systems may schedule the reporting phase based on the status of not only the procedure, but also the availability of the images associated with the procedure. *(Image Availability*)

   Confirming the scenario: Verify the status of the procedure during acquisition at the modality and up through the time that the procedure is ready to report on. As images become available on the PACS, verify that the RIS status for the procedure is updated to reflect this.

For each of these areas, detailed sets of tests need to be developed with the appropriate data sets. The RIS is in the center of the radiology department, so this set may need to be fairly extensive. These data should include:

1) Development of HL7 records to be sent from the HIS to the RIS. *(a)* These records should include all HL7 messages, which will be sent from the HIS to the RIS to generate such items as patient demographics and patient orders. This includes HL7 messages, such as Admission, Discharge and Transfer (ADT) messages A01 (patient admission), A04 (patient registration), A05 (preadmission) and general order messages (ORMs). See the IHE TF for the specific transactions being tested. *(b)* These records should include all of the fields, which will be propagated to the modalities (through MWLs), and PACS systems (through DICOM images). patient demographics/patient orders include critical fields such as patient name, ID, sex, requested procedure ID, Accession Number and performed procedure ID.

2) Development of HL7 records to be sent from the RIS to the HIS. (These may be data, created as part of the tests.) *(a)* These records should include all HL7 Messages, which will be sent from the RIS to the HIS to generate such items as patient demographics and patient orders. *(b)* These records should include all of the fields, which will be propagated to the modalities (through MWLs), and PACS (through DICOM images). patient demographics/patient orders include patient name, ID, AN, requested procedure ID, scheduled location, modality, scheduled protocol codes, and scheduled protocol description. See IHE TF Vol 2 Table 4.5-3 for a full list of parameters.

3) Development of codes and mappings on the RIS to be used within the radiology department. HL7 to DICOM mapping may need to occur as part of the system setup. This is necessary for such things as MWLs. If the Assisted Protocol Code Option is supported within SWF, protocol codes will need to be developed and set up both on the RIS and the modalities.

Patient Information Reconciliation (PIR)

A critical function of the RIS is to ensure that the patient demographics and order information are kept current throughout the enterprise. During a patient visit, updates may need to occur. This information needs to be appropriately propagated throughout the radiology systems. The following are high-level tests associated with the PIR, which may occur as part of SWF.

1) Patient update prior to procedure scheduling. *(Patient Update)*

   Confirming the scenario: Verify that the critical patient demographics, encounter information (PV-1), etc., reflected on the RIS through the Patient Management User Interface consists only of the updated patient data. See Section 4.1.4 of the IHE TF Vol. 2 for specific information sent by the HIS as HL7 messages (e.g., patient name, ID, address, class, consulting physician, allergy type).

2) Patient update after procedure scheduling. *(Patient Update)*

Confirming the scenario: Same as before. In addition, make sure the changes are reflected in the PACS.

3) Reconciliation of patient ID during image acquisition. *(Patient Update)*

   Confirming the scenario: Same as before. Make sure the changes are reflected in the PACS. Then verify that the images created for the procedure reflect the new patient demographics when viewed and reported on.

4) Order replacement prior to procedure scheduling. *(Procedure Update)*

   Confirming the scenario: Verify that the procedural information for the registered patient has been changed on the RIS. View the order information for the scheduled patient by using the Order Management User Interface on the RIS. See Section 4.2.4 of the IHE TF Vol. 2 for specific information sent by the HIS as HL7 messages (e.g., order number, universal ID).

5) Order replacement after procedure scheduling. *(Procedure Update)*

   Confirming the scenario: Verify that the patient registered after the fact is associated with the correct unidentified patient. This will require verification that the procedural information for the registered patient has been changed on the RIS. View the order information for the scheduled patient by using the Order Management User Interface on the RIS. See Section 4.2.4 of the IHE TF Vol. 2 for specific information sent by the HIS as HL7 messages (e.g., order number, universal ID). Then verify that the procedural information for the registered patient has been changed on the PACS. View the order information for the scheduled patient by using the Scheduled Procedure User Interface for the PACS. See Section 4.13.1.2 of the IHE TF Vol. 2 for specific information sent by the RIS as HL7 messages (e.g., procedure cancelled, changed, discontinued).

6) The following scenarios deal with unidentified patient registration and order fulfillment: *(a)* Unidentified patient registered at the HIS with orders placed at the HIS—fill the order and schedule the procedure through the RIS. *(Patient Registration, Placer Order Management, Filler Order Management)*. *(b)* Unidentified patient registered at the HIS with orders placed at the RIS. *(Patient Registration, Placer Order Management, Filler Order Management)*. *(c)* Unidentified patient registered at the HIS but exam completed at the modality prior to the order being placed. *(Patient Registration)*. *(d)* Procedure executed at the modality prior to patient registration at the HIS or orders being placed.

   Confirming the scenario: Verify that the patient demographics information on the RIS and PACS is updated after the patient information is updated on the HIS. The unidentified patient and the updated patient should be the same. See Section 4.12.4.4 of the IHE TF Vol. 2 for specific information sent by the HIS as an HL7 message (A40 Patient Merge). The development of test data for this Profile is similar to the SWF, except that there will be additional HL7 message types.

2.2.3. Considering Installation Issues

Even with IHE, installation is not "plug & play"—the systems are not self-configuring. For the RIS, you will likely need to do the following:

2.2.3.1. Scheduled Workflow (SWF) and Patient Information Reconciliation (PIR)

- Configure the AE Title, IP address, and port for your DICOM MWL. This information needs to be shared with all the modality vendors so they can be individually configured to query your RIS's MWL.
- Configure the AE Title, IP address, and port for your RIS's DICOM MPPS. This information needs to be shared with the PACS vendor (if it is the configured MPPS Manager) so they can forward MPPS messages from modalities to your RIS. Otherwise, if your RIS is acting as the MPPS manager, it will be receiving MPPS messages and forwarding them, so all modalities would need your RIS's MPPS configuration information.
- For your HL7 interfaces, configure the IP address and port for your ADT and order interfaces. These may or may not be the same. This information should be shared with your HIS so it knows where to send the HL7 messages. Locate the IP address and port for the HIS or clinical information system so procedure update messages can be sent from your RIS. Finally, for HL7 procedure messages, you will need to get the IP address and port for HL7 orders from your PACS vendor to allow your RIS to send orders and patient demographics to your PACS.

There is a significant amount of time that goes into creating and keeping various codes in sync between different systems. You will need to establish codes for many parts of your system—as simple as a set of gender codes to a much larger set of data, like provider codes. These codes are typically kept in sync manually, and if they are out of sync, the receiver may not accept data, as it may not be aware of a coded value.

2.2.4. Identifying and Addressing "Legacy" Problems

IHE Integration Profiles are built assuming that all relevant systems support these Profiles. If some systems do not support the Profiles you have selected but do support the standards the Profile is built on, some benefit is still possible. If you have deficient systems, consider how to work around the deficiencies in the short term and when you plan to replace or upgrade those systems.

2.2.4.1. Connecting the RIS to a Non-IHE PACS

Interoperability between the RIS and the PACS enables the patient demographics and order and procedural information to be preserved (and updated in the case of PIR) when new or updated information is provided through the HIS or RIS. Image status can be provided to ensure that images are made available as quickly as possible. Some or all of these capabilities may be available based on the capabilities of the non-IHE PACS. The following are some guidelines consider when determining how to integrate the RIS with a non-IHE PACS.

Request a current DCS and HL7 "interface specification" from your PACS vendor. See Appendices F and G.

2.2.4.1.1 Scheduled Workflow (SWF)

In the SWF Profile, the RIS expects the PACS to support several DICOM and HL7 services, using specific attributes and responding to messages in specific ways (refer to the TF). The critical DICOM and HL7 services are DICOM MPPS as an SCP, DICOM Query/Retrieve as an SCP, DICOM Instance Availability Notification as an SCP, and HL7 ORMs.

Your PACS should be able to receive DICOM MPPS status updates from a modality. These updates include status on when acquisition is started and completed, as well as information related to the study and exam (Study Instance Unique Identifier and AN). In the absence of the DICOM MPPS capabilities on your PACS, your new RIS should be set up as the PPS Manager so your RIS will receive status updates.

Your PACS receives HL7 "procedure scheduled" messages (refer to Radiology TF Vol. 2 4.4) from the RIS when exams have been scheduled. This includes patient demographics, scheduled procedure steps, and RIS-created Accession Number and Study Instance Unique Identifier. This allows the PACS to associate received images with the correct patient and exam and prefetch relevant prior images. In the absence of the ability to receive the HL7 "procedure scheduled" messages, the PACS operator would be required, when a modality stores images that don't match the order, to manually handle reconciliation by entering patient demographics and exam-specific information, such as AN. The PACS would then start prefetching relevant prior images as soon as it starts receiving current images rather than when it receives the HL7 message. A broker/interface engine may be used to receive HL7 messages and convert these orders to a message the PACS does support. These workarounds obviously take time, and depending on how non-standard they are, may be expensive to implement.

2.2.4.1.2 Patient Information Reconciliation (PIR)

In the PIR Profile, the RIS expects the PACS to support several HL7 services, using specific attributes and responding to messages in specific ways (refer to the TF). The critical HL7 services

are HL7 update ORMs and HL7 patient update messages (ADTs). Your PACS should be able to receive HL7 "patient update" messages (refer to Radiology TF Vol. 2 4.12) and HL7 "procedure/order update" messages (refer to Radiology TF Vol. 2 4.13) from the RIS when patient demographics or procedure information changes or when two patients are merged. The PACS uses the HL7 patient update and procedure/order update messages it receives from the RIS to keep patient and encounter data current in the PACS' objects. This is especially important in the case of unidentified (trauma) and misidentified patients.

In the absence of the PACS' ability to receive the appropriate HL7 ADT and/or ORMs, the ability of the PACS to maintain consistency of patient and encounter data may be limited. In this case, the PACS operator would be required, when a modality stores images that don't match the order, to manually handle reconciliation by entering patient demographics information and exam-specific information, such as AN. A broker/interface engine may be used to receive HL7 messages and convert these orders to a message the PACS does support.

2.2.4.2. Connecting the RIS to a Non-IHE Modality

The interoperability between the RIS and the modality enables the patient demographics and order and procedural information to be passed to the modality from the HIS and/or RIS. Procedure status is provided by the modality to ensure that images are made available as quickly as possible. Some or all of these capabilities may be available based on the capabilities of the non-IHE modality. Some guidelines to consider when determining how to integrate the RIS with a non-IHE modality are listed below.

Request a current DCS from your modality vendor for each of your installed products. See Appendix F.

2.2.4.2.1 Scheduled Workflow (SWF)

In the SWF Profile, the RIS expects the modality to support several DICOM services, using specific attributes and responding to messages in specific ways (refer to the TF). The critical DICOM services are DICOM MWL as an SCU and DICOM MPPS as an SCU. Modalities should use DICOM MWL to retrieve patient and order information from the RIS. IHE extends the required attributes to be displayed on the modality. Check to see that all of the following IHE extended attributes are available for display in the Worklist on the modality: Scheduled Procedure Step start date/time, modality, Scheduled Procedure Step description, requested procedure description, requested procedure ID, AN, referring physician's name, and patient name, ID, birth date, and sex.

The modalities should issue a DICOM MPPS to the RIS system to track the acquisition status (in progress, completed) to close the acquisition loop and provide additional data on the work done for billing purposes. This can be implemented in a later phase and negotiated accordingly with suppliers of both modalities and registration system. If your modality is missing support for one or both of these DICOM services, see the next section on connecting the RIS to a non-DICOM modality.

2.2.4.3. Connecting the RIS to a Non-DICOM Modality

Since your modality does not support DICOM MWL and/or DICOM MPPS, there is no standards-based conformance statement to request of your vendor. Ask your modality vendor for a proprietary mechanism for querying/receiving patient and exam information. In the absence of DICOM MWL capabilities on acquisition devices, possible workarounds for querying/receiving patient and exam information are: using bar codes (an alternative way of accessing at least essential identification data), using a modality gateway from (semi-) proprietary interfaces to

DICOM (might add some burden with additional costs and/or maintenance), and manually entering data at the modality by reading at a RIS terminal or on hard copy.

Critical information for the modality to have includes basic patient demographics, RIS-assigned AN, and if possible, RIS-assigned Study Instance Unique Identifier (to ensure consistent data throughout the enterprise). In the absence of DICOM MPPS capabilities on acquisition devices, possible workarounds for reporting study status are *(a)* "broker" systems or PACS options that can send MPPS on behalf of the modality, *(b)* the PACS may have a "fallback mode" that allows it to guess study status based on Storage and Storage Commitment or other events or triggers from the modality or the RIS, and *(c)* you can put a RIS terminal near each of the modalities to manually enter the study status update.

2.2.4.4. Connecting the RIS to a Non-IHE HIS

The interoperability between the RIS and the HIS enables patient demographics and order information to be passed to the RIS and the rest of the radiology enterprise. Some or all of these capabilities may be available based on the capabilities of the non-IHE HIS. Some guidelines for consideration when integrating the RIS with a non-IHE HIS follow. Request a current HL7 "interface specification" from your HIS vendor—see Appendix G.

2.2.4.4.1 Scheduled Workflow (SWF) and Patient Information Reconciliation (PIR)

In the SWF Profile, the RIS expects the HIS to support several HL7 message types, using specific attributes and responding to messages in specific ways (refer to the TF). The critical HL7 message types are *(a)* HL7 patient registration messages, including at a minimum (depending on your facilities functions) the following ADT messages: *(i)* A01, registration of an inpatient visit; *(ii)* A04, registration of an outpatient visit; A08, update patient information, and *(iii)*, A40, patient merge; and *(b)* HL7 procedure-ordering messages, including at a minimum *(i)* new ORM and *(ii)* cancel ORM.

This minimal set of HL7 messages should provide the basic ability to pass patient demographics and visit information from your HIS to your RIS. These messages should also support any updates to the patient demographics and the ability to merge two patients together. For a complete set of IHE-defined HL7 messages required, see Radiology TF Vol. 2 4.1-4.4 and 4.12.

Procedure-ordering messages should allow the HIS to create orders and send ORMs to the RIS for scheduling. Without this basic HL7 support, patient and/or exam identification may not be consistent throughout the enterprise. For example, if the HIS cannot notify the RIS of patient updates or merges via HL7 messages, the RIS may have the ability to perform the patient updates or merge operations directly.

Typically, there is an interface engine between a HIS and a RIS, which can be used to transform any of these messages. This may include minor changes to HL7 messages shared between the RIS and HIS, or if the HIS does not support HL7, the interface engine may allow proprietary messages to be converted to HL7 messages and vice versa. IHE also requires the HIS to support a bidirectional interface to receive order updates. Without the bidirectional interface, the following issues will arise: *(a)* An order may need to be re-entered at the HIS if it is placed at the RIS. *(b)* The HIS is not going to be up-to-date on patient and exam information. This has clinical and billing implications. *(c)* When the order is placed at the RIS, there is HL7 message handshaking (General Order Response Message) to allow the RIS to get the order number from the HIS. If the HIS does not support HL7, ask the vendor for interface specifications. Provide this to the RIS vendor or the interface analysts to determine how to manipulate the proprietary data to/from HL7. See Appendix G.

3. SCENARIO: INSTALLING A HIGHLY INTEGRATED PACS

A radiology department intends to install a new large-scale integrated PACS. Increasing study sizes, rising numbers of studies in several departments and the desire to better integrate with the HIS and electronic order entry system are key issues. The new PACS will serve all the hospital's departments for the purpose of digital archiving of images, diagnostic interpretation and reporting.

Most modalities will archive studies to the PACS. Several older legacy modalities with partial or no DICOM capability will need workarounds. Reading will be done on soft-copy review workstations with a limited amount of film printing for surgery, referrals and teaching. Reporting is still done with dictation and transcription, but the site is planning to upgrade to an electronic reporting system.

The PACS serves as the imaging source for both soft- and hard-copy interpretation. Long-term archiving will eventually shift from film to digital. The radiology department also offers radiology interpretation services to other medical facilities in the region—i.e., reading studies from other institutions sent to the hospital PACS for a second opinion or specialized diagnosis. The results of diagnosis (images and reports) should be distributed to referring sites electronically or on films or CDs.

3.1. The Planning and Purchasing Process

Intended for administrators in charge of making purchasing decisions, this section discusses organizational goals to consider when specifying requirements for a PACS system, how to select IHE Integration Profiles that will address those goals, how to clearly state IHE requirements in an RFP and how to interpret vendor responses.

3.1.1. Achieving Organizational Goals

The benefits of deploying IHE in clinical practice are described by more then 20 medical centers. For more details on these IHE success stories, visit *www.ihe.net/resources/success_stories/index.html.*

Clearly identifying organizational goals is an important first step in defining the requirements for any equipment acquisition. Each IHE Integration Profile is designed to meet a specific set of goals. Below is a theoretical list of goals when acquiring a new PACS and the contributions that each relevant IHE Integration Profile makes in supporting these goals.

Reduce Errors and Enhance Patient Care

Scheduled Workflow (SWF) on the PACS:

- Prevents mistaken patient identification because the PACS monitors ORMs from the RIS (which include patient demographics and order details) and checks the corresponding images received from the modality for consistency
- Prevents inaccurate diagnosis due to missing images because the PACS uses MPPS and Storage Commitment to confirm with the modality the study list of images sent to the PACS
- Reduces image availability delays because the PACS responds to image availability queries from the RIS
- Instance Availability Notification Option (in SWF) on the PACS:

- Reduces reporting delays because the PACS notifies reporting and other interested systems when imaging data become available
- Prevents misread studies caused by radiologists doing initial reads before all images are available because the PACS notifies the review system when the complete study is available

Patient Information Reconciliation (PIR) on the PACS:

- Reduces patient demographics errors because the PACS monitors RIS messages with updates to patient information (from identifying John Does, correcting registration errors or merging patient records)
- Reduces procedure detail errors because the PACS monitors RIS messages with updates to the procedure exam information (due to schedule or procedure changes)
- Prevents misdiagnoses caused by missing data being filed under different names because the PACS tracks initial and update messages for patient and order information and quickly keeps all available records in PACS in sync
- Prevents delays in trauma care because the PACS allows the data to be used normally then quickly reconciles all stored images and reports with the rest of the patient's medical record once the patient is identified

Portable Data for Imaging (PDI) on the PACS:

- Prevents missing data from other sites because the PACS is able to import data sent on CDs and integrate it with the patient's record
- Prevents mismatched patient identifiers in data imported from CDs from other institutions because the PACS reconciles this information to local values at import time
- Improves patient peace of mind because the PACS provides patients with straightforward access to CD copies of their personal health information

Consistent Presentation of Images (CPI) on the PACS:

- Reduces misdiagnoses due to low-contrast images because the PACS calibrates its displays to the Grayscale Standard Display Function curve
- Reduces misdiagnoses caused by poorly presented images (incorrectly windowed, flipped, shuttered, etc.) because the PACS uses stored GSPSs with appropriate viewing settings to display the images
- Prevents misleading differences in interpretation caused by different image presentations being displayed to the clinician and the radiologist because the PACS provides presentation states with the images so both display systems can present the images the same way

Multiple Sources Option (in Access to Radiology Information) on the PACS:

- Reduces incomplete imaging records because the display provides consolidated access to additional clinically relevant data from other archives (such as the Cardiology PACS, long-term archive, etc.)

Key Image Notes (KIN) on the PACS:

- Prevents difficulty locating clinically significant images because the PACS allows key images to be flagged and noted for a patient demographics query, access and display to referring physicians, surgeons and others

Evidence Documents on the PACS:

- Prevents incomplete clinical data because the PACS stores and provides evidence documents containing clinical measurements, CAD results or ultrasound structured reports

Simple Image and Numeric Reports (SINR) on the PACS:

- Prevents incomplete clinical data because the PACS stores and provides diagnostic reports that integrate clinical text, measurements and images

Increase Throughput

Scheduled Workflow (SWF) on the PACS:

- Reduces waiting for priors because the PACS monitors scheduling messages from the RIS and starts retrieval of priors when the study is scheduled instead of waiting until after image acquisition
- Prevents losing studies due to modality deletion after presumed transmission to the PACS because the PACS explicitly confirms to the modality that it has taken ownership of the images with Storage Commitment
- Eliminates technologist time wasted manually confirming successful storage on the PACS by using the Storage Commitment service
- Reduces delays in initial reads because the PACS monitors the acquisition in progress and completes messages so radiologists can keep abreast of the current status

Instance Availability Notification Option (in SWF) on the PACS:

- Reduces postprocessing delays—the PACS notifies the Postprocessing Manager as soon as the images are available for postprocessing
- Reduces reporting delays—the PACS notifies the Reporting Manager when the images are available

Patient Information Reconciliation (PIR) on the PACS:

- Prevents manual re-entry of patient demographics—the PACS monitors messages from the RIS with updated patient demographics and scheduled procedure information
- Reduces manual reconciliation of incorrect patient and procedure information in the PACS—the PACS handles many of these changes automatically based on received information

Multiple Sources Option (in Access to Radiology Information) on the PACS:

- Prevents manual searches of multiple systems (Radiology and Cardiology PACS, enterprise archive) for pertinent patient data—the PACS provides a consolidated view of DICOM data from multiple systems

Consistent Presentation of Images (CPI) on the PACS:

- Reduces radiologist time spent adjusting display settings—the PACS uses the presentation state created at the modality to present the images
- Prevents radiologist time spent adjusting the monitor by calibrating the display devices to DICOM Grayscale Standard Display Function curves

Presentation of Grouped Procedures (PGP) on the PACS:

- Prevents radiologist time spent searching for the images relevant to a given part of a grouped acquisition—the PACS presents the relevant images as preselected by the technologist
- Prevents radiologist time spent adjusting the display settings for each different part (e.g., computed tomography [CT] of the head, chest) of a grouped acquisition—the PACS displays each part with the appropriate display settings created at the modality
- Eliminates technologist time spent manually splitting image sets—the PACS provides access to the images for each order via the appropriately labeled presentation state (virtual split)

Evidence Documents on the PACS:

- Reduces radiologist time spent accessing multiple workstations—the PACS allows the review of non-image data, such as CAD results, modality measurements and ultrasound structured reports, on the PACS diagnostic workstation

Portable Data for Imaging (PDI) on the PACS:

- Prevents time scanning film priors from other sites—the PACS supports the import and reconciliation of studies on CD

Key Image Notes (KIN) on the PACS:

- Prevents surgeon time wasted searching for significant images (or similarly referring physician time)—the PACS uses Key Image Notes to provide immediate direct access to images flagged by the radiologist

Improve Data Accessibility

Portable Data for Imaging (PDI) on the PACS:

- Improves access to other sites' data—the PACS can import and reconcile patient and diagnostic information on CD from other institutions and clinics
- Improves access by clinical data consumers (referring physicians, second-opinion radiologists, neurosurgeons, orthopedic surgeons, other institutions, clinics, referrals, etc.)—the PACS exports patient and diagnostic information on CD when a reliable high-speed network connection is missing
- Improves patient information portability (a HIPAA issue)—the PACS implements the standardized distribution of patient imaging history on CD

Web Option (in PDI) on the PACS:

- Improves access from simple Web browsers (for the patient, referring physician, etc.)—the PACS includes Web-viewable versions (JPEG, HTML) of DICOM images and reports together on the same CD

Access to Radiology Information (ARI) on the PACS:

- Improves access around the hospital—the PACS supports the query/retrieve of DICOM images and data at viewing workstations

Multiple Sources Option (in ARI) on the PACS:

- Improves access to data from multiple PACS—the workstation consolidates query results and accesses data stored on physically separate systems (e.g., ultrasound miniPACS, cardiology PACS, and radiology PACS)

Key Image Notes (KIN) on the PACS:

- Improves access to the most significant images—the PACS uses a queryable flagging mechanism to allow key images to be immediately separated from large study sets

Maintain/Improve Image Quality

Consistent Presentation of Images (CPI) on the PACS:

- Prevents inconsistent image display—the PACS uses presentation states to consistently use the same window level, contrast, flip, zoom, user annotations, etc., when displaying on monitors or printing on film
- Prevents inaccurate and inconsistent image display—PACS displays are calibrated to a standard using the DICOM Grayscale Standard Display Function

Reduce Operational Costs

Scheduled Workflow (SWF), Consistent Presentation of Images (CPI) and Presentation of Grouped Procedures (PGP) on the PACS:

- Prevents extra head count due to the efficiencies and improvements in throughput described above

Portable Data for Imaging (PDI) on the PACS:

- Reduces unnecessary films for referrals to other sites, referring physicians or even surgery because the modality creates Portable Data for Imaging CDs to send to those users

Scheduled Workflow (SWF) on the PACS:

- Largely eliminates film printing, management and storage costs because the PACS display presents images for soft-copy review instead of film

Reduce Patient Radiation Dose

Scheduled Workflow (SWF) on the PACS:

- Prevents repeat acquisitions due to lost studies by reducing lost studies, as described in the above section on throughput

Consistent Presentation of Images (CPI) on the PACS:

- Reduces repeat acquisitions due to consumers perceiving poor images because the PACS uses DICOM calibrations and stored presentation states to give all consumers the same high-quality display

Presentation of Grouped Procedures (PGP) on the PACS:

- Prevents multiple scans and setups because the PACS uses the presentation states to access the relevant subsets of images, allowing the modality to perform a single grouped acquisition

Reduce Deployment Cost/Time

All IHE Profiles on the PACS:

- Prevent custom interface specification time and cost—IHE TF provides detailed specifications for a powerful interface, supported and tested by many vendors
- Prevent custom interface implementation time and cost—many IHE Integration Profiles are already supported by many vendor products
- Reduce interface compliance testing time and cost—many implementation variations have been ironed out in systems tested at IHE Connectathons
- Reduces intersystem testing time and cost—many combinations of systems have already been directly tested together at IHE Connectathons
- Reduces custom interface maintenance time and cost by maintaining a single IHE interface instead of multiple custom interfaces

It is not always possible to address all organizational goals by making a single equipment purchase. Achieving the full benefit of an IHE Integration Profile requires that the systems interacting with the PACS also play their roles as defined in the Profile. Frequently, partial benefits can be achieved by implementing an Integration Profile on a single Actor, such as the PACS, in an environment where the interacting systems have some but not all of the functionality described in the Profile. Appendix A addresses sequencing requirements and planning individual purchases as part of a long-range plan. To track progress toward organizational goals and determine return on investment, a well-defined set of performance metrics is needed; see Appendix I.

3.1.2. Selecting IHE Integration Profiles and Actors

Specifying integration requirements for the system you are purchasing involves selecting which IHE Integration Profiles and Actors you want supported. Note that some Profiles include options that provide additional functionality you may also select. The Integration Profiles relevant to the purchase of a PACS and the functionality each provides at the PACS are given below.

The Scheduled Workflow (SWF) Profile and the PIR Profile are the cornerstones of integrating a PACS system. They establish a seamless flow of information that supports efficient patient care in a typical imaging encounter and certain exception cases by specifying transactions that maintain the consistency of patient information from registration through ordering, scheduling, imaging acquisition, storage and viewing. Large institutions should start with these Profiles and implement additional IHE Integration Profiles based on specific needs and priorities.

The IHE Consistent Presentation of Images Profile is also strongly recommended because of the importance of image quality and consistency and its major role in the diagnostic reading process.

- IHE Access to Radiology Profile to make images and reports available to other environments (e.g., orthopedics, neurosurgery)
- IHE Presentation of Grouped Procedures Profile to efficiently manage and display grouped procedures
- IHE Portable Data for Imaging Profile to create and/or import imaging data on CDs
- IHE Radiology Option (in the Audit Trail and Node Authentication Profile) to create security- and privacy-related audit trails

- IHE Key Image Notes Profile to store, access and/or display images flagged for various purposes with associated text
- IHE Evidence Documents Profile to store and/or display measurements and CAD results on the PACS
- IHE Nuclear Medicine Image Profile to store and/or provide proper clinical display of nuclear medicine images and result screens
- IHE Simple Image and Numeric Reporting Profile to store and manage DICOM diagnostic reports

The Image Manager/Archive Actor is the key role played by a PACS system. Most PACS also play the roles of the Image Display Actor and the PPS Manager Actor. Additional Actors the PACS can perform include:

- Evidence Creator Actor to generate reprocessed images or additional measurements or CAD results
- Media Creator Actor to create CDs with imaging data
- Media Importer Actor to import imaging data from CDs into your PACS
- Print Composer Actor to send print requests to DICOM printers (for image distribution to "non-digital" users)
- Report Creator Actor to create and export reports containing interpretations of imaging and other evidence
- Report Manager Actor to manage diagnostic reports and the reporting process
- Report Repository to archive and distribute diagnostic reports
- Report Reader Actor to retrieve and display diagnostic reports
- Secure Node Actor to generate data access audit records
- Audit Record Repository Actor to receive and act as a central archive for data access audit records

The benefits provided by each Profile and Actor are outlined in the previous section. For further information, see Appendix B.

3.1.3. Putting Integration Requirements in Your RFP

Requiring IHE support in your RFP is as simple as stating which IHE Integration Profiles (and options) you want the system to support and which IHE Actor roles the system should play in that Profile.

The following are sample statements to specify Profiles and Actors for a full-featured PACS:

- *"The PACS shall support the **Image Manager/Image Archive Actor** in the following IHE Integration Profiles: Scheduled Workflow, Patient Information Reconciliation, Consistent Presentation of Images, Presentation of Grouped Procedures, Access to Radiology Information, Key Image Notes, Evidence Documents, Nuclear MedicineImage, and the Radiology Option of Audit Trail and Node Authentication."*
- *"The PACS shall support the **Evidence Creator Actor** and the **Image Display Actor** in the following IHE Integration Profiles: Scheduled Workflow, Consistent Presentation of Images, Access to Radiology Information, Key Image Note, Evidence Documents, and Nuclear Medicine Image."*

- *"The PACS shall support the Portable Media Creator, Portable Media Importer, Print Composer, Image Display and Report Reader actors in the IHE **Portable Data for Imaging Integration Profile**."*
- *"The PACS shall support the Report Manager, Report Repository, Report Reader, and Report Creator actors in the IHE **Simple Image and Numeric Report Integration Profile**."*

For further discussion of the RFP process, see Appendix C.

3.1.4. Identifying Suitable Products

While you may choose to proceed directly to sending your RFP to a broad group of potential vendors, you can get an idea of which vendors may have products with relevant IHE integration capabilities by referring to public sources. For a description of these sources, see Appendix D.

3.1.5. Reading Integration Statements from Vendors

Vendors may respond to your RFP by providing an IHE Integration Statement document. You may also find IHE Integration Statements for many products at *www.ihe.net/Resources/ihe_integration_statements.cfm.*

An Integration Statement is a direct statement of which IHE Profiles, Actors and options are supported by a particular model of a particular system from a particular vendor. For the contents of an Integration Statement, see Appendix E.

3.2. The Configuration and Implementation Process

The following sections are intended for the implementation team. They discuss important clinical and IT considerations when deploying a PACS system with IHE capabilities, including how to approach "legacy" issues when connecting the PACS to systems, which do not support IHE Profiles.

3.2.1. Considering Changes to Your Workflow

IHE Profiles are designed to implement digital imaging in a streamlined clinical workflow. For instance, they eliminate the need to enter patient information at the modality, searching for lost film folders or reconciling cases in the unmatched study folder on the PACS. They also allow images to be immediately available for viewing. To gain the full benefit of these changes, there are several tasks that need to be performed in the correct manner.

3.2.1.1. Scheduled Workflow (SWF) and Patient Information Reconciliation (PIR)

The SWF and PIR Profiles will be used to ensure that patient demographics and order and procedural information are correct and consistent throughout the enterprise. Additionally, internal system status updates provide access to clinical data in a more timely fashion. Radiologists will be able to rely on patient demographics and order and procedure information, as the HIS and RIS system updates will be prorogated to the PACS. Additionally, radiologists will be provided with current image status for a particular study.

3.2.1.2. Consistent Presentation of Images (CPI)

The CPI Profile ensures that image views are consistent throughout the enterprise, regardless of the monitor or printer used. Radiologists on the PACS need to be aware of the existence and meaning of these presentation state objects, in addition to the images. Well-understood identifying descriptions should be used for the presentation states, so the radiologist knows which

one to select (e.g., when the as-last-seen view is required at the PACS workstation). Likewise, radiologists should use these well-defined descriptions in the creation of any additional presentation states.

IT personnel will regularly calibrate the monitors and printers, according to the Grayscale Display Function Standard (DICOM PS 3.14), to preserve the consistency of the presentation on all monitors and film printers used.

3.2.2. Confirming that it's Working

The following sections provide guidance on how to confirm that the PACS is operating within the system. Each section provides elements for testing an individual Profile as it relates to the PACS. Note that in many cases, there are multiple ways to confirm the data and the transactions. This method is only one way. For an introduction on testing strategies, see Appendix H.

3.2.2.1. Scheduled Workflow (SWF)

For the PACS, it is important that the DICOM images and related DICOM objects from performed procedures and subsequent workstation renderings are permanently stored. Furthermore, it is critical that workstations may inquire for available images and retrieve them for use within the postprocessing and reporting phases. The following is an example of the high-level list of tests that may need to be run on a new PACS System for SWF:

1) Complete scheduled procedures for each of the relevant modalities as scheduled on the modality, with verification of the availability of the images *(MPPS Complete, Image Availability)*. Also, *(a)* perform an unscheduled procedure on a modality where the patient demographics and procedural information will be entered (it may be from a bar code or manually), *(b)* append a new procedure to a scheduled procedure after the radiologist reviews the resulting images, and *(c)* abandon the procedure on a modality before it is completed.

2) Archive the images from the modality to the PACS System (either through auto-store or manual storage of images). *(Modality Images Stored)*

   Confirming the scenario: Verify that the images created on the modality are stored on the PACS system. Then verify that the procedure status on the RIS (or PACS) has been updated based on the procedure being performed on the modality. Make sure the number of images available matches the number of images acquired.

3) Attempt to delete the images from the modality prior to the PACS claiming possession of the images. *(Storage Commitment)*

   Confirming the scenario: Verify that the images on the modality cannot be deleted because they have not been permanently stored through the PACS system.

4) Attempt to delete the images from the modality after the PACS claims possession of the images. *(Storage Commitment)*

   Confirming the scenario: Verify that the images on the modality can be deleted because they have been permanently stored through the PACS system.

5) For each modality type on the enterprise, display images from the PACS. *(Query Images, Retrieve Image)*

   Confirming the scenario: Verify that the images can be retrieved from the PACS and properly displayed. Then verify that the patient demographics and order and procedural information on the RIS matches those on the images.

6) Create postprocessing images and archive them to the PACS. *(Creator Images Stored)*

7) Confirming the scenario: Verify that the images can be retrieved from the PACS and properly displayed.

For each of these areas, detailed sets of tests need to be developed with the appropriate data sets. These data will need to include development of images to be sent from the modalities to the PACS; scheduled procedures created for each modality, so that the DICOM images created from the modalities include all of the critical patient demographics and procedural information; and DICOM images created on workstations for each of the postprocessing procedures.

3.2.2.2. Patient Information Reconciliation (PIR)

It is critical that patient demographics information is updated if changes on the HIS or RIS occur to ensure proper reporting. Furthermore, study attributes must be maintained to ensure reporting efficiency (and subsequent report viewing).

1) Reconciliation of patient identification during image acquisition. *(Patient Update)*

2) Confirming the scenario: Verify that images created for the procedure reflect the new patient demographics when viewed and reported on.

3) The following scenarios deal with unidentified patient registration and order fulfillment:

   (a) Unidentified patient registered at the HIS, with orders placed at the HIS. Fill the order and schedule the procedure through the RIS. (*Patient Registration, Placer Order Management, Filler Order Management)*

   (b) Unidentified patient registered at the HIS with orders placed at the RIS. (*Patient Registration, Placer Order Management, Filler OManagement)*

   (c) Unidentified patient registered at the HIS, but exam completed at the modality prior to the order being placed. (*Patient Registration)*

   (d) Procedure executed at the modality prior to patient registration at the HIS or orders being placed.

   Confirming the scenario: Verify that after patient demographics has been updated, it matches with actual patient demographics by displaying the images retrieved from the PACS.

For each of these areas, detailed sets of tests need to be developed with the appropriate data sets. These data will need to include development of HL7 records to be sent between the HIS and the RIS. These records should include all HL7 messages to update the patient demographics and encounter information, which will be sent from the HIS to the RIS (or vice versa). See IHE TF for specific transactions being tested.

3.2.2.3. Consistent Presentation of Images (CPI)

Efficiency and accuracy can be improved through the use of CPI. PACS plays a critical role in maintaining the Presentation States associated with CPI. The following is an example of the high-level list of tests that may need to be run on a new PACS CPI.

1) Calibrate all workstations and printers to be used in associated with CPI (see Vendor's Documentation).

2) Create postprocessed images that have been window/leveled, magnified, and rotated on a workstation and store them to the PACS. *(Creator Presentation State Stored)*

3) Retrieve the processed images from the PACS for display on another workstation. *(Retrieve Images)*

Confirming the scenario: Verify that displayed images are identical to original postprocessed images. See DICOM 2003 PS 3.4: GSPS Storage for a full list of display attributes that can be saved.

4) Print the processed images from the PACS. (Print Request with Presentation Look-Up Table)

   Confirming the scenario: Verify that film images are identical to original postprocessed images. See DICOM 2003 PS 3.4: Presentation LUT SOP Class for a full list of print attributes.

For each of these areas, detailed sets of tests need to be developed with the appropriate data sets. These data should include representative images that can be processed.

3.2.3. Considering Installation Issues

Even with IHE, installation is not "plug & play"—the systems are not self-configuring. For PACS, this is a list of configuration and installation items that will need to be considered.

3.2.3.1. Scheduled Workflow (SWF) and Patient Information Reconciliation (PIR)

1) Configure the PACS with the AE Title, Integration Profile address, and port for the modality's DICOM MPPS (if it is the configured MPPS Manager) so the PACS can forward MPPS messages from the modality to the RIS. Otherwise, if the RIS acts as the MPPS Manager, it will receive MPPS messages and forward them to the PACS.
2) Configure the PACS with the AE Title, Integration Profile address, and ports for all modalities and workstations with DICOM Storage Services.
3) Configure the AE Title, Integration Profile address, and port for your PACS' DICOM print services. This needs to be shared with the printer vendor so the printer can be configured to provide print on film services. In addition, configure in your print composer the printer properties supported for the specific printer, such as medium type, minimum and maximum density, film orientation, film size ID, magnification type, trim, configuration information and polarity.

There is a significant amount of time that goes into creating and keeping various codes in sync between different systems. Codes will need to be established for many parts of your system—as simple as a set of protocol codes to a much larger set of data, such as procedure codes. These codes are typically kept in sync manually. If they are out of sync, the receiver may not accept data, as it may not be aware of a coded value.

In the case of PIR, there may be a need to assign temporary IDs to be used. This includes the "issuer of patient ID," which is used to ensure consistency between the DICOM and HL7 patient IDs.

3.2.3.2. Consistent Presentation of Images (CPI)

Regular calibration is required of the monitors and printers, according to the Grayscale Display Function Standard (DICOM PS 3.14). Naming conventions will be needed for the Presentation States that are created.

3.2.4. Identifying and Addressing "Legacy" Problems

IHE Integration Profiles are built assuming that all relevant systems support these Profiles. If some systems do not support the Profiles you have selected but do support the standards the Profile is built on, some benefit is still possible. If you have deficient systems, consider how to

work around the deficiencies in the short term and when you plan to replace or upgrade those systems.

3.2.4.1. Connecting the PACS to a Non-IHE Modality

Interoperability between the modality and the PACS enables the patient demographics and the order and procedural information to be preserved (and updated in the case of PIR) when new or updated information is provided through the HIS or RIS System. Additionally, image status can be provided to ensure that images are made available as quickly as possible. Some or all of these capabilities may be available based on the capabilities of the non-IHE modality. Some guidelines to consider when determining how to integrate the PACS with a non-IHE modality follow.

Request a current DCS from your modality vendor for each of your installed products. See Appendix F.

3.2.4.1.1 Scheduled Workflow (SWF)

In the SWF Profile, the PACS expects the modality to support several DICOM services, using specific attributes and responding to messages in specific ways (refer to the TF). The critical DICOM services are DICOM Storage as an SCU, DICOM MPPS as an SCU, DICOM MWL as an SCU, and DICOM Storage Commitment as an SCU.

If your modality has all of these services, confirm that critical DICOM attributes are being provided in the DICOM images (and any other DICOM objects) the modality stores to the PACS. A summary of the key identifying attributes defined by IHE to ensure information consistency throughout the acquisition workflow is the following (for a complete mapping of key attributes, see Radiology TF, Vol. 2, Appendix A):

- Patient Name (0010,0010)
- Patient ID (0010,0020)
- Accession Number (0008,0050)
- Requested Procedure ID (0040,1001)
- Scheduled Procedure Step ID (0040,0009)

If one or more of your current modality systems is missing any of the services listed above, your vendor may have an option or upgrade to provide these attributes. Support for MPPS on modalities is useful to "close the acquisition loop" by enabling automated procedure status tracking and billing. Though workflow may be hampered by absence of the MPPS service, data consistency between systems is not endangered in the absence of this service. If your modality does not have DICOM MPPS, it will not be able to report study status to the PACS (and the RIS). In this case, reducing the workflow problems this causes in terms of "closing the acquisition loop," tracking procedure status and performing fast and accurate billing can often be accomplished by one of the following means: *(a)* "Broker" systems or PACS options may be available that can send MPPS on behalf of the modality. Such systems frequently also provide Worklist functions to the modality. *(b)* Your PACS may have a "fallback mode" that allows it to guess about study status based on Storage and Storage Commitment or other events or triggers from the modality or the RIS. *(c)* You may also track the work status by using a RIS client on or near the modality—e.g., by manually "signing off" the acquisition task.

Support for DICOM Storage Commitment on modalities enables automatic removal of images from the modality once the PACS has accepted "commitment" of them. If your modality does not have DICOM Storage Commitment, it will not be able to confirm that the PACS has received and taken ownership of the imaging data. To reduce the problems this causes, manually confirm all

images for each study have been received on the PACS and "committed" to permanent, long-term storage before deleting them from the modality system. Keep copies of all images on the modality until reports have been generated and images archived.

If your modality cannot retrieve DICOM MWLs, it will not be able to automatically get accurate patient, order and procedure information as scheduled by the RIS. Although this interaction is defined in IHE as occurring between the modality and the RIS, it does have a bearing on the quality of integration between the modality and the PACS. To reduce the problems this causes: *(a)* "Broker" systems or PACS options may be available that can query and retrieve MWLs on behalf of the modality. *(b)* Your PACS may have an option to update images it receives from a modality with the most accurate patient and procedure information received from the RIS. This will definitely exist if your PACS supports PIR and is receiving patient and study information from the RIS.

If your modality does not support DICOM Storage, you may want to temporarily use an interface box to provide it. However, DICOM Storage should really be a bare minimum. It will only be missing on outdated systems. For strategies on handling integration with non-DICOM modalities, see below.

3.2.4.1.2 Consistent Presentation of Images (CPI)

In the IHE CPI Profile, the PACS expects the modality to support a specific DICOM service by using specific attributes and responding to messages in specific ways (see the TF). The critical DICOM service is:

- DICOM Storage as an SCU (for GSPS)

One of the foundations of the CPI Integration Profile is the creation, storage and use of DICOM GSPS objects to convey all grayscale processing operations and all spatial and graphic transformations necessary to present the associated images in an "as-last-seen" view. If your modality cannot create and store GSPS objects, it will not be possible to view the image "as-last-seen" on the modality console.

To reduce the problems this causes, a user at the PACS or PACS workstation may be able to create and save the GSPS objects to reflect the grayscale processing operations and spatial and graphic transformations performed on the PACS workstation. (This will be true if the PACS or PACS workstation claims support for the CPI Profile as an Evidence Creator). This will likely require that the desired presentation parameters (e.g., window width and level, rotations and image flips) are "communicated" to the user at the PACS or Quality Assurance workstation via manual/procedural mechanisms, such as handwritten notes or phone calls.

3.2.4.2. Connecting the PACS to a Non-DICOM Modality

As mentioned in the section on integrating a PACS with a non-IHE modality, the ability to transmit and store modality-generated images to a PACS using DICOM is a necessity to achieve even the most basic level of integration, since all IHE-capable PACS systems will expect to receive images via DICOM. It is recognized that legacy non-DICOM modalities still exist within healthcare environments. To address the situation where one or more of your modalities does not support DICOM Storage, one of the following approaches can be taken to correct this situation until such time where these outdated modalities can be replaced.

1) The modality vendor may have a software upgrade or option that adds DICOM Storage capability to the modality. In addition, there may be upgrades/options available from the modality vendor that enable DICOM MWLs, Storage Commitment and/ or MPPS (MPPS).

2) "Brokers" or PACS options exist that will convert many proprietary formats into DICOM and store them to a PACS. Such brokers may also request MWLs and Storage Commitment on behalf of the modality and/or provide MPPS.

3) In some cases, the legacy modality will not even have the ability to provide digital images. In this case, devices exist to capture raw video and convert it to digital DICOM data and transmit/store to a PACS.

3.2.4.3. Connecting the PACS to a Non-IHE RIS

Interoperability between the PACS and the RIS enables the patient demographics and order and procedural information to be preserved and updated (in the case of PIR) when new or updated information is provided through the HIS or RIS. Image status can be provided to ensure that images are made available as quickly as possible. Some or all of these capabilities may be available based on the capabilities of the non-IHE RIS. Some guidelines to consider when determining how to integrate the PACS with a non-IHE RIS follow.

Request a current DCS and HL7 "interface specification" from your RIS vendor. See Appendices F and G.

Note that this deployment scenario considers integrating a PACS to a separate RIS system. A combined PACS-RIS product handles the PACS and RIS communication internally, but any communication with other PACS systems still requires a thorough interface review.

3.2.4.3.1 Scheduled Workflow (SWF) and Patient Information Reconciliation (PIR)

In the SWF Profile, the PACS expects the RIS to support several DICOM and HL7 services, using specific attributes and responding to messages in specific ways (see the TF). Critical DICOM and HL7 services are:

- DICOM MPPS as an SCU
- DICOM Instance Availability Notification as an SCP
- DICOM Query/Retrieve as an SCU, HL7 ORMs
- HL7 ADT messages.

If your RIS has all of these services, confirm that the RIS can accept the critical DICOM attributes that are being provided in the DICOM MPPS messages. Key identifying attributes defined by IHE to ensure information consistency throughout the acquisition workflow are:

- Patient Name (0010,0010)
- Patient ID (0010,0020)
- Accession Number (0008,0050)
- Requested Procedure ID (0040,1001)
- Scheduled Procedure Step ID (0040,0009)
- PPS ID (0040,0253)

For a complete mapping of the key attributes, see the Radiology TF, Vol. 2, Appendix A.

In addition, verify that the RIS can provide the following key patient, order and procedure identifying attributes in the HL7 ORMs it sends to the PACS:

- Patient Name (patient demographics-5)
- Patient ID -2

- Patient demographics-3)
- Filler order number (ORC-3)

For a complete mapping of the key attributes see the Radiology TF Vol. 2, Appendix B.

Support for MPPS between the RIS and modalities (or PACS) is useful to "close the acquisition loop" by enabling automated procedure status tracking and billing. If your RIS does not support DICOM MPPS, it will not be able to receive study status updates from a modality, nor will it be able to forward them to the PACS. In this case, reducing the workflow problems this causes in terms of "closing the acquisition loop," tracking procedure status and performing fast and accurate billing can often be accomplished by one of the following means. *(a)* "Broker" systems or PACS options may be available that can send MPPS-equivalent information to the RIS via HL7 on behalf of the modality. *(b)* Work status may be tracked by using a RIS client on or near the modality—e.g., by manually "signing off" the acquisition task directly on the RIS.

In the absence of the DICOM MPPS capabilities on your RIS, your new PACS should be set up as the PPS Manager so your PACS will receive these status updates.

The RIS often plays a key role in departmental workflow management. As such, it is important for the RIS to be aware when all images for a procedure are available so that subsequent workflow steps, such as reporting or additional image postprocessing, can begin. Support in the RIS for the DICOM Instance Availability Notification Service or DICOM Query Service is useful to provide this awareness. If the RIS does not support either DICOM Query as an SCU or DICOM Instance Availability Notification as an SCP, the RIS will not have an automated way to determine when all images from a procedure are available. To reduce the problems this causes, you may use a PACS client for querying to determine if all images are available, an interfacing mechanism may be able to perform the DICOM query on behalf of the RIS, and an interface converter may receive, route or process a DICOM Instance Availability message for enabling automated availability notifications (e.g., by converting the DICOM message into a message the RIS can understand and process).

The PACS uses the HL7 order (procedure scheduled) messages it receives from the RIS to streamline image review workflow by enabling the prefetching of relevant prior studies. If the RIS does not send HL7 ORMs, the ability of the PACS to perform prefetching may be limited. To reduce the problems this causes, a broker/interface engine may be used to convert the proprietary order/procedure scheduled message provided by the RIS into an HL7-based ORM, or the RIS vendor may have a software upgrade or option that adds HL7 capability, including the transmission of HL7 ORMs.

The PACS uses the HL7 ADT messages it receives from the RIS to keep patient and encounter data current in the PACS' DICOM objects. This is especially important for correctly handling instances of unidentified (trauma) patients and misidentified patients. If the RIS does not send HL7 ADT messages, the ability of the PACS to maintain consistency of patient and encounter data may be limited. To reduce the problems this causes, a broker/interface engine may be used to convert the proprietary patient or encounter message provided by the RIS into an HL7-based ADT message, or the RIS vendor may have a software upgrade or option that adds HL7 capability, including the transmission of HL7 ADT messages.

3.2.4.4. Connecting the PACS to a Non-IHE Workstation

The interoperability between the workstation and PACS enables the viewing and manipulation of images and other objects that are stored on the PACS. The workstation may be able to create new images derived from the images originally acquired at the modality and store these to the PACS. The workstation may also be able to store information to the PACS indicating various viewing

parameters and image manipulations that were performed. Some or all of these capabilities may be available based on the capabilities of the non-IHE Workstation. Some guidelines to consider when determining how to integrate the PACS with a non-IHE workstation follow.

Request a current DCS from your workstation vendor for each of your installed products. See Appendix F.

3.2.4.4.1 Scheduled Workflow (SWF)

In the SWF Profile, the PACS expects the workstation to support several DICOM services, using specific attributes and responding to messages in specific ways (see the TF). The critical DICOM services are:

- DICOM Query/Retrieve as an SCU
- DICOM Storage as an SCU (in cases where the workstation can create derived images)
- DICOM Storage Commitment as an SCU (in cases where the workstation can create derived images)

A workstation in the SWF Profile is expected to query for images and retrieve them from the PACS for the purpose of displaying them and performing postprocessing, which may not have been scheduled. If your workstation does not support DICOM Query/Retrieve, it will be more difficult to view and postprocess the images stored on the PACS. In this case, you will need to find alternate ways to identify the images and get them to the workstation for viewing and/or postprocessing. This can be accomplished in the following ways: *(a)* The workstation may be capable of receiving DICOM images sent to it. Identify the images by using an integrated PACS workstation. Send them to your legacy workstation for further viewing/processing. *(b)* Your PACS may be able to transfer the images to the workstation by using a piece of media your workstation is able to read (e.g., the PACS could create a DICOM-formatted CD that the workstation is capable of reading). *(c)* Your workstation vendor may have a software upgrade or option that enables DICOM Query/Retrieve functionality.

A workstation that can postprocess images and create derived images is expected to store them to the PACS and request that the PACS take ownership for the images as part of the SWF Profile by using the DICOM Storage and Storage Commitment Services. Support for DICOM Storage Commitment on the workstation enables automatic removal of images from the workstation once the PACS has accepted "commitment" of them. If your workstation does not have DICOM SC, it will not be able to confirm that the PACS has received and taken ownership of the imaging data. To reduce the problems this causes: Manually confirm that all images for each study have been received on the PACS and "committed" to permanent, long-term storage before deleting them from the workstation. Keep copies of all derived images on the workstation until the images have been archived.

If your workstation does not support DICOM Storage, you may want to temporarily use a broker/interface engine to provide DICOM Storage for the derived images. However, DICOM Storage should really be a bare minimum in the cases where your workstation performs postprocessing or creates derived images. It will only be missing on outdated systems.

3.2.4.4.2 Consistent Presentation of Images (CPI)

In the IHE CPI Profile, the PACS expects a workstation to support several DICOM services, using specific attributes and responding to messages in specific ways (see the TF). The critical DICOM services are DICOM Query/Retrieve as an SCU (specifically query and retrieval of GSPS objects, in addition to images), and DICOM Storage as an SCU (specifically for GSPS objects when the workstation needs to preserve the viewing state of the images displayed).

One of the foundations of the CPI Integration Profile is the creation, storage and use of DICOM GSPS objects to convey all grayscale processing operations and all spatial and graphic transformations necessary to present the associated images in an "as-last-seen" view. A workstation in the CPI Profile should be able to apply any GSPS objects it receives when rendering and displaying associated images. If the workstation cannot apply GSPS objects when displaying images, achieving consistency of viewed images will not be possible in a practical way.

If your legacy workstation is capable of applying GSPS objects to images when viewing them but does not support DICOM Query/Retrieve, it will be more difficult to view the images in an "as last viewed" manner. You will need to find alternate ways to identify and get the GSPS objects to the workstation for use during image viewing. This can be accomplished in the following ways: *(a)* Your workstation may be capable of receiving DICOM GSPS objects sent to it. Identify the GSPS object for the images of interest by using an integrated PACS workstation. Then, send them to your legacy workstation for further viewing/ processing. *(b)* Your PACS may be able to transfer the GSPS objects to the workstation by using a piece of media that your workstation is able to read (e.g., the PACS could create a DICOM-formatted CD that the workstation is capable of reading). Your workstation vendor may have a software upgrade or option that enables DICOM Query/Retrieve functionality.

Appendix A Developing an Integration Strategy

Integration does not begin and end with the purchase of a single piece of equipment. Integration involves all the systems in the department or enterprise contributing efficiently and intelligently to the overall flow of work and information. It is important to develop an overall departmental or enterprise strategy for integration. Envision what the completed integration will look like and how it will work, and consider what steps will lead you from where you are now to that destination. This will help dictate what integration interfaces and capabilities your current purchase should support to play its part in the grand scheme.

Information technology is a crucial component of an efficient workflow process. The implementation of such a process usually requires purchasing new equipment or upgrading existing equipment. IHE provides a useful vocabulary for writing the integration portions of purchasing specifications.

On rare occasions, an opportunity arises to outfit a complete healthcare enterprise with all new equipment. In these situations, it is relatively easy to implement a fully integrated system. Usually however, a complete or nearly complete suite of partially integrated information systems already exists, and a pragmatic stepwise development and integration strategy is easier to manage and fund.

In either case, the planning method is the same: Focus on integrating operational workflow processes. Start by understanding the basic process flow, and then include "tributaries" and special cases. Next, identify the systems and transactions involved in those processes. Then, for each system involved in the process and already existing in the enterprise, determine whether the product can be upgraded to implement the required transactions. For existing product upgrades or new products to be purchased, include the requirement to implement the necessary IHE transactions in the purchasing specification.

There are two ways to specify the required transactions: the hard way and the easy way. The hard way is to understand each of the transactions defined in the IHE TF, decide which specific transactions are required to meet the objectives of the current phase of the project, and require in the purchasing specification that the purchased product or upgrade implement those transactions. The easy way is to systematically use IHE Integration Profiles and the detailed use case and solutions specified in these Integration Profiles, which offer a smooth evolution path toward higher interoperability.

Unless you purchase all your equipment at once, a single purchase will not achieve all the goals but will typically result in incremental benefits immediately, and the integration features will bear additional fruit as other components are added and integrated in the future. As an example of a stepwise integration strategy in a radiology department (which demonstrates that incremental benefits are possible), consider the following:

Assume that at the start, the situation in the radiology department is such that there are some modalities connected to a printer, and there is no RIS to control the workflow in the department. What IHE brings you in this situation is the vision, blueprint and strategy for the quest toward the IHE.

The first simple and pragmatic step could be to introduce a few postprocessing workstations, for instance to do quality assurance of the acquired images. IHE has a Profile available for this step, the CPI Profile, which ensures that images have the same perception when looked at from the workstation and on film.

The second step could be to introduce a RIS and connect the modalities to the RIS by means of the DICOM MWL. IHE has a Profile available for this step, the SWF Profile, which brings all the

benefits of an automatic transport of patient ID and patient demographics, and in addition specifies exactly what the behavior of the RIS and the modalities must be to prepare for the next phase, when the department is ready to introduce a PACS.

The third step then would be the introduction of a PACS. In this phase, the full power of the IHE TF comes to play, with the following relevant Integration Profiles: the full SWF, PIR, Presentation of Grouped Procedures, and Access to Radiology Information. See the applicable sections in this Handbook about benefits to expect from these IHE Profiles.

Some time after PACS introduction, the department will be ready for the next phase: Introduce in the workflow the tasks for the creation and use of additional productivity-enhancing objects like measurement and Computer-Aided Diagnosis, and flag important images by means of Key Image Notes. IHE has the following Integration Profiles available in this phase: Postprocessing Workflow, Key Image Note and Evidence Documents. See the applicable sections in this Handbook about benefits to expect from these IHE Profiles.

To close the loop for the patient's imaging procedures in the radiology department, reporting and billing need to be addressed. The workflow will be extended to include the reporting tasks and the preparation of the procedure billing. For this, IHE has the following Integration Profiles available: Reporting Workflow, Simple Image and Numeric Report and Charge Posting.

In summary, with the IHE approach to enterprise integration, one may expect a reduction of the hospital's integration costs, which represent 20%–25% of the total hospital's IT budget. As a result, more funding becomes available for healthcare-specific investments. The reduction is caused by using standard protocols in products according to IHE specifications. These products are tested at regular interconnectivity sessions (Connectathons), where most healthcare vendors participate. Reduced product prices can also be expected owing to the market dynamics of products based on open and mature standards.

IHE provides a proven and pragmatic roadmap for integrating existing IT systems within and among hospitals. The roadmap covers new clinical domains, such as Cardiology and Laboratory, and the infrastructure for the patient's Electronic Health Record and Clinical Pathways in a Regional Health Information Network.

The user- and iteration-driven standardization process ensures that IHE specifications address real-world integration problems. The IHE roadmap is divided into 1-year iterations, where each iteration provides self-contained integration solutions.

The availability of IHE-compliant products from multiple vendors is ensured, since IHE is endorsed by a growing number of healthcare IT vendors. As a result, a hospital can choose from a large variety of available products to build best-of-breed IHE-based systems and reduce its dependencies on single vendors. The interoperability among IHE products from different vendors is improved because of the detailed message description, the validation of IHE implementations at multi-vendor testing sessions (Connectathons) and the publication of "ISs" describing specific IHE capabilities of a product.

That this strategy is successful in practice, is shown by the many IHE success stories available at *www.ihe.net/Resources/user_success_stories.cfm.* You will not be the first to start this integration journey—many others paved the way for you. Along the way, you can set a baseline and measure progress toward your goals (see a discussion of metrics in Appendix I).

A.1 Integration Approaches in IT Environments with Legacy Systems

Interoperability between systems in the IHE means that the systems use precisely defined interfaces for data exchange. In addition, essential system behavior on how to compose data to be exchanged or how to process data received in such an exchange is often defined. This reduces

installation or configuration efforts and realizes communication of essential data in a defined quality.

In legacy systems that do not follow such integration mechanisms, specific adaptation of existing interfaces may help to establish data exchange in a less comprehensive but potentially transitionally sufficient manner. Therefore, common legacy integration approaches are described here that may be a viable step to connect non-IHE-capable equipment to IHE-capable machines to match integration needs at your institution.

In the "non-IHE" integration scenarios described above, the communicating systems provide at least the most important standards-based interfaces, mainly DICOM, HL7 v2.x interfaces. This should ease integration efforts because defined messages with a limited variability need to be adapted.

The "non-DICOM," non-HL7 integration scenarios are based primarily on proprietary interfaces between communicating systems, which may complicate the integration effort. In these cases, interface adaptation may work.

Interface adaptation or conversion can be a tedious but valuable effort. Check relevant interfaces, including data structures, content meanings and configuration options or variability on each side of the systems to be prepared for communication. If the message types, structures or contents do not match between sending and receiving systems (e.g., different message versions, data differently structured, different codes used), the receiving system cannot accept or understand the sent message. A message conversion mechanism may solve this communication and integration problem. Depending on the purpose, scope of the involved systems, and your organization or equipment, there are different approaches to interface adaptation:

1) Individual mapping of interfaces ("manual interfacing"): The adaptation is done for this specific case, and for the two communicating systems only. Such a non-reusable solution can only be recommended for peripheral systems with specific usage in a limited organizational scope—e.g., to realize data collection for research.

2) Specific adaptation mechanisms for certain system types ("broker," "interface converter"): Such integration systems sit between specific system types (e.g., HIS-RIS, RIS-PACS) and translate a certain set of messages, often with considerable preconfigured message translations. They allow easier legacy integration for specific scenarios, mostly on a departmental level—e.g., a RIS-PACS converter may translate a RIS' HL7 data into DICOM MWL services that it can offer to modalities. Such a mechanism may be appropriate if you need to implement a rather dedicated message conversion for specific imaging purposes or in your imaging department.

3) General, multipurpose, high-throughput message adaptation system ("interface engine"): Such a system has highly configurable message conversion mechanisms, often combined with different message distribution functions—e.g., routing, broadcasting. It can connect many system types and is normally offered as a central service in an enterprise. For instance, a RIS may get laboratory data via the interface engine from a legacy laboratory system. If your enterprise operates such a central interface engine, it may be possible to use it for your imaging integration scenario instead of installing separate interfacing software in your imaging department.

If the cost/benefit ratio of above described interface adaptation does not seem satisfying to you, a newer software version of one or both of the communicating systems may be an alternative in solving the integration problem at hand, and possibly additional integration problems with other systems.

Appendix B Understanding IHE Integration Profiles

There are several sources of additional information for understanding the Integration Profiles, depending on the depth you are interested in.

B.1 Integration Profile Summaries and Tutorials

Presentations and documents providing summaries and tutorials on IHE and its Profiles are available at *www.ihe.net.*

The Integration Profiles document provides a basic description and graphics for each of the Profiles (*www.ihe.net/pdf/iheyr3_integration_Profiles.pdf*).

The "What Does IHE Offer" presentation from the SCAR 2003 workshop provides a brief graphic overview of the basic Profiles *(www.ihe.net/presentations/ihe_scar_2003.html)*.

A textual overview of the first seven Radiology Profiles is provided at *radiographics.rsnajnls.org/cgi/content/full/21/5/1343.*

Presentations from the 2004 IHE Workshop provide a more detailed presentation for each of the Profiles *(www.ihe.net/participation/workshops/workshop_2004/index.html)*.

Ultimately, the most detailed description of each Profile is contained in Vol. 1 of the IHE TF, which has a chapter for each Profile, outlining the problem solved, the Actors involved in the solution and the transactions they use to interact. Specifically, Section 2.1 provides an overview of the current Profiles, Section 2.2 describes the current Actors, Table 2.2-1 shows which Profiles each Actor is involved in, and Chapter 3 and onward document each Profile in detail. If you wish to dig deeper, explore the IHE TF documents. Refer to the section below on reading the IHE TF.

B.2 User Success Stories

Another source of relevant information is the collection of user success stories available at *www.ihe.net/resources/success_stories/index.html*. These case studies were submitted by sites that have deployed IHE Profiles. Each document is a concise one-page summary of the experience of the site, the Profiles they deployed and the specific products involved.

B.3 Reading the IHE Technical Framework

The complete IHE TF is available for download at *www.ihe.net/Technical_Framework/index.cfm.* Each IHE domain publishes a separate TF; however, they are completely compatible and interoperable. In fact, domains often make use of transactions and Profiles from other domains, and products often implement Profiles from more than one domain. The TF published covers the domains of Radiology, IT Infrastructure, Laboratory and Cardiology. Others will likely be added soon.

When new Profiles are published for trial implementation, they will appear on the site as Supplement documents. Once a Profile has been tested and judged stable and correct enough for final text, the Profile Supplement document is merged into the next release of the appropriate TF document. A TF is broken down in roughly the same way in each of the domains: Vol. 1 of the TF has a chapter for each Integration Profile. It explains what problem the Profile is intended to solve and then outlines a solution in terms of Actors (the different roles to be played in the solution) and Transactions (how the Actors are required to communicate and behave). Vol. 2 of the TF specifies in detail how each Transaction is performed. This volume describes the use of the relevant standards in great detail. It is essentially an implementation guide for the vendor engineers. Technical staff at healthcare sites that wish to understand the operation of IHE in detail may also find it useful. In some domains, where the number of transactions is large, Vol. 3 is added to include additional transactions. Vol. 4 of the TF, when required, includes any variations

required to meet the particular needs of individual countries. These are referred to as National Extensions. Since the goal of IHE is to serve common global needs, Vol. 4 is generally brief.

Appendix C Writing Integration Capabilities into an RFI/RFP

Integration Profiles provide precise shorthand communication between purchasers and vendors of medical equipment. A purchaser can include a requirement for a particular Profile, and IHE provides several hundred pages documenting what the vendor needs to do to claim conformance to that requirement. Referencing an IHE Profile has the advantage of being both brief and precise. When using IHE Integration Profiles to express your requirements, you may want to reference the IHE Radiology TF and include a link to *www.ihe.net/Technical_Framework/index.cfm* in your RFI/RFP. The simplification of using IHE leaves the details of the TF for the vendors to implement in their products. You may want to specifically request that vendors provide the IHE Integration Statement for applicable products either before or in response to the RFI/RFP.

RFI versus an RFP

An RFI asks a vendor to describe their technology and how it would solve your problems. An RFP is a proposal of what you plan on doing and includes a project schedule, budget, and statement of need. This Appendix describes an RFI. To make this RFI into an RFP, your timetable and budget will be added to the RFI.

Methodology for Ranking Vendors on Integration

Integration is key for evaluating and ranking competing systems. For each area of integration, the buyer will need to determine their "LIMits": Like to haves, Intend to haves, and Must haves. For each IHE Integration Profile, identify the integration problem it solves for you and internally assign a rating of how important this integration is for you to accomplish successful implementation in your facility: Use 1 for Like to haves, 3 for Intend to haves, and 5 for Must haves.

Perform this task internally and then decide if you want to share this prioritization of integration features with your vendors. For each Integration Profile, provide a brief description of what you intend to accomplish through integration and ask how the vendor's solution can solve that problem. Rate the answers from the vendors on the following scale: 0 points if they cannot perform that integration, 1 point if they integrate through proprietary methodologies, 3 points if they integrate through DICOM/HL7 but not according to IHE specifications, 4 points if they use IHE but not with all the options you want, and 5 points if they integrate fully through IHE methodologies. An evaluation of integration features might look like the following example for a PACS:

Integration Profile	Problem	Internal Rating	Vendor Capability	Rank*
Scheduled Workflow (SWF)	Integration of orders into scheduling and acquisition process, providing a MWL on the modality and procedure status information back on the RIS and or PACS.	5	4	20
Patient Information Reconciliation (PIR)	Synchronizing the RIS, PACS and HIS databases automatically to patient demographics changes.	5	3	15
Patient Synchronized Applications	Sharing patient context information to multiple "aware" applications on the user's computer to synchronize to the same patient.	3	0	0
Total				**35**

Summing the total product of the all the ranks together with their respective vendor capability will provide an objective metric for the vendor's ability to integrate to your individual needs.

Example Vendor RFI Scorecard

The following is an example scorecard. It does not contain all available Profiles from the IHE Radiology domain and includes a few from IHE IT Infrastructure domain. You should create your own scorecard to reflect the Profiles that interest you.

Integration Profile	Problem	Internal Rating	Vendor Capability	Rank*
Scheduled Workflow (SWF)	Integration of orders into scheduling and acquisition process, providing a MWL on the modality and procedure status information back on the RIS and or PACS.			
Patient Information Reconciliation (PIR)	Synchronizing RIS, PACS and HIS databases automatically to patient demographics changes.			
Consistent Presentation of Images (CPI)	Storing window/level information, shuttering, zooms, flips and annotations. This is the work product of the radiologists and needs to accompany images in migration and in communication to referring physicians.			
Presentation of Grouped Procedures	Linking multiple orders to a single study and intelligently delivering that subset to end users while maintaining correct order tracking details for billing.			
Patient Synchronized Applications	Sharing patient context information to multiple "aware" applications on the user's computer to synchronize to the same patient.			
Key Image Notes	Flagging key images in large data sets and attaching text for communicating to referring physicians and surgeons; also for teaching and QC purposes.			
Enterprise User Authentication	Sharing a "single sign-on" password for this and other enterprise applications. Since users do not have to remember many passwords, this increases convenience and reduces support costs.			
Portable Data for Imaging	Creating CDs that are readily readable at other locations—improves data availability and reduces support costs.			
Patient Identifier Cross-Referencing	Using a central ID cross-referencing system to bridge multiple Master Patient Index domains when a system must communicate with systems in different domains.			
Audit Trail and Node Authentication	Creating an audit trail for HIPAA compliance and authenticating other systems you communicate with for security.			

The Language of the RFP

For your Must-haves and perhaps your Intend-to-haves, use "shall" terminology in your RFP, as shown in the following examples:

"The PACS system shall support the SWF Integration Profile and the PIR Profile as the Image Manager/Image Archive Actor."

"The PACS system shall support the SWF Integration Profile as the Evidence Creator Actor and the Image Display Actor."

"The PACS system shall support the IHE Portable Data for Imaging Integration Profile as a Portable Media Creator Actor."

"The PACS System shall support the Instance Availability Notification Option of the IHE Scheduled Workflow as the Image Manager/Image Archive Actor."

For your Like-to-haves and especially for newer Integration Profiles, vendors may not yet be able to comply with shall language, as they may not currently offer that functionality in their product offering. Decide how you will include promissory components of a contract negotiation to

include future roadmaps. You are putting unrealistic expectations on a vendor to deliver functionality if it is not incorporated in the contract.

Appendix D Identifying Suitable Products

There are several ways to find vendors and products involved in IHE.

D.1 IHE Connectathon Results

IHE Connectathon results indicate which vendors are developing and successfully testing which Integration Profiles. IHE Connectathons are annual testing events that vendors participate in on a voluntary basis. They allow vendors to test the IHE integration capabilities of their products with those of many other vendors in a structured and supervised environment. The results indicate which vendors have demonstrated proficiency in implementing a given Actor in a given Profile.

The results do not list specific products or versions. Vendors are not required to participate in the Connectathon to claim support for IHE in their products. The Connectathon should not be considered a certification of a vendor or product; rather, published results can be considered a useful litmus test. When a vendor that has successfully tested a given Profile at a Connectathon makes a direct claim that their product has implemented said Profile, you have some evidence they know what they are talking about. For direct claims of conformance to IHE for a specific version of a specific product, refer to the IHE Integration Statement published by the vendor, which is discussed in the next section.

IHE Connectathons are held each year in North America, Europe and Asia. Obtain Connectathon Results from *www.ihe.net/* and *www.ihe-europe.org/con_result.* The results are generally laid out with a row for each vendor and a dot showing which Actors in which Profiles the vendor was judged to have tested successfully at the Connectathon. Success is judged by the Connectathon Project Management Staff, who are independent technical experts hired by the sponsoring professional society (e.g., HIMSS, RSNA, ACC). Success generally means a vendor successfully tests their product with products from at least three other vendors.

D.2 IHE Integration Statements

IHE Integration Statements are declarations by vendors of support for specific IHE Integration Profiles in specific products. Many vendors post product Integration Statements on their Web sites. These are linked to a single index page at *www.ihe.net/Resources/ihe_integration_statements.cfm.* Vendors who wish to have a link to their Integration Statements on this page can follow the instructions there for submitting a request.

An Integration Statement is a claim made by the vendor to the consumer. Vendors are not required to test the system in question at a Connectathon before publishing an Integration Statement. See Appendix E for details on interpreting the contents of an Integration Statement.

Appendix E Reading Integration Statements

IHE Integration Statements are simple statements (frequently a single page) of which IHE Integration Profiles are supported by a product and which IHE Actor roles the system plays in those Profiles. Vendors may publish Integration Statements on their Web sites or provide them in response to an RFP. Here's an example:

<table>
<tr><th colspan="4">IHE Integration Statement</th></tr>
<tr><th>Vendor</th><th>Product Name</th><th>Version</th><th>Date</th></tr>
<tr><td>Integrated Medical Systems</td><td>Mega CT</td><td>V3.2</td><td>17 Oct. 2002</td></tr>
<tr><td colspan="4">This product implements all transactions required in the IHE TF to support the IHE Integration Profiles, Actors and Options listed below:</td></tr>
<tr><th>Integration Profiles Implemented</th><th>Actors Implemented</th><th colspan="2">Options Implemented</th></tr>
<tr><td>Scheduled Workflow</td><td>Acquisition Modality</td><td colspan="2">Patient-based Worklist Query, Assisted Acquisition Protocol Setting</td></tr>
<tr><td>Portable Data for Imaging</td><td>Media Creator</td><td colspan="2">No options defined</td></tr>
<tr><td colspan="4"><u>Web address for vendor's IHE information:</u> www.integratedmedicalsystems.com/ihe</td></tr>
<tr><th colspan="4">Links to Standards Conformance Statements for Implementation</th></tr>
<tr><td>HL7</td><td colspan="3">N/A</td></tr>
<tr><td>DICOM</td><td colspan="3">www.integratedmedicalsystems.com/dicom/MegaCT-DCS.pdf</td></tr>
<tr><th colspan="4">Links to general IHE information</th></tr>
<tr><td>In North America: www.ihe.net</td><td>In Europe: www.ihe-europe.org</td><td colspan="2">In Japan: www.jira-net.or.jp/ihe-j</td></tr>
</table>

Integration Statements are discussed in more detail in the IHE Radiology TF, Vol. 1, Appendix D.

The first part of the statement indicates that it applies to version 3.2 of the Mega CT System from a vendor called Integrated Medical Systems, and it was published on 17 Oct. 2002.

The middle part of the statement indicates that this CT System supports the IHE Scheduled Workflow Profile as the Acquisition Modality Actor and it supports two options within Scheduled Workflow (i.e. Patient Based Worklist Query, and Assisted Acquisition Protocol Setting). It also supports the IHE Portable Data for Imaging Profile as a Media Creator Actor.

Appendix F Obtaining and Reading DICOM Conformance Statements

Vendors will generally provide a DICOM Conformance Statement (DCS) for each product at the customer's request. Frequently, these documents can be found on the vendor's Web site for download. Otherwise, ask a salesman to obtain a DCS from engineering. A DCS provides a detailed description of the DICOM capabilities of a vendor's product.

Because DICOM leaves many details up to the vendor and many things are optional, the vendor must document what their product does in a detailed DCS. DICOM recently updated the documentation on what should be included in a DCS and its format. For further details, see Part 2 of the DICOM Standard, available at *dicom.nema.org.*

The DCS will describe:

which services the vendor has implemented such as: DICOM Storage or DICOM MWL Management),

whether they have implemented support for the service as a client (SCU) of the service, a server (SCP) or possibly both; and

what objects are supported for certain key services (e.g., storage of the CT object, the enhanced MR object or cath lab procedure reports).

Often, key details such as finding out if the product supports a particular service as an SCU or an SCP can be found by looking on the title page or in the table of contents. Often, a search for the phrase "SOP Class Unique Identifier" will answer questions about the specific objects supported by a product.

Although an IHE Integration Statement provides a much simpler approach to some of the issues addressed by DCSs, the Integration Statement does not replace the DCS. Further, the DCS will be particularly useful when handling legacy integrations with non-IHE systems. Detailed analysis of the contents of DCS documents is beyond the scope of this Appendix.

Appendix G Obtaining and Reading HL7 Interface Specifications

Although vendor claims of conformance to HL7 are not as widely distributed or as strictly formatted as DCSs, it is often possible to ask the vendor to provide an HL7 "interface specification" that details the types of messages their system produces and accepts, the fields in those messages, when the messages are sent or expected and how the fields are filled. Often, HL7-based systems can be quite flexible, and their HL7 interface behavior can be adapted to your needs. Depending on the complexity of your needs, you may want to hire someone experienced with these sorts of interfaces to help you in the process of evaluating and customizing your HL7 interfaces.

If your vendor asks you to provide some details on what you want their interface to do, you may find it useful to provide the vendor with a pointer to the IHE TF and tell them which Profile and Actor roles you expect their system to fulfill. While this does not address the full use to which you will put their system, it will at least provide detailed specifications for part of the functionality.

Appendix H Conducting Acceptance Testing

Sites are strongly encouraged to include Acceptance Testing as part of the implementation phase. This requires developing an Acceptance Plan, which includes the Acceptance Tests to be performed, specification of what constitutes a pass or failure and some kind of a schedule. Typically, Acceptance Tests to be included in the plan are agreed on by the vendor and the customer. Acceptance Tests can be developed once the systems to be integrated have been identified. It is preferable to run the Acceptance Tests only after all of the physical systems are installed and properly connected to the network. It may be possible to do Acceptance Tests on a subset of the systems, but that may require additional analysis and test setup.

The development of the Acceptance Plan requires technical staff (consultants or internal development resources). Note that this Handbook deals only with Acceptance Testing of interoperability features and not all the other features provided by the individual systems. Also, the testing here focuses on functionality, not on performance issues such as speed.

Once all of the IHE Profiles, Actors and transactions involved in the installation have been identified, a list of Acceptance Tests can be written for each of the systems involved. Using Vol. 1 of the IHE TF, a high-level list of transaction tests can be developed by reviewing the Table of Actors/Transactions for each of the relevant Profiles. Using Vols. 2 and 3 (and 4 for country-specific changes) of the IHE TF (along with your project specifications, HL7 specifications and DCSs), details of Acceptance Test data sets and expected results of running the tests can be developed.

Once all of the test specifications are brought together, the test plan is developed. The test plan should include the following components:

What systems are required to perform the testing?

What is the list of tests that should be run?

What data are required to perform the testing?

How will the operation of the test be verified (e.g., What test tools are required?)

What are the expected results for each of the tests?

Each of the components is critical, and time should be dedicated to developing them.

Test System Suite: The Test System Suite needs to include all of the systems that interconnect. In some cases, a separate test environment will need to be set up to ensure that the live environment is not impacted by testing. In other cases, the live environment may be used, but the timing and the data used to test the system will need to be carefully thought through.
Development of Tests: Test strategies will depend on which systems are being integrated. Likewise, confirmation of the results will depend on the capabilities of the systems being deployed and the workflow of the institution itself. Note that if non-IHE systems are involved in the enterprise, additional evaluation is needed to determine what the expected results should be, since they may deviate from what would happen in a full IHE environment.

Some test specifics are listed in the Acceptance Testing section of each chapter/scenario in this Handbook. Additionally, many of the Profiles documented in Vol. 1 of the TF include use cases, which detail variations addressed by IHE that you may want to include in your tests—e.g., unscheduled acquisitions, simple single-step scheduled acquisitions, appended acquisitions and "group case" acquisitions.

Test Data: Specific test data will depend on the use cases being tested and what data are relevant to the operations of the site. The data should be representative of real cases and include complete

sets of patient demographics and order and procedural information. In some cases, it may be necessary to have representative "canned results," such as DICOM images and reports. An array of modality systems from several manufacturers with specific data fields may be required to fully test interoperability features.

Not all IHE use cases may be relevant to implementation for a given site. For example, a site may always construct their procedures so that there is only a single procedure step per requested procedure. In this case, IHE functionality dealing with multiple scheduled procedure steps is not relevant.

Test Tools: Verification of results may require the use of tools and multiple systems. For example, HL7 tools, DICOM tools, the use of the modality to display result images, or alternatively the use of a PACS system to verify that the information within the DICOM images contains all of the retrieved MWL information. The following are classes of tools that may be used to validate results:

HL7 Parsers: Parse out the fields of HL7 messages and present the components in a more human-readable way.

DICOM Validators: Check the content of DICOM Image Headers for conformance to the DICOM standard. (See *www.dclunie.com/* for freeware.)

DICOM Sniffers: Watch traffic on a TCP/IP network, identify DICOM-related traffic and provide a way to assemble and store the contents of DICOM communications for review. (See *www.dclunie.com/* for freeware.)

MESA Tools: As a part of the IHE testing process, HIMSS and RSNA commissioned the development of a set of software tools by the Electronic Radiology Laboratory at the Mallinckrodt Institute of Radiology, Washington University of St. Louis. They provide communication partners, test data and test plans to allow vendors to perform baseline testing as they implement the IHE TF. These tests are limited in scope but may be useful in the development of test plans. (See *www.erl.wustl.edu/mesa/index.html.*)

In some cases, it may be advantageous to use multiple tool sets to verify different system behaviors. Your vendors may also provide tools to test their systems. It should be noted that IHE does not promote specific vendor tools.

Appendix I Performance Metrics

Use of relevant performance metrics is extremely important to any process you intend to effectively manage and improve. The workflow and other processes of radiology are no different. Selecting relevant metrics, collecting measurements and responding to resulting feedback can make the difference between informed management and ad-hoc intervention. Even considering what metrics to measure is a useful exercise in reflecting on your current priorities and goals and what they should be.

Diligently selecting, measuring and tracking relevant metrics has proven to be easier said than done. One argument in favor of IHE is that by facilitating the shift from paper to electronic workflow, collecting many relevant values automatically is more practical than manually collecting measurements, which disrupts and diverts the actual work (the Heisenberg Principle in action).

When considering an integration project, the time to start collecting metrics is now. Metrics are particularly useful when planning changes. Good metrics help with establishing a baseline measurement of your current practice, making the case that there is room for improvement, estimating the impact from the proposed process and technology changes, tracking the potential initial disruption caused by the changes and the return to equilibrium, and confirming/revising the impact on the process and ultimately the success of the project.

Additionally, metrics are useful for the healthcare industry at large, as they deal with pressures to improve care, reduce costs and effectively apply new technologies for those goals. Sites that collect metrics are strongly encouraged to share results. In particular, RSNA is interested in publishing comparative studies of before-and-after IHE implementations.

I.1 What to Measure

Choosing what to measure and optimize can be a non-trivial task. Systems and the people in them will adapt to optimize the chosen target, sometimes using unexpected strategies that make undesirable sacrifices. Although not all clinical benefits can be boiled down to a representative measurable value, many can, and metrics are a valuable way of establishing targets and measuring progress toward those targets. Some values to consider are given below as a starting point. Select metrics that reflect your priorities and your process. Refer to the sources mentioned later in this section for more academic information.

Department Operational Metrics: patients per year per specialty, patients per day per piece of equipment, procedures per year, steps per procedure, film media costs per year, film processing and disposal costs per year, film storage and handling costs per year, report turnaround time, repeated exams per year, "reconcilation events" per year, time spent per reconciliation event and manual demographic data entry error rate

Patient Experience Metrics: patient "turnaround time" from arrival to departure and patient waiting time in radiology

Project Implementation Metrics: time to specify systems and interfaces, time to test integration and time/money spent on custom interfaces

One approach to metrics is to record for each exam the time stamps at certain key milestones/progress points in your process.

Inpatient exam: order written, exam scheduled (optional), prior films available (optional), procedure protocol selected (optional), patient consent obtained (optional), transport dispatched, patient arrival in department, patient in procedure room, scan started, scan completed, patient out of procedure room and patient returned to room

Outpatient exam: exam scheduled (optional), patient arrival, order written, prior films available (optional), procedure protocol selected (optional), patient consent obtained (optional), patient in procedure room, scan started, scan completed, patient out of procedure room and patient dispatched

Image handling: exam transferred to PACS, current exam matched with prior exam, current exam interpreted, current exam placed in active file, exam moved to less active files and exam purged

Reporting: preliminary report called, report dictated, report transcribed, report edited, report signed, report distributed and report archived

Reimbursement: patient demographics collected

With raw time stamps, many time-related metrics can be calculated. Specific milestones will depend on your institution's workflow. The order of time stamps will likely vary at some institutions, and some may vary between exams. Some flexibility will be required.

Many other sources of information and ideas exist on the use of metrics in radiology. Some sources to consider are papers and publications from RSNA, including *Radiology* and *RadioGraphics*; SCAR (Society for Computer Applications in Radiology) and their publication, *Journal of Digital Imaging*; AHRA (American Healthcare Radiology Administrators) and their publication, *Radiology Management*; RBMA (Radiology Business Managers Association) and their publications on Radiology Productivity Measurement; ECR (European Congress of Radiology) and their publication, *European Radiology*; EuroPACS (European Association for PACS); and MIR (Management in Radiology).

Another source is your peers: Ask about their goals and what they measure. To find "best in class" hospitals, consider winners of the annual HIMSS Davies Award of Excellence in healthcare IT.

I.2 Sample Measurement Results

This section discusses measurements considered useful by some sites and what values they recorded. This is a quick sample of some of the available information. More can be found by referring to the sources listed above. Many sites have focused on the time until availability of the report as the performance metric of most significance to the customers of a radiology operation. Different studies start the timer at different points: some from when the study is ordered, others from when the patient arrives for the exam, others from when the images are available for review. Having clear definitions of your selected metrics is a key point to making them comparable and useable as references to other sites.

Combined* Inpatient and Outpatient Report Turnaround Time† Percentiles—Hospitals

Turnaround time	Percent	Number of respondents	Turnaround time	Percent	Number of respondents
General radiology			Nuclear medicine		
≤6 hours	30%	71	≤6 hours	25%	55
7-12 hours	21%	51	7-12 hours	24%	54
13-18 hours	8%	18	13-18 hours	9%	19
19-24 hours	27%	64	19-24 hours	27%	60
25-30 hours	3%	6	25-30 hours	2%	4
31-36 hours	6%	15	31-36 hours	6%	14
>36 hours	6%	13	>36 hours	6%	15
Computed tomography			Special procedures		
≤6 hours	27%	63	≤6 hours	27%	54
7-12 hours	22%	52	7-12 hours	19%	37

13-18 hours	10%	23
19-24 hours	25%	60
25-30 hours	4%	9
31-36 hours	6%	14
>36 hours	7%	16
Magnetic resonance		
≤6 hours	21%	37
7-12 hours	17%	31
13-18 hours	8%	15
19-24 hours	33%	60
25-30 hours	5%	10
31-36 hours	5%	10
>36 hours	11%	21
Ultrasound		
≤6 hours	29%	69
7-12 hours	22%	54
13-18 hours	9%	22
19-24 hours	26%	63
25-30 hours	4%	9
31-36 hours	5%	13
>36 hours	5%	12
13-18 hours	6%	11
19-24 hours	29%	57
25-30 hours	4%	8
31-36 hours	7%	13
>36 hours	10%	20
All radiology exams		
≤6 hours	25%	81
7-12 hours	22%	72
13-18 hours	9%	30
19-24 hours	26%	83
25-30 hours	3%	11
31-36 hours	7%	23
>36 hours	7%	24

*Combined data was provided by respondents.

†Data outside the ±2 SD range was eliminated for each exam category

Reprinted with permission from Table 9 of the American Healthcare Radiology Administrators (AHRA). Hanwell LL, Conway JM. "Radiology Report Turnaround Time." Amercian Healthcare Radiology Administrators, AHRA Survey (1995).

A study at one 450+ bed hospital found their average report turnaround time (defined as the time from order to finalized report) to be 26 hours. They established a target goal to get the average below 18 hours.

A study by RDI Marketing Service comparing performance of sites with a RIS to sites without a RIS found:

Procedures per month	5,760 with RIS	1,690 without RIS
Report turnaround time	24 hours	30 hours
Transcription turnaround	11 hours	14 hours

A throughput study of magnetic resonance (MR) imaging sites found that 182 sites (representing 197 MR imaging sytems) were estimated to have performed an estimated 2,045,954 patient examinations, which breaks down into an estimated average number of patients scanned per year of 3,010 ± 188 (standard deviation) (range, 626–6,000 patients scanned per year) *(www.invivoresearch.com/arti_clin_seda.html)*.

From "Reinventing the Radiology Report, 2: Time to Adapt" by Bruce Reiner, MD, and Eliot Siegel, MD: "One recent study reported that the average report turnaround time for a CT examination was 3.7 days for the preliminary report alone and 5.5 days for final reports. These

numbers speak clearly to the inefficiencies and delays of conventional reporting and resultant dissatisfaction among referring clinicians."[4]

A project at one site quantified their success with a metric showing the turnaround time to schedule a radiology exam and provide a report decreased from an average of ten days to two *(www.cisco.com/en/US/strategy/healthcare/hospitals_sentara.html).*

One site found that by converting all imaging appointment slots to 30 minutes and expanding hours of operation, they were able to boost diagnostic imaging productivity, volume and revenue. With the ability to scan over lunch breaks and rest periods, potential appointment capacity increased by 140 CT scans per month. Overall, the CT project increased potential for outpatient appointment capacity by nearly 75% and projected over $1.5 million in additional annual gross revenue *(www.ahraonline.org/AHRAArticles/AHRAArticles.dll/Show?ID=414).*

Many institutions have documented improvements in some of these turnaround types. In one institution, the time between study performance and interpretation averaged approximately 20 minutes (down from 8–24 hours), and between interpretation and transcription (and made immediately available for reading with the PACS or HIS) from 1–2 days down to 2 hours (available immediately after being read by phoning the digital dictation system).[5] Other reports of decreases in turnaround times are similarly impressive.

[4] Mehta A, Dreyer K, Boland G, et al. Does PACS improve report turnaround time? Journal of Digital Imaging 2000;13:105–107.
[5] Mattern CW, King BF Jr, Hangiandreou NJ, et al. Electronic imaging impact on image and report turnaround times. Mayo Medical Center, Rochester, MN 55905.