

Guidelines and standards for implementation of new PACS/RIS solutions in the UK

Board of the Faculty of Clinical Radiology
The Royal College of Radiologists

Foreword

The renegotiation to the picture archiving and communication system (PACS) contracts is due in 2013. Many hospital trusts are already in negotiation with IT companies regarding this. They should be aware that Connecting for Health, learning from the lessons from the last contract, have recognised that national standards should be set to help guide purchasers. To this end, Fellows of The Royal College of Radiologists working with the Imaging Informatics Special Interest Group (SIG) and Connecting for Health have devised a set of standards which are contained in this document. It is in the interest of all hospital chief executives, IT departments and radiology clinical directors to be aware of these standards when entering into PACS contract negotiations. They should also be aware that this is a rapidly changing and evolving field and that these standards might need to be revised from time to time in line with this. The Royal College of Radiologists will do its best to review and update these standards but more immediate information can be obtained from the Imaging Informatics SIG website (www.pacsgroup.org.uk).

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Scope

The principal aims of this document cover the following:

- Picture archiving and communication systems (PACS)/radiology information systems (RIS) interoperability
- Image display
- Improved image sharing
- Rationale for image storage.

The main purpose of this paper is to support those organisations which are undergoing or approaching the stage of procuring a new PACS/RIS in terms of operational and technical requirements by means of raising awareness of various national and international standards that support interoperability between PACS and RIS and PACS vendors. Increasing adherence to more open standards for interoperability will enable a more level platform for data sharing between organisations in a timely and efficient manner. In addition, guidelines (additional insights) are given to support a rationale for data storage and archiving.

It is imperative that diagnostic imaging departments, PACS administrators, business managers and IT departments work closely together to understand workflow requirements within and between organisations, the technical requirements to integrate various clinical information systems (such as RIS and cardiology information systems) and have an understanding and awareness of changing technologies for data storage, management and sharing.

The principal driver for changes in the way PACS and image and report sharing is delivered will be cost and some functionalities traditionally associated with a classical PACS model such as storage should be delivered in a more cost-effective manner.

This paper should be considered in conjunction with the following previously published RCR documents:

- *A practical guide to implementing Ordercomms in radiology*¹
- *Standards for a results acknowledgement system*²
- *Retention and Storage of Images and Radiological Patient Data.*³

Other relevant documents on PACS and RIS may be found on the RCR website.

Introduction

The vast majority of imaging studies conducted in the UK are now stored, manipulated and shared via a picture archiving and communication system (PACS). PACS has been rolled out to all healthcare organisations over the last ten years as local, regional or national implementations with different degrees of connectivity to radiology information systems (RIS), either via a local RIS or shared with other organisations (domain based).

Many of the systems are due for renewal, either in terms of the extant contracts and/or there is a need to reconsider the nature (model) of PACS in terms of future clinical and economic benefits, taking into account future additional requirements for PACS and the changing nature of diagnostic imaging service delivery.

The main impetus for this recent RCR document stems from the need for healthcare organisations in England to take on the responsibility and ownership of PACS from 2013 (2015 in London). However, the guidance is clearly applicable to any organisation developing a case to upgrade their PACS.

It needs to be emphasised that all trusts in England will become responsible for their local PACS in terms of contracting, funding and configuration and therefore there needs to be a high level of expertise within trusts to understand the business and IT requirements to implement and manage a PACS.

Classical PACS and future PACS

The current concept of PACS is that of a product or system delivered by a particular vendor which supports the acquisition, storage, viewing and sharing of images (the latter within the healthcare organisation). This model for PACS effectively 'locks' the different functionalities associated with PACS with one vendor.

Current challenges facing the management of increasing volumes of imaging data, data sharing across a wide range of healthcare communities, and potential new ways of delivering diagnostic imaging services demand a review of the current IT model with potential clinical and cost benefits being achieved from dismantling the current concept of PACS in terms of procuring the component functionalities separately, mainly the storage and the image viewing components. This would lead to dealing with different vendors for different functionalities and moreover demands a level of expertise in those negotiating a different PACS delivery model.

Image storage and sharing: considerations for the future

The challenges

Data storage and archiving

Since the virtual demise of film and the almost exponential rise in imaging data output, there is a need to manage image data in terms of availability for data sharing and to support clinical workflow, and second for longer term historical archiving – storage for data sharing versus longer term historical archive.

Data storage and archive model

Points to consider in establishing a healthcare organisation or healthcare community[†] storage model are as follows.

- Distinguish between image data that is required for clinical purposes and clinical workflows needed for patient management and data that has no immediate impact on clinical workflow but may be required for future reference.
- Two types of data storage requirements arise from this distinction namely a 'short-term', rapid-access storage that is readily available for data sharing across organisations (data ready) and a longer term slow-access historical archive.
- Volumetric analysis and data retrieval rates suggest that for clinical purposes 10% of images are reviewed with one year, with an almost exponential tail off thereafter such that after five years less than 1% are retrieved – many of which are not purely for medical decision-making.
- Many organisations may already have sufficient local or community-based short-term, rapid-access storage to meet their data access and sharing needs but the principle recommendation is a minimum of three years and an optimum of five years rapid-access storage is implemented to support the range of clinical workflow requirements.
- All image data that is required for patient management including prior imaging should be available for viewing within 3 seconds. All such data will be online for rapid access.
- A disaster recovery system for the short-term archive is required and needs to be configured locally or perhaps community-based depending on local IT infrastructures. Recovery of lost data from the short-term archive must be achieved within one hour.
- The role of the historical archive is simply a data repository for future reference and does not fulfil the role of data sharing in the same way as the short-term store. The historical archive should be of low-cost storage where requests for retrieval of data may take several days to respond to; that is, slow retrieval times.
- The configuration of historical archives can be either local or again community based but will clearly require a link to the data-ready short-term storage solution.
- The historical archive is *not* a solution for disaster recovery which is addressed by other means (above).
- Organisations can decide when to archive the image data. Provided the short-term archive and disaster back-up are robust and depending on local and community policies on data retention, data may not be sent to a historical archive until three or five years have elapsed. This would be a means of reducing storage costs. Other organisations may choose to archive all data immediately.
- Organisations will need to consider the options for data storage infrastructure which may include local storage only or storage management offered by an online service (a remote server). In either case, robust disaster recovery processes need to be in place.
- At all times, mechanisms need to be in place to ensure that the images and reports are always linked.

The key message is that all imaging data considered by the organisation or healthcare community to be essential for patient management must be available to view within 3 seconds of request. Images placed in an historical archive are not considered vital to patient management but may be required, for example, for medical legal purposes. These images can be in a lower cost storage device with slower access times. How much data is made available for sharing and how long data is retained on an historical archive will be determined by local and healthcare community policies.

[†] A healthcare community (HCO) is defined as a group of several healthcare organisations ranging from primary care to specialist centres and supporting organisations (eg, imaging centres) in which the majority of patients (>95%) reside and gain access to their healthcare.

How long should image data be kept for? Data retention periods

The length of time image data is stored is currently determined by local hospital policies which will take into account national legislation and guidance advice.

The data retention periods for images, as set out in the Department of Health Code of Practice⁴ for the retention of medical records, cites the relatively recent recommendation by the RCR that the code of practice should apply to images and the imaging report equally.³ These periods vary according to the age of the patient, modality and clinical circumstance.

In terms of the Data Protection Act 1988,⁵ the Code of Practice is guidance for the retention of records (and images) and under the broad framework of the Act, Principle 5 of the Act states that, 'Data shall not be kept longer than is necessary'. The Act does not define periods for retention but the Code of Practice suggests guidance to the NHS to what a suitable minimum retention period of a health record should be based on professional good practice.

A healthcare organisation also needs to take into account retaining data for a sufficient period of time to cover issues of medical negligence claims and attendant statutes of limitation. To establish local guidelines on data retention for images, healthcare organisations will need to adhere to local policies on record retention and supporting legal advice.

It may be that the application of differential retention periods for different sets of images for patients proves too complicated to put into practice and an overall 'blanket' policy is applied such as to retain all images until a certain time after death. (Statutes of limitation would need to be considered here.) If this is the decision, the need for low-cost historical archiving is paramount. Irrespective of the storage architecture an organisation chooses (including storage as a service by a third party), it is that organisation's local rules on data retention that will govern how data is managed including deletion and compression. This paper should be considered in conjunction with the following previously published RCR guidance.³

Retention of images for research

It is likely that local and national research programmes may require the retention of images on local or service-provided stores for longer than the local retention policies stipulate. Therefore, there will need to be locally and nationally agreed policies to undertake this and storage systems able to tag such data with the appropriate retention rules. Moreover, such data may be left uncompressed and therefore require more than the usual storage space. Any additional costs for storage could be met by the research organisation.

Image data compression and archiving

Guidance on the use of lossy compression of images has been provided by the RCR⁶ and the European Society of Radiology.⁷

Considerable cost savings may be made by the adoption of Lossy compression for images. For example, chest radiographs can be compressed at least by a ratio of 10:1 without any loss of clinical detail or perceivable difference compared with the uncompressed image which amounts to a considerable reduction in storage space requirements.

Some questions remain open with to regard to the effect of compression on multi-planar reconstruction (MPR), 3D reconstruction and the accuracy of volumetric analysis on such images, although it is likely that these are not significantly affected.

The recommended levels of compression for each modality and body part are set based on the standard that the compressed image is perceptually no different from the original image for clinical interpretation purposes and can be used for primary image interpretation. However, given the lack of clarity with regard to post-processing described above the following recommendation is made.

Lossy compression of images, at levels conforming to current guidelines, is undertaken at the point of commitment to the long-term historical archive. Images on the short-term (data-ready store) are not compressed as there is some likelihood that these images may need post-processing. In reality, most post-processing (MPR and so on) is done within the first few months after the acquisition of the image data.

Current and future provision of data storage

Currently it is highly likely that both short-term, data-ready storage and historical archiving functionalities are provided by the PACS vendor and, moreover, image stores are separate from the organisation's other clinical data stores. Some organisations have deployed storage area networks both for imaging and non-imaging data independent of the PACS vendor. These may provide a disaster recovery function and, in many instances, are

forming the function of a longer-term archive, although these images remain available for rapid access and cheaper options for longer-term archiving should be considered.

It is now possible to consider other vendors for short- and long-term storage options – both locally and at higher regional levels. In the future, there may be national storage providers to provide storage for historical archives.

Data sharing

Currently, there is no one method for sharing data between organisations and the methods in use are determined by the level of PACS implementation. A national single PACS solution would mean that all participating organisations have access to images, while local PACS implementations may share images by pushing data to another organisation or by means of a router model – the latter having been successfully employed across many healthcare organisations in England. The point-to-point pushing of data and the use of a router model has considerably reduced the need for CDs, although there are still areas where CDs are being used.

Adapting the Integrating the Healthcare Enterprise (IHE)⁸ – a global framework for workflow integration – profiles (XDS-I and XDA) for data sharing of images and reports within and between healthcare communities should provide a more uniform and standard-based means for image (and other clinical documents) sharing and should be explored as a model for data sharing between healthcare organisations as a scalable solution that can incorporate individual PACS entities as required. Details of IHE pertinent to imaging can be found on the IHE UK website. By creating such a solution for sharing data, it reduces the dependence on specific proprietary methods of storing data, limiting who can access the data.

Future PACS data storage and archiving: data migration and ‘vendor neutral archives’

Future models of PACS delivery may separate the storage of images provided by one vendor from the image viewing application provided by another. Furthermore, the access to images on one particular data store may be required to be viewed by a variety of different clinical viewing applications.

A model which allows flexibility of choice between the image viewing applications and data storage and sharing solutions raises the issue of how to configure data storage in such a manner that allows access by any vendor’s image viewer – either by another organisation if allowed to do so by agreement or in the event of changing the image viewing application to a different vendor. In addition, how can future PACS models avoid the current need to migrate all the image data from one vendor-associated PACS storage to another should one choose to change the model?

The answer may lie in the concept of ‘vendor neutral archives’ (VNA). Simply, this would indicate a standard/universally agreed standard for storing data in a way that is accessible to all at a given time and would support future PACS models negating the need to migrate image data at great cost. In reality, there currently is no ‘pure’ VNA but there is no reason why current PACS vendors cannot commit data to storage in a format that is significantly less vendor-specific and allow future models of PACS provision to evolve without the need for massive data migration. Clearly this issue needs addressing in future PACS business case specifications.

In the interim, a view may be taken that one of the benefits of the evolving router solution in England is that it is able to reconcile image data in a variety of different PACS vendor data stores and make them available to other vendor’s stores for local use (by means of changing the DICOM attributes). Hence, despite disparate local data stores, there is the ability to share image data between organisations, although this would involve creating a copy of the image data at another organisation’s site unless the images are simply viewed by a web viewer with the images remaining on the router server.

Functional and interoperability requirements and associated standards for specifying new PACS implementations

The following summarises the requirements for incorporation into a PACS business case and summarises the IHE profiles which support the specific workflow requirements.

Current PACS perform two basic functions:

1. Image manager – storage of images. This can be either provided by a VNA (see above) or by the PACS supplier)
2. Image display – display of images stored in the image store above. This can be either be provided by a PACS vendor or a separate image viewing provider.

PACS can integrate with the following IT systems:

- Patient administration system (PAS) for demographics, current location, current responsible consultant/GP
- RIS for scheduling information and report information
- Modalities receive images and image-related information.

Demographics and admission, discharge and transfer (ADT) information consistency

All demographics and ADT information must be kept up to date on all clinical IT systems within any organisation. Any demographic update or patient merges on PAS must be updated in real time within PACS and RIS.

PACS, RIS and PAS must all comply with the IHE-PIR profile.

IHE profile: patient information reconciliation (PIR)

*'PIR handles unidentified/emergency patient, demographic information updates (for example, patient name changes (marriage, etc.), correction of mistakes, ID space mergers). Such changes are reliably propagated to all systems, which update all affected data. The result is a complete patient record.'*⁹

Patient banner information

The patient demographics and ADT information for a patient *must* be consistently displayed on the top demographic banner of any clinical system (PACS, RIS and Ordercoms) with real-time demographics synchronisation with PAS as mentioned above. This is critically important for patient safety and care in terms of ensuring timely communication and correct patient ID. The following should be visible:

- Patient name
- Date of birth
- Sex
- NHS number
- PAS number
- Current patient location
- Current responsible consultant.

Search criteria for a single patient or group of patients

It should be possible to search for a single or group patients using one or any combination of the following criteria:

- Name
- Date of birth
- Sex
- NHS number
- PAS number
- Current responsible consultant
- Requesting responsible consultant
- Current patient location

- Operator
- Reporter
- Exam status of study
- Modality
- Exam description
- Exam room
- Date range (for exams).

Data fields on PACS

The information that needs to be stored and available for display for the clinical user/radiologist viewing the PACS image is described below. This also identifies what clinical data fields should be transmitted as metadata fields or tags to a cross-enterprise document sharing (XDS) registry/repository (if XDS is made the standard for including radiology images into the electronic patient record [EPR]).

- PATIENT
 - Patient demographics
 - Name
 - Date of birth
 - Sex
 - PAS number
 - NHS number (community health index (CHI) number for Scotland) – the NHS number may not be present in 100% of exams sent to PACS
 - Current patient location
 - Current responsible consultant
- REQUESTER – synchronised with RIS
 - Name of requester
 - Grade of requester
 - Contact number of requester
 - Requesting responsible consultant/GP¹⁰ (Team) – (Also RECIPIENT)
 - Requesting specialty/department/GP surgery
 - Requesting institution
 - Date and time of request made
- IMAGE DOCUMENT – synchronised with RIS and modalities
 - Modality
 - Exam description – national exam codes and descriptions
 - Exam status
 - Date and time image acquired on modality
 - Date and time of image sent from modality
 - Date and time received on PACS
 - Exam room (where the exam has been performed)
- OPERATOR/IMAGE CREATOR – synchronised with RIS and modality
 - Name of operator
 - Grade of operator
 - Contact number of operator
 - Performing responsible consultant
 - Performing department/specialty – radiology
 - Performing institution/NHS trust
- REPORTER – synchronised with RIS
 - Name of reporter
 - Grade of reporter
 - Contact number of reporter
 - Reporting responsible consultant
 - Reporting department/specialty
 - Reporting institution/NHS trust
 - Date and time report verified.

It is important that the above information is synchronised between PAS, RIS, modalities and PACS.

Exam status notification

This is a key concept for driving workflow within the radiology department. The status must be synchronised between Ordercomms, RIS and PACS, and results acknowledgement systems. The notifications should include the following:

- Requested (ORDERCOMMS)

- Request vetted (RIS)
- Request held/deferred – with reason (RIS)
- Scheduled or appointment given (RIS)
- Cancelled (RIS/ORDERCOMMS) with reason
- Arrived/attended (RIS)
- Did not attend (RIS) or was not brought (for example, from the ward)
- Exam started (RIS)
- Exam completed (RIS)
- Exam not performed – with reason (RIS)
- Report dictated (RIS)
- Unauthorised report (RIS)
- Authorised/verified report (RIS)
- Amended report (RIS)
- Report viewed (Ordercomms/RAS)
- Report acknowledged (ORDERCOMMS/RAS)
- Review requested (Ordercomms).

The DICOM modality worklist

When a patient arrives within a department, a modality (computed tomography, magnetic resonance, ultrasound and so on) needs to be 'aware' that the patient is in the department and pull the relevant demographics and study information from the RIS to avoid manual data entry. In simplistic terms, a DICOM modality worklist (DMWL) is a list of patients on RIS who have an 'arrived' status. As the scheduling system, RIS is responsible for scheduling patients and ensuring logging patients' arrival into the department. Each modality will continuously query the RIS (which should provide a DMWL) for any exams based on modality and exam room. Normally, the DMWL provider is the scheduling system used for scheduling information to a modality. (In radiology, RIS provides a DMWL for radiology modalities.) The following information needs to be provided by RIS to modalities.

- Patient demographics
 - Name
 - Date of birth
 - Sex
 - PAS number
- Modality
- Exam description – usually national/local exam codes and descriptions
- Exam room
- Accession number (RIS generates this for every exam)
- Study unique identifier (RIS generates this for every exam).

The modalities query the RIS and display a list of patients who have an 'arrived' status in RIS for that particular modality and examination room. Once the examination has been completed on the modality the RIS status is changed to 'exam performed' (or 'exam not performed' if the examination was not undertaken) on RIS and the exam should drop off the DMWL and will no longer be visible to modalities.

Once the exam is completed on the modality, radiographers must be able to send images to PACS.

Modalities (as acquisition modality actor), RIS (as departmental system scheduler actor), PACS (as image manager and image display) must all support the scheduled workflow profile of IHE.

IHE profile: scheduled workflow (SW)

*'Scheduled workflow establishes a seamless flow of information that supports efficient patient care workflow in a typical imaging encounter. It specifies transactions that maintain the consistency of patient information from registration through ordering, scheduling, imaging acquisition, storage and viewing.'*¹¹

A standardised approach to DMWL provision is essential when supporting long-term storage of DICOM images from non-radiology modalities such as cardiology, ophthalmology and in the future histopathology which will entail integration with other clinical scheduling systems.

The current situation in the NHS

In many hospitals within the NHS, PACS brokers (often called connectivity managers, RIS gateway, PACS broker and so on) provide DMWL functionality. This could be related to the inability of RIS to provide a DMWL or PACS vendors insisting on including brokers as part of their PACS solution. However, if a RIS is capable of providing a DMWL, there is no need to create an additional weak link between RIS and modalities, thus introducing an

additional point of failure. The use of PACS brokers is a non-standard implementation. Hence, when submitting new business cases for PACS solutions, there is now the ideal opportunity to adopt global workflow standards, which are key to ensuring plug and play interoperability and reduced costs.

Exceptional circumstances where a PACS broker may be required

The use of brokers should only be in exceptional circumstances; for example, where there two separate clinical systems providing scheduling information to the same modality and location. This may occur when scheduling for mammography comes both from the National Breast Screening Programme and the local RIS, or scheduling for ultrasound comes from a cardiology information system (CIS) for cardiac echocardiography and from RIS for general ultrasound.

Image transmission from modalities to PACS

Images once created in a modality will be sent to PACS for storage. Radiographers must ensure that the images are of good quality before transmitting to PACS. As it is important that image quality is kept intact during transmission from the modality to PACS, adherence to DICOM standards and IHE will ensure that the quality of images and data are not compromised.

Acquisition modalities and PACS (as image manager and image display actors) must support the consistent presentation of images profile of IHE.

IHE profile: consistent presentation of images

*'Consistent presentation of images maintains the consistency of presentation for grayscale images and their presentation state information (including user annotations, shutters, flip/rotate, display area, and zoom). It also defines a standard contrast curve, the Grayscale Standard Display Function, against which different types of display and hardcopy output devices can be calibrated. Thus it supports hardcopy, softcopy and mixed environments.'*¹²

Audit data

In addition to the DICOM image, the following data also need to be sent to PACS from modalities.

- Date and time image acquired on modality
- Date and time of image sent from modality.

PACS should also record the time that the images arrive on PACS. This information is important for auditing the performance of PACS and networks; for example, the time it takes for images to arrive on PACS after they are sent, quantify PACS downtime and so on.

It is important that the following data is easily accessible to the system administrator/PACS managers:

- Time of image creation to arrival on PACS
- Number of exams of a modality per room
- Time from image arrival on PACS to verified report and so on.

Single sign-on (SSO) and desktop integration (DTI) or context synchronisation

SSO

The process of logging in should be quick and slick. The system should support a SSO process as used in a hospital. As a minimum, an additional user name and password should not be required when using RIS and PACS. When a user logs into RIS for reporting, the user credentials must be passed onto PACS with no need for additional user name and password input.

Desktop integration (DTI)

DTI must be at the exam level in all information systems. DTI with RIS is well established with PACS.

- Automatic RIS to PACS integration – in most NHS trusts, RIS is used for reporting of radiology images. For efficiency reasons there should be automatic display of relevant radiology images when an exam is picked up for reporting on RIS.
- Manual PACS to RIS integration – when images are displayed on PACS, it should be able to display the RIS for that episode. This would be important at multidisciplinary team meetings, or when a request is made for a second opinion for example, to allow for an addendum to be recorded on the RIS.

Similarly DTI is required with other information systems such as cardiology, ophthalmology systems, breast screening systems, endoscopy systems, as more images from other sources are stored on PACS.

Contract clarity: As part of contractual agreement, there *must* be clarity on the how DTI will be possible with other clinical information systems.

Plug-ins: integration with other clinical display systems

PACS suppliers should allow integration with best of breed specialist display systems chosen by the customer. However, a 3-second launch of images into the specialist display systems must be maintained. Functionalities include:

- 3D display and MPR
- CT colonoscopy display
- Cardiac CT display and analysis
- Mammography display (if required)
- PET-CT fusion display (if required)
- Optical display
- Computer-aided detection (CAD) for mammography
- Orthopaedic templates.

Having access to best of breed plug-ins is key to improving user experience of the display software.

If a user wishes to save an image created on the plug-in, the system should allow the user to save images in a DICOM format as a separate series within PACS. Similarities are seen with orthopaedic templates display where templated images will need to be saved on PACS as a separate series.

Contract clarity: As part of contractual agreement, there *must* be clarity that the system will allow plug-ins of other best of breed display systems. Clarification is required on the technical requirements and the cost of integration and that images created by additional software can be added to the patient's exam series on PACS.

Testing and training system

There should be a separate test and training system that is separate from the live environment. This should act as a test-bed for integration/testing of new features before roll out into the live environment.

For training:

1. There should be an e-learning tool provided. The system should be intuitive enough so as require minimal training
2. There should be a single user interface – this is key as it reduces the training and support needs for customer and suppliers. (Separate PACS displays for radiologists and other clinical users are more cumbersome for training)
3. There should be a separate test system available for training (so that training does not need to be performed on a live system).

Local configuration of user roles

User roles should be defined locally; for example:

1. Clinical users: all medical users should be able to view images and reports
2. Radiologists and radiographers should be able to send images to another DICOM destination (on-call neurosurgical unit)
3. System administrators should be able to delete images, correct attributes and so on.

Support, business continuity and disaster recovery

Support needs to consist of:

- Twenty-four hour/seven days a week support
- Single phone number to call
- Should consist of a firstline dedicated team of qualified engineers with the ability to directly deal with local network manager to distinguish whether it is a network or PACS issue
- Online tracking of issues raised
- Transparency on response time to types of support calls
- Remote and on-site support capabilities
- Support should include integration to third party systems.

Business continuity and disaster recovery

There should be no need for a planned or unplanned downtime. Business continuity should be aimed for. There should be a disaster recovery plan identified in the contract.

Audit trails/view log

All access to a patient's image by a user should be recorded. This should be logged and the 'view log' should be accessible to any user to see. This will remind users that their data access is logged and thus improve patient confidentiality.

IHE profile: audit trail and node authentication (ATNA)

*'The audit trail and node authentication (ATNA) integration profile establishes security measures which, together with the security policy and procedures, provide patient information confidentiality, data integrity and user accountability.'*¹³

Electronic patient record (EPR)

A more global approach to the storage and sharing of images is required and they must become part of a wider clinical record (EPR). Future models of PACS need to move away from a radiology data silo and make diagnostic imaging a part of the holistic patient record. Adoption of global standards is fundamental to this concept. This can be achieved by the adoption of IHE framework profiles,⁸ for example:

1. PACS must act as a source actor of the cross-enterprise document-sharing profile – imaging (XDS-I) of IHE – PACS must act as XDS and XDS-I consumer actor of the cross-enterprise document-sharing profile – imaging of IHE. This will allow viewing of other clinical documents/images that are registered on the XDS registry.
2. Adoption of XDS by PACS will allow radiologists and other clinical users access to an integrated view of *all* clinical documents and images, such as echocardiograms (ECG), medical photographs, radiology images and discharge summaries, through a viewer that is XDS consumer compliant.

IHE profile: standard cross-enterprise document sharing for imaging, XDS-I

*'Allows the sharing of imaging documents between radiology departments, physicians, clinics, long-term care and acute care with different clinical IT systems and thus make it possible for radiology images to become part of the patient-centred EPR.'*¹⁴

Remote reporting and on call

Increasingly NHS trusts are encouraging radiologists to do on call from home and this must be a feature of all models of PACS. Radiologists must be able to report from home and verify reports on PACS which will prevent the dependence on verbal reports and documentation in paper notes, improving communication, and thus improving patient care and safety. In the future, we will see some radiologists requesting for part working from home. Technology needs to support this by:

- Access to any image from any location (including home)
- Consistent user interface (in or outside hospital), with the full set of image manipulation tools as if within hospital
- Adaptive loading of images with uncompromised scrolling speed through CT/MRI images. It is important that over slow networks the solution is able to cache images, so that once loaded the radiologist is able to scroll through thousands of images smoothly without any 'jumps' or skipping of images.
- Consistent DICOM image quality of images (even when reporting remotely)
- Access to other information, such as request cards, scanned documents, clinic letters and so on
- Ability to DICOM push to other hospitals even when working remotely (for example, neurosurgical centres).

Teaching files creation

It is essential that there is the ability to create teaching files which are part of the radiology network. Interoperability standards are fundamental to the creation of teaching files. If a non-standard approach is adopted, there is a good chance that radiologists will lose their teaching files; for example, if the PACS vendor is replaced.

To ensure teaching files are future proofed:

- PACS must be compliant with the export selector and export manager actors of the TCE profile of IHE
- If the radiology PACS is going to be used as a teaching files server, ensure that it is specified that it is the receiver actor for the TCE profile. Alternatively, one could use the free Medical Imaging Resource Community (MIRC)¹⁵ from the Radiological Society of North America (RSNA) as the teaching file server which is compliant with the receiver actor of TCE profile of IHE.

IHE profile: teaching files and clinical trials export profile (TCE profile)

*'The IHE TCE profile describes a method for using existing standards to simplify and standardise the export of key medical images for education, research, and publication.'*¹⁶

Storage and PC display hardware

Storage hardware

The PACS vendors can define the specifications of the storage hardware. However, they should not be the supplier of storage hardware. NHS trusts must be able to look at storage with a holistic view, for all storage requirements – both for clinical and administrative applications.

Display hardware

PACS vendors need to specify the display hardware requirement for adequate display of the images – grey scale, graphics card and so on. However, trusts must be able to buy the hardware at open market competition. The PCs must not be limited to PACS display only. It must be multipurpose equipment.

Image display and manipulation tools

The image viewer appearance must be user friendly and simple to navigate:

- Users must not be overwhelmed. Workflow is inversely proportional to the number of buttons on the PACS desktop
- The number of steps for commonly performed tasks should be minimal.

The PACS needs to be operable by the least technically savvy radiologist. A large number of tools to choose from on the display can be frustrating for a user. There should be an intelligent display of commonly used image manipulation tools – windowing, measure, zoom, scroll and so on should all be activated with one mouse click/step. The tools when configured by a user for a modality should be consistently displayed for each modality the next time that the user logs on; for example:

1. CR – windowing, measure, zoom and so on
2. CT – scroll, windows presets, link studies, measure, zoom and so on
3. MRI – synchronised scrolling with position between series in different planes and so on
4. Thumbnails should be displayed for every series.

It is recommended that you drive before you buy.

However, the IHE profile, basic image review, will ensure that your PACS display has at least the bare minimum features required for radiology image display.

PACS (as image manager and image display actors) must support the basic image review profile of IHE.

IHE profile: basic image review

Compliant software must provide a predictable user interface and functionality sufficient to review images for the purpose of clinical decision-making by ordering physicians:

- *display of grayscale and color images from any modality*
- *visual navigation of the available series of images through the use of thumbnails*
- *side-by-side comparison of at least two sets of images (with synchronized scroll, pan and zoom for cross-sectional modalities)*
- *annotation of laterality, orientation, and spatial localization*
- *annotation of demographics, management and basic technique information for safe identification and usage*
- *simple measurements of linear distance and angle*
- *cine capability for images that involve cardiac motion (eg, cardiac US, XA, 500 CT or MR)¹⁷*

Automatic display of relevant priors

Image and reports

For all imaging, all previous images and reports should be available for comparison purposes and all relevant images and reports should be displayed in a manner where there is easy reference to them. A good dynamic display protocol is required which automatically displays the previous similar exam on the right-hand monitor, for example, (with the middle monitor displaying the current image for reporting). The associated report also needs to be displayed automatically. Making these displays default automatically increases the chance of previous images and reports being reviewed and compared.

Radiology report and requests

Radiology report and radiology request are documents which are created in other clinical systems – RIS for radiology report and Ordercomms for radiology requests. However, they must always be linked together with the images and available for display (in the same way as the traditional film packets in NHS contained both these documents.) With one mouse click, these linked documents must be displayed along with the images. XDS/XDS-I standards adoption by PACS, RIS and Ordercomms should facilitate this. PACS must be able to query and display radiology reports and request cards from the trust-based XDS registry and repository.

Reporting workflow

A three-click reporting workflow should be possible from the RIS and PACS integration.

1. Draw up a RIS worklist for reporting.
2. Launch a patient's exam for reporting on RIS with automatic display of images on PACS and automatic display of relevant previous images with simultaneous dictation of a report on RIS.
3. Click on the next exam on RIS worklist, which closes the previous PACS images and launches the next patient on RIS and PACS.

DICOM connectivity with new modalities

PACS must readily allow DICOM connectivity to all new additional imaging modalities and in addition allow storage and display of DICOM non-radiology images such as retinal light images or endoscopy light images. Adoption of interoperability standards is the key to scalability of the PACS solution. Adopting a broker-less solution for PACS will allow scheduling to be done on clinical scheduling systems (cardiac information system, ophthalmology information system and so on). The contract should be transparent on this issue and both sides aware of additional costs of DICOM connectivity of additional modalities.

DICOM connectivity with other organisations and image sharing

To enable continuity of patient care and facilitate clinical networks, the ability to share data within and between organisations must not be restrictive. This will be enhanced by the adoption of national and international DICOM standards which are more open and less restrictive than some current proprietary models.

Current sharing solutions include:

- DICOM push

- DICOM push and retrieve via a router model
- Encrypted CDs.

Any new PACS solution must allow all known variations in image and report sharing methodologies.

Future image sharing models (see above)

DICOM push creates duplication of images in other PACS systems. The adoption of IHE profiles (XDS and XDA) will allow for the ability to share without duplication using cross-community access (XCA). PACS images must be able to follow a patient's journey. XDS-I/XCA concepts are key to this approach.

IHE profile: cross community access (XCA)

The cross-community access profile supports the means to query and retrieve patient relevant medical data held by other communities.¹⁸

Stability

Software display should be stable and show a consistent display once a display protocol is set up by the user. Software errors may occur, but there needs motivation within the supplier to correct the errors in a timely manner. The supplier must have local developers who are involved in the product development, who will be able to understand the user needs and correct errors that may be present.

User group meetings and product development

During the lifetime of the contract, there must be a user and provider forum such that:

- The customers have input into future system design and functionality. The supplier must have a vibrant user group including an electronic forum (with both clinical users and system administrators involved) where product enhancement upgrades and improvements are suggested
- There must be a rolling agenda for product enhancement during the contract. Product development days where users and providers discuss improvements to the system must be defined at the start of the contract period
- Clarity within the contract is required to determine how product upgrades and improvements are paid for. Will they be part of the normal revenue expenditure or attract additional payments?
- A product developer must be present at the user group meetings and involved in the electronic discussions to have an honest dialogue between users and suppliers about what enhancement suggestions are viable for the supplier.

Selective deletion of images and image data compression (Also see section on image storage)

There must be links between PAS and the PACS data stores to enable real-time updates on the patient's status.

Depending upon the healthcare organisations policy for data deletion, there must be a user-defined controllable mechanism for deleting imaging data after a predetermined period after death.

The PAS–PACS model should be able to support differential tagging of images which determines the data retention periods for different groups of patients (such as paediatric or cancer) determined by local healthcare organisation policies.

To reduce image data storage costs, the image storage systems must be able to accept lossy compressed image data or have the ability to compress uncompressed images in the data store.

It is important that this irreversible compression follows DICOM standards so that the compressed images can be migrated over to another data storage vendor in the same way as the rest of the DICOM images.

CT display requirements

Increasing volumes of data are being produced from CT examinations such as in cardiology, CT colonography, oncology and trauma. The volumes of data consist of increasingly thin slice thicknesses which may require manipulation as in MPR or 3D reformatting. The viewing application must have the following functions.

1. The PACS image display application must have an automatic and seamless loading of MPR to manipulate the thin CT slices rather than reliance on stand-alone modality workstations which are time consuming and inefficient. This facility will negate the need to store to PACS images in three orthogonal planes and therefore reduce the pressure on storage capacity.
2. Allow for synchronized scrolling in 3 planes for cross-sectional imaging (CT/MRI).
3. Allow automatic display of relevant prior
4. Allow synchronised scrolling with previous scan.
5. Ability to create 3D images.
6. During MPR/3D viewing, radiologists should be able to save some key images (for example, a coronal image/sag image that shows the key lesion) as a separate series for reference to the report.
7. Users must be able to define slab thickness and create images of different thickness in real time.
8. Ability to measure distance, circumference, angle and volume of lesions, this should be easy and intuitive.
9. Ability to measure Hounsfield density (for example, average density of a lung nodule, with maximum and minimum density). This task should be intuitive and easy for any radiologist.
10. Scrolling speed should be such that image to image transition is smooth – even with >1000 images. The users should be able to scroll through images smoothly. Cine display must be present.
11. CT displays at home-based applications for on-call reporting radiologists may be inadequate due to limited bandwidth. Scrolling speed over slow networks may be restricted but can be improved by the provision of local caching.

Nuclear medicine image display

PACS must be able to store and display nuclear medicine images along with all other imaging modalities. There is no need to have a separate display application.

PACS (as image manager and image display actors) and gamma camera and so on (as acquisition modality actor) must conform to the nuclear medicine profile of IHE.

IHE nuclear medicine profile

*'The nuclear medicine profile is a set of specifications as to how NM systems (Gamma cameras etc) and PACS systems should interact when dealing with NM data. The primary focus deals with storage and display of such data on PACS systems.'*¹⁹

Mammography image storage and display

In most NHS hospitals, radiologists perform mammography reporting among the other radiology reporting activities. In addition, MRI and ultrasound form a group of modalities used in combination for breast radiology. Hence, it is vital that the PACS is able to store and display mammography images adequately along with other imaging modalities.

PACS (as image manager and image display actors) and mammography CR/FFDM (as acquisition modality actor) must conform to the mammography image profile of IHE.

IHE mammography image profile

*'Efficient mammography reading requires specific display quality, behaviour, layout and annotation of images, as well as convenient comparison of prior with current images. The IHE Mammography Image Profile was developed specifically to define the necessary mammography requirements.'*²⁰

Radiation dose

It is important that radiology departments are able to monitor doses to an individual patient, group of patients (for example, children, and women) by a specific modality, specific exam type and so on to compare with national averages/standards.

Modalities (as acquisition modality actor) and PACS (as image manager actor) must support the radiation exposure monitoring profile of IHE.

This will allow feeding of such information into a national radiation monitoring registry for NHS in the future.

IHE profile: radiation exposure monitoring (REM)

*'The REM profile facilitates the collection and distribution of information about estimated patient radiation exposure resulting from imaging procedures. The REM profile requires imaging modalities to export radiation exposure details in a standard format. Radiation reporting systems can either query for these 'dose objects' periodically from an archive, or receive them directly from the modalities.'*²¹

Current situation in the NHS

Currently radiation dose information is entered into the RIS manually. Support of this profile will provide more accurate information as this will reduce errors related to manual data entry into RIS and, therefore, improve working practices for radiographers.

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References

1. The Royal College of Radiologists. *A practical guide to implementing Ordercomms in radiology*. London: The Royal College of Radiologists, 2010.
2. The Royal College of Radiologists. *Standards for a results acknowledgement system*. London: The Royal College of Radiologists, 2010.
3. The Royal College of Radiologists. *Retention and Storage of Images and Radiological Patient Data*. London: The Royal College of Radiologists, 2006 (updated 2008).
4. Department of Health. *Records Management: NHS Code of Practice: Annex D1 Health Records Retention Schedule*
http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_093027.pdf
(last accessed 21/06/11)
5. Data Protection Act 1998.
http://www.dh.gov.uk/en/Managingyourorganisation/Informationpolicy/Recordsmanagement/DH_4000489
(last accessed 21/06/11)
6. The Royal College of Radiologists. *IT guidance: The adoption of Lossy Image data compression for the purpose of clinical interpretation*. London: The Royal College of Radiologists, 2008.
7. European Society of Radiology. Usability of irreversible image compression in radiological imaging. A position paper by the European Society of Radiology (ESR). *Insights into Imaging* 2011; 2(2): 103–115.
8. IHE UK (<http://ihe-uk.net>) (last accessed 21/06/11)
9. http://wiki.ihe.net/index.php?title=Patient_Information_Reconciliation (last accessed 21/06/11)
10. The Royal College of Radiologists. *A practical guide to implementing Ordercomms in radiology*. London: The Royal College of Radiologists, 2010.
11. http://wiki.ihe.net/index.php?title=Scheduled_Workflow (last accessed 21/06/11)
12. http://wiki.ihe.net/index.php?title=Consistent_Presentation_of_Images (last accessed 21/06/11)
13. http://wiki.ihe.net/index.php?title=Audit_Trail_and_Node_Authentication (last accessed 21/06/11)
14. http://wiki.ihe.net/index.php?title=Cross-enterprise_Document_Sharing_for_Imaging (last accessed 21/06/11)
15. http://mirwiki.rsna.org/index.php?title=Main_Page (last accessed 21/06/11)
16. http://www.ihe.net/Technical_Framework/upload/IHE_TF_Suppl_Teaching_File_Clinical_Trial_Export_TI_2_005-04-22.pdf (last accessed 21/06/11)
17. http://wiki.ihe.net/index.php?title=Basic_Image_Review (last accessed 21/06/11)
18. http://wiki.ihe.net/index.php?title=Cross-Community_Access (last accessed 21/06/11)
19. <http://gamma.wustl.edu/ihe/handouts/FAQ-IHE-NM-Profile-v3.1pdf.pdf> (last accessed 21/06/11)
20. <http://www.pacsgroup.org.uk/forum/messages/2/51629.html?1297165745> (last accessed 21/06/11)
21. http://wiki.ihe.net/index.php?title=Radiation_Exposure_Monitoring (last accessed 21/06/11)

Appendix 1. Specifying the IHE standards for PACS

1. PACS must be an image manager actor for the patient information reconciliation (PIR) profile of IHE.

'PIR handles unidentified/emergency patient, demographic information updates (for example, patient name changes (marriage, etc.), correction of mistakes, ID space mergers). Such changes are reliably propagated to all systems, which update all affected data. The result is a complete patient record.'⁹

2. PACS must conform to image manager and image display actor for scheduled workflow (SW) profile of IHE.

'Scheduled workflow establishes a seamless flow of information that supports efficient patient care workflow in a typical imaging encounter. It specifies transactions that maintain the consistency of patient information from registration through ordering, scheduling, imaging acquisition, storage and viewing.'¹⁰

3. PACS must conform to image manager and image display actors for basic image review profile of IHE.

'Compliant software must provide a predictable user interface and functionality sufficient to review images for the purpose of clinical decision-making by ordering physicians: display of grayscale and color images from any modality, visual navigation of the available series of images through the use of thumbnails, side-by-side comparison of at least two sets of images (with synchronised scroll, pan and zoom for cross-sectional modalities) annotation of laterality, orientation, and spatial localisation, annotation of demographics, management and basic technique information for safe identification and usage simple measurements of linear distance and angle cine capability for images that involve cardiac motion (eg, cardiac US, XA, 500 CT or MR).'¹⁶

4. PACS must conform to image manager and image display actors of consistent presentation of images profile of IHE.

'Consistent presentation of images maintains the consistency of presentation for grayscale images and their presentation state information (including user annotations, shutters, flip/rotate, display area, and zoom). It also defines a standard contrast curve, the Grayscale Standard Display Function, against which different types of display and hardcopy output devices can be calibrated. Thus it supports hardcopy, softcopy and mixed environments.'¹¹

5. PACS must conform to secure node/secure application actor of audit trail and node authentication (ATNA) profile of IHE.

'The audit trail and node authentication (ATNA) integration profile establishes security measures which, together with the security policy and procedures, provide patient information confidentiality, data integrity and user accountability.'¹²

6. PACS must conform to XDS-I source and XDS/XDS-I consumer actors of cross-enterprise document sharing profile of IHE.

'Allows the sharing of imaging documents between radiology departments, physicians, clinics, long-term care and acute care with different clinical IT systems and thus make it possible for radiology images to become part of the patient-centred EPR.'¹³

7. PACS must conform to export selector and export manager actors of teaching files and clinical trials export profile (TCE profile) of IHE.

'The IHE TCE profile describes a method for using existing standards to simplify and standardise the export of key medical images for education, research, and publication.'¹⁴

8. PACS must conform to image manager actor of radiation exposure monitoring (REM) profile of IHE.

'The REM profile facilitates the collection and distribution of information about estimated patient radiation exposure resulting from imaging procedures. The REM profile requires imaging modalities to export radiation exposure details in a standard format. Radiation reporting systems can either query for these 'dose objects' periodically from an archive, or receive them directly from the modalities.'²⁰

9. PACS must conform to image manager and image display actors of the nuclear medicine profile of IHE.

'The nuclear medicine profile is a set of specifications as to how NM systems (Gamma cameras etc) and PACS systems should interact when dealing with NM data. The primary focus deals with storage and display of such data on PACS systems.'¹⁸

10. PACS must conform to image manager and image display actors of the mammography image profile of IHE.

'Efficient mammography reading requires specific display quality, behaviour, layout and annotation of images, as well as convenient comparison of prior with current images. The IHE Mammography Image Profile was developed specifically to define the necessary mammography requirements.'¹⁹

<http://www.ihe-europe.net/external/framework.htm> – this link identifies the PACS vendors who have participated in worldwide Connectathons to show interoperability.

Appendix 2. IHE specifications for RIS

1. RIS must be a department system scheduler actor for the patient information reconciliation (PIR) profile of IHE.

'PIR handles unidentified/emergency patient, demographic information updates (for example, patient name changes (marriage, etc.), correction of mistakes, ID space mergers). Such changes are reliably propagated to all systems, which update all affected data. The result is a complete patient record.'⁹

2. RIS must conform to department system scheduler actor for scheduled workflow (SW) profile of IHE.

'Scheduled workflow establishes a seamless flow of information that supports efficient patient care workflow in a typical imaging encounter. It specifies transactions that maintain the consistency of patient information from registration through ordering, scheduling, imaging acquisition, storage and viewing.'¹⁰

<http://www.ihe-europe.net/external/framework.htm> – this link identifies the PACS vendors who have participated in worldwide Connectathons to show interoperability.

Appendix 3. IHE specification of acquisition modalities

1. Modalities must conform to the acquisition modality actor for the schedule workflow profile of IHE.

'Scheduled workflow establishes a seamless flow of information that supports efficient patient care workflow in a typical imaging encounter. It specifies transactions that maintain the consistency of patient information from registration through ordering, scheduling, imaging acquisition, storage and viewing.'¹⁰

2. Modalities must conform to the acquisition modality actor of consistent presentation of images profile of IHE.

'Consistent presentation of images maintains the consistency of presentation for grayscale images and their presentation state information (including user annotations, shutters, flip/rotate, display area, and zoom). It also defines a standard contrast curve, the Grayscale Standard Display Function, against which different types of display and hardcopy output devices can be calibrated. Thus it supports hardcopy, softcopy and mixed environments.'¹¹

3. Nuclear medicine modality must conform to the acquisition modality actor of the nuclear medicine profile of IHE.

'The nuclear medicine profile is a set of specifications as to how NM systems (Gamma cameras etc) and PACS systems should interact when dealing with NM data. The primary focus deals with storage and display of such data on PACS systems.'¹⁸

4. Mammography modality (CR/FFDM) must conform to the acquisition modality actor of the mammography image profile of IHE.

'Efficient mammography reading requires specific display quality, behaviour, layout and annotation of images, as well as convenient comparison of prior with current images. The IHE Mammography Image Profile was developed specifically to define the necessary mammography requirements.'¹⁹

5. Modalities must conform to the acquisition modality actor of the radiation exposure monitoring profile of IHE.

'The REM profile facilitates the collection and distribution of information about estimated patient radiation exposure resulting from imaging procedures. The REM profile requires imaging modalities to export radiation exposure details in a standard format. Radiation reporting systems can either query for these 'dose objects' periodically from an archive, or receive them directly from the modalities.'²⁰

<http://www.ihe-europe.net/external/framework.htm> – this link identifies the PACS vendors who have participated in worldwide Connectathons to show interoperability.

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