Picture Archiving and Communication Systems Planning: A Methodology

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This article presents the Picture Archiving and Communication Systems (PACS) planning methodology used by the Department of Defense's (DOD) Joint Imaging Technology Project Office (JITPO). This methodology evaluates four areas of PACS planning and implementation: strategic planning, clinical scenario planning, installation planning, and implementation planning. The first task is to develop a PACS team, from the local facility, that will execute the program. A written PACS plan is developed by the JITPO, with active input and final say from the site's PACS team. This plan includes the PACS goals and objectives, clinical requirements, facility requirements, and the status of the implementation. This methodology, when applied fully at a military clinical site, has resulted in the site obtaining best "value" in terms of cost and performance by requiring the DOD's contracted PACS vendors to propose a PACS package that meets or exceeds the site's unique requirements. The identification of the requirements and the matching of a known PACS configuration with them has reduced the number of unknowns within the vendors' proposals and created true competition in both initial cost and the cost to maintain PACS in the maintenance years. Although there are certain factors unique to planning a military PACS, such as preselected vendors, the planning methodology described in this article should provide a valuable strategy for any hospital planning a PACS.

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KEY WORDS: Picture Archiving and Communication System (PACS), Joint Imaging Technology Project Office, Department of Defense, PACS planning, PACS education, PACS implementation, teleradiology.

THE INCREASING NUMBER of viable Picture Archiving and Communication Systems (PACS) and increased interest by numerous radiology groups in the conversion to digital (filmless) radiology have lead to multiple military and commercial PACS implementations.^{1,2} The Joint Imaging Technology Project Office (JITPO) within the

Department of Defense (DOD) is responsible for worldwide implementation of DOD PACS. The JITPO's responsibilities include planning, programming, implementation, and acceptance testing PACS. The DOD has more than 20 operational PACS and teleradiology sites with multiple facilities operating as virtual radiology departments in the United States and Korea.^{3,4} The DOD also has utilized teleradiology in war time deployments such as Operation Desert Storm.⁵ Currently, the DOD has a variety of PACS implementation programs at different stages of the planning/implementation process and expects to bring more than 20 additional sites on line in the next 3 years. To facilitate such a large PACS program, a technique for planning, programming, and implementation of PACS has been developed by the JITPO using a standard methods approach. This article outlines the planning approach used by the JITPO.

PACS is expensive to purchase with an associated large maintenance cost that must be planned and programmed for the life of the system. Unlike a radiology acquisition device (eg, CT, MRI, x-ray), PACS affects the entire hospital not just radiology. The changes in radiology business practices are felt not only in radiology but throughout the different clinical departments within the hospital. When planning PACS, a site's attention to the potential changes and a keen insight into the impact on the facility will ease its transition to digital radiology. Digital radiology for the purpose of this report refers to replacing plain film (that would be read hard copy on a film light box) with soft-copy images that would be interpreted and reviewed from display workstations. The definition also includes the interpretation of soft-copy images from intrinsically digital modalities, such as CT and MRI.

There are many techniques to planning and budgeting for a PACS. The following methodology will break down a process of planning a PACS and outline the critical procedures for each plan. This methodology will describe four planning steps to implement a PACS: (1) strategic planning, (2) clinical scenario planning, (3) installation planning, and (4) implementation planning. Although the planning steps are separated into four major categories,

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ries, the steps can overlap one another, as shown in Fig 1.

MATERIALS AND METHODS

Strategic Planning

The strategic planning phase is a top-level outline of the overall scope of the program. It defines the program objectives, educates the hospital staff, outlines a methodology, develops broad program milestones, identifies financial resources, and develops the PACS team. Strategic planning typically involves four procedures: hospital executive briefing, PACS team building, PACS goals and objectives planning, and resource planning.

Hospital executive briefing. A PACS is not a radiology acquisition device. The functionality of the system, as well as a common PACS language, must be understood by all key players. A PACS is an information system that manages radiology images for interpretation, review, and medical archiving. This concept must be understood by the hospital's key decision makers, starting from top level management down to each clinical department that will be affected by the PACS. If "buy-in" for the PACS does not come from the executive level, the cost and complexity will make it difficult (if not impossible) to accomplish most of the goals necessary to successfully complete the program.

PACS team building. To be successful, a PACS team must be established within the facility to provide input and perform the necessary tasks, duties, and hospital education. The team members must develop a common PACS understanding and language. This methodology calls for the hospital to have two teams: the program team and the consulting team.

The program team consists of no more than six people running the PACS program. Because the current evolution of PACS is primarily to support hospital-wide or enterprise-wide distribution of radiology images, the Chief of Radiology (or someone who has been empowered by the Chief of Radiology) typically is the team leader. The radiology department manager typically is the deputy team leader of the PACS team. These two individuals will be required to manage the program. Other members of the programming team include a medical physicist, a clinical engineer, and an information management representative.

The consulting team includes senior representatives from each clinical department to approve of decisions that affect their respective clinical areas. Examples of key clinical departments include Orthopedics, Internal Medicine, Family Practice, Surgery, Pediatrics, Emergency, OB/GYN, Urology, Oncology, Inpatient Wards, Neurology, Neurosurgery, and ICUs. One spokesperson who fairly represents all other clinical areas also can be an active member of the PACS consulting team. Additional key individuals who could assist include representatives from the purchasing department, facility management, and administrative staff.

PACS goals and objectives planning. The PACS team must determine the site's clinical goals and objectives for the system. During this planning, documentation begins to outline the PACS plan at a conceptual level. This outline should be well documented, evaluated by all stakeholders, contain enough detail to grossly program money, and be approved at the hospital's executive level. The PACS teams should begin looking at the different operational clinical scenarios within which the PACS

potentially will be operating. This may include planning for one hospital or a consortium of hospitals. Other planning may include moving radiologists out of radiology reading rooms and into remote clinical environments for consultations, while continuing to interpret full-time equivalent workloads.

Resource planning. The final step in the strategic planning process is determining the required financial resources. Fiscal restraints can limit the scope of the PACS implementation and thus need to coincide with the goals and objectives. The financial requirements and responsibilities can be broken down into three major areas: equipment cost (including network upgrades), installation cost, and annual maintenance cost. All three must be planned for.

PACS Clinical Scenario Planning

The term *clinical scenario* refers to how the clinicians perform their work in their environment. This is a critical issue because, for example, radiologists' encounters with film in the reading room are very different from orthopedic surgeons' encounters with film in the operating room or when they meet with patients in examination rooms. The PACS clinical scenario planning phase defines how each user will interface with the PACS. A well-developed clinical scenario will ensure the PACS provides all individual users with capability that is well matched with their needs (clinical requirement). A generic PACS equipment configuration is developed based on the clinical scenario (technical requirement). This phase fleshes out the outline that was developed in the strategic planning phase. Clinical scenario planning includes facility/region planning, radiology department planning, clinical department planning, and equipment planning.

Facility/region planning. A facility and regional clinical scenario within which the PACS will operate is developed from a "global" perspective. The goal is to begin stratifying how the PACS will fit within the hospital or consortium of hospitals including any teleradiology objectives. To set the hospital's objectives, the radiology requirements of all users are determined in the following order: (1) radiology department, (2) high-volume clinical users (eg, primary care and orthopedics), and (3) all other clinical users. This is followed by broad objectives that define the phases for the installation and how each department will migrate to digital radiology. At this point, an operational plan and a diagrammatic representation of the general PACS clinical scenario are developed by the PACS team. This is a dynamic representation of the PACS environment for the program that will be finalized during the installation planning phase.

An important recognition to make at this junction is: teleradiology and PACS are not synonymous and must be planned both individually and in conjunction. In addition to defining teleradiology missions, the hospital may have radiology acquisition devices not within radiology (eg, cardiac catheterization laboratory) and/or not controlled by radiology. All radiology acquisition devices passing images to the PACS system will need to be defined as well as how the image interpretation and review (with the radiology reports) will be handled.

Radiology department planning. The radiology department will be affected by the PACS more significantly than other clinical areas. Therefore, it is very important to develop a well-thought-out and thorough radiology clinical scenario. The Chief of Radiology and his department must determine how

workflow will be managed with the PACS. This will be formalized and placed in the PACS clinical scenario. Considerations for this conversion include image acquisition, image interpretation, report generation, quality control, and department staff interfacing with the system. It is very important to include how the system will be used by the radiological technologists.

Clinical department planning. The PACS program team works individually with each Department Chief (or representative) to evaluate the requirements of each department and how the PACS will be integrated into daily practice. A PACS clinical scenario is developed for each clinical department that begins looking at potential phases for migration to digital radiology. This information is incorporated into the overall PACS clinical scenario.

Equipment planning. The PACS equipment configuration is outlined in the clinical scenario. This equipment configuration requires each clinical department to plan for equipment space. Therefore, planning must begin early in the process so that facility limitations will be addressed, researched, and resolved. Specific equipment planning issues include location of equipment, equipment size and weight, heating ventilation and air conditioning (HVAC), power, and potential facility modifications. This information is used to develop the equipment package as well as round out the PACS clinical scenario that the team uses formally to discuss the program. During this time, no final decision is made with respect to equipment location. Final decisions on equipment locations will be made during the installation planning phase.

Installation Planning

The hospital PACS team and JITPO develop an installation plan. This plan covers overall program objectives, team members and responsibilities, PACS clinical scenarios, PACS equipment requirements, project schedule, PACS vendors responsibilities (system level, installation level, acceptance requirements, preventive maintenance, and maintenance plan), facility requirements, room layouts and designs, utility requirements, network requirements and plan, DICOM requirements by modality, and the quality assurance (quality control) plan. During this process, the details of the initial outline are completed. Installation planning is broken down into four procedures: preliminary installation planning, procurement requirements planning, vendor planning, and installation plan.

Preliminary installation planning. The objective is to develop a formalized shell for the installation plan. The program team develops the overall equipment package required to meet the functionality as defined in the clinical scenario. This includes, for example, decisions on types and numbers of workstations required and where the equipment is going to reside physically. At this point in the process, a "PACS Plan" is developed, which includes estimated life-cycle costs. Once developed, the PACS program team will need to make the first decision to proceed or not (refer to Fig 1).

The PACS Plan includes, but is not be limited to, equipment locations, equipment configuration, equipment specification, PACS network (image and database), modality interfaces, DICOM functionality, existing hospital network infrastructure (LAN), telecommunications (WAN), teleradiology, and electrical, heating ventilation, and air conditioning.

During this phase of the planning process, careful attention should be given to equipment that will be required to interface

with the PACS. The interfaces include acquisition modality interfaces and the Hospital Information System (HIS) to the PACS Radiology Information System (RIS); if there is an existing hospital RIS, it is important to determine whether it will integrate with the PACS. The DICOM conformance statement of each acquisition modality will be required for evaluation. If the DICOM functionality does not match the desired functionality (eg, DICOM Worklist Management), action to resolve this issue must be taken before implementing a PACS. HIS and RIS interfaces typically use the Health Level 7 (HL7) communication standard, and PACS communicate using the DICOM standard. Planning for a broker device to convert HL7 messages to DICOM is necessary. The broker typically maps data elements between HL7 and DICOM bidirectionally.

Procurement requirements planning. The DOD currently purchases PACS from an indefinite-delivery, indefinite-quantity contract called Digital Imaging Network and Picture Archiving and Communication (DIN-PACS). This contract is administered by the Defense Support Center of Philadelphia (DSCP). DIN-PACS includes two commercial PACS vendors that provide their commercial PACS. The DIN-PACS contract is a follow-on to the Medical Diagnostic Imaging Support System (MDIS) contract administered by the US Army Engineering and Support Center, Huntsville. Civilian institutions should evaluate the different PACS vendors with whom they are interested in doing business. The most effective way to evaluate the true functionality of a particular vendor's PACS would be to visit a functional site and see first-hand how the system works in an active clinical setting.

During the procurement requirement planning process, JITPO and the PACS team convert the PACS Plan to a "Requirements Document" that includes the PACS plan without the programming figures (remove the cost data). This Requirements Document is provided to the contracting office (DSCP) to begin coordination of the requirement with the DIN-PACS vendors.

Vendor planning. The vendors are not brought into the process until the Requirement Document has been completed. Once the vendor has been allowed to review and comment on the Document, the vendor's proposal will be submitted and evaluated. The various proposals will be evaluated with regard to cost, functionality, requirements, and equipment. This process allows the facility to compare known equipment configurations from the vendors. Thus, the PACS team can assess each vendor's bid based on identical equipment and functionality. This encourages competition between the PACS vendors.

At this point, the final life-cycle costs for the PACS are known. Therefore, the second decision—to proceed or not—occurs (Fig 1). If the hospital decides to proceed, a vendor is selected.

Installation plan. The installation plan is finalized and completed by the PACS vendor who was awarded the contract. The hospital works as a team with the PACS vendor to complete a formal installation plan signed by both the PACS program team and the vendor. This is a formal binding document that clearly defines the roles and responsibilities (terms and conditions) for both the hospital and PACS vendor through to the maintenance period (eg, 1 year warranty plus 8 years' maintenance). It is used to guide the hospital and PACS vendor in the installation and conversion to digital radiology.

Fig 1. The PACS planning process.

Implementation Planning

The final major planning phase is to operationally convert the facility to digital radiology. The goal for this planning is to ensure the system is fully operational. Considerations for the implementation phase include testing the PACS for performance (versus the specifications), training the hospital staff to use the system, and planning to maintain the system. If the system does not function as planned or if staff are not properly trained, the PACS will not achieve full clinical acceptance. Implementation planning is broken down into minimally 4 procedures: installation and acceptance testing, clinical training planning, implementation of digital radiology, and maintenance planning.

Installation and acceptance testing. Once the system is installed and ready for clinical use, the PACS is tested to validate the functionality of the system. The DIN-PACS and MDIS contracts ensure that the systems will not be accepted or final payment made until it passes the acceptance testing. A commercial site will use the request for proposal (RFP) for this purpose. The JITPO has an acceptance testing protocol that is used for all DOD DIN-PACS acceptance testing. This protocol was reviewed and agreed on by both DIN-PACS vendors.

Clinical training planning. All hospital personnel who will interact with the PACS system at some level require training. Planning to train such a large hospital population (especially because a large number of the personnel will be physicians) is difficult to coordinate.⁵ Therefore, training of hospital personnel is based on the schedule to convert departments to digital radiology. The vendor is required to sign up for both phased training and follow-on training for hospital clinicians. A strategy for training new personnel must be planned. Possibilities include train-the-trainer or having the vendor provide follow-on training at specified time intervals.

Implementation of digital radiology. Converting to digital radiology has three major considerations: converting the entire hospital, converting individual clinical departments, and utilizing hard copy historical images. The JITPO is prepared for all three situations.

There are two possible approaches for a hospital to make a transition to digital radiology: phase out the film department-by-department or turn off the film throughout the facility simultaneously, except where required (eg, surgical suites). Both have worked effectively within the DOD.

Transitioning an individual clinic to digital radiology has the same consideration as transitioning the hospital. Ideally, it is not cost-effective to provide both film and digital review. In most cases, the implementation strategy is to turn off the film within the clinic being transitioned. There are exceptions. To transition a clinic that is a heavy user of radiology (such as orthopedics), the implementation strategy may be to phase the film out of the department. Therefore, there may be a very short period when both film and soft-copy display are being utilized.

Historical images, which are developed on conventional film, will be required for comparison. Possible strategies include viewing the images on a lite-box adjacent to the workstation, digitizing old films and thus allowing them to be viewed on the PACS, and/or transitioning to digital radiology and continuing to print film for a certain period, allowing the archive to be built before converting to soft-copy interpretation and review.

It is important to remember that providing radiology images in only soft-copy form is a change in business practices, and it may not always be possible to effect this change overnight.

Maintenance planning. The vendor develops plans for quality control, preventive maintenance, and unscheduled maintenance on the system. The hospital reviews these plans and incorporates the procedures into daily operations. Quality control typically is performed by the users or a hospital representative periodically. Preventive maintenance is performed by the vendor on a scheduled basis. Unscheduled maintenance is the procedure to be followed in the event of a system or a component failure.

Because PACS are still new, vendors should be asked to provide a quality-control plan that hospital users can easily understand and follow. The vendors must provide a preventive maintenance plan that can be easily tracked by the hospital. In the event of an unscheduled maintenance procedure, hospital staff must follow a clear action plan to notify the vendor that covers all circumstances (eg, after-hours calls). Once the PACS is installed, the hospital will become dependent on the system, and mechanisms must be in place to minimize down time. The hospital will need to develop a database to track both system and component maintenance records (vendor should provide this tracking ability).

RESULTS

The JITPO currently has 12 hospitals using this methodology to implement DIN-PACS.⁶ In addition, the DOD has as many other PACS and teleradiology sites using an abbreviated version of this methodology. The Requirements Document provides the vendors with site-specific PACS requirements that guarantee only needed functionality is purchased. This leads to a best-value procurement.

There have been savings in the initial purchase cost (equipment and installation) ranging from 1 to 2 million dollars per site compared with the generic implementations outlined in the DIN-PACS contract (small, medium, large hospital). Competitive pricing also is seen in the operation and maintenance pricing compared with the DIN-PACS contract. As a result, the overall life-cycle cost saving amounts to 2 to 4 million dollars per site.

This methodology has been an effective tool for preparing business plans to procure the PACS. This provides the key decision makers at the hospital with written plans that show clear objectives of the project, life-cycle cost for a total of 9 years, and implementation milestones that can be tracked.

This methodology has ensured that the PACS meets the clinical requirements throughout the hospital. In other words, there will be no areas within the facility in which the PACS implementation has created an inefficient provision of radiology service (eg, orthopedists not having access to images in examination rooms). As a result, this

methodology has been an effective tool in gaining overall acceptance of the PACS by all clinical providers.

The involvement of both provider and administrator personnel in all decision processes ensures that both parties are fully accepting of and satisfied with the implementation. This leads to each site taking early ownership of its PACS.

DISCUSSION

There are factors unique to planning a military PACS, such as preselected vendors and a DOD-wide HIS. However, this planning strategy remains a powerful tool in the planning and implementation of any PACS, civilian or military.

The planning processes outlined in this report are not mutually exclusive and are not designed to be followed sequentially (Fig 1). The planning phases should be occurring concurrently, with the entire team aware of the status of the program. Proper planning can make the transition to digital radiology smooth for both radiology and the clinical departments. Planning input representation from all users markedly decreases the initial opposition to digital radiology that is encountered at startup. Our experience has shown that instant accessibility to images and reports, as well as the increased efficiency provided by the PACS, rapidly becomes the standard level of performance.^{7,8} After a brief period of clinical usage, anything less will not be accepted by the clinicians.

PACS planning for either a hospital or a consor-

tium of hospitals should not be the sole responsibility of the desired PACS vendors. Possible pitfalls of relying on the vendor for a PACS plan include (1) the vendor possibly excluding needed functionality or including unneeded functionality and its associated costs, and (2) difficulty in comparing proposals from different vendors when the requirements are not identical. This leads to significant difficulties in attempting to determine which vendor is providing the best value. A well-educated and organized local PACS team will have a much better understanding of the objectives and requirements of the facility/facilities. The hospital should have a clearly annotated program objective and criteria before the PACS vendors are brought into the process.

Should the hospital not have personnel with significant PACS experience, an outside unbiased PACS consulting team should be considered. If an outside consulting team is used, a clear plan should be presented by the consulting team to the hospital, defining how PACS planning will be accomplished. This plan should contain a clear methodology capable of standing on its own. Also, the consultant must provide credentials showing that he has previously planned and successfully implemented a PACS site of similar size. It would be wise to speak directly with personnel from sites that have previously used that consultant. Another excellent source of information on the planning and implementation of a PACS would be team leaders at an institution that has previously planned and installed a PACS.

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