IMPLEMENTATION PLAN FOR

A DIGITAL DENTAL IMAGING AND A

PICTURE ARCHIVING

COMMUNICATION SYSTEM (PACS)

U.S. AIR FORCE

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EXECUTIVE SUMMARY

Since the late 1980s advancements in imaging technology have made digital dental imaging a reality in the practice of dentistry. The Air Force Dental Service has embarked on the establishment of these implementation guidelines to promote the introduction of digital imaging in order to ensure interoperability within the dental service. It is important to note that the goal of this technology infrastructure is to establish a network that connects the treatment room with offices, the front desk and other vital areas electronically. This will enable all digital imaging needs to be accomplished along with the proper utilization of image management tools. Realize that it is possible to use the digital technologies without the infrastructure in place; however, it is difficult to operate with the digital systems that do not integrate seamlessly to other office technologies.

These guidelines attempt to cover every aspect of implementing a ***completely integrated digital imaging environment***, including physical plant, networking, communications, image acquisition, display and storage. The goal is to provide guidance in the design and purchasing of new equipment as well as establishing good operating procedures for a reliable and maintainable imaging system for dental services. The purpose is **not** to recommend any specific system as the imaging solution for the Air Force Dental Service.

SECTION 1 – GENERAL

1.1. Purpose

This document provides guidelines for the implementation of a digital imaging system to be used to support the peacetime dental mission within a Dental Treatment Facility (DTF), as well as in the field of wartime dental missions. These guidelines attempt to cover every aspect of implementing a ***completely integrated digital imaging environment***, including physical plant, networking, communications, image acquisition, display and storage. It describes the use, employment and responsibilities associated with implementing dental digital radiology and a Picture Archiving and Communications System (PACS).

1.2. Description

Digital dental imaging includes all non-film based methodologies and serves as an important adjunct to providing oral health diagnosis and care for the treatment of our patients. The recent rapid advances in computer technology, capture methodology and display devices have revolutionized the field of diagnostic imaging. A truly integrated and effective digital dental imaging system utilizes an open standards-based protocol (such as DICOM), as well as a telecommunications transmission media to distribute and manage dental digital images. Such images include video, static photos or any form of digitally acquired image that are utilized to provide definitive diagnostic imaging support. An open systems network of digital devices is essential for the effective acquisition, transmission, display and management of diagnostic dental imaging studies.

A PACS is used in medium to larger dental treatment facilities that are converted to a “filmless” environment. The PACS includes: PACS workstations, a digital archive and a database server. The PACS should have the capability to be fully integrated or have interface capability with a Hospital Information System (HIS), such as the proposed Composite Health Care System II (CHCS II).

1.3. Goal

Digital Dental Imaging Systems allow for a robust digital imaging network coupled to an image archiving system that delivers correct patient imaging information, providing dental providers maximum diagnostic capability for patient care. The goal of this document is to provide guidance in the design and purchasing of new equipment as well as establishing effective operating procedures for a reliable and maintainable imaging system for dental services. Additionally, the goal is to create an infrastructure facilitating a Dental Treatment Facility's ability to move forward with a digital dental enterprise. The purpose here is **not** to recommend any specific system as "the imaging solution" for the Air Force Dental Service.

1.4. Strategy

Digital Dental Imaging Systems provide comprehensive diagnostic services to support the dental healthcare services by enabling the dental care provider access to high technology imaging modalities which can provide numerous advantages:

- Easily integrate digital images with electronic patient and dental records
- Eliminate hazardous chemical and physical film waste management associated with the chemical processing of film
- Potentially reduce storage area of records due to elimination of physical film
- Electronically enhance digital images to enable optimum appearance of abnormal anatomic structures or the detection of dental diseases
- Network AF dental treatment providers together to facilitate timely diagnosis and treatment options, critical for geographically separated dental clinics and deployed forces in times of military and homeland defense contingencies, assuming all network safety protocols are established and adequate infrastructure is in place

- Potentially reduce radiation dose to patients by up to 70% from conventional techniques
- Link geographically separated dental clinics with the various dental specialty consultants
- Assist in creation of an electronic repository of dental panoramic images for all active duty and reserve Air Force personnel to use for forensic identifications and to serve as a source for population health studies
- Promote Dental Care Optimization within a dental treatment facility, with potential productivity gains

SECTION 2 – DESCRIPTION

2.1. Modalities

Modalities are devices that can be used to not only obtain digital radiographic images, but also other digital modalities such as intra-oral cameras and digital camera pictures**.** These modalities are an important component of the imaging technology and have made the practice of dentistry simpler and more precise because of the technological advances. Key factors with all modalities are: Image Acquisition, Image Viewing, Image Interpretation, and Image Archiving. It is important to note that the key emphasis will be that of digital dental radiographic imaging modalities.

2.1.1. Image Acquisition: The decision on which image acquisition hardware to purchase is typically where most clinics start. However, this is the wrong area to begin the process of digital dental conversion. The infrastructure must be set up prior to any decision on hardware purchase. Once the infrastructure is completed, image acquisition is accomplished with a DICOM (Digital Imaging and COmmunications in Medicine) open standards imaging format that supports the given modality. Acquisition may be accomplished via an image photostimulable phosphor (PSP) plate, charged couple device (CCD), complementary metal oxide sensor (CMOS) or may be acquired directly through a fixed or portable acquisition device/instrument such as a scanner, digital camera, or intra-oral camera.

Basic recommendations for digital dental radiographic imaging include the following:

1. **Solid-state CCD/CMOS x-ray sensors recommended for field use**
2. **USB interface for CCD/CMOS x-ray sensors and intra-oral cameras**
3. **Photostimulable phosphor (PSP) imaging plates for general clinical use**

There are currently two main types of dental digital systems that are available: direct (charge-coupled device/CMOS) or indirect (photostimulable phosphor).

- Direct systems will have a sensor connected directly to a computer, which may be a laptop or desktop unit. Sensors can be somewhat bulky, susceptible to breakage and costly. The attachment of the cord to the sensor may make intra-oral placement challenging, especially for vertical bitewings. It has yet to be seen if caries diagnosis is influenced because of the cord that results in an "open" bite for horizontal or vertical bitewing analysis. It must be noted that the main advantage is that the image is quickly acquired. The computer and sensor must be in the same room as the x-ray machine. There are some new "wireless" direct systems using infrared technology, but they still require close location (within 10 feet) of the sensor to the computer. Examples of direct intra-oral systems are Schick®, Dexis®, Sidexis®, RVG®, Dixi®.

- Indirect systems use PSP plates, which are about the same dimension as conventional film. The plate is exposed and then placed in a laser scanner to be read out. The costs of the plates are relatively inexpensive (at $15-20 for an intra-oral size 2), with the cost of the scanner starting at $12,000. The plates are reusable following "erasure" of the image with intense light. The scanner and computer do not need to be in the treatment room, but can be kept in a central location (much like conventional films can be exposed in various treatment rooms, centrally processed). Depending upon the resolution desired, image acquisition can take as little as 17 seconds once the plate is placed into the scanner or may take up to 5.5 minutes for a panoramic image. Indirect systems offer wider exposure latitude and will have higher spatial resolution, less "noise." Conversion of a traditional panoramic machine may be accomplished by using PSP plates (with special cassettes), loaded into the same scanner utilized for intra-oral plates. Examples of PSP

systems are Digora®, DenOptix®, and A/T ScanX®. Digora® and DenOptix® can be purchased with their own software, but A/T ScanX® needs the purchase of software.

- **The two types of systems are complementary**. Local clinic needs should drive which system should be purchased. For some dental clinics both a direct and an indirect digital system should be acquired. Purchase of extended warranty is recommended, as well as customer service. Contact clinics that have purchased systems and inquire about the reliability of customer service that they have had. Poor customer service will make for a difficult transition to full digital conversion. Questions regarding the type of hardware should be referred to AF Dental Investigation Service (DIS) and/or the Chief Military Consultant for Oral & Maxillofacial Radiology.

Sensor Type	**CCD/CMOS**	**PSP**
Acquisition	***Direct*** - Cord attached to sensor, USB connection to computer. "Wireless" sensor must be within 10' of computer.	***Indirect*** – Exposed image plate placed in laser scanner, "read." Computer/scanner not required in treatment room.
Time to image	Seconds (nearly instantaneous)	Depends on scanning system & resolution. As fast as 17 seconds for initial film. Up to 5+ minutes for pano
Price of sensors	$4000+	$15 for periapical plate (Scanner price $12,000+)
Durability of sensor	Susceptible to breakage	Can become scratched with rough handling
Thickness of sensor	3 - 8 mm, depending upon manufacturer	1.6 mm (less than conventional film)
Sensor sizes	0, 1, 2 for intra-oral systems; separate pano/ceph systems available	All intra- and extra-oral or pano can be loaded into scanner

2.1.2. Image Viewing: Dental providers should be able to sit down at any dental treatment room or PC/workstation on the AF Network, access the dental patient record, pull up the imaging folder, view any image and make any appropriate

comparison to previous studies. Additional capabilities allow for imaging tools and formatting that permit enhancement of the entire image for better diagnostic yield. Image viewing should follow the following three reference models: evaluation, review, and interpretation.

Choices for viewing media should include:

- Minimum display XVGA with 1024 x 728 native resolution at 24-bit color
    - Realize the resolution availability will depend on the combination of the quality of the graphics card and the native resolution of the monitor
- 15” flat panel display minimum for desktop form factor
- Wide angle of vision which will minimize color shift or distortion
- Free mount capability that allows for a freestanding (countertop) or wall- or arm-mounting options to accommodate any preference or design
- Minimum of 16.7 million display colors
- Minimum of 400:1 contrast ratio
- Maximum pixel pitch (dots per inch-dpi) 0.297 x 0.297
- Realize that LCD flat-screen monitors are optimized for a particular resolution and do not display non-native resolutions well; therefore, check to see the native resolution compatibility
- Digital graphics adapter for flat panel display (digital interface capability)
- Care must be given in the choice of a monitor. An “off the shelf” monitor does not outperform higher-end monitors that have better capabilities

2.1.3. Image Interpretation: Typically this is when diagnosis is being made off of any digital imaging modality. The only model that can be used for interpretive image studies and definitive diagnosis requires a high-bright pixel resolution. This is more typical of medical imaging interpretive capabilities and specifications are based on the American College of Radiologists Standard for Teleradiology. Proceeding with a high-resolution monitor for all areas is not necessary.

2.1.4. Image Archiving: When it comes to a “hard copy” of radiographic or clinical image, the choices are limited at this point. It is important to note as all clinics are converted to digital media, the need for a printed copy will not be necessary. During this transition period, the printed image should be of high quality with archival capability (example, high-end inkjet or dye sublimation printer). Note: A diagnostic quality printer may need to meet FDA standards.

1. If a patient with digital radiography images transfers to a base without digital radiography support, the digital images may both be copied to a CD and placed in the record or the images may be printed out. If images are printed as a permanent part of the record, the "hard copy" print should be of archival quality.
2. Ensure that there is at least one “hard copy” panoramic image maintained in the dental record during transition (in case if there is no computer access). If a recent digital panoramic image has been taken following extensive dental treatment, it is recommended to print the panoramic image for inclusion in the paper record.
3. In the transition from a base with digital capability to one with conventional films only, copy digital images to CD. There should be a provision for writing of a simple “viewer” to the disk. Images should be copied to the disk in both DICOM and JPEG formats.

As technology improves, all patient information will be electronically captured, retrieved and transferred, or carried by the patient via some type of storage media (CD-RW) from a DoD enterprise level database.

2.2. Picture Archiving and Communications System (PACS)

2.2.1. System Definition: A PACS enables the distribution of images and associated patient demographic information throughout a medical and dental enterprise. A PACS also has the capability of being fully integrated with an electronic patient record or a hospital information system, such as CHCS. The

system allows for the functional ability to not only distribute images to a requestor, but also communicate patient demographics to modalities, track image location and assemble all forms of dental digital images. The enterprise level setting of multiple, concurrent users along with the extensive diagnostic digital imaging database of a dental treatment facility necessitates a PACS be utilized on a enterprise level setting. Typical dental software currently being utilized does not lend itself to an enterprise level setting. Essential to the management of this enterprise level setting PACS is the server, which maintains the database of patient data and controls access through required security protocols. Utilization of a server enables secured access and flexibility to grow with future needs. One of the most difficult decisions will be where to maintain the server. Ideally, the server should be kept with the other hospital servers in a controlled environment. By doing so, the server would have the appropriate administrator, preferably a medical systems staff-member. **A key point to understand is if one does not have the support of medical systems, it will put the responsibility for any troubleshooting, upgrades, systems failures, etc., on dental personnel who may not be properly trained.** This is an area that one must precede with care so that all responsibilities are clearly delineated. Additionally, the server specifications should be calculated to accommodate the concurrent access of multiple dental personnel.

3.2.2 Planning & Data Collection Requirements: In order to aid with the acquisition process and ensure a PACS is capable of supporting the local requirements, an inventory of all imaging modalities and equipment should be accomplished. The server requirement should be based on clinic size and workload. In addition, the patient population and projected staff that would have access at one time are factored into any size calculation. Realize this is more for the utilization of all digital modalities. For radiographic use only, a PACS is still recommended if there are more than 6 individuals accessing the system at once. Otherwise, the system will become bogged down and inefficient.

1. Requirements based upon clinic size:
    a. Small – up to 50 workstations
    b. Medium – 50-100 workstations
    c. Large – 100+ workstations

    *Note: Include both office and treatment room locations of workstations

	Small	**Medium**	**Large**
Number of CPUs	Single (1 CPU)	Dual (2 CPUs)	2-4 CPUs
CPU speed	High	Medium	High
RAM	Max affordable; minimum of 2 GB	Max affordable; minimum of 4 GB	Max supported; Minimum of 8 GB

2. Server computer should be a server class computer, not a desktop computer.
3. Calculation of workstations, based on clinic size, should include treatment rooms, working areas, and offices.
4. Server should support redundant hot-swap power supplies.
5. RAID level 5 storage subsystems.
6. Minimum 1-hour uninterruptible power supply (UPS) is recommended.
7. Storage size should be based on 3-5 years of data. Requires an analysis of number and types of films over the past 5 years. Calculations of images to be storage per year should be based on the following:

Type of X-ray	**Number of Exposures**	**Size of Image (MB), Uncompressed**	**Total (MB)**
Panoramic		Up to 10 MB	
Cephalometric		Up to 16 MB	
Intra-oral		Up to 5 MB	

8. Bottom line – buy as much as you can afford!

2.2.3. Server and Workstation Software Requirements: The software that one will utilize in a digital dental imaging system will need to follow the following

recommendations in order for it to be truly successful in an enterprise level. One does not necessarily have to follow all these recommendations, however, the integration with other imaging modalities will be more difficult and the ability to communicate and access imaging files within as well as between treatment facilities may not necessarily be achievable.

Server Software

1. Windows 2000 Server or higher operating system, consistent with local, DoD policies.
    a. Care must be taken to ensure that the imaging software will work with later versions of Windows operating systems. Contact manufacturer and systems personnel.
2. All software should be DICOM 3.0 conformant.
3. Software should support the following DICOM SOP classes
    a. Network storage of Digital X-ray Objects (e.g., extra-oral, pano)
    b. Network storage of Digital Intra-oral X-ray Objects (e.g., PAs, etc.)
    c. Network storage of Visible Light Photography Objects
    d. Network storage of Visible Light Endoscopy Objects (e.g., intra-oral camera)
    e. Network storage of Secondary Capture Objects (e.g., scanned conventional x-rays)
    f. Network query/retrieve of Digital X-ray Objects
    g. Network query/retrieve of Digital Intra-oral X-ray Objects
    h. Network query/retrieve of Visible Light Photography Objects
    i. Network query/retrieve of Visible Light Endoscopy Objects
    j. Network query/retrieve of Secondary Capture Objects
    k. Read & Write to removable media of Digital X-ray Objects
    l. Read & Write to removable media of Digital Intra-oral X-ray Objects
    m. Read & Write to removable media of Visible Light Photography Objects
    n. Read & Write to removable media of Visible Light Endoscopy Objects

o. Read & Write to removable media of Secondary Capture Objects

4. Software should provide for inclusion of a simple viewer application to be recorded to removable media, which will auto-launch to display DICOM images.
5. Enterprise based software to provide support for:
    a. Multi-client
    b. Multi-user
    c. Scalability
    d. Integration with DoD systems

Workstation Software

1. Windows 2000 Profession or higher operating system, consistent with local, DoD policies.
2. Software should support the acquisition of images from different hardware vendors.
3. Software should support acquisition of images from CCD/CMOS sensors, photostimulable phosphors (PSP) image plates, intra-oral cameras and digital cameras.
4. All software should be DICOM 3.0 conformant.
5. Software should support the following DICOM SOP classes
    a. Network storage of Digital X-ray Objects
    b. Network storage of Digital Intra-oral X-ray Objects
    c. Network storage of Visible Light Photography Objects
    d. Network storage of Visible Light Endoscopy Objects
    e. Network storage of Secondary Capture Objects
    f. Network query/retrieve of Digital X-ray Objects
    g. Network query/retrieve of Digital Intra-oral X-ray Objects
    h. Network query/retrieve of Visible Light Photography Objects
    i. Network query/retrieve of Visible Light Endoscopy Objects
    j. Network query/retrieve of Secondary Capture Objects
    k. Read & Write to removable media of Digital X-ray Objects

l. Read & Write to removable media of Digital Intra-oral X-ray Objects
m. Read & Write to removable media of Visible Light Photography Objects
n. Read & Write to removable media of Visible Light Endoscopy Objects
o. Read & Write to removable media of Secondary Capture Objects

6. Software should provide for inclusion of a simple viewer application to be recorded to removable media, which will auto-launch to display DICOM images.
7. Enterprise based software to provide support for:
    a. Multi-client
    b. Multi-user
    c. Scalability
    d. Integration with DoD systems

2.2.4. Workstation Hardware The workstation is the primary tool for image acquisition and viewing. Its role should not be overlooked, for any delay of information can be attributed to its specifications. Data retrieval and display occur initially at the workstation, via the server.

1. Pentium 4 class or higher CPU
    a. Intel processors with Intel Chipsets are recommended. A number of digital x-ray systems have conflicts with other types of processors or motherboard chipsets.
    b. Ensure written specification is obtained for hardware requirements from software vendor
2. CPU clock speed – medium range performance
3. RAM – minimum 256 MB
4. Hard disk storage – minimum 20 GB
5. Laptop or desktop form factor (site selection)
    a. Laptops have advantages but should be cautioned in their use (as well as single unit enclosed computers) because they tend to cost

more and tend not to be expandable) and may have network compatibility issues.

6. Removable media – CD-RW at a minimum

Workstation capability is only as good as the initial specifications. Be sure to allow for upgrade ability. This is part of the initial infrastructure requirements and should be addressed with medical systems personnel. In addition, consideration should be given to roles in addition to diagnostic imaging that may be required of the workstation. Decisions regarding additional software requirements or Internet capability for the workstations should be based on the optimization of patient treatment. Specifications of the workstation will determine the local environment and speed. However, the majority of speed difficulties can be attributed to the number of individuals accessing the server at one time.

2.3. Clinical Considerations

The primary diagnostic purpose in the utilization of digital dental imaging is to serve as an adjunct in the diagnosis and treatment of the dental patient. Image interpretation, whether radiographic or clinical imagery, should have at a minimum an acceptable standard for diagnostic image interpretation, which is to review the digital images that support the full DICOM data set. There are many similarities between film-based imagery and digital imagery. Techniques from radiographic imaging to intra-oral photography still require the same fundamental positioning techniques. For radiographic procedures, one still needs to use an X-ray source. Additionally, there may be some technique pitfalls associated with x-ray sensors. The thickness, rigidity and presence of a cord for some sensors present additional challenges when positioning in the intra-oral cavity, which may lead to technique errors. PSP plates also have pitfalls: plates can be easily scratched and must be sent through a scanner.

The use of sensors is recommended for endodontic procedures, surgical procedures, implant evaluation, and other procedures where time is of importance. In general clinical diagnostic procedures such as exams, full mouth radiographs and other detail orientated imaging needs, the use of PSP plates are

recommended due to the procedural similarity and dose response similar to that of conventional film. Realize the size of the sensor often dictates exposing multiple images compared to that of a PSP plate or conventional film.

The use of printed digital radiographic images must be carefully considered since most “off the shelf” printers that are available produce a non-diagnostic interpretation medium. This is due to their decreased resolution resulting in lost anatomic clarity and the potential for a missed diagnosis. The use of high quality medical grade printers tends to be overly expensive and may not be cost effective. Ultimately, the best scenario would be to write the patient images and information written to a CD-RW with a viewer installed.

2.4. Back-Up

Back-up is necessary to ensure to proper access of patient data when individual workstations or the main server is down. The backed-up data should be available at all times, but located separate from the main data storage.

1. Back-up schedule should be established to provide for daily and weekly back-ups.
2. Back-up should be made on any back-up system that provides the data security, back-up capacity and speed for the task, which should be able to process during after-hours.
3. Back-up should be stored in off-site facility.
4. Management staff must be assigned responsibility for back-up.

The back-up schedule could be performed by electronic means or by assigned personnel. It should be preferably completed according to individual clinic needs. One must ensure that the data that is backed-up can be verified as well.

SECTION 3 – RESPONSIBILITIES

3.1. Oral and Maxillofacial Radiology Consultant to the AF Surgeon General

The Dental Radiology Consultant serves as the functional area expert on issues relating to dental diagnostic imaging, clinical processes and practices dealing with Oral & Maxillofacial Radiology. In this capacity, the consultant coordinates current technology and bridges conventional methods that are available to the field of dentistry. The consultant will provide guidance in matters relating to radiographic imaging and can be reached at Lackland AFB, TX (DSN: 473-2343).

3.2. Dental Investigation Service (DIS)

DIS conducts a diversified program of investigation, testing, and evaluation specifically relevant to the needs of the Air Force Dental Service as directed by HQ USAF/SGD. DIS will provide assistance in the design or modification of dental facilities. Additionally, DIS will test, evaluate and provide protocols for dental equipment, devices and procedures. DIS does have limited technical and educational support for dental devices. The Dental Treatment Facility should consult with DIS prior to purchase of any imaging software or hardware.

3.3. Digital Dental Imaging End-User

The Dental Treatment Facility pursuing the conversion to digital dental imaging is integral in the planning and implementation of the system. The providers and technicians are the end-user and must have an understanding of the entire system and have the appropriate training. Ultimately, the decision of which system that will be chosen for acquisition should have input from all end-users.

SECTION 4 – COMMUNICATIONS/COMPUTER SYSTEM SUPPORT

4.1. Local Area Network (LAN)

The Digital Dental Imaging System will traverse the Local Area Network at the local dental clinic site. The networking requirements serve as the basis for the infrastructure that is necessary for any digital system to operate properly. The cables in the wall should be placed in optimal locations for proper use and ensure that they will support the hardware that will be used. The gaining site will have a network that will support the bandwidth required for intra-facility transmissions. The items listed are at a minimum what are necessary to effectively ensure the correct operation of a digital dental system.

1. Minimum - Category 5 UTP cable minimum for transmission media; ***Recommended Category 5e or 6 UTP.***
2. 10/100 Mbps NIC for desktop computers and 100/1,000 Mbps NIC for servers.
3. 100 Mbps Ethernet to the desktop with 1,000 Mbps Ethernet for backbone between Ethernet switches and for server connections.
4. Ethernet Switches with 100 Mbps ports for desktop connections, 1,000 Mbps for network backbone, and 1,000 Mbps for server connections.
5. “Intelligent ethernet switches” (example of Cisco Catalyst 4000 or equivalent) to enable administrators to configure V-LANS and control network traffic.

The locally designated approval authority (DAA) will approve all connections to the local network. All necessary support and documentation must be furnished so that a detailed System Security Authorization Agreement can be completed. The medical systems or base systems personnel typically manage support for the LAN connectivity. Most clinics will already have this infrastructure in place. If new wiring is required, they will determine the appropriate required cable and switches. The items listed previously should support the current

technology and be able to support future advancements in technology. For future flexibility, whenever possible place empty conduit (with draw wire and swept bends) from cabinetry to the floorbox supplying the dental patient chair. This will save a lot of expense and hassle if one decides to add equipment to the chair mounted delivery system. The key is to plan for flexibility with accessible wiring channels.

4.2. Wide Area Network (WAN)

The Digital Dental Imaging System may traverse the AF WAN via the medium and ports designated by the local DAA and in accordance with the parameters detailed in the C4ISP process. All necessary documentation and support will be detailed in the CON, CTO and SSAA at the local site. Support for the WAN connectivity is coordinated and managed with the Air Force Communication Agency at Scott AFB.

4.3. HIS Interface

The Digital Dental Imaging System should have the capability to interface with the future release of the CHCS II Radiology module. Potentially, a two-way interface to CHCS II may be developed to further gain efficiencies within the system. The CHCS II program manager will determine any support for this interface.

4.4. Physical Plant

The development of a high technology treatment facility is an ongoing process. Fortunately, the physical plant has been planned appropriately the majority of time. However, one has to be prepared to expect the periodic updates of the space required to accommodate any changes with the equipment. The following should be investigated and established prior to any conversion process:

1. Adequate space and ventilation should be provided for image server hardware. The preferred location for the dental image server would be in a central systems office with the rest of the facility's servers.
2. Network closet, such as the existing communications closet, should be provided to locate patch panels and network hardware.
3. Both spaces above should have security measures to prevent unauthorized access.
4. Dental operatory/image acquisition center design should provide secure location of workstation with display visible to both operator and assistant.

All these deal with Communications and fortunately, these parameters are already established. The future designs of dental clinics have typically incorporated these items into the planned final product. Any remodeling efforts planned should also incorporate these provisions. Questions should be referred to the facilities manager or systems personnel. Design questions should be referred to DIS. Most clinics already have this infrastructure in place. Contact medical systems or base systems personnel for information. If new wiring is required, they will determine the appropriate required cable and switches. The items listed should support the current technology and be able to support advancements in technology. For future flexibility, whenever possible place empty conduit (with draw wire and swept bends) from cabinetry to the floorbox supplying the dental patient chair. This will save a lot of expense and hassle if one decides to add equipment to the chair mounted delivery system. The key is to plan for flexibility with accessible wiring channels.

4.5. Recommendations

Coordinate with the Information Systems office to get the details relating to any network upgrades and enhancements (e.g. MSIM), and provide a synopsis of network capabilities internal to the DTF that details performance, i.e. what is the network vertical and horizontal backbone bandwidth and what are the bandwidth capabilities out of the facility to satellite clinics or supporting DTFs. The capabilities of the network external to your facility and off the base will be

critical in realizing the true potential of a digital dental imaging project. It is imperative that discussions with the Base Communications Squadron are initiated early and they must be kept in the loop to ensure a successful deployment; it is extremely likely that your system will traverse the base firewall as the true potential of a digital imaging network are realized.

SECTION 5 – INTEGRATION/INTEROPERABILITY

5.1. Open Standards

The use of the DICOM standard and its components will allow for an interoperable dental imaging enterprise. The American Dental Association continues the interoperability efforts for the standard file format, archiving and storage of digital dental images enabled through the DICOM standard. These open architecture systems are designed to work with a wide range of imaging systems, enabling one to choose from more than one manufacturer's hardware or to change to another system at a later date and still use the same software. Any open architecture standard that is supported by DICOM devices is acceptable for a conversion to digital dental imaging. Interoperability must be assured across image formats, communication protocols and equipment interfaces. Proprietary software and hardware are not recommended and should not be used. The most important aspect of any software decision is to make sure that it is DICOM III conformant. This will allow for an easy exchange of images between varieties of different software. DICOM conformance is essential to AF dental image acquisition, archiving, storage and networking --- enabling Dental Treatment Facilities to purchase acquisition hardware that meets their individual clinic preferences.

5.2. Multiple Vendors

The digital dental imaging system should allow for a multi-vendor solution to allow for the most flexible and best value for the Dental Imaging Enterprise. Multiple vendor solution ensures equitable competition and spurs innovation within the marketplace. This innovation allows for a long-term sustainable solution, which can be supported throughout the product lifecycle. The digital imaging system software should have compatibility with all the digital radiographic equipment that may be on the market. This allows maximum flexibility in choosing an imaging system and allows for future upgrades and additions. Additionally, it is recommended that the software have the capability to not only obtain digital radiographic images, but also other digital modalities

such as intraoral cameras and digital camera pictures. The goal is to have a complete imaging enterprise that allows for the storage of all image forms. Having this capability will ensure that all digital media will have a common storage area.

5.3. Workflow within the DTF

The workflow should be tracked and be accounted for by the American Dental Association Current Dental Terminology (CDT) 4 codes. These standardized codes ensure a dental procedure code reference will be useful for processing and addressing administrative matters. This will additionally ensure accurate radiographic and digital imaging accounting for all dental facilities throughout the Dental Service. Digital imaging should support the entire diagnostic and treatment process of the patient and not be the sole means of detection of disease. As an adjunct, the system should cater to the flow of patient care and not impede or slow down the process.

5.4. Workflow between DTFs and Services

Workflow between the DTFs should occur through appropriate USAF communications protocols. Utilizing open architecture systems with DICOM capabilities will enable potential communication with other services or departments. Information exchange is recommended so that patient care can be optimized.

5.5. Recommendations

Any digital dental imaging system being considered should have open architecture and must have DICOM III conformance that have capabilities to service multiple imaging modalities.

SECTION 6 - SECURITY

6.1. Command, Control, Communications, Computers & Intelligence Support Plan (C4ISP)

The Information Technology (IT) oversight process tends to be conducted largely independently without the benefit of an integrated view. Typically the assessment procedures for the network software were accomplished separately with problems resulting in delays in fielding of DoD and Air Force IT systems. As a result, the fielding of systems was found to be not adequately supportable or interoperable, and did not meet user requirements. The C4ISP plan for digital dental systems shall be assessed on the requirements defined in “Department of Defense Trusted Computer System Evaluation Criteria” (DOD 5200.28-STD). The C4ISP identifies Command, Control, Communications, Computers & Intelligence needs, dependencies, and interfaces focused on interoperability, supportability and security concerns.

6.2. DoD Information Technology Security Certification and Accreditation Process (DITSCAP)

The DITSCAP establishes a DoD standard that will protect and secure the entities comprising the Defense Information Infrastructure (DII). The process will standardize the process for single IT entities that leads to more secure system operations and a more secure DII. Additionally, the process will consider the system mission; environment and architecture while considering the impact of the operation of the system will have on the Defense Information Infrastructure. The main purpose of obtaining DITSCAP approval is to protect and secure DITSCAP SSAA (system security authorization agreement adheres to security policies and outlines risk management approach). In essence the DITSCAP establishes a standard process, set of activities, general task descriptions and a management structure to certify and accredit IT systems that will maintain the security posture.

6.3. Certificate of Networthiness (CON)

A CON and System Security Authorization Agreement (SSAA) is to be pursued through the Air Force Communications Agency (AFCA). The CON ensures systems adhere to security policy and is compatible with Air Force Enterprise Network. MAJCOM Medical Systems can be contacted for guidance in obtaining CON; one must realize the actual process can take up to one year before being deemed “networthy.”

6.4. Certificate to Operate (CTO)

The local dental facility that proceeds with a digital dental imaging system will need to obtain a CTO. The CTO verifies system/application and will ensure that the MAJCOM is ready for implementation on the MAJCOM IT infrastructure. These documents are based on the implementation of the system in the local site environment. It is the responsibility of the local site for organizing the local certification and ensuring that all necessary certification activities occur to meet the requirements. Typically, one should inquire for assistance through medical systems personnel. Both the CON and CTO processes are separate and tightly focused on certain security aspects. Failure to properly identify to the assigned AFCA Action Officer (AO) systems/applications and associated modifications/upgrades which require Networthiness Assessments could stop, delay or revoke the IT capability to receive or retain a CTO and base connection (local DAA) approval.

6.5. Non-Network Protocol

The Dental Treatment Facility may choose not to have the digital dental system wired to the base network. The advantage in this scenario is that one may just have local approval for use of the system as long as the digital system does not have access to the LAN. Contact DIS or the Chief Military Consultant for Oral & Maxillofacial Radiology for more information.

6.6. Recommendations

All connections to the network will comply with the designated authority's approval and requirements for a CON and a CTO if images are to be transmitted via the network. This is recommended so that the connection to the AF network allow for images to travel electronically from base-to-base or clinic-to-clinic with the appropriate approved protocols and configurations.

SECTION 7 - TRAINING

7.1. Clinical

The local dental treatment facility will be responsible for organizing and providing all activities necessary to accomplish appropriate training for the digital dental system purchased. This can be accomplished through the purchase of training packages through the vendor. Note: the majority of vendors share the same image enhancement features, yet the actual application may be subtlety different. The recommendation is to allow for the purchase of imaging systems that will fit the needs of the clinic; therefore, multiple vendors may be present in the same clinic or at different DTFs. As such, one should expect to accomplish additional training with every change of permanent duty station for providers and technicians.

7.2. Maintenance

The digital dental system vendor should provide maintenance support training for the in-house information systems personnel, dental technicians, dentists and biomedical equipment personnel. Training should include basic troubleshooting techniques, preventive maintenance and calibration/QC procedures required to support the basic system components. This training is recommended and is often an additional purchase. Be sure to inquire with other bases that have purchased digital systems for quality of support. Lack of support may be an indication of potential problems that may occur and ultimately lead to frustration and failure of the entire enterprise.

7.3. Systems Administrator

If a PACS is part of the digital dental imaging system, ideally there will be a systems administrator designated to understand the principles and procedures for the system's operation, administration and disaster recovery for all equipment and archives. It is essential to have a formal administrator to manage the system. The following are suggested guidelines in determining the need for a systems administrator:

1. Small bases must have buy-in from medical systems administrator
2. Medium/large bases must have own PACS administrator
3. Successful implementation of a PACS is critically dependent on standardization of the manner in which the image data is interchanged between different medical imaging devices - a feature which does not currently exist between systems from different manufacturers (and indeed, in some instances, between different imaging systems produced by the same manufacturer!). The main advantage of PACS is related to the ease, convenience and accuracy factors which are common to all computerized environments.

7.4. Recurring

The vendor should provide training and upgrade training that will enable new personnel to be oriented to the existing systems. Any necessary refresher training is the responsibility of the local site. Additional training may incur additional costs from the vendor.

SECTION 8 – ADDITIONAL CONSIDERATIONS

8.1. Installation of a Digital Dental Imaging System

The vendor, with systems and communications personnel oversight, should accomplish the installation of a digital dental imaging system. The system should be fully operational prior to any training that the vendor may have planned. All network and communications protocols should be in place.

8.2. Funding

There is limited funding available to properly install a digital dental imaging system throughout the entire enterprise. Local Dental Treatment Facilities must go through their new equipment protocol to secure the digital systems. Often Pollution Prevention Funding may be available through the Wing. However, adequate research and the appropriate presentation must be accomplished prior to the expectation of any prevention funds. Ensure the appropriate physical plant and viewing stations are in place prior to seeking "fall-out" monies for digital imaging hardware (the imaging hardware is often the least expensive aspect and least important). Failure to do so will result in inefficiency and frustration.

8.3. Cost Analysis Tool

The cost of conversion must take into account a multitude of items. The conversion is not strictly for digital dental radiology, but for all aspects of digital imaging. The initial expenses for digital imaging include the equipment and software cost, possible networking cost and staff training. This tends to be the bulk of the costs necessary for digital conversion. However, there are certain consumable, maintenance and upgrade costs that one also must factor into any decision. See Appendix C for formula.

8.4. Equipment Positioning

The Dental Investigation Service should be consulted for equipment positioning matters. Workflow, space and other requirements should be analyzed for optimal workstation and hardware placement.

SECTION 9 - SUMMARY

This Implementation Plan describes the rationale and guidelines to reach an operational enterprise level digital dental imaging system. This endeavor will provide the capability to transmit diagnostic images across a variety of transmission medium to meet the needs of an extensive patient database and multiple providers. Digital dental imaging will serve as an integral component of the USAF Dental Service's peacetime and wartime mission. For this desired end state to become a reality, four important factors must be present:

- Leadership commitment to support the effort through its life cycle
- Tailoring the system to meet the imaging needs of the facility
- Resources available to plan, deploy and sustain dental imaging systems
- Technology advancements to enable efficient, affordable solutions

These guidelines provide the basis for a long-term effort. The ability to specify, deploy and maintain these systems requires a concise process that ensures all critical paths are addressed and followed to produce a fully functional system that supports the mission.

APPENDIX A: Glossary

Archive - a repository for digital medical images in a picture archiving and communications system (PACS), typically with a specific purpose of providing either short-term or long-term (permanent) storage of images. Erasable or nonerasable media may be utilized in an archive.

Baud - the number of events processed in 1 second, usually expressed in bits per second (bps) or kilobits per second (kbps**)**. Typical rates are 14.4 kbps, 28.8 kbps and 56 kbps.

Bit (binary digit) - the smallest piece of digital information that a computing device handles. It represents off or on (0 or 1). All data in computing devices are processed as bits or strings of bits. A pixel that has one bit can be black and white only.

Bit depth - the number of bits used to encode each pixel of the image. An 8-bit image is 2x2x2x2x2x2x2x2 = 256 shades of gray or colors (indexed or palletized color). 8 to12-bit processing is sufficient for radiographic imaging considering that the human eye can perceive from 25-60 shades of gray.

Byte - a grouping of 8-bits used to represent a character or value.

CCD (charge-coupled device) - a photoelectric device that converts light information into electronic information. CCDs are commonly used in television cameras and image scanners and consist of an array of sensors that collect and store light as a buildup of electrical charge. The resulting electrical signal can be converted into digital values and processed digitally in a computer to form an image.

CCD scanner - a device that uses a CCD sensor to convert film images into electronic data.

Clock - a component in a computer's processor that supplies an oscillating signal used for timing command execution and information handling.

Clock speed - the rate at which the clock oscillates or cycles. Clock speed is expressed in MHz, equal to 1 million clock ticks per second.

Compression ratio - the ratio of the number of bits in an original image to that in a compressed version of that image. For example, a compression ratio of 2:1 would correspond to a compressed image with one-half the number of bits of the original.

Co-processor - a device in a computer to which specialized processing operations are delegated such as mathematical computation or video display.

The advantage of a coprocessor is that it significantly increases processing speed.

CPU (central processing unit) - the device in a computer that performs the calculations. It executes instructions (the program) and performs operations on data.

CRT (cathode ray tube) - refers to the monitor or display device in the teleradiology system.

Data carrier - the signal used to transmit the data. If this signal is not present, there can be no data communication between modems.

Data communication - all forms of computer information exchange. Data communication may take place between two computers in the same building via a local area network (LAN), across the country via telephone or around the world via satellite.

Data compression - methods to reduce the data volume by encoding it in a more efficient manner, thus reducing the image processing and transmission times and storage space required. These methods may be reversible or irreversible.

Data transfer rate - the speed at which information is transferred between devices, such as a scanner and a computer; between components within a device, such as between storage and memory in a computer or between teleradiology stations.

Dedicated lines - a telephone line that is reserved for the exclusive use of one customer. It can be used 24 hours a day and usually offers better quality than a standard dial-up telephone line but may not significantly increase the performance of data communication.

DICOM (Digital Imaging and COmmunications in Medicine) - a standard for interconnection of medical digital imaging devices, developed by the ACR-NEMA committee sponsored by the American College of Radiology and the National Electrical Manufacturers Association.

Digital signal - a form of information transmission in which the signal varies in discrete steps, not in a continuous manner.

Digitize - the process by which analog (continuous value) information is converted into digital (discrete value) information. This process is a necessary function for computer imaging applications because visual information is inherently in analog format and most computers use only digital information.

Direct image capture - the capture or acquisition of digital image data that have been acquired in digital format by an imaging modality. The image produced from the data, regardless of the modality that produced it (CT, MRI, computed radiography, ultrasound) is identical to the original.

dpi (dots per inch) - while in conventional radiography, resolution is commonly expressed in line pairs per millimeter (lp/mm), film digitizer resolution is commonly expressed as dots (pixels) per inch.

Dynamic range - the ability of a communication or imaging system to transmit or reproduce a spectrum of information or brightness values.

File - a set of digital data that have a common purpose, such as an image, a program or a database.

G (giga) - stands for the number 1 billion. It is used primarily when referring to computer storage capacities; for example, 1 GB = 1 billion bytes or 1000 megabytes.

Gray scale - the number of different shades of levels of gray that can be stored and displayed by a computer system. The number of gray levels is directly related to the number of bits used in each pixel: 6-bit = 64 gray levels, 7-bit = 128 gray levels, 8-bit = 256 gray levels, 10-bit = 1024 gray levels, 12-bit = 4096 gray levels.

Gray-scale monitor - a black-to-white display with varying shades of gray, ranging from several shades to thousands, thus being suitable for use in imaging. This type of monitor also may be referred to as a monochrome display. (see also monochrome monitors)

Hard disk drive - an internal computer device that is used for storage of data.

Hardware - a collective term used to describe the physical components that form a computer. The monitor, CPU, disk drives, memory, modem, and other components are all considered hardware. If you can touch it, it is hardware.

HIS (Hospital Information System) - an integrated computer-based system to store and retrieve patient information including laboratory and radiology reports.

IDE (Integrated Device Electronics) - a type of interface used for hard disk drives that integrates the control electronics for the interface on the drive itself. Its purpose is to increase the speed at which information can be transferred between the hard disk and the rest of the computer.

Image - a computer's digital representation of a physical object. Note that this is not really the definition of an image (it refers to an electronic image) … this should probably be clarified or modified.

Image compression - reduction of the amount of data required to represent an image. This is accomplished by encoding the spatial and contrast information more efficiently, discarding some non-essential information, or both.

Interface - the connection between two computers or parts of computers. It consists mainly of electronic circuitry.

Irreversible compression - some permanent alteration of digital image data. This is sometimes referred to as lossy compression.

K (kilo) - stands for the number one thousand. It is used primarily when referring to computer storage and memory capacities: for example, 1 kbps = 1024 bps .

LAN (local area network) - computers in a limited area linked together thereby allowing the exchange of data.

Laser film scanner - a device that uses a laser beam to convert an image on x-ray film into digital image data.

Lossless - see reversible compression.

Lossy -.see irreversible compression.

M (mega) - stands for the number 1 million. It is used primarily when referring to computer storage and memory capacities; for example, 1 MB = 1 million bytes. 1 MB = 1000 kbytes or 1,000,000 bytes.

Memory - electronic circuitry within a computer that stores information.

Modem - a device that converts digital signals from a computer to pulse tone signals for transmission over telephone lines.

Monochrome monitor - a computer display in which an image is presented as different shades of gray from black to white. (see also gray-scale monitor)

Operating system - software that allocates and manages the resources available within a computer system. UNIX, MSDOS, Macintosh and Windows are examples of operating systems.

Optical disk - a computer data storage disk used primarily for large amounts (GB) of data.

PACS - Picture Archiving and Communication System.

Peripheral - a device that is connected to a computer and performs a function. Scanners, mouse pointers, printers, keyboards, and monitors are examples of peripherals.

Phosphor - the coating on the inside of a CRT or monitor that produces light when it is struck by an electron beam.

Pixel (picture element) - the smallest piece of information that can be displayed on a CRT. It is represented by a numerical code within the computer and displayed on the monitor as a dot of a specific color or intensity. An image is composed of a large array of pixels of differing intensities or colors.

Protocol - a set of guidelines by which two different computer devices communicate with each other.

RAM (random access memory) - a type of temporary memory in a computer in which programs are run, images are processed, and information is stored. The amount of RAM that a computer requires varies widely depending on the specific application. Information stored in RAM is lost when the power is shut off.

Resolution - the ability of an imaging system to differentiate between objects.

Reversible compression - no permanent alteration of original image information upon reconstruction. This is sometimes referred to as lossless compression.

ROM (read memory) - a permanent memory that is an integral part of the computer. Programs and information stored in ROM are not lost when the power is removed.

SCSI (small computer systems interface) - SCSI is an interface protocol that is used to link dissimilar computer devices so that they can exchange data. SCSI interfaces are most common in image scanners and mass storage devices. This type of interface is well suited for imaging applications.

Secondary image capture - the capture in digital format of image data that originally existed in another primary format (e.g., a digital image data file on a CT scanner or analog radiographic film) through the process of video capture or film digitization.

Software - a name given to the programs or sets of programs that are executed on a computer.

Tera (T) - stands for approximately 1 trillion (10^{12}). Note change in previous number. It is used primarily when referring to archive storage capabilities; for example, 1 TB-one trillion bytes or 1 million MB or 1000 GB.

Throughput - a measure of the amount of data that is actually being communicated, expressed in bits per second. It is related to the baud rate but is usually somewhat less in value due to non-ideal circumstances. Typically, modems with higher baud rates can attain a higher throughput.

Video capture - the process by which images are digitized directly from the video display console of a modality, such as CT, MRI or ultrasound. The video signal is converted to a digital signal. This process is more efficient and produces better quality images than scanning films that are produced by the same equipment.

WAN (wide area network) - a communication system that extends over large distances (covering more than a metropolitan area), often employing multiple communication link technologies such as copper wire, coaxial cable and fiberoptic links. The cost of these wide area networks is presently dominated by transmission costs.

APPENDIX B: CHECKLISTS

PHYSICAL PLANT

Yes	No	
		Adequate Space and Ventilation (Medical Systems)
		*If not in Medical Systems, then space in Dental Treatment Facility
		Network closet (may be existing communications closet)
		Secured system and closet space
		Secured dental operatory

NETWORKING

Yes	No	
		Dental clinic wired with appropriate cables
		Appropriate Network interface card
		Appropriate Ethernet switches
		Appropriate Ethernet switch for network administrators

SERVER/WORKSTATION HARDWARE

Yes	No	
		Dedicated Server (separate from workstation)
		Workstation (Laptop or desktop) (256 MB RAM, 20 GB hard drive)
		Monitor (XVGA 1024 x 728 at 24-bit color)
		Digital graphics adapter
		CD-RW capability
		Back-up plan

SOFTWARE

Yes	No	
		Multi-user/client capability for software
		Adheres to Network Security Protocols
		DICOM III conformant
		Windows 2000 Profession or higher, consistent with local, DoD policies
		Supports multiple imaging hardware
		Integration ability with other DoD systems

IMAGING HARDWARE

Yes	No	
		Direct solid-state system for Field use
		USB connection to computer
		Evaluation of clinic layout for optimized usage
		Purchase extended service warranty

APPENDIX C: COST ANALYSIS TOOL

Cost Analysis							
(A) Monthly Cost Of Film Supplies							
No. of Bitewings films taken		x	4	=		X rays/day	
No. of Periapical films taken		x	1	=		X rays/day	
No. of Full Mouth Series films taken		x	18	=		X rays/day	
No. of Other X rays taken films		x	1	=		X rays/day	
Total No. of X rays/day				=		X rays/day	
(A) Total No. of X rays/day	___	**x**	**$ 1.10**	**x**	**20**	**=**	**$**
We have estimated a cost of *$1.10 per film, but you can calculate your own by taking into account the cost of the film, chemicals, mounts and waste disposal. The average clinic workweek is 20 days a month. Therefore **(A)+(B)=TOTAL COST**.							
(B) Monthly cost of Developing							
No. of Bitewings films taken		x	6 minutes	=		mins/day	
No. of Periapical films taken		x	4 minutes	=		mins/day	
No. of Full Mouth Series films taken		x	15 minutes	=		mins/day	
No. of Other X rays taken films		x	4 minutes	=		mins/day	
Total No. of minutes spent developing				=		mins/day	
(B) Total Spent on Developing /month =	**___ mins/day**	**x**	**20**	**x**	**$.70***	**=**	**$**
*($0.70 is a conservative estimate of production cost per minute)							
TOTAL =	**(A) $___**	**+**	**(B) $___**	**=**	**$___**	**per month**	
*Note: The total cost per month does not factor for the labor costs involved.							

APPENDIX D: Image Disposition (Ref AFMAN 37-139)

Length of Time Required for Image Storage	
Film Type	Action
Taken for evaluation, treatment, and follow-up care of dental diseases or oral manifestation of systemic diseases	Hold as part of the Dental Health Record AUTH: N1-AFU-90-3
Initial, full-mouth X-rays	Hold, so long as legible, as part of the Dental Health Record AUTH: N1-AFU-90-3
Taken incident to hospitalized dental cases	Include with individual clinical records when required AUTH: N1-AFU-90-3
Obtained for other purposes, and determined to be of no more value	Destroy when appropriate findings are entered on individual's Dental Health Record AUTH: N1-AFU-90-3
Judged by a dental officer to be of unusual interest or selected for teaching or research purposes	Hold in separate file, and destroy when no longer usable or needed AUTH: N1-AFU-90-3
Unidentifiable	Destroy immediately AUTH: N1-AFU-90-3

Point of Contact for Disposition Questions:

NPRC, 9700 Page Avenue, St. Louis, Missouri 63132-5100 (314) 425-5768; Fax (314) 425-5781