Parlaying Digital Imaging and Communications in Medicine and Open Architecture to Our Advantage: The New Department of Defense Picture Archiving and Communications System

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The Department of Defense (DoD) undertook a major systems specification, acquisition, and implementation project of multivendor picture archiving and communications system (PACS) and teleradiology systems during 1997 with deployment of the first systems in 1998. These systems differ from their DoD predecessor system in being multivendor in origin, specifying adherence to the developing Digital Imaging and Communications in Medicine (DICOM) 3.0 standard and all of its service classes, emphasizing open architecture, using personal computer (PC) and web-based image viewing access, having radiologic telepresence over large geographic areas as a primary focus of implementation, and requiring bidirectional interfacing with the DoD hospital information system (HIS). The benefits and advantages to the military healthcare system accrue through the enabling of a seamless implementation of a virtual radiology operational environment throughout this vast healthcare organization providing efficient general and subspecialty radiologic interpretive and consultative services for our medical beneficiaries to any healthcare provider, anywhere and at any time of the night or day.

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THE DEPARTMENT OF DEFENSE (DoD) has been invested in the development and implementation of picture archiving and communication systems (PACS) and teleradiology systems since the early 1980s. In the early days of this technology, the investigative emphasis was initially on teleradiology and the use of the newer digital modality of computed radiography as the plain film equivalent in providing access to radiologist interpretation of images remotely from small clinics or for use from geographically isolated events such as in support of emergency and disaster relief efforts or from the modern battlefield. As storage, communication and display technology advanced through the 1980s and medical management emphasis

evolved aggressively toward automation of medical information processes, the project emphasis began to turn toward support of image communication systems within fixed facilities and the basic tenets of PACS development and implementation, in addition to the continued deployment and use of teleradiology.

In 1989, the DoD Surgeon's General supported the initiation of contracting efforts for the procurement and deployment of the first fully functional DoD PACS system, the Medical Diagnostic Imaging Support (MDIS) system.¹ This contract was awarded in September 1991 and more than 30 PACS and teleradiology systems have been deployed and are functioning today throughout the world.² During the mid-1990s, business practice reengineering (BPR) of the radiologic services processes in the three Services of the DoD military healthcare system (MHS) was formulated and a series of business process improvement initiatives centered around the full implementation of digital imaging throughout the DoD MHS were developed and approved for implementation. Future medical practice envisioning projects looking deeply into medical concepts of the early years of the next millennium were also undertaken and the radiology services envisioned by this group were also focused on transparent and immediate access by healthcare providers to medical images throughout the healthcare environment regardless of the location of the patients, the archives, or the providers requiring access. In 1997, with the BPR of radiology as a long-term goal in the DoD MHS, continued rapid progression in applicable technology and the interval development of communication standards, a new acquisition contracting effort³ was initiated with subsequent contract award in November 1997 for the current DoD PACS system, the digital imaging network (DIN-PACS) with fielding of the first PACS and teleradiology systems currently underway. We discuss the major differences of the DIN-PACS and MDIS systems and the advantages available to the DoD through implementation of these advantages.

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MATERIALS AND RESULTS

The MDIS system contract focused on obtaining the best available system in 1990, in the eyes of the acquisition team and its consultants, to support principally the deployment of isolated PACS systems in DoD with some emphasis on teleradiology. This essentially bi-Service (Army and Air Force) effort focused on overcoming many of the manual inefficiencies being experienced in the DoD MHS facilities, many exacerbated by the manpower drawdown being experienced by DoD in the late 1980s and 1990s. As a single-vendor system, interoperability with other systems was not critical in the specification formulation, while smooth and fast internal operations were crucial in these relatively early days of full PACS system implementation. The American College of Radiology–National Electrical Manufacturer’s Association (ACR-NEMA) interface standard was specified in the system acquisition document for use across all image interfaces to MDIS. Although an early medical imaging communication standard, there were difficulties experienced in interfacing modalities, with the MDIS system requiring sometimes extensive intervender cooperation and modification of equipment. The HL7 standard was used to accomplish a one-way interface to the DoD MHS hospital and radiology information system (H/RIS), the Composite Health Care System (CHCS).

The predominant imaging modality within radiology, the plain film, and its replacement with digital imagery was the center of focus of PACS implementation with the MDIS system making it different from other PACS systems of the early 1990s, which predominantly were outgrowths of systems designed around the smaller digital images of computed tomography and magnetic resonance modalities or systems designed to handle these smaller images or 8-bit digitized plain film images for consultative quality review. These and other variables between the MDIS and DIN-PACS systems are compared in Table 1.

The development, publication and subsequent updating and expansion of the Digital Imaging Communications in Medicine (DICOM) standard provided a key initiative to respecify DoD PACS and teleradiology requirements requiring full vendor implementation of all service classes of the DICOM standard and supplements as they are adopted and published. The implementation of this standard by imaging equipment manufacturers en-

Table 1. Comparison of MDIS and DIN-PACS

Variable	MDIS	DIN-PACS
Emphasis of implementation	PACS	Telepresence
Services involved	Army, Air Force	Navy, Army, Air Force
Vendor	Single	Multiple
Sites supported	Fixed facilities	Fixed; deployed; shipboard
Communication standard	ACR-NEMA	DICOM; HL7
HIS/RIS interface	Unidirectional	Bidirectional
Workstation	Dedicated, proprietary	Dedicated; PC; web-based
Acquisition devices	CR, film digitizer	None

abled DoD not to have to specify acquisition modalities, such as computed radiography or film digitizers, in the DIN-PACS contract and these are now all separately acquired by facilities depending on their individual requirements.

The DIN-PACS system, a truly tri-Service DoD acquisition effort, focuses on the interoperability of not only individual imaging modalities seamlessly integrated with an individual PACS as in the MDIS project, but also the seamless integration of PACS and teleradiology systems between different vendors interoperating over large geographic regions and being used to supplement the radiologic services of any other site. This regional to global geographic emphasis of radiologic services operations heavily emphasizes the use of teleradiology in both traditional and “reverse teleradiology” implementations, in contradistinction to the limited point-to-point emphasis of this tool in the MDIS model enabling the implementation of the “virtual radiology operational environment” envisioned by the Radiology BPR Team of 1996 through the interfacing of systems with intelligent metamanagers for appropriate distribution of radiologic images for interpretive and consultative purposes over large geographic regions throughout a healthcare organization.

Finally, in an expansion from the dedicated workstation platforms of the MDIS system, the DIN-PACS additionally specifies the provision of workstation software to be operable on customer-provided personal computers (PCs), as well as web servers for the PACS systems to enable controlled intranet and internet access to images. This will enable communications for fixed or portable primary diagnosis and/or consultative service locally

or at a distance from the acquisition site using powerful dedicated image navigation software or web browsers with plug-in tools for lower volume situations.

DISCUSSION AND CONCLUSIONS

The development and relative widespread implementation of the DICOM standard and mandatory incorporation of this standard in the new DoD DIN-PACS system promises the transition from image transmission on a point-to-point basis within a single system to an true interoperability between systems of various vendors. This provision of and commitment to interoperability-facilitating standards of communication between products of varied vendors is a core difference in implementation of DIN-PACS versus MDIS. Equipment modality vendors understand the commitment of the DoD in acquiring imaging modalities that support the current implementation of DICOM and kept up to date with the future supplements published to the DICOM standard. This is of tremendous advantage to the DoD enterprise by allowing incorporation of varied vendors products into the radiologic telepresence meshwork being established in DoD.

The theme of the MDIS acquisition team of "any image, anywhere, anytime, to any authorized user" is truly amplified by the DIN-PACS focus on telepresence throughout the MHS. This allows for a large or even global geographic provision of general and subspecialty radiologic interpretive services to fixed or deployed land-based facilities and ships at sea equipped with radiologic acquisition modalities. This enables tremendous advantage for the DoD to work on a tri-Service basis in providing around-the-clock coverage to deployed facilities and ships located at any location on the oceans through routing of images to locations where radiologists and clinical consultants are on-duty at the time of clinical need for these services. Additionally, the telepresence concept allows for better distribution of radiologists into remote areas, whose workload by itself would not justify the assignment of a radiologist. Images of any modality can be routed to that radiologist for interpretation thus filling his time and allowing him access to a full radiologic practice, teaching file, and continuing medical education opportunities that would otherwise not be available during his assignment to a small facility. The opportunity arises to work with civilian teleradiology groups practicing 24-hour

coverages and adhering to communications standards. Additionally, the telepresence concept allows for coverage in the absence of the remote radiologist by other facilities during periods of deployment, vacation or for emergency coverage on a routine basis so that this individual is not left in on-call status 24 hours per day.

Provision of workstation software for use on modern customer-provided PCs equipped with appropriate display monitors will allow the bulk purchase of excellent desktop "workstations" for the general clinician for review of images of his patients and for primary interpretation of these images in lower volume situations with an appropriate understanding of caveats of lower resolution monitors. Portable interpretation of images using PC web browsers (with downloaded image viewing and manipulation software) accessing the image database of a facility enables on-call coverage and access to remote subspecialty providers (both radiologic and clinical) for case management determinations 24 hours per day. This adds the potential for access to multiple consultants in varied locations for assistance in individual case management. The incorporation of increased options of image compression methodologies into the DICOM standard is eagerly awaited by this community to facilitate rapid transmission of large image files through lower bandwidth communication routes.

The BPR efforts of the mid-1990s on a tri-Service cooperative basis coupled with the determined efforts of the DIN-PACS acquisition team members to acquire standards-based open architecture PACS and teleradiology systems has established a solid basis for an inter-Service cooperative approach to the provision of radiologic services to our beneficiaries, potentially on a widespread and changing geographical basis, as the MHS progresses into the next century and millennium.

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