

# Buyers' guide

## PACS workstations and software

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A picture archiving and communications system (PACS) is a computer network system designed to store, retrieve and transfer digital medical images. A PACS integrates image data from system to system, allowing for transfers within and between healthcare settings. This facilitates the availability of both images and image-related data at the point of care, as and when required.

Digital medical imaging technologies have already been adopted by NHS centres across the UK as a means of replacing the older film imaging technologies, in much the same way as digital cameras have replaced 35mm film in photography. The range of clinical applications for digital images has grown swiftly, supported by the development of medical image viewing workstations and associated software. The PACS workstation software industry is now mature, with a number of different manufacturers providing a diverse range of products with different functionalities.

CEP buyers' guides are aimed at a broad purchasing audience, including health service managers, finance managers, chief executives, clinicians, technicians and supplies professionals. This guide has been designed to present the technical and operational information relating specifically to workstations designed for viewing and reporting medical images. These are primarily used by radiologists or imaging specialists based at imaging departments within hospitals and trusts.

## The workstation

The term 'medical image workstation' describes a computer system that allows a user to search, retrieve, display and manipulate images that have been created from the various imaging modalities, such as a digital x-ray unit (computed radiography or direct digital radiography), computed tomography (CT) scanner, magnetic resonance imaging (MRI) scanner, ultrasound or any of the other digital imaging technologies found in the modern imaging department. The images created by these modalities are stored on the PACS and may then be retrieved and viewed using imaging workstations. These workstations are generally referred to as PACS workstations, which should not be confused with more general modality workstations, designed to work only with the images generated from specific modalities (such as MRI or CT).

## Radiology reporting workstation

The reporting workstation is a PACS workstation specifically designed to generate and display primary reports on the images selected for viewing. In order for this to work effectively, users must be confident that the image is displayed as accurately as possible. High resolution, monochrome display monitors are used to ensure a high quality presentation of the images, and a consumer colour display monitor is also available for use with the radiology information system (RIS), so that colour images can be viewed effectively. The reporting workstation is not only required to view images, but also to interface with other sources of data, such as the RIS, voice recognition applications, and those developed for the manipulation and measurement

of the images held within the PACS system. The reporting process is driven by a reporting worklist, which displays a list of studies that are waiting for a report. Clicking on the worklist displays the image itself, together with the original request form, containing the clinical history of the patient, and the reasoning behind the image request. For example, if reporting on a chest x-ray, the system will automatically check the PACS archive for any other stored patient images, thereby allowing previous images to be compared with current ones. Historical versions of PACS workstation reports can also be accessed by the workstation in a similar way.

## **Mammography workstation**

The radiology reporting workstation can be specialised and configured as a mammography workstation. The ability to detect fine details in mammography images is paramount to their effective use in diagnosis and treatment of a number of conditions. The mammography workstation must be capable of resolving micro-calcifications, the appearance of which can be a clinical indicator of pre-cancerous changes in the breast. The file size of each mammography image is between 9 and 45 MB, regardless of whether they have been digitised by computed radiography (CR) or captured on full field digital mammography (FFDM) systems. High resolution (5 megapixel, MP) monochrome display monitors, are recommended to view the details contained within these images. Mammography images are viewed using preset 'hanging protocols', which arrange the order of images on the display monitor. Hanging protocols can usually be customised and preset by user login, to suit the individual viewing preferences of each reporting radiologist. The mammography workstation should also be able to display other breast images, for example those captured from ultrasound or MRI. The positions in which the selected DICOM tags are displayed must be sensitive as to whether the view of the breast is the left one or the right one. It should also be noted that the image processing algorithms are usually manufacturer specific and may only be used with specific manufacturer equipment.

## **Cardiology workstation**

PACS cardiology workstations also differ from PACS general radiology workstations. In the case of the radiology workstation, the workflow for viewing and reporting studies is primarily driven by an imaging request. In contrast, the cardiology workstation contains all cardiology imaging details against each patient, which may be stored across a number of different storage systems, such as a cardiology PACS, or taken directly from a cardiology device. The range of images and other data typically stored within the cardiology department of most hospitals is wider than that applicable to the radiology department. For example, ECG traces and monitoring data recorded during a cardiac catheterisation procedure might also be available for viewing on a PACS cardiology workstation. As a result, the reports that are generated via the cardiology system are generally created from a variety of different types of data, captured from a range of devices and imaging techniques. This results

in the cardiology reporting process being less prescriptive than PACS radiology reporting.

## **Review workstation**

The PACS review workstation is the most frequently used form of medical imaging workstation utilised within NHS hospital wards and clinics. This workstation is not intended for primary reporting of images. It is designed to facilitate the secondary viewing of digital images alongside any radiology reports generated through the reporting workstation. It therefore acts as an interface to the archived files, to bring the images quickly and effectively onto a display monitor for review.

## **Quality assurance workstation**

The PACS quality assurance workstation can either be alongside the image acquisition device itself, with direct connections, or be independently located from the modality, resulting in remote use and connections. The quality assurance system is used to check the quality of each image prior to the transfer of the image to the PACS storage and archive system. The functionality and features associated with this particular tool concentrate on image manipulation, annotation, quality assurance and monitoring.

## **National guidance**

The National Programme for Information Technology (NPfIT) is intended to create a coherent IT infrastructure across the NHS. As of 1<sup>st</sup> April 2007, accountability for the delivery of the NPfIT transferred from NHS Connecting for Health (CFH) to Strategic Health Authorities (SHAs) as part of the NPfIT Local Ownership Programme (NLOP). CFH therefore strongly recommended that you seek advice from your local SHA / NPfIT regarding procurement of IT software and connectivity to any PACS delivered by a local service provider (LSP). CFH have advised that any application software procured for use in an LSP NPfIT environment would need to meet not only the CFH information governance requirements [1], but any other relevant requirements and standards (e.g. N3 connectivity requirements) that CFH or the LSP might impose.

Workstations fall within the scope of the Medical Devices Directive, 93/42/EEC [2] concerning the placing on the market of medical devices. This ensures that the device is fit for the purpose stated by the manufacturer. PACS workstations and the associated software are classified as class IIa medical devices.

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## Introduction

The PACS reporting workstation has developed into the 'standard' configuration for wider distribution across healthcare settings. The system will usually drive two primary class monochrome display monitors and one secondary class colour display monitor, used for displaying RIS images and others, such as Doppler ultrasound images. Primary class display monitors are those used for the interpretation of medical images and are sometimes referred to as 'diagnostic'. Secondary class monitors are those used for viewing medical images for purposes other than providing a medical interpretation [3].

## Workstations and the DICOM standards

Historically, manufacturers and equipment vendors of medical imaging devices used their own proprietary methods for storage and distribution of digital images. Following discussions between the American College of Radiology (ACR) and the National Electronics Manufacturers Association (NEMA), an ACR-NEMA standard [4] was developed to address the issues of interoperability of devices dealing with medical image data. Subsequently, the standard was renamed Digital Imaging and Communications in Medicine (DICOM) and published to manufacturers and clinicians as a means of bringing clarity and uniformity to the industry.

DICOM specifies the format of the image file structure, as well as specifications for the organisation, storage, retrieval and transmission of the DICOM image files. Each radiology examination is described as a 'Study' containing one or more 'Series' which contains one or more 'Images'. Each study, series and image has a unique identifier specified by the DICOM standard, consisting of groups of digits separated by a point, eg 1.2.840.113619.2.67.2158294438.16324010109084413.245

A single DICOM image file is made up of two parts.

- The header holds the metadata, which is the information associated with the image. Metadata include patient information, organisation data and imaging parameters, as well as information that is used in the interpretation and display of the pixel data. These can also contribute as a method of identifying the image.
- The pixel data, which constitute the image itself.

Workstation software uses the header data from the image to display the image. The data in the header, for example, about the position of the patient for a CT scan, (whether prone or supine; head first or feet first) will enable the correct orientation and labelling of the scan by the workstation.

## **The database**

The database in PACS stores data about the image. The DICOM standard specifies how the images are stored and location of the image in the PACS archive. DICOM services use a limited number of basic DICOM operations called DIMSE operations. The main ones used for storage and retrieval are:

- C-MOVE - used to copy images, for example from a PACS archive to a workstation
- C-STORE – used to send images from an imaging modality to PACS, or to create a mechanism for C-MOVE
- C-FIND – this takes parameters and searches the PACS database to find a match. Initially it was used as part of the query / retrieve service, but is now also used in modality worklist and general purpose worklist services.
- Query / retrieve – is a combination of C-FIND and C-MOVE, to find and transfer the study to the workstation or device.

## **DICOM conformance**

DICOM conformance statements are produced by vendors for each specific implementation of the technology, such as for a workstation. These statements specify the service classes, information objects, and communication protocols supported by the system. The statement specifies how each item of equipment related to the imaging device will adhere to the various parameters approved by the DICOM standard. This then results in a DICOM conformance statement for each component of the system, which can be accessed, published or audited as required.

## **Network image distribution**

Various mechanisms are used in transferring the images from the PACS archive to the viewing workstation. The workstation application is run on individual personal computers (PCs). The query or retrieve message is sent to the PACS image server. The correct study is located from archive and returned to the requesting workstation. The full DICOM image can then be viewed by the user on the workstation, where the range of tools to view the image is also installed. The database query function and image files themselves generally contain large amounts of data, usually requiring each workstation to be of a higher specification than standard desktop PCs.

## **Web browser technology**

Initially, web browser technologies to view medical images were developed as a solution to the problem of viewing these outside the imaging department. Web

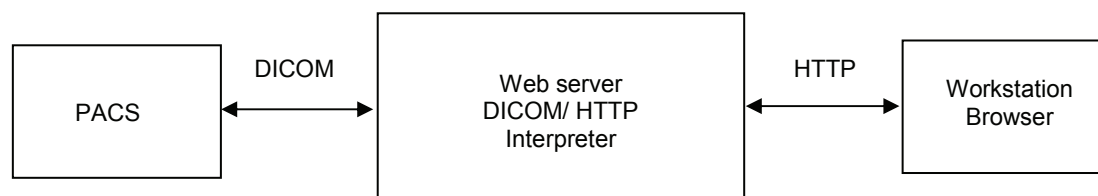


browser technology has since become widespread in use and is now found on PACS review workstations in clinics and on the wards.

The web browser is a software application that communicates with a web server using the Hypertext Transfer Protocol (HTTP) and renders webpage files written using the hyper text mark-up language (HTML), XHTML (eXtended HTML) and extensible mark-up language (XML).

The web browser supports jpeg image rendering and therefore the PACS web server is able to convert the DICOM image into a jpeg image. A link is then created to the image on the web server and embedded into an html webpage, which can easily be sent and accessed by any user with access to the internet. PACS software technology has a component-based architecture, and the display components used in the workstation software can be deployed in web browsers to facilitate remote viewing. The workstation tools can be added to the browser with the use of 'plug in' applications, usually in the form of JAVA, COM or ActiveX components. These additional components installed onto the PC are designed to expand the capability of the browser technology, so that the full DICOM image can be viewed together with the same tools and functionality available to the standard workstation user.

**Figure 1. PACS web server concept**



Many of the major PACS vendors now use a form of the component-based web browser. One advantage of this change in technology is that the component part of the browser can be updated remotely from the web server, thereby making software upgrading simpler and quicker to administer.

## **Thin client applications**

With a thin client application, the imaging application is run on a central server. The user's machine acts like a remote 'client', with the image processing taking place on the application server and database systems. The client PC relays the data instructions from the client to the server. The server then interprets these instructions and performs the required action, for example to locate a specific image and return to the client. The image data will then be sent back for the user to view or amend as required. There is a real-time connection between the client and the server, where the server is able to interpret and update client machine data in a constant stream,



thereby giving the user the impression of using a local machine. As with component-based web applications, the client software may also be run on a web browser.

The advantages to this method are:

- CPU intensive work (such as 3D reformations) is performed on the server, so the client machine does not require a high specification in terms of processor type or memory
- upgrades and software administration can be managed centrally
- easier control of licensing arrangements
- it changes workflow to allow access remotely and from different hardware platforms

One disadvantage to this configuration of the PACS is that if the server breaks down, then all the reporting workstations will be affected. This disadvantage can quite easily be overcome through the use of back-up servers.

Many vendors offer a choice of web enabled and thin client technology.

## The display monitor

The display is the focal point of the workstation for the user. Display monitors on the market use thin film transistor (TFT) liquid crystal display (LCD) technology. The LCD is constructed from a matrix of pixels, which are each addressed individually using thin film transistor technology. This technology has the advantage of the display monitors taking up less desk space, as well as consuming less power than the cathode ray tube (CRT) models used previously.

Two principal display types may be used on reporting workstations.

- Consumer displays - which are standard colour displays used with personal computers and are often used with a workstation to display the RIS information and colour images.
- Monochrome high resolution medical displays - generally used to view the greyscale medical images.

While both types of display use the same fundamental technology, the construction of the monochrome display differs from that of the consumer display in a number of ways. In a colour display, each pixel is composed of three individual sub-pixels, one each for the red, green and blue (RGB) components of the colour of the individual pixel. The intensity of each sub-pixel affects the colour of that pixel. Consumer colour displays use 8 bits to represent each RGB component in a pixel, or 256 levels of brightness, giving a total of 16,777,216 different colours available per pixel. However,

this only equates to 256 shades of grey, as each sub-pixel contributes equal intensity to create a grey shade on a colour display.

In the monochrome display, the colour filters are absent, so each of the three sub pixels contribute proportionately to the intensity, giving an increased number of shades of grey. Medical images often use 10 or 12 bits to describe each pixel with 1024 and 4096 shades of grey respectively. The monochrome display is able to accurately display these, whilst an 8 bit colour display has to use a look up table (LUT) to map the pixel values. Monochrome displays also have sophisticated stabilisation control circuitry and built in sensors to maintain a consistent light output and aid quality control. There has recently been a move towards high resolution colour medical displays with 10 bit capability, which can be calibrated to the DICOM Grayscale part 14 standard, with similar luminance and contrast ratios to the monochrome displays.

## **Display card**

Standard graphics display cards may be used for the consumer display, but to display 10 and 12 bit images on the monochrome medical displays, special display cards are required. These include a three head display card, which has controllers for two 10 or 12 bit high resolution monochrome displays and one for a colour consumer display.

## **Quality control**

Calibration of the displays ensures that images are viewed under consistent conditions. The standards specify a function that relates pixel values in an image data file to luminance values displayed to an observer. There are a number of different calibration standards for medical displays. The DICOM part 14 greyscale display function [5] specifies a standardized display function for the display of greyscale images and is commonly used for calibrating monochrome PACS displays. DIN 6868-57 is a standard mandated in Germany, and displays from Germany may be calibrated to the DIN standard rather than DICOM part 14. The medical displays are initially calibrated at the factory to one of the standards, usually DICOM, and the calibration should be checked regularly. The display manufacturers supply tools for checking the calibration of their displays, some of which can be performed remotely, over the network.

There are also guidelines published by the American Association of Physicists in Medicine (AAPM) [3] for the assessment of display performance that should be used for calibration and QA procedures. In the UK, the Institute of Physics and Engineering in Medicine (IPEM) has published guidelines on quality assurance of displays [6]. The NHSBSP has also included guidance on the QA of mammographic displays [7].

The Royal College of Radiologists has also published guidelines on displays and quality assurance of monitors [8].

Other documents from the International Electrotechnical Commission (IEC) will also aid purchasers in carrying out constancy tests [9, 10].

### Display characteristics that influence image viewing

**Screen resolution:** The resolution of a display is quoted as the number of horizontal pixels multiplied by the number of vertical pixels. LCDs have a fixed resolution and while it is possible to run the display at a lower resolution, it is not recommended. Medical device resolution is described differently to consumer displays and Table 1 compares these two types. Display sizes are quoted as the screen diagonal of the display, with most 2MP and 3MP displays being 20"-22" (50 to 53cm) for a monochrome primary display and 15"-17" (36 to 41 cm) for the secondary display.

Table 1. Display resolution comparison

Medical displays		Consumer colour displays	
Description	Pixel resolution	Description	Pixel resolution
		XGA	1024 x 768
1MP	1280 x 1024	SXGA	1280 x 1024
2MP	1600 x 1200	UXGA	1600 x 1200
3MP	1536 x 2048	QXGA	2048 x 1536
4MP	2560 x 1600	WQXGA	2560 x 1600
5MP	2560 x 2048	QSXGA	2560 x 2048
6MP	3280 x 2048		

**Contrast ratio:** The ratio of intensity between the brightest white and the darkest black of a particular display device or image. Studies have shown that with increased contrast ratio, the ability to perceive these differences is increased. Both medical and consumer displays have contrast ratios in the range of 750 to 900:1. However, this is only when the screen is viewed at 90°. There is loss of contrast and brightness when the screen is viewed at an angle.

**Luminance:** How bright the screen needs to be is dependent on viewing conditions and the amount of ambient light in the viewing area. Too bright a screen can lead to eye fatigue after a period of time. Medical displays are capable of luminance levels up to 1000 candelas per square meter (cd/m<sup>2</sup>). The displays may be calibrated at 450 cd/m<sup>2</sup> so that as the backlight dims over time, the internal electronics of the display can compensate to keep the luminance constant.

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## Workstations and RIS

While the main function of the reporting workstation is to view and manipulate the images, other information such as the patient's imaging history, previous images, reports and electronic request form can also be accessed. This type of information is often also stored on the radiology information system (RIS). It is therefore important that the RIS and the PACS reporting workstations are synchronised, so that the information relating to the patient and any relevant studies are up-to-date and correct. There are a number of methods used to achieve this.

- The workstation can directly access the data held in the RIS using a messaging interface with the RIS database. The information will then be displayed on the workstation display.
- A copy of the RIS application runs on the third display of a workstation and the information required is displayed as a result of the messages from the RIS application accessing the database. The received data are displayed on the workstation via this application.
- Alternatively, the systems can be integrated, with the work list being driven by the RIS, allowing the workstation to display the study information when selected.
- The RIS data could be stored directly onto the PACS, where they would be accessible to the workstation via the PACS applications, without the need for RIS access.

## Integrating the Healthcare Enterprise (IHE) and workstations

Integrating the Healthcare Enterprise (IHE) [11] is a joint initiative of the Radiological Society of North America (RSNA) and Healthcare Information Management Systems Society (HIMSS), designed to encourage manufacturers to develop DICOM and HL7 compliant equipment and information systems for clinical use. IHE created a process by which interoperability can be implemented through the use of technical frameworks, which specify a common vocabulary using standards such as DICOM and HL7, to create well defined clinical transactions. The objective of this initiative is to encourage manufacturers in the digital imaging arena to design and develop systems which can be sufficiently integrated to be interoperable in the clinical setting. (See *Appendix 3: Purchasing and IHE.*)

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## Introduction

The range of tools and functions used for viewing and manipulating images on a reporting workstation is one of the most important features to consider when choosing workstation software. There are, however, many other factors relating to the software itself, and the operating environment, which should also be considered.

## The reporting workstation

When individual users log onto a PACS reporting workstation, they will simultaneously access the PACS and the RIS. All three systems should be capable of being accessed through a single log-in.

There should be no significant delay to a user retrieving a study for display either from an ad hoc search enquiry, or a worklist request. Three seconds for the first image to be displayed is generally considered a reasonable timescale for the query, although studies with a large number of images or data, or CT images in particular, may result in a longer timescale for the retrieval process, resulting in a delay to the images being displayed on the user's screen. Using the image data for 3D work, such as multi planar reformat or volume rendering, requires the entire data set to be loaded and so will also take longer than other functions. All images should be displayed on workstation screens in accordance with the display protocol contained within the system. Where available, previous images and reports will also be available for selection and comparison. Comparing images is a straightforward process, requiring a minimum amount of user interaction.

PACS workstations also have functionality to access other types of patient data, such as blood test results, pathology and emergency notes. Access to electronic libraries, the internet and decision support tools can also be supported by the workstation, which is especially useful when using a workstation for multi-disciplinary teams operating in various clinical settings. In some instances, the PACS supplier may be reluctant for additional tools to be added onto the workstation PC. This is usually due to concerns that these can affect the performance of the system, or add to the operational risk of downtime, which could cause a problem in meeting service level agreements (SLA) for data retrieval.

Studies have shown that that a large amount of diagnostic information is extracted from the first few seconds of viewing so the more useful information that is made available to the user during the initial image presentation, the more likely it will be interpreted correctly [12]. In order to present this useful information, it is crucial to have a well designed workstation-user interface.

The user interface design should be intuitive, with an emphasis on minimising mouse movements and clicks.

Individual users are able to customise their own interface settings, such as hanging protocols and display settings, so as to allow easier and quicker navigation around the system in relation to specific job roles. Shared workstation environments can be designed to facilitate all of these elements, so that all workstations hold individual setting information.

The National Diagnostic Imaging Board (NIB) has issued guidance on radiology reporting times best practice [13]. PACS facilities and reporting systems, should help departments to reduce reporting times, ensuring achievement of the 18 week patient pathway.

## Location and environment

Layout and working practices can significantly influence the effectiveness and use of PACS workstations, regardless of whether the workstations are located in an individual's office, shared between users, or used in workstation clusters. For optimum reporting conditions, the room or environment housing the workstation should have a dimmable lighting system and the displays themselves should be positioned in such a way that light sources, such as lamps and windows, are not reflected onto the display screen. The ambient lighting in the room can affect the perceived image quality. Studies [14] have found that background lighting of around 25 to 40 lux aids visualisation. The average office lighting is around 400 lux, therefore controlled and significantly lower lighting levels are required to optimise image visualisation.

The furniture used in conjunction with the workstation should allow for height adjustments, particularly if the workstation is used by a number of different users. Health and safety best practice indicates that the height of the display screen and any associated seating should be adjustable to each different user's build and height. Specific information relating to the safe use of displays and computers can be found on the Health and Safety Executive web site [15]. Guidance is also available from the RCR [16] and the International Organisation for Standardisation (ISO) has produced 9241-300 [17].

## Reporting workstation tools

An outline of the tools available on PACS workstations, which facilitate viewing and manipulation is provided in tables 2 to 4.

## Viewing images

Medical images may be viewed in a number of different ways.

- **Tiled:** A sequence of images is viewed in a grid format on the display screen. This method is commonly used to view multi-slice studies, such as those captured during CT or MRI scans. Users can quickly and easily view a large number of images by scrolling forwards and backwards. Double clicking on an image will bring the selected image into a bigger window for closer viewing and manipulation.
- **Stack:** Refers to the system displaying a sequence of images, viewed consecutively, in a single window. Again, this type of view is commonly used in conjunction with CT and MRI images, as there is the ability to compare scans efficiently by synchronising so that both series can be scrolled simultaneously on the user display.
- **Cine:** Allows image sequences to be viewed in rapid succession.



**Table 2. Radiology workstation tools – image manipulation**

Image manipulation tools	
Window level/width	This controls the range of image pixel values displayed on the monitor. The size of this range is defined by the window width, and the centre of the range is defined by the window level. The result of varying the window width/level is analogous to varying the brightness and contrast controls on a television monitor. As well as providing manual controls for adjusting the window width and level, controls are provided for preset values which may be determined by the user and by the mode of the image being viewed. For example, if the image being viewed is a CT image, options for viewing chest images, lung window settings and mediastinum settings are provided.
Magnifying tool	This is a virtual magnifying glass. The position of the magnifying tool is determined by the mouse position and the size of the window and amount of magnification can usually be varied.
Zoom/pan	Zoom magnifies the entire image. The degree of magnification can be varied and zoomed image can then be moved around by using the pan tool.
Toggle overlay	Displays and hides patient and examination related information as an overlay on the image.
Toggle annotations	Displays and hides user annotations as an overlay on the image.
Flip/rotate	The currently displayed image may be flipped horizontally or vertically, and rotated clockwise or anticlockwise.
Invert greyscale	Light grey shades in the image are swapped for dark grey shades, and visa versa.
Region of interest	The display of the image pixel values in a user-selected region of the image to be optimised. Regions may be rectangular or circular and polygon for irregular shapes. Measurements displayed depend on the modality but usually include the area and size with additional information such as mean, maximum, minimum and standard deviation for the Hounsfield units for CT.
Histogram	Displays a graph of image pixel values along a line drawn on the image by the user.
Pseudo colour	The greyscale values of each pixel are converted to colour resulting in easier differentiation of structures with low contrast.
Image filters	Filters may be applied to the displayed image to aid in diagnosis. Examples of image filters are smooth, sharpen and edge enhancement.
Digital subtraction angiography (DSA)	Usually, only the subtracted images would be viewed. However it may be carried out at the PACS workstation freeing-up the DSA workstation and suite.
Image merge	One image may be overlaid on another for direct comparison of anatomical structures. (See fusion)
Image crop	A tool used to remove the area of the image located outside a user selected region.
Image stitch	Images may be stitched together to form a larger image.
Patient anonymisation	Used to remove any patient identification information from an examination before exporting the examination for teaching or demonstration purposes.
Hanging protocols	Also known as display protocols. These settings control how image series are displayed.

Apart from simply manipulating the display of an image, most PACS software includes tools to make measurements and extract statistical information from the image data. Measurements are normally made by drawing on the image using the selected measurement tool. These drawings are shown and hidden by selecting the 'Toggle annotations' tool and the annotations may normally be saved and recalled at a later date.

**Table 3. Radiology workstation tools – image measurement**

Image measurement tools	
Elliptical tool	Measures the area of a drawn ellipse on the image. Some elliptical tools also display statistical information regarding the pixel values within the drawn ellipse.
Rectangle and Polygon	These tools measure the area of a drawn rectangle or polygon on the image. As with the "Elliptical" tool, some rectangle and polygon tools can display statistical information regarding the pixel values within the drawn shape.
Pixel or Point tool	Displays the x-y position and original greyscale or Hounsfield value of the pixel under the mouse pointer.
Calibrate image	This tool used to calculate the scale of a digitised image, therefore allowing accurate measurements to be made by the measurement tools
Annotation	Annotation allows user comments to be added to an examination. The note is displayed as an annotation and is saved when the examination is closed.
Multi-slice tools	
Series synchronization	Multiple series may be synchronized so that as the user scrolls through the images in one series, the other series' auto scroll. All of the series therefore display images from similar levels in the body.
Cine	Multi-slice examinations may be viewed as an animation, i.e. the images from a series are scrolled through without any interaction from the user.
Key images	Identification and display of key images allows significant images in a series to be flagged for printing or quick future retrieval. The latter allows key images to be retrieved without having to navigate through all the images in a series.
Show reference lines	Displays the position on the scout image of the cross-sectional images. Normally the first, last and currently displayed cross-sectional images are highlighted.
Display or remove scout view	Display or remove the scout image in a multi-slice examination. Some software able to create a scout view from the original axial data.
Multi-planar reformatting (MPR).	MPR is used to reformat a volumetric data set in any user-defined plane
Maximum intensity projection (MIP)	MIP is used to reformat projection images of a volumetric data set showing only those voxels with the highest values. The direction of projection can be altered to produce images from any user-defined viewing angle.

**Table 4. Radiology workstation tools – advanced visualisation**

Advanced visualisation tools	
Fusion	A technique where images from two different modalities overlay each other, PET and CT scan fusion being the most common.
Computer aided detection or diagnosis (CAD)	Computer aided detection or diagnosis is a tool used to alert the radiologist to potential pathological structures in the image. At present, the most successful use of CAD has been in the detection of suspicious micro-calcifications and masses in mammography. However, there have also been a large number of studies investigating the application of CAD in lung CT and virtual colonoscopy.
Vascular analysis software	<p>There are a number of tools for vessel analysis including:</p> <p>Vessel analysis tools – These allow the user to measure stenoses and analyse the type of atheroma.</p> <p>Calcium Scoring - A technique where amount of calcium detected in the coronary arteries from a CT scan is converted to a calcium score which correlates with the severity of the blockage. The results are reported on a numerical scale.</p> <p>Automatic vessel segmentation and labelling.</p> <p>Cardiac function measurements such as ejection fraction.</p>
Perfusion	<p>Perfusion is a technique in CT, MRI and nuclear medicine scanning where a sequence of scans are performed at set intervals using intravenous contrast media for CT and MR and radio-isotope tagged medium in nuclear medicine. The blood flow through the region over time is mapped. Examples of perfusion are:</p> <p>Brain – MR and CT perfusion scans may be used to assess the brain to aid stroke management.</p> <p>Breast – MR perfusion of the breast may be used detection and classification of breast tumours.</p> <p>The use of perfusion in CT scanning of the colon and the liver perfusion is also being assessed.</p>

When a PACS is installed, the workstations are supplied by the PACS vendor. The first consideration is therefore to look at the costs of the existing PACS supplier's workstation products, where the main advantage will be minimal compatibility issues. Users should require less training to use the new workstation, as in most cases the software should be familiar to them. In some instances, a software addition may be all that is required to bring about the change, with no need for extra hardware. Maintenance costs can be aggregated with existing products.

Additional cost considerations for the purchase of PACS workstations include:

- integration costs. Design and development time will be associated with the integration of PACS to any other systems (such as RIS), which could result in additional charges being incurred to consult on and implement any changes in relation to the development of the application to facilitate the integration.
- hardware. Vendors often supply the hardware (PC and displays) associated with the PACS system as a contract 'package'. The advantage to choosing this purchasing / contract option is that the software/hardware combination used by the vendor has been tried and tested, and therefore should result in less problems with the installation and set-up of the workstations themselves. A number of smaller suppliers will also offer the service of installations onto hardware supplied by the trust or clinic. This could be a cheaper purchase option, but may take longer to set up if there are hardware inconsistencies, leading to higher integration costs.

## Licensing

Choosing an appropriate licensing model will result in the most cost-effective option according to individual trust and user needs. The licensing types available are listed below.

- Single product licence. This option requires each individual workstation with PACS software installed to have an individual licence. This would be appropriate for use where budgets may be dispersed, or there are relatively small numbers of workstations required.
- Concurrent licensing. Different providers use different terminology regarding concurrent licensing, it is therefore important that the user understands the implications of buying such a licence. The licensing is controlled centrally. Multiple copies of the workstation software can be installed, but the number which can be used at the same time is limited by agreement between the vendor and trust. For example, ten PCs may have the application loaded, but if the licensing agreement covers only five concurrent users, the sixth user would then need to wait until one of the five users had logged off before the

system would allow them to access the system. Other providers describe concurrent licenses as being related to the precise time of logging on. It is worthwhile looking at all the various licences available before buying a system as changing licences at a later date could be costly.

- Site licence. The licence agreement will apply to the whole site and will generally allow for unlimited access across the site for a set fee. The software can be loaded onto any number of workstations, with an unlimited number of users for instant access and use when required. This type of access would generally be recommended where there are high volumes of staff members requiring access to the system concurrently, and where the use of the system has been fully integrated into working practices.

## National guidance - STEP

The Standards Enforcement in Procurement (STEP) process was developed to ensure that IT systems within the National Health Services in the United Kingdom conform to agreed standards. The process details the standards with which suppliers have to conform and provides supporting guidance [116]. Suppliers of IT systems must complete a STEP questionnaire. Their responses will generally form part of the procurement contract.

## NHS Connecting for Health (CFH) and the National Programme for IT (NPfIT)

Accountability for the delivery of the National Programme for IT has been transferred to the Strategic Health Authorities (SHAs) as part of the NPfIT Local Ownership Programme (NLOP). Connecting for Health is working closely with the 10 SHAs in ensuring activities with LSPs continue effectively. Three geographic areas have been established, linking the LSPs and SHAs together:

- North, Midlands and East Programme for IT (NMEPfit) with six SHAs and Computer Sciences Corporation (CSC) as the LSP;
- London Programme for IT (LPfit) with one SHA and BT as the LSP
- Southern Programme for IT (SPfit) with three SHAs. At the time of writing a new LSP has yet to be selected.

Not all commercially available workstation products are necessarily included in each LSP's catalogue; as such items may directly affect their service level agreements (SLAs). Prospective purchasers of workstations and related products might wish to seek guidance from their local SHA on the available options. It is not compulsory to purchase products in this way and purchasers are free to source products in whichever way is most convenient and economic for them.

## Interoperability considerations

Advice on purchasing new equipment that uses patient-related data and that may be required to interoperate with other new or existing equipment has been produced by the IHE-UK Technical Committee. This advice is reproduced in appendix 2.

## Purchasing procedures

The Trust Operational Purchasing Procedures Manual provides details of the procurement process [19].

European Union procurement rules apply to public bodies, including the NHS, for all contracts worth more than £90,319 (from January 1<sup>st</sup> 2008) [20] (appendix 1). The purpose of these rules is to open up the public procurement market and ensure the

free movement of goods and services within the EU. In the majority of cases, a competition is required and decisions should be based on best value.

NHS Supply Chain ([www.supplychain.nhs.uk](http://www.supplychain.nhs.uk)), a ten year contract operated by DHL on behalf of the NHS Business Services Authority, offers OJEU compliant national contracts or framework agreements for a range of products, goods and services. Use of these agreements is not compulsory and NHS organisations may opt to follow local procedures.

## **Sustainable procurement**

The UK Government launched its current strategy for sustainable development, Securing the Future [21] in March 2005. The strategy describes four priorities to progress sustainable development:

- sustainable production and consumption – working towards achieving more with less
- natural resource protection and environmental enhancement – protecting the natural resources and habitats upon which we depend
- sustainable communities – creating places where people want to live and work, now and in the future
- climate change and energy – confronting a significant global threat.

The strategy highlights the key role of public procurement in delivering sustainability.

## **Workstations and sustainability**

Workstations are a combination of component parts from various suppliers. The constituent parts are the computer, which itself is made up of various discrete components, the motherboard; processor, memory, hard disk, etc. and the displays. The manufacturers of the computer and display equipment each have their own guidelines as to the disposal of its products.

## **End-of-life disposal**

Consideration should be given to the likely financial and environmental costs of disposal at the end of the product's life. Where appropriate, suppliers of equipment placed on the market after the 13<sup>th</sup> August 2005 should be able to demonstrate compliance with the UK Waste Electrical and Electronic Equipment (WEEE) regulations (2006) [22]. The WEEE regulations place responsibility for financing the cost of collection and disposal on the producer. Electrical and electronic equipment is exempt from the WEEE regulations where it is deemed to be contaminated at the point at which the equipment is scheduled for disposal by the final user. However, if it is subsequently decontaminated such that it no longer poses an infection risk, it is



again covered by the WEEE regulations, and there may be potential to dispose of the unit through the normal WEEE recovery channels.

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**3D data set** The complete set of images that make up the data volume. For example, in CT this is usually the full series of axial images acquired by the CT scanner.

**3D render** see volume rendering

**Application specific integrated circuit (ASIC)** An integrated processor chip that is designed for a specific application as opposed to a general purpose central processing unit (CPU). This means there are lower performance overheads over that of a general purpose CPU.

**Batch reformat** A series of MPR or MIP images reformatted at set distances.

**Base T switched full duplex** An implementation of Ethernet that uses twisted pair cabling, segments the network using a switch and allows nodes on the network both to transmit and receive data packets simultaneously

**BMP** Also known as bitmap, this is a file format used to store digital image data. It is a simple format that is easy to implement and is very portable between different systems. Its primary disadvantages are the large size of the files when compared to other image data storage formats and the limited information that can be stored in the file header.

**Cathode ray tube (CRT)** A vacuum tube in which a beam of electrons is focused onto a fluorescent screen, so producing a spot of visible light. Moving this beam around the screen, and varying its intensity, produces images.

**Central processing unit (CPU)** Often referred to as “the processor,” this is where calculations take place in a computer. On larger systems such as servers, there can be more than one CPU found on separate circuit boards; on smaller systems such as desktop machines the CPU is found in a single chip called a microprocessor. The CPU consists of two components: the arithmetic logic unit (ALU) which performs all logical and arithmetic operations, and the control unit, which receives instructions from memory, decodes and executes them.

**Client / server model** In the client/server model, a server waits for requests from clients, and after receiving such a request, processes it and sends a response. The communication between the two peers is based on a protocol, which defines the possible interaction patterns and the information being exchanged.

**Curved planar reformatting** The curved reformat projection allows the user to trace a path along a curved object, usually a blood vessel. The view is used to ‘straighten out’ the vessel and more accurate measurements may be made of the vessel.

**Digital Imaging and Communications in Medicine (DICOM)** The AC-NEMA standard protocol adopted by manufacturers of equipment associated with medical

imaging. The standard provides a method of linking a series of heterogeneous modalities, workstations and printers without the need for customised hardware to allow them to communicate and transfer images

**Extensible Markup Language (XML)** A general-purpose specification for creating custom markup languages. The user defines the mark-up elements. By encoding documents in XML information systems are able to share structured data, especially via the internet.

**Extensible Hypertext Markup Language (XHTML)** A markup language that has the same depth of expression as HTML, but also conforms to XML syntax.

**Gigabyte (GB)** A unit of computer data storage. When referring to data storage and file sizes it is equivalent to  $1024^3$  bytes and for other uses it is usually equivalent to  $1000^3$  bytes.

**Health Level 7 (HL7)** The international standard protocol for the exchange of data between information systems in healthcare.

**Hounsfield Unit** Used in the display of CT images, the Hounsfield Unit is a normalised index of X-ray attenuation, based on a scale of -1000 (air) to +1000 (bone), with water being 0.

**Hot swap disks** The hard drive or similar device may be removed or replaced while the computer system is still in operation. The drive is enclosed in a device that allows easy removal from the computer system.

**HyperText Transport Protocol (HTTP)** A communications protocol used for retrieving inter-linked text documents.

**Hyper text mark up language (HTML)** is the predominant mark up language for web pages. It is written in the form of tags, which are used to describe the structure of text-based information in a document by denoting certain text as links, headings, paragraphs, lists, interactive forms, images. It can also describe, to some degree, the appearance and semantics of a document, and can include embedded scripting language code (such as JavaScript) which can affect the behaviour of Web browsers and other HTML processors.

**Internet Protocol (IP) address** An identifier for a computer or device on a TCP/IP network. Networks using the TCP/IP protocol route messages based on the IP address of the destination. The format of an IP address is a 32-bit numeric address written as four numbers separated by periods. Each number can be zero to 255. For example, 1.160.10.240 could be an IP address.

**JAVA** A high level programming language which enables the programmer to associate a set of procedures with each type of data structure. The code is platform independent as the code is run on a 'virtual machine' that interprets the code for the system being used.

**Joint Photographic Experts Group** A standards committee which created the JPEG and JPEG 2000 standards.

**JPEG** A data storage format used to store image data files. The JPEG algorithm allows for data compression using both lossy (i.e. information is lost during the compression process and the original file cannot be reconstructed exactly) and lossless (i.e. no information is lost during the compression process, allowing for exact reconstruction of the original file) techniques. The JPEG compression algorithm was developed by the Joint Photographic Experts Group.

**Keyboard shortcut** A key or set of keys on a computer keyboard that performs a predefined function. These functions can often be done via some other, more indirect mechanism, such as using a menu and/or using a mouse. By reducing such sequences to a few keystrokes, this can often save the user time.

**Liquid crystal display (LCD)** A display device utilising liquid crystal technology. These devices are generally thinner and lighter than equivalent displays manufactured using cathode-ray tube technology.

**Maximum intensity projection (MIP)** Maximum intensity projection is used in medical imaging to visualize blood flow. MIP finds the brightest voxels in the volume, the voxels lying in front of and behind the bright voxel are not displayed. As a result depth information is lost but density information is preserved.

**Maximum Intensity Projection (MIP)** is used to reformat projection images of a volumetric data set showing only those voxels with the highest values. The direction of projection can be altered to produce images from any user-defined viewing angle.

**Megabit (Mb)** A unit of data measurement commonly used when referring to data transfer. One megabit is 1,000,000 bits. Networks are often described in terms of their data transfer speeds which can be measured in megabits per second (Mbps,  $\text{Mbs}^{-1}$ ).

**Modality** A modality is a device that generates digital medical images and also other information such as measurements. Examples are computed radiography devices, computed tomography scanners, ultrasound scanners.

**Mouse** A device that when rolled, usually by hand, along a flat surface directs an indicator to move correspondingly about a computer screen. This allows an operator

to move the indicator freely and, in conjunction with one or more buttons on the device, to select operations or manipulate text or graphics.

**Multiplanar reformat (MPR)** MPR uses the slice images that have been acquired in one plane (e.g. axial) to reconstruct other slice images in other planes (e.g. sagittal and coronal).

**National Programme for IT** A programme within the English National Health Service (NHS) in England to move towards an electronic care record for patients and to connect General Practitioners to NHS hospitals Trusts. Connecting for Health is responsible for delivering this programme.

**Operating system** The software component of a computer system that is designed to control the hardware of that system in order that other programmes and system users may use it.

**Picture archiving and communications system (PACS)** A computer-based system that enables for the storage, distribution and display of medical images within a hospital department, a hospital or across multiple sites.

**Patient administration system (PAS)** A hospital computer system which allows for the storage and retrieval of data concerning patients and their attendances at the hospital. The PAS may exchange data with other hospital systems, e.g. a PACS.

**Personal computer (PC)** A computer that is economically cheap enough and physically small enough to be viable for the sole use of an individual. The abbreviation 'PC' is often used to refer specifically to an IBM PC compatible computer (i.e. one running Microsoft Windows).

**Random-access memory (RAM)** A type of computer data storage that allows the stored data to be accessed in any order and retrieved in constant time, irrespective of the physical location of the data within the storage. Random-access memory is usually volatile, i.e. its contents are lost when power to the storage is removed.

**Red green blue (RGB) colour component video** A type of video signal used in electronic displays. The video signal consists of three components – red, green and blue – each carried on independent cables and conforming to the RGB colour model. The RGB colour model is a model in which red, green and blue are combined in varying proportions to produce different colours.

**Redundant array of inexpensive disks (RAID)** A RAID is a multi disk system where one or more of the disks provide fault tolerance. A RAID should be able to withstand disk failure and have the ability to reconstruct the data from a failed disk.

**Segmentation** The process in the rendering process whereby the volume data set is analysed and values assigned to points in the data set that defines the anatomy. It's this process that results in the rendered 3D image. The term is also used for the process whereby the anatomy can be virtually dissected; a typical case would be to remove overlying bone structure of the skull to view the cranial arteries in a CT angiogram of the head.

**Server** A computer which controls the function of network resources. A server is often applied to a dedicated task, e.g. a file server controls delivery of files and a network server controls network traffic. However it is possible for servers to fulfil more than one task if they have multiprocessing operating systems.

**Tagged image file format (TIFF)** A file format for the storage of image data. It allows for the image data to be stored within the TIFF file using different algorithms and also allows for multiple images to be stored in a single TIFF file.

**Toolbar** A row or column of icons on a computer screen which activate functions within a computer program, usually when clicked by a mouse.

**Transmission control protocol/Internet protocol (TCP/IP)** TCP is one of the main protocols in TCP/IP networks. Whereas the IP protocol deals only with packets, TCP enables two hosts to establish a connection and exchange streams of data. TCP guarantees delivery of data and also guarantees that packets will be delivered in the same order in which they were sent.

**Thick client** In a network system the main application is performed on the data by the client machine with server in a subsidiary role.

**Thin client** In a network system the main application is performed on the data by the server with client machine in a subsidiary role.

**Volume rendering** A method by which the workstation software is able to generate images of anatomical structures which appear similar to how the eye would view them. The 2D images are generated from an acquired volume of data by simulating the physics of light interaction with the volume.

**Volume rendering** The complete data scene is explored and the contribution of each voxel to the final image is calculated. The rendering algorithm includes factors for voxel value, tissue type and other properties which determine the colour, opacity and hue of the projection. These factors vary according to the application and settings of the visualisation parameters. The additional time and effort in processing the entire data set is balanced by the increased detail available in the presented image; detail of features below surfaces can now be viewed in relation to the surface structures.



**Virtual endoscopy** A rendering technique used to visualise the *inner* surfaces of structures where the lumen is of interest such as the large bowel or the bronchus. The view shown simulates that of an endoscope.

**Workflow** The sequence of actions required to arrive at a desired outcome.

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All URLs assessed on 04/08/2009

## Lease options

National frameworks are in place for operating leases to help the NHS procure leases more cost efficiently and effectively. Further details are available from the PASA website [23].

## EU procedures

The Public Sector Directive (2004/18/EC) has been transposed into UK law. This has been achieved by means of the following statutory instruments:

- the Public Contracts Regulations SI 2006 No.5 (the regulations)
- the Utilities Contracts Regulations SI 2006 No. 6 (not relevant to this guide).

The regulations apply to contracts worth more than £90,319 (from January 1<sup>st</sup> 2008) [20] over their whole life, and specify the procedures to be followed for public sector contracting, including adherence to strict timetables, requirements for advertising, invitation to tender and the award of contract. Organisations undertaking a procurement exercise covered by the regulations must give all suppliers an equal opportunity to express an interest in tendering for the contract by placing a contract notice in the Official Journal of the European Union (OJEU).

At all stages of the procurement process, the purchaser must be demonstrably fair, as any decision made can be challenged by the unsuccessful suppliers.

## Establishing a procurement strategy

To achieve a successful outcome, decisions need to be made on:

- whether an existing contract/agreement can be used
- the need to consider sustainable development issues
- whether EU directives apply
- the type and form of contract
- sourcing potential suppliers
- duration of contract and opportunity to review/extend
- payment schedules
- how to minimise any risks with the chosen strategy, including supplier appraisal and evaluation/clarification of suppliers' bids.

## Preparing a business case

A business case should be drafted and approved before conducting any procurement exercise. Further guidance on preparing business cases is available from the Office of Government Commerce [24] and an illustrative example is provided in the *NHS PASA Operational Purchasing Procedures Manual*, Procedure 1-01 [25].

## The EU tendering exercise

EU procurements usually take between 4 and 6 months to complete. This needs to be taken into account in the planning stages. The length of the exercise depends on the chosen procedure (open or restricted). Further information is available from the Department of Health [26].

## The procurement panel

A multidisciplinary team should be selected to guide the purchase. Representatives from clinical, user, technical, estates and financial areas should be considered.

## Identifying potential suppliers

Criteria for supplier selection must be established. A pre-qualification questionnaire, seeking background information (e.g. on the skills and experience of the service engineers) may be employed as an initial screen to exclude unsuitable suppliers.

## Evaluation criteria

Performance specifications should be derived from local operational requirements, and agreed by the procurement panel. They will form the basis for assessing the adequacy of suppliers' technical specifications, provided in response to the technical specification questionnaire.

It is important to have agreed on the performance specifications of the product as they will be used in the adjudication against company specifications.

Requests for features which are supplier-specific are not permitted under the regulations. Very specific features which are not supported by operational requirements are also not allowed.

## Award of contract

Following award of the contract to the successful supplier; unsuccessful suppliers may need to be debriefed. This is at the supplier's request.

Buyers must be aware of the 'Alcatel' procedure (see the *Trust Operational Purchasing Procedures Manual* [19], Procedure No.T-08, section 6 - '*Mandatory Standstill Period*').

For more information on procurement please refer to the Department of Health Website [27].



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*This document was produced by the IHE-UK Technical Committee and is reproduced with their kind permission. It was written with a Radiology audience in mind but the principles described apply generally.*

## **New Healthcare Equipment Purchase, Existing Equipment and IHE**

### **1 Introduction**

Much modern healthcare equipment relies on the use of patient-related data for its functionality and this data is often received from, or supplied to, other healthcare equipment. For example, a Picture Archiving and Communications System [PACS] may receive information concerning a patient from a Radiology Information System [RIS], or it may receive information concerning an examination from an imaging modality. It is therefore essential that all such equipment can interoperate. Where existing equipment is required to interoperate, the details of the requirements for interoperability between the individual pieces of equipment are usually apparent and the functionality of any necessary interface can easily be specified. However, when specifying new equipment, it is often not clear how the new equipment should be specified in order to ensure interoperability of this new system with further items of new equipment which may be purchased at a later date.

The Integrating the Healthcare Enterprise (IHE) organisation has been established to help improve interoperability between existing pieces of equipment and to help with the specification of new purchases, whether this be to enable the new equipment to interoperate with existing equipment or with possible future purchases.

IHE was established in 1999 by healthcare professionals (represented by RSNA, the Radiological Society of North America) and industry (represented by HIMSS, the Health Healthcare Information and Management Systems Society) to improve the way computer systems in healthcare share information. This is done by promoting the coordinated use of established standards, such as DICOM and HL7, to address specific clinical needs. Information on tried and tested ways to do this is presented in 'IHE Integration Profiles'.

In order to enable the interoperability of systems purchased from different suppliers, it is good practice to specify that the equipment purchased shall be able to support the appropriate parts of the relevant IHE Integration Profiles. This is the case even if it is not intended to use the features of those Integration Profiles immediately. There are a number of reasons for doing this:

- The new piece of equipment can be expected to interoperate with an existing piece of equipment, if the latter supports appropriate parts of the relevant Integration Profile(s).

- It may be that the software of the existing equipment can be upgraded to enable interoperability.
- It is still good practice to specify new equipment that either supports IHE functionality - or can be upgraded so to do - in order to minimise future interfacing costs.

It is expected that in the near future the majority of equipment in use will support IHE integration profiles. New systems should be bought with DICOM services installed and licensed as standard, instead of just being options. When this is carried out it will be easier for newly purchased equipment to achieve interoperability with equipment in place.

## 2 Specifications for new equipment

In order to enable the interoperability of systems purchased from different suppliers, it is good practice to specify that the equipment purchased shall be able to support the appropriate parts of the relevant IHE Integration Profiles. This is the case even if it is not intended to immediately require interoperability of the new equipment with existing equipment. Various situations arise when purchasing new equipment:

- existing equipment supports appropriate parts of the relevant Integration Profile(s)
  - the new piece of equipment can be expected to interoperate with the existing equipment
- existing equipment can be upgraded to support appropriate parts of the relevant Integration Profile(s)
  - the new piece of equipment can be expected to interoperate with the existing equipment (once upgraded)
- existing equipment cannot be upgraded to support appropriate parts of the relevant Integration Profile(s)
  - the new piece of equipment cannot be expected to interoperate with the existing equipment. However, it is still good practice to specify new equipment that either supports IHE functionality or can be upgraded so to do, in order to minimise future interfacing costs.

### 2.1 Specification of immediate requirements

There are two approaches to specifying requirements for new equipment:

- a) Specify that the equipment shall meet the provisions of the relevant IHE integration profiles

b) Specify the functionality required from the equipment.

- For example, an imaging modality may be required both to send its images to a PACS and to be able to query a worklist. The specification should include, for each piece of equipment, the name of the IHE functionality and the name of the relevant IHE integration profile to be supported.

## **2.2 Specification of upgrade requirements**

As well as any immediately required functionality, a tender should include the cost of upgrading the system to have the functionality required to support IHE integration profiles that are desired in the future. Obtaining upgrade costs is recommended even if it is not intended to interoperate using IHE tested communication immediately.

## **3 Specifications for existing equipment**

Existing equipment may or may not meet the provisions of the IHE integration profiles. To enable interoperability, it may be necessary to specify upgrade requirements for existing equipment.

### **3.1 Specification of requirements**

As noted for new equipment (see section 2.1) there are two approaches that can be taken:

- a) Specify that the upgraded equipment shall meet the provisions of the relevant IHE integration profiles;
- b) Specify the functionality required from the upgraded equipment. For example, an imaging modality may now be required both to send its images to a PACS and to be able to query a RIS worklist. The specification should include, for each piece of equipment, the names of the IHE functionality and integration profiles to be supported.

### **3.2 Strategies for achieving interoperability with existing equipment**

Depending on what functionality is available on the existing equipment, there are a number of strategies for achieving interoperability. These include:

#### **3.2.1 Existing equipment supports some IHE functionality**

It may be that the limited IHE functionality available is sufficient to enable interoperability with other systems.

### **3.2.2 Existing system has some DICOM/HL7 support**

The existing system may have functionality that will enable it to meet the requirements of the required integration profile, without following the exact method specified in IHE. Please refer to the IHE Radiology User's Handbook (see *Appendix 2*) for more information.

### **3.2.3 Existing system has no IHE functionality or DICOM/HL7 support**

It may be possible for the vendor to provide a proprietary mechanism for exchanging the information required to achieve a degree of interoperability with other systems.

For each of the above scenarios it may be that the existing equipment vendor, or a third party, can offer an upgrade to provide the necessary IHE functionality.

It may also be possible to translate information output from a modality into a form that supports IHE by means of an interface engine. This interface engine may be called an 'IHE broker'.

## **4 DICOM 'Options'**

- 4.1 DICOM, HL7 and other standards include optional elements within their specifications. Use of IHE reduces the degree of optionality by recommending settings for these options. This helps ease integration between systems that follow the IHE guidelines.
- 4.2 Some degree of optionality does, however, remain within IHE. This allows for choice in precisely which real-world system performs a particular task.
  - 4.2.1 For example, it is possible for a PACS to request that a copy of an examination report is sent from a RIS each time that a copy of the report is required to be viewed on the PACS, or for copies of these reports to be retained within the PACS.

## **5 System evolution**

Over time, it is expected that the systems involved with data exchange will have increasing IHE functionality. This may be as a result of the upgrade of existing systems or the replacement of systems with new systems that more fully support IHE

## 6 Example PACSnet DICOM questionnaire

This questionnaire is designed to be used to obtain information from an equipment vendor regarding the DICOM functionality of the equipment. It asks the vendor to note which DICOM services are available on the equipment and whether the services are included as standard or as an optional extra. It also asks the vendor to note whether the DICOM compliance is full or partial.

The user should replace *[modality]* with the specific make and model of the equipment concerned.

The questionnaire includes the table that the vendor is required to complete and a brief explanation of each of the DICOM Service Classes included in the questionnaire.

### DICOM Questionnaire

Images from the *[modality]* will be required to be sent into an open network environment, initially a Picture Archiving & Communications System (PACS). The industry standard for such communication is DICOM.

DICOM defines Service Classes (Store, Print etc) and Object Classes (*[modality]* Images, Worklists etc.) which are combined in Service Object Pairs (SOPs) for which each device may be one or both of Service Class User (SCU) and Service Class Provider (SCP).

### INFORMATION REQUIRED

Manufacturers are required to provide a response to each of the numbered requirements. The response to each requirement must begin by stating the level of compliance categorised as follows:

Fully compliant

Partially compliant

Non compliant.

The response must be made within the box below the requirement but in a different colour text. Any supporting documentation must be cross-referenced to the relevant requirement(s).

A brief explanation of each Service Class is provided after the table. For more information on DICOM or on the Service Classes listed below, please contact PACSnet ([www.pacsnet.org.uk](http://www.pacsnet.org.uk)).

<u>Service</u>	<u>Compliance</u> <u>(Full/Partial/No)</u>	<u>Included as</u> <u>(standard/optional/no)</u>
1. Modality Push		

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2. Modality Worklist		
3. Print Service		
4. PACS Push		
5. Performed Procedure Step		
6. Storage Commit		
7. Modality Pull		
8. PACS Pull		
9. Modality Verification		

1. <i>Modality Push</i> (DICOM C_Store) This allows the [modality] to send images to the PACS. Therefore, it should be a Service Class User (SCU) of the C_Store service for all applicable Service Object Pairs (SOPs).
2. <i>Modality Worklist</i> (DICOM C_Find) The DICOM Modality Worklist service allows the [modality] to retrieve schedule information and patient demographics at the [modality] console from the PACS to avoid re-entering information. Therefore, it should be a SCU of the C_Find service for all applicable SOPs.
3. <i>Print Service</i> (DICOM N_Get, N_Create, N_Action and N_Set) This enables the [modality] to use any DICOM compatible networked printer. Therefore, the [modality] should be a SCU of all the DICOM print services for all applicable SOPs.
4. <i>PACS Push</i> (DICOM C_Store) This service enables old images to be made available at the [modality] console from the PACS, for comparative studies. To allow for use of this facility, the [modality] should be a Service Class Provider (SCP) of the C_Store service for all applicable SOPs.
5. <i>Performed Procedure Step</i> (DICOM N_Create and N_Set) The DICOM Modality Performed Procedure Step service allows the [modality] to inform the PACS that an examination has been performed. This requires the [modality] to be a SCU of the N_Create/Set service for all applicable SOPs.
6. <i>PACS confirms storage</i> (DICOM N_Action and N_Eventrep) This service allows the PACS to confirm that it has received images and taken responsibility for them. Once the PACS notifies the [modality] that the images are 'committed' to be stored, the [modality] can delete them from its temporary storage. To use this service, the [modality] should provide the DICOM Storage Commitment Service as an SCU to request the guarantee that the images are stored within the PACS.
7. <i>Modality Pull</i> (DICOM C_Find and C_Move) Using the DICOM Query/Retrieve Service, the [modality] can query the PACS regarding previous studies that were performed on a patient and can to retrieve the studies. To do this, the [modality] should be a SCU of the C_Find service and a SCP of the C_Move service for all applicable SOPs.
8. <i>PACS Pull</i> (DICOM C_Find and C_Move) Using the DICOM Query/Retrieve Service, the [modality] can allow the PACS to query the [modality] regarding any images or studies that were performed on a patient and have not yet been sent to the PACS. To do this, the [modality] should be a SCP of the C_Find service and a SCU of the C_Move service for all applicable SOPs.
9. <i>Modality Verification</i> (DICOM-Ping) The DICOM Verification service allows the

[*modality*] to verify the existence and state of its configured destinations. In order to do this, the [*modality*] must be both a SCU and a SCP of the DICOM Verification service for all applicable SOPs.

## 7 IHE Integration Statements and IHE connectathons

### 7.1 IHE integration statements

IHE Integration Statements are documents prepared and published by vendors to describe the intended conformance of their products with the IHE Technical Framework. They identify the specific integration capabilities a product is designed to support in terms of the key concepts of IHE: Actors and Integration Profiles. Links to the Websites of companies that publish IHE Integration Statements for their products are provided on the IHE website.

IHE integration statements are prepared by vendors for each of their products and are specific to a particular item of equipment. They are not subject to external verification.

### 7.2 IHE connectathons

IHE connectathons are held annually in the USA and annually in Europe. An IHE connectathon is a multi-vendor, week-long event, in which vendors bring samples of their systems to test their implementation of IHE with corresponding systems from other vendors. During a connectathon, vendors work together to validate how well their systems can work together and as a result demonstrate that, as individual organisations, they have a full understanding of IHE. Passing a connectathon demonstrates that a company has achieved competence in IHE. It does not validate an individual product or its IHE conformance statement



## 7.3 Overview of IHE Integration Profiles, Actors and Transactions. The Cross Enterprise Document Sharing Profile

### 7.3.1 IHE Integration Profiles

IHE Integration Profiles provide a common language for vendors and purchasers to use in communicating requirements for the integration of products. They describe real-world scenarios and apply to a specific set of 'Actors' and, for each Actor, specify the 'Transactions' necessary to support those capabilities. There are two types of Integration Profile – those that apply within an enterprise and the more recently-introduced inter-enterprise Integration Profile known as Cross-Enterprise Document Sharing (XDS).

Whilst some Profiles will function independently some require other profiles to be operational in order to function themselves. The Actors and Transactions relevant to each Profile are defined in the Technical Framework and are also described in detail in the Radiology User's Handbook (see below). Some established and important Profiles are briefly described below, but this list is not exhaustive and the reader is recommended to consult the resources referred to below for additional information.

*Scheduled Workflow (SWF)* – This establishes the continuity and integrity of basic departmental imaging data, maintaining the consistency of patient and requesting information as well as defining scheduling and image acquisition procedure steps.

*Patient Information Reconciliation (PIR)* – This profiles extends SWF by offering the means to match reports, images and other evidence objects acquired for a mis-identified or unidentified patient (for example, an unconscious patient).

*Consistent Presentation of Images (CPI)* – This specifies transactions which maintain the consistency of presentation of grey-scale images (including annotations, shuttering, flip/rotate, zoom). It also defines a standard contrast curve against which various pieces of display equipment can be calibrated.

*Presentation of Grouped Procedures (PGP)* – This allows the viewing of image subsets resulting from a single acquisition, with each image subset related to a different requested procedure (e.g. CT Chest, CT Abdomen and Pelvis).

*Cross-Enterprise Document Sharing (XDS)* – facilitates the sharing of documents within a healthcare institution or between different institutions. This is done by storing the documents in one or more repositories and storing metadata about the documents, including information about the documents' locations, in a registry. Searching the metadata held in the registry allows the relevant documents within the repository to be discovered and shared. The XDS profile has been extended to add profiles that describe scenarios such as 'including imaging documents' (XDS-I) and 'notification of the availability of documents' (NAV).

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Details of other Integration Profiles such as Access to Radiology Information (ARI), Key Image Note (KIN), Simple Image and Numeric Report (SINR), Post-Processing Workflow (PWF) and Reporting Workflow (RWF) can be obtained from the resources below.

### 7.3.2 Actors

Actors are information systems or components of information systems that produce, manage or act on information associated with operational activities. There are currently 23 Actors defined in IHE and these include:

- Acquisition Modality (e.g. CT scanner)
- ADT Patient Registration – system for adding or updating patient demographic or episode information
- Department System Scheduler/Order Filler – provides functions related to the management of requests from external systems.

### 7.3.3 Transactions

These are interactions between actors that transfer required information through standards-based messages. There are currently more than 60 IHE Transactions including Patient Registration; Placer Order Management; Filler Order Management; Modality Images Stored. For more detail the reader is referred to the resources below.

### Useful resources

The following websites contain more information on IHE and other relevant information:

IHE: [www.ihe.net](http://www.ihe.net)

*This site provides good information regarding Integration Profiles, Integration Statements and Connectathon Results. The Radiology User's Handbook is particularly useful for guiding procurement of equipment with IHE capability and can be found at*

[http://www.ihe.net/Resources/upload/ihe\\_radiology\\_users\\_handbook\\_2005edition.pdf](http://www.ihe.net/Resources/upload/ihe_radiology_users_handbook_2005edition.pdf)

IHE Europe: [www.ihe-europe.org](http://www.ihe-europe.org)

*Provides information specific to European implementations of IHE and details of European connectathons.*

IHE UK: [www.ihe-europe.net/national\\_initiatives/uk.htm](http://www.ihe-europe.net/national_initiatives/uk.htm)

## **Buyers' guide to PACS workstations and software**

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