

Planning for PACS: A Comprehensive Guide to Nontechnical Considerations

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A complete picture archiving and communication system (PACS) installation is one of the largest projects a radiology department will undertake. Although technology issues are important, they often draw focus away from many other significant issues. This paper describes in detail all of these other necessary components that need to be addressed if a PACS installation is to be relatively trouble free, provides guidelines for successful PACS implementation, and details pitfalls to be avoided.

Key Words: Process reengineering, PACS, radiology economics, PACS installation

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INTRODUCTION

When considering a picture archiving and communication system (PACS) implementation, one first seeks a viable economic justification. If this is found, one next identifies the best hardware and software and develops a robust network that will drive the PACS system. All are important elements of a PACS implementation, but a successful PACS program requires careful and deliberate attention to many other critical issues.

This review does not deal with system measures (e.g., compression, transmission rates, storage capacity) or the detailed technical specifications that must be met to ensure a smoothly functioning PACS; several good articles exist [1–3]. These technical issues may overshadow other equally important considerations. This article thus is not a comprehensive review of the PACS literature but recounts personal experiences and focuses on many of the often neglected smaller items that are essential for a satisfactory PACS purchase and installation.

FINANCIAL JUSTIFICATION

The idea to implement a PACS in an organization often comes from a radiologist. The typical institutional response is moderate interest, followed by demands to justify the significant cost. A PACS has obvious costs (hardware, software, and service contracts) but also obvious savings (a reduction in personnel and the elimination of

film and film processing). Unfortunately, neither the costs nor the savings can be presented in such a simplistic fashion.

Capital costs include hardware and software, network equipment, Digital Imaging and Communications in Medicine (DICOM) upgrades, computed radiography systems, and facility modifications [4]. Every institution will begin PACS evaluation at a different point in its evolution from analog to digital imaging. Some may already acquire nearly all radiographic images digitally, with extensive computed radiography systems and digital fluoroscopic units, and have DICOM-compliant magnetic resonance (MR) and computed tomography (CT) systems. But if an organization lacks computed radiography and has MR and CT systems that are not DICOM compliant, it will have to spend heavily to acquire these systems, and these costs will be added to its PACS program. The presence of preexisting computed radiography systems or direct digital systems for plain-film radiography can determine whether PACS installation is potentially profitable [5]. Other items may be included in the costs of a PACS program. For example, some institutions may already have sophisticated networking capabilities that require little expansion to be able to support the demands of a PACS, but others will need to develop these systems. Some institutions may have extensive information technology (IT) resources available, whereas others may have to expand these resources. Cost assigned to the PACS project will also vary depending on whether other costs are included (e.g., hardware and software upgrades, service maintenance contracts, system obsolescence).

Clearly, it is quite difficult, if not impossible, to identify the true costs of PACS implementation, and such costs are very site specific. Financial analysis of the PACS

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Table 1. Financial benefits of a picture archiving and communication system

Real, tangible dollar savings	<ul style="list-style-type: none"> ● Reduction of personnel ● Elimination of film and film processing ● Film loan space available for other use
Time value of money	<ul style="list-style-type: none"> ● Improved technologist productivity ● Improved radiologist productivity ● Improved referring physician productivity
Qualitative value of money	<ul style="list-style-type: none"> ● Improved report turnaround time ● Decreased length of patient stay in the hospital ● Improved patient satisfaction ● Improved referring physician satisfaction

benefit is further complicated by a trend of continually declining purchase costs, causing analyses to quickly become out of date [4].

The savings generated from implementing a PACS are even more difficult to quantify. Financial benefits from a PACS may be placed in three broad categories (see Table 1). Savings should include reduced film library space, warehouse cost, the cost of film and development supplies, salary reductions from personnel cuts, and the potential replacement of equipment such as film processors [4]. However, even these tangible dollar savings may not be realized. For example, personnel may not be decreased, and old film storage space may not be fully used.

Studies have clearly demonstrated improved technologist productivity after a PACS installation; the time required to perform ultrasound studies decreased [6], and the time for performing CT studies was decreased by as much as 45% [7]. However, the increase in technologist productivity may be gained in small segments of time that are not fully used to increase patient throughput or to decrease staffing, and the potential cost savings may thus not be realized [8].

The qualitative savings may be extremely important, but it can be difficult to assign measurable dollar amounts to them. Some of the intangible benefits of a PACS may indeed be of more value to an institution than some of the tangible dollar savings. A PACS clearly delivers benefits to multiple departments and improves the overall quality of patient care [4].

It is thus very apparent that a decision to move ahead with the implementation of a PACS program cannot and

should not be based purely on the analysis of cost and savings. These can be presented to create almost any predetermined economic result and may also miss many of the important benefits of a PACS program. Although it is important when building a business case for a PACS to go beyond purely financial considerations [4], it is also necessary to work with an organization's leaders to insure their financial justifications for a PACS are met.

VENDOR SELECTION

The choice of a PACS vendor is completely unlike the purchase of an imaging machine. Not only is a PACS installation probably the biggest purchasing contract a radiology department will ever undertake, for many vendors, a PACS installation is among their largest and most complex projects. Complexity is partly the result of rapid flux in PACS technology; the evolution cycle of technology is very short, and thus product definitions (and consequently the products) change continually. Another difficulty is that the scope of a project can be very difficult to define. Although vendors define the specific hardware and software components in their quotes (which are often no more than long lists of such components), this is only the start of what is needed. Of much more importance is the need to understand the operational functionality of the system. Because each organization is so very different, it is almost impossible to simply review product specifications and accurately understand how a product will work in a particular organization. Site visits to similar facilities are helpful but cannot provide a true picture of how a system will work elsewhere. A vendor's representatives often lack the knowledge or the experience to understand the daily operations of any particular institution.

Unlike a single system such as a CT scanner, one cannot "test drive" a PACS. Therefore, in negotiations with a vendor, it is important to include the following.

- Detailed specifications and descriptions of functionality of the hardware, the software, all interfaces, and network requirements. The costs and responsibility for each interface must be clearly agreed on if unpleasant surprises and later conflict with the vendor are to be avoided.
- The operational functionality of the system.
- Hardware and software upgrade provisions. Vendor terms such as *replacement*, *upgrade*, *update*, *new functionality*, and *improved functionality* have different and specific definitions, and a purchaser must understand them. Promises made during presentations must appear in the final contract.
- The linkage of hardware with software upgrades. One must understand that whereas software may be provided free as part of a long-term service contract, ex-

pensive hardware upgrades may be needed to run the new software.

- Detailed project documentation, including a project plan and scope document. The plan should include a timeline with tasks, task duration, work effort required, and task dependencies. The scope document will define the goals and objectives of a project by which success will be measured; it should comprehensively detail the major work areas needed in the project and issues with which the vendor will assist (and to what extent). The scope document should define human resources that the vendor will provide and for how long, including how many days these individuals will be working at the host site and how many days off site. One should clearly understand the number and type of resources the host site must provide and for how long. A lack of documentation risks management problems and the potential for unforeseen costs.
- Service. It must be clear who will provide the service, how after-hours coverage will be obtained, and the delineation between service provided by the vendor and the host organization.
- A detailed educational program. A solid training plan and quality training materials are as important as the hardware and software specifications, but the customer often mistakenly assumes that the vendor will provide good education. The vendor should provide examples of its end-user training materials. Because training requirements (e.g., length, timing, and format) may differ greatly between the various user groups, the vendor training plan should address how each group will obtain the specific competencies necessary to perform its new duties.

Is a large company or a smaller dedicated PACS provider the best choice? Smaller companies often offer more flexible functionality at a lower price than large vendors. However, with a PACS, a long-term vendor relationship is crucial to ensure continuous system upgrades. Small companies are more likely either to be unsuccessful and go out of business or to be purchased by larger vendors that may discontinue product lines or services. A potentially more expensive but larger vendor may thus be a better choice.

Purchase options for a PACS are complex and include leasing, cash payment, shared risk on savings, outsourcing, and paying on a use basis (e.g., per patient or per unit of storage used). Complex solutions limit the up-front costs but may cost more in the long term. Because of this complexity and the high level of buy-in needed by different groups in an organization, PACS purchasing decisions should be delegated to a committee. This committee should include representatives from radiology, radiology administration, hospital finance, and hospital

IT, as well as a basic PACS physicist. One should involve potential “power users” of the system, such as orthopedists or neurosurgeons, to ensure that their image management needs will be met as well. An independent PACS consultant may be needed to assist the committee if sufficient expertise does not exist in the organization.

TECHNOLOGY ISSUES

Hardware

Because image storage hardware is continually changing, we do not discuss the various options for storage, other than to emphasize that a system must provide adequate storage with rapid access to images. There are many viable options.

However, image viewing monitors provoke considerable debate, with often emotional rather than rational decision making and thus expensive mistakes. The debate involves choices such as the number of monitors (two or four), monitor size (19 or 21 inches), and resolution (1K or 2K; ACR standards exist but are controversial). Monitors at 2K resolution provide sharper images but cost more, produce more heat, are less bright, and are operationally slower. A four-monitor system is more costly and loads images slightly more slowly, yet some radiologists may favor this system because it more closely resembles the traditional four-panel film viewer. Other radiologists may prefer the cheaper two-monitor system because it is faster to electronically change the image display than to turn one’s head to view four monitors. Some believe that four-monitor systems are essential for studies with very large numbers of images, but others disagree. Yet there are many other important issues besides monitor number and resolution [9], such as the workstation graphics card and the monitor refresh rate and brightness. For example, whereas a typical desktop monitor has a brightness or luminescence of about 100 lumens, high-brightness monitors can have a luminescence of 300 to 600 lumens [9]. Color monitors often have lower brightness (and resolution) than black-and-white monitors [9]. Because all users will want the biggest, fastest, and brightest, with all the bells and whistles, the PACS committee must persuade users that bigger is not always better; users must define their needs and select monitors that meet these needs.

In addition to image viewing, each radiologist’s work area needs additional computer functionality, including access to the hospital and department information systems and a method of viewing voice dictation reports. Although these functions can be embedded into the PACS workstations, it may be easier to install a separate free-standing computer monitor adjacent to the PACS monitors.

Software

All PACS vendors provide software allowing many functions to be performed at the workstation, and innovations from one vendor are quickly copied by its competitors. Because functionality is usually more than adequate, preferences are mostly subjective. It is more important to consider the ease of the software interface with hospital information systems, the radiology information system (RIS), and imaging systems, as well as how the software affects communication between systems. In general, the hospital information system is the source of patient demographic and billing information, the RIS sends imaging requests to the PACS and to the imaging systems, the imaging systems send images to the PACS, and the PACS tells the RIS that the study is complete. Signed reports initially enter the RIS, which forwards the report to the PACS, where the report and images are integrated. These complex technical details are not discussed here, but they must be carefully designed and specified. Each interface must be adequately tested before it is used.

Networks and IT

Radiology equipment purchases are usually controlled and made by the radiology department, and the equipment usually resides within the department and is maintained exclusively by department personnel. A PACS project has a much wider scope, requiring significant involvement of the hospital's IT staff. Moreover, departmental personnel may lack the technical skills for PACS administration. Compounding the problem is the need for the PACS in areas outside of radiology, such as cardiology and endoscopy. For these reasons, IT departments often must take the lead in PACS administration. Conversely, IT departments may lack the technical information required to manage PACS-RIS integration, such as DICOM expertise. Therefore, the two groups must share knowledge and build skill sets related to PACS technology. Radiology must be willing to yield significant control to the hospital IT program, whereas IT personnel must acknowledge the specific needs and expertise resident within radiology departments. Responsibilities must be clearly defined; in general, radiology should control hardware and software decisions, equipment location, and workflow issues; IT should control the network and its monitoring, maintenance, and upgrades, as well as technical support. Both must be involved in final decisions regarding purchasing, configuration, and implementation.

DISASTER PLAN

The various hospital departments and the vendor should include a disaster plan as a cost within the initial pur-

chase. The disaster plan has two components: the backup storage of images in a remote location and a detailed operational plan if failure of all or part of the PACS occurs, including the underlying network infrastructure. The plan should identify equipment to be served by emergency power supplies. These plans will be complex and expensive but are crucial.

SECURITY

The technology to provide Health Insurance Portability and Accountability Act-compliant security within a PACS (e.g., limiting image access to only those who need it on a patient-by-patient basis) is available. Many PACS vendors have not fully implemented it, because implementation is costly and may inhibit workflow. Yet there is a legal need to limit access to the PACS to maintain confidentiality, and it should be addressed in the initial project scope.

SPACE AND ENVIRONMENT ISSUES

The installation of the PACS will eventually free up film storage space in the radiology department, as film is phased out. The PACS may free up space in reading room areas as large alternators are removed and smaller work stations are installed, but renovation may be required to create optimal reading environments. Yet the PACS makes huge demands for new space. In every area where technologists or receptionists work, new space will be needed for additional computer terminals, as well as printers, bar code readers, and/or CD burners; this space may be difficult to find. Special consideration should be given to the extra space needed during the transition to a PACS; when historical comparisons are on film and not the PACS, work areas will be extremely crowded with new workstations and legacy viewing technology.

Space may be a major issue in inpatient and outpatient areas, depending on the selection of PACS viewing stations and presence of existing computer equipment. Little new space may be needed in organizations that choose to rely heavily on Web access to PACS images; this is especially true if high-end computer workstations are already in place. However, the installation of new dedicated PACS workstations may be difficult. Decisions on the type of PACS viewing systems to be used should be made with consideration of the existing space constraints in these areas. Space renovation in numerous inpatient and outpatient areas may add significantly to the overall PACS project cost.

Whether in the radiology department or on the inpatient wards or clinical outpatient areas, the provision of low lighting for viewing of images is important. This may be difficult in the radiology department and almost impossible in very busy clinical areas. In the reading rooms,

Table 2. Keys to the success of a picture archiving and communication system project implementation

- Strong project manager, dedicated to the project
- Clear and realistic timetables
- Phased implementation
- Clear definition of individual responsibilities and accountability
- Comprehensive scope document
- Committed and effective executive administrative and medical sponsors
- Timely and accountable vendor participation
- Strict adherence to project change management policies
- Substantial radiologist involvement in the development of workflows and system design

focused ambient lighting is needed that minimizes reflected light produced by the monitors and other bright objects [9]. Other environmental considerations in these areas should include dark wall colors, noise reduction (through wall, floor, and ceiling treatments), temperature control, and comfortable chairs [10]. Room layout should allow radiologists to work together yet preserve as quiet an environment as possible. Full or partial walls may be needed to create individual reading stations. The actual workspace on the reading station desktop is often too small [11]. It must be adequate for the computer monitors, keyboard, barcode reader, telephone, and dictation system, and it should have space for paperwork. Merely removing film alternators and dimming lights in an existing reading room cannot provide an adequate PACS work environment.

PROJECT IMPLEMENTATION

Planning and implementation of a PACS is complex and should not be underestimated. A large number of trade-offs must be made. Personnel from many different departments within the hospital must become involved. Workflow and “cultural” change must be made by many individuals who are naturally frightened by such change. The critical success factors of a successful PACS project are summarized in Table 2. The project plan should identify all tasks required during the planning, execution, and closeout phases of the project. Adequate resources must be allocated to each task and individuals must clearly understand their own responsibilities. The implementation of a PACS should be phased in so issues and problems can be identified and resolved before the

project is rolled out to a larger audience. The project manager should be skilled in change management and have experience in complex project implementation. A background in industrial process management may be helpful. The project manager needs some knowledge of the technology of a PACS but does not need to be an expert. The keys to implementation include manpower allocation, project reengineering and planning, communication, and education.

Manpower

Significant manpower resources must be allocated to the project, from both the host institution and the vendor. The responsibilities of the host institution and the vendor must be clearly defined to avoid later conflicts and surprises. The host institution should expect its employees to play a much greater role in the PACS installation than is usual with other radiology equipment. Resource needs will vary on the basis of the size of the implementation and the current level of digital technology in the department. For smaller sites, a single person may fill multiple roles. Required manpower resources include the following.

- A project manager. Both the host organization and the vendor must supply a project manager. Ideally, each should be full-time on the PACS implementation project. Many health care organizations do not have a strong pool of project management resources and need the vendor to assist in this area. Vendors may make many promises regarding the role that their project manager will fill because they like to sell project management services. Some vendors deliver a quality project management service, but others may fail to deliver the type of project management that most health care organizations require. One must determine exactly what aspects of the project the vendor’s project manager will “own.” Will this person coordinate and drive all tasks in the project (e.g., communications, risk, and scope management), or just the ones that the vendor is directly involved in (e.g., hardware procurement and installation)? The determination of the specific task areas that the host institution will manage must be made before the actual project planning begins, so that the particular strengths needed can be assessed.
- Network engineers to design and install the required network infrastructure.
- Field engineers to install the PACS equipment and integrate imaging modalities. Knowledgeable vendor-provided field engineers are crucial to smoothly inte-

grating the RIS, imaging systems, and the PACS. Depending on the organization's level of previous integration, the hospital's field engineers may not be familiar with all of the required modality settings.

- Clinical engineers to research, design, and implement the integration and upgrades of the imaging systems to the PACS environment. Clinical engineers should be directly involved in modality integration. If non-DICOM-compliant modalities are present, they can be very helpful in identifying the best technology to use.
- "Problem solvers" who have both applications and engineering knowledge.
- Radiology department personnel, including administrative directors, technologists, nurses, and clerical workers. The implementation of a PACS changes the workflow of almost all departmental activities. Involving key personnel from each functional area early in the planning process will help ensure a smooth transition.
- System administrators to design and build the application, data flow, and databases. They should be identified before the system is built, because it is easier to learn the system (e.g., database structure, work lists, filters) if one is involved in the actual system build. Guessing at system design logic may be time consuming and frustrating. Reliance on a vendor for this service after installation can be costly and may not meet expectations.
- Radiologists to champion the project, make needed compromises, and contribute to workflow development. They are responsible for selling the project to administration, referring physicians and other hospital stakeholders. Limited radiologist input in workflow development greatly risks the success of the implementation.
- Education and communication personnel. Technology-savvy educators are needed to develop training programs, documentation, and tools for a wide variety of users, including remote users. A marketing person may be invaluable to communicate the project through a variety of vehicles to diverse audiences.
- A testing team. Because the PACS will likely be integrated with the RIS and imaging systems, the integration relationships must be tested. There must be project team members who have knowledge of testing methods and can develop testing scripts, execute the test transactions, and verify the outcomes. The testing of all points of system integration and workflow changes is a critical preparation for production usage.

Process Reengineering and Planning

After project approval, PACS stakeholders will likely push to move forward quickly. Many times, the pressure

for the immediate gratification of installing hardware and displaying the images electronically overshadows the need for true project planning, including process evaluation and reengineering. To be successful, one must understand that the most important phase of the project is not implementation but planning. Not understanding this fact makes workflow disruptions, schedule delays, and budget overruns very likely. Although unexpected hurdles will be encountered in even a well-planned project, they are more easily dealt with around a discussion table than after a disruption in production workflow. The PACS technology represents a change in the way radiology has done business for over 100 years; a physical element (film) is being taken out of the hands of physicians, and they are asked to look at a computer monitor. Anxiety will be high as you ask them to change their habits and move out of their comfort zone. As physicians encounter problems in doing their work, they will question the quality of the project implementation and the viability of the overall solution. Dedicating adequate resources and time to the planning phase will help reduce the number of problems encountered by the end users. Because some issues identified during the planning phase may not be resolved at system rollout, communicating these outstanding issues to the end-users will let them know that the problem is known and what is the planned solution.

The implementation of a PACS requires many processes within radiology and also outside radiology to be changed. Each component of the value chain of radiology needs to be carefully analyzed, and the impact of PACS on each component must be understood. These components include study ordering and scheduling, patient reception, patient flow through the department, film loan functionality, image generation by technologists, image transfer to radiologists, radiologists' workflow, image reporting, and image and report distribution to referring physicians. In addition, the work patterns of the referring physicians will change; how they receive images, where they review them, and how they share them with patients requires careful analysis.

Early in the project, the institution must decide whether to tackle these problems on its own, to seek help from the PACS vendor, or to employ skilled consultants. Consultants can provide a detailed baseline analysis against which change can be evaluated. Their experience might also help predict the impact of suggested changes on outcomes and help optimize the final workflow state. Consultants also have expertise in other areas, such as security and benchmarking. Yet consultants add to the cost of the project, and the quality of their input is extremely variable; many claim to be experts but few are truly knowledgeable.

Although every step of the radiology process needs to be analyzed, some of the key challenges that will be faced include the following.

1. When to go filmless. The cheapest and simplest answer is to turn a PACS on and stop the generation of film on the same day, but this is usually impractical. The phased implementation of a PACS, starting within radiology, allows several months of digital images to accumulate while films continue to be printed and distributed to referring physicians. This overlap adds cost but results in a workable archive of digitized images. Hard copy production can then end on a certain date, and most subsequently imaged patients will have had comparison images previously acquired in digital format. The other solution is a crash program to quickly digitize all stored films, which is an unbelievably expensive project that very few institutions are willing to tackle.
2. Personnel and job duties. Radiology personnel must understand that their job duties will change. Technologists will rely more heavily on computers to manage workflow rather than spend time developing film. Film loan personnel may transition to other duties. New job descriptions must be created so that staff members understand expectations and accountabilities associated with the new technology and resultant workflow processes. Achieving the acceptance of new responsibilities can be a challenge, but buy-in may be stronger if key personnel are included on the team creating the new job descriptions.
3. A digitization policy for prior and outside films. Although the digitization of all hard copy storage films is not needed, each institution should develop a policy to choose selected images for digitization. A caveat is that clinicians usually overpredict the number of old films that need digitization. A policy for digitization of outside films that accompany patients to the institution should be developed as well.
4. Paper requisitions. If the system is set up such that paper requisitions are no longer required, workflow will increase.
5. Voice dictation. If voice dictation does not exist in the organization, one must decide whether to implement it together with the PACS or to wait until the PACS is installed and successfully operating. A PACS makes images very rapidly available to referring clinicians, and they will come to expect reports to be available just as quickly. However, if voice dictation is not in use before PACS installation, because it represents another sharp break in routine, it is best phased in after the PACS is up and running successfully.
6. The maintenance of unspecified or broken studies. The integration of PACS with RIS and the imaging systems with a DICOM modality work list service helps ensure the accurate matching of specific studies to specific patients. However, simple errors such as the misspelling of a patient's name or entering an incorrect digit may result in unspecified or "broken" studies. A staff member must be charged with continually monitoring and resolving these issues.
7. Software usage and workstation operations. Many decisions must be made about the usage of the PACS software. Although many functionalities of the PACS workstation software can be individualized to specific users, others must be universal. The custom individualization of software functionality is time consuming and may require direct collaboration of application specialists and radiologists. Systemwide decisions, such as prefetch rules, are difficult and require consensus and buy-in. These rules decide which prior studies are fetched, when they are fetched, and whether they are "pushed" or "pulled" to the workstation. Prefetch variables include the age of prior studies, the number of prior studies, "newest or oldest," modality, body part, and active studies. For example, if prior studies will automatically be displayed with a new study, then "prior studies" must be defined. If the new study is a chest radiograph, do users want only prior chest radiographs to be automatically displayed, or do they require all previous imaging of the chest (e.g., CT, MR)? The number of studies to be prefetched is also an issue; increasing the number increases the range of studies immediately available for comparison but also increases the load placed on the system and may slow system operation. Another decision that must be made with prior images is to decide which images to prefetch and display. For example, one might choose the six preceding chest radiographs, or the three preceding chest radiographs and the first three chest radiographs acquired on that patient, or another of a seemingly infinite number of combinations. Display presets are also seemingly infinite and decisions must be made. What defaults should be used? Should the defaults be standardized by modality or should there be a very large number of defaults for each anatomic area by each modality? What preset windows should be determined?
8. Work list creation. There are countless ways to display work lists, including by modality, time, patient location, or image acquisition location. The structure and organization of work lists must meet the needs of the radiologist. To what degree can they be individualized? This will vary between different PACS systems.

Table 3. Picture archiving and communication system (PACS) implementation, concerns of referring physicians

Quality of images	<ul style="list-style-type: none"> ● Will image quality be adequate for my needs? ● Will I get the same image quality as the radiologists?
Workflow	<ul style="list-style-type: none"> ● I have a view box in my consulting room. I like to show patients images in my consulting room. Will I retain this functionality? ● Who will pull up the studies? ● Can I print images with a laser printer?
Workstations	<ul style="list-style-type: none"> ● Will I have the same functionality as the radiologist? ● Who will pay for my workstations?
Availability of prior studies	<ul style="list-style-type: none"> ● I am used to old films available in x-ray jackets. Will prior studies be available?
System failure	<ul style="list-style-type: none"> ● Electronic system failures may be more catastrophic. What guarantees do I have that my clinic will not be shut down by a PACS failure?
Consultation with radiologists	<ul style="list-style-type: none"> ● With PACS I will not spend so much time in the imaging department. How will I get good consultation from my radiologist?

9. The distribution of viewing stations on inpatient wards and outpatient clinic areas. Although a simple computer for Web access takes up little space, is cheap, and may provide the functionality needed by most referring clinicians, other clinicians (such as neurologists) may need the flexibility of dedicated workstations for viewing complex studies such as MR. Yet all clinicians will expect to be treated "equally," and some of their concerns are summarized in Table 3. There is not a single simple solution.
10. Operating rooms. The provision of a PACS in operating rooms is difficult, and each institution finds

its own solution. Cost and space issues are often major obstacles to installation. In many institutions, hard copy film is still provided to surgeons in operating rooms.

11. Clinical conferences. Before the PACS, films were hand-carried to conference rooms. Inexpensive wall-mounted view boxes or overhead projectors allowed the easy display of images. With the PACS, the ability to display images in multiple conference rooms scattered throughout the hospital must be envisioned. To encourage clinicians to continue to do rounds in the radiology department, well-equipped and comfortable conference rooms should be available there, with wall-mounted image screens to rapidly display images.
12. Clinical histories and other clinical information. Will radiologists continue to get patients' histories from paper requisitions, or through the electronic system? Will information be displayed on the PACS workstation or on a separate workstation connected to the hospital information systems? If the latter, then additional space must be provided.

Communication

This is an often-neglected component of PACS implementation. The project is complex, time consuming, lengthy, and involves a huge number of individuals throughout the organization. It involves cultural and process changes. It is thus surprising how frequently communications are neglected. Unfortunately, people believe that if they just get the hardware installed and the software up and running, the PACS program will be successful. This is not necessarily true. It is critical that referring physicians perceive and believe that all their needs are being understood and met. Communication should be a major priority of the PACS implementation team. A primary communication challenge will be to help people understand that PACS is not a "radiology" project but an enterprise-wide project that will positively affect workflow and patient care beyond the walls of radiology.

The objectives of a successful communication plan are to build early excitement and buy-in for the project, set expectations, and manage information flow to ensure successful project implementation. To achieve this, there should be regular communication addressing the following questions:

- What is happening?
- Why is it happening?
- When is it happening?
- How is it happening?
- How will it affect me and my patients?

- How will it change the way I work?

Communication should use all available portals, including individual and group meetings, e-mails, attendance at regular hospital organizational meetings, the development of a PACS informational newsletter, and the inclusion of PACS items in regular hospital bulletins. Other portals include Web pages, videotapes, attendance at grand rounds, and open house demonstrations. Messages need frequent repetition, because individuals may pay attention only at the time that they feel the message will directly affect them.

The key to a successful communication program is to get everyone on board early, anticipate and address concerns proactively, cultivate internal advocates, understand anxieties and needs of constituents, and set and manage reasonable expectations to ensure acceptance. End users must feel engaged and must feel that their specific needs and concerns are being addressed and will be met. End users' concerns include the following.

- What is the PACS?
- What is "filmless"?
- What will be the cost to me?
- Will all my needs be taken care of?
- How do I see demonstrations?
- What will be the functionality?
- How will I get prior images?

One should query end users after several communications to see if they are obtaining needed information and identify questions or concerns to be addressed in follow-up communications.

Education

The educational process for new radiology equipment usually involves an applications expert, on site for a few days, who trains a small number of technologists and radiologists who usually have a good initial understanding of the technology. Such training is relatively straightforward, inexpensive, and has a limited audience. Education for a PACS is exactly the opposite. Many vendors have limited experience in PACS training and underestimate its needs and complexity. They thus often follow educational models that have worked with the sales of other radiology equipment but are inadequate for a PACS. Yet education is so critically important in PACS implementation that it should be a specific item in the contract negotiated with the vendor, with its own budget and with clearly defined vendor responsibilities.

Education for a PACS must be viewed as an ongoing process over many months. Training must be provided at multiple sites at multiple times, and ongoing education must be available as new users continually rotate into the institution. Because poor attendance at training is the

norm, communications must stress the importance of training. Although training is often provided before final implementation, the most valuable training occurs after a PACS is operational. It is only then that the user may become engaged and motivated to learn.

It is critical that training support materials be provided, which should include responses to frequently asked questions. Flip charts or other simple guide material should be made available at every workstation, and a mechanism provided to ensure that this material is removed from the workstation. A well-staffed help hotline must be available. More detailed educational material must be available to end users who want information on customizing the functionality of the system.

Trainer selection is difficult. Should one provide individuals with superficial but very broad-based knowledge of the PACS, or with more focused, very detailed knowledge so that the needs of the most demanding users can be met? The answer is probably a compromise, with a need to produce both types of training in different circumstances. Training is often needed in multiple locations, and an effective way to train a large number of users is to provide tiers of training. There can be demonstration classrooms set up for large numbers of new users or those wanting to view the system for the first time. User-specific training can take place at the site of actual use of the system. If training resources are at a premium, general training can be accomplished by training CDs, videos, or well-written and self-directed training manuals. A list of all individuals to be educated should be generated, and careful tracking should ensure that all of the end users are in fact trained. Although some vendors desire to develop expert trainers within the organization, this should not substitute for the other components of a good educational program that have been described above.

SUCCESS CRITERIA

A project can be measured in many ways: by procedures or timelines met, by the deliverables achieved, or even by the project team's perception. It is important that the project plan initially defines not only the project scope and goals but also how the success of the project will be measured. Success criteria should be specific, measurable, and time based. It is very important to celebrate as specific objectives are completed.

MISTAKES, PITFALLS, AND PROBLEMS

The following is a list of potential hazards. Awareness of these traps may help a new PACS purchaser avoid them.

Vendor Issues

- Believing the vendors and not having items specifically addressed in the signed purchase contract. Meaningful incentives and penalties are key to motivated vendor participation.
- Inadequate specificity in the contract.
- The absence of a well-written, comprehensive scope document.
- The failure to uphold initial project scope (scope creep). The project may continue to grow beyond its initial definitions and budget.
- The failure to understand that vendors are very good at selling traditional x-ray equipment and even hardware and software but may have limited experience in process change and management.
- Not specifying a clear plan for upgrades, software enhancements, and future product releases in the contract.
- The failure to appreciate that no vendor product is perfect and that all vendors are continually trying to improve their products.
- Not understanding that the vendor cannot customize improvements to meet each individual customer's needs.
- Overestimating the return on the investment of the project and the time frame in which it will be achieved.
- Believing that software will function as it is marketed.

Technology Issues

- Focusing too much on the technology and not enough on the people.

Space and Environment Issues

- Insufficiently evaluating the type, location, and distribution of viewing stations needed in the hospital wards, hospital outpatient clinics, and private practitioner offices.

Implementation Issues

- Recognizing that because an enterprise-wide PACS program from initial concept to final implementation may take several years, there may be significant turnover of involved individuals both in the host organization and in the vendor.
- Underestimating the complexity of integration of the RIS with the PACS, imaging modalities with the PACS, and imaging modalities with the RIS.
- Underestimating hospital manpower needs.
- Underestimating the complexity of finding a good solution for the operating rooms.
- The lack of process benchmarks and data and the lack of industry best practices. Do not rely on the vendor for these.

- Believing that best practice solutions will be adopted by your organization. Frequently reinventing the wheel, when best practice solutions may be available from other organizations.
- Not insisting on initial default operational settings when the vendor provides too much flexibility.
- Underestimating the number and complexity of problems arising after PACS use begins.
- Not implementing a mechanism of ongoing system audits and preventive maintenance programs.
- A lack of understanding of the complexity of the development of body part use and work lists.
- Not insisting on greater radiologist involvement in the workflow design.
- Underestimating the level of the computer literacy of end users.
- Not creating a hospital-wide viewing solution standard; allowing referring physicians to choose their technology.

Communication Issues

- Not understanding that all of the physician end users desire top-of-the-line monitors, particularly if they are not paying for them.
- Allowing end users to develop unrealistic expectations beyond those that can be provided and beyond those that already exist in their practices.
- The failure to provide an adequate educational program and an excellent help desk.
- Not understanding that a single product cannot please everyone.
- The compromise of training schedules by trainee no-shows.
- Underestimating the anxiety of potential end users.
- Underestimating original radiologist resistance to change.
- Allowing too many people to influence project direction.

CONCLUSION

Every facility is different, and every PACS project will be different. The current state of technology, institution size, skill sets in place, project goals, and financial resources all affect a new technology implementation project such as a PACS. The aim of this article is to identify many of the critical factors for success in planning for a PACS. However, the implementation of a successful PACS project is a giant undertaking; not every situation or issue can be anticipated. Through careful planning, coupled with attention to all the issues outlined in this review, a PACS project can become fun and hugely rewarding.

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