How to Use the SHOWDOWN Testing Results

Introduction: The purpose of the Veterinary Digital Radiography SHOWDOWN and DICOM validation is to help veterinarians with their digital radiography purchasing decisions. There are a bewildering number of digital radiography products on the market so it is often difficult to sort through vendor claims and obtain objective information about the different products.

To help provide objective information about the different digital products, digital radiography vendors were invited to put their products to the test. This testing included obtaining a series of test images, evaluation of their software offerings, and validating their images for DICOM conformance. Participation in the SHOWDOWN was entirely voluntary and open to all vendors. The following vendors participated in 2009:

- All Pro
- Agfa
- ALARA
- Cuattro
- Del Medical
- DVMax
- Eklin
- Fuji
- Idexx
- ImaSight
- Ompromed
- Konica
- Metron
- Quantum
- Radinfosystems
- Sedecal
- SimonDR
- Sound Technologies

During the SHOWDOWN important aspects of the digital radiography systems were evaluated. Digital radiography is not just about images. These images must be moved around the hospital and shared with people outside of the hospital. Software functionality is as important as image quality and is often the difference between systems.

Some vendors say “you get what you pay for.” Other vendors say “don’t pay for what you don’t need.” To determine what functionality is appropriate for your situation, you will need to understand what software functionality is important to you. The following is a short guide to the software and hardware elements were evaluated during the SHOWDOWN. **A current version of the testing matrix is available at http://www.animalinsdes.com/showdown.htm**

Part 1: Image Acquisition

In this section, we tested the basic functionality of the image acquisition component of each digital radiography system. The image acquisition component of the system is the hardware and software used to acquire the image (i.e. CR or DR machine).

- **2.5 lpmm resolution:** A line pair test phantom was used to test resolution of the imaging system. The ACR and ACVR both recommend a minimum imaging resolution of 2.5lpmm. The line pair phantom image can be found on the SHOWDOWN DVD.

  Vendors like to make a big deal about the inherent resolution of a system. However, it is questionable whether minor differences in LPMM values affect the diagnostic value of an image. Furthermore, some vendors advertised resolution does not match what is obtained in the real world. All of our vendors obtained a 2.5lpmm resolution so this is not a major differentiator between the different systems.

- **DICOM conformance statement:** Vendors were asked to provide a web link to their DICOM conformance statement or provide us with a copy of the statement. We did not evaluate the statement for accuracy.

  A DICOM conformance statement is extremely beneficial if you run into connectivity problems. Evaluating conformance statements before purchasing a system may be useful if you are configuring several modalities on a PACS system.

- **DICOM c-store (DICOM SEND) verified:** DICOM c-store is the DICOM service that allows users to send images from the acquisition station to a PACS system, external workstation, or a radiologist for review. Images were sent from the acquisition station to a remote server that supported many DICOM transfer syntaxes. The transfer syntax was neither specified or recorded.

  The ability to send images to a remote server is essential. Without this functionality, your images may be trapped on your acquisition station and you will not be able to use your digital radiography system with other vendors PACS. C-store functionality is one of the items necessary for compliance with the ACVR Teleradiology Guidelines.

- **DICOM header verified:** DICOM is the de facto imaging standard for medical images. Compliance with the DICOM standard is essential for system interoperability. The DICOM validation toolkits at www.dvtk.org and http://www.dclunie.com/dicom3tools/dciodvfy.htm were used to test DICOM object compliance. Drs. David Clunie and David Harvey judged this segment of the SHOWDOWN.

  Compliance is a science not an art. There is very little room for discussion here. Without conformance to the DICOM standard you cannot be sure that your images will be able to store or save your images in other digital imaging systems.

- **Auto exposure Index:** The exposure index is used as a quality control mechanism to monitor digital radiographic system function and track the exposures that patients are receiving.

  The exposure index is interesting to you because the technical staff can use the exposure index to tell them if the image is overexposed, underexposed, or properly exposed. This is a feedback mechanism that takes all of the guess work out of determining if an image is properly exposed. If the exposure index falls within a certain range (varies between vendors), the technician keeps the image. If it is too low, the technician repeats it. If it is consistently too high, you have a discussion with your technician about radiation safety.

  Some vendors use an autoexposure index. Some don't. The presence of an autoexposure index is an indicator that a system may be easier for your technicians to use.

- **Ability to change DICOM header/ Audit trail for header alterations:** Traditional radiographs should have the patient name, hospital name, and date included on the radiographic marker included in the image emulsion. This type of marker cannot be altered. Digital radiographs have the patient and hospital information included in the DICOM header but this information is not protected and can easily be altered. Most systems allow users to change the DICOM demographic information even after the study is closed. This is necessary, for example, if the wrong patient name or ID was entered when the images were acquired. Without the ability to change the DICOM header, images cannot be tracked properly in the database.

  Although a necessary component of a digital radiography system, the ability to alter demographic information leaves open the possibility for abuse. For example, in a breeding animal, it would be quite easy to change the name on the image header. In human medicine, there is a set of laws (HIPPA) that place safeguards on patient information. In veterinary medicine we do not currently have HIPPA (or similar) regulations in place.

Ideally, an audit trail will be in place to track any alterations to the DICOM header. At the present time, the veterinary profession is not bound by any laws that mandate this type of tracking. Users should be aware of the potential for abuse. Failure to address this issue may result in the implementation of laws similar to HIPPA which will be a costly headache. The veterinary profession is wise to police itself in this regard.

- **Is the unit able to autoroute images?** Autorouting (automatically sending images to a remote server) images facilitates storage in a PACS, sending images for remote archival, or high volume teleradiology. Autorouting of images is one of the requirements for compliance with the ACVR Teleradiology Guidelines.

  Autorouting is a feature that may or may not be important to you. If you will be archiving your images off site, it is an essential tool. If you will be doing teleradiology it can be a useful tool. If you will be using a PACS from a 3rd party vendor it is an essential tool.

- **Border Masks – Automatic/Manual?** With traditional radiography, collimation leaves a large unexposed border around radiographic images. This was a necessary nuisance. With digital radiography is an unnecessary annoyance. Purchasing a system that allows the user to apply frames to the images to crop away this annoying border is essential because applying frames to images obviates the need to zoom each and every image prior to viewing and the presence of the bright white frame will blow out your retina if you are viewing on a high quality - bright - monitor. Radiologists who read a lot of digital images object to the presence of this unnecessary image fault.

  Border masks are recommended. Evaluate images with and without border masks on the SHOWDOWN DVD to determine if this is a feature that you need/want.

- **Image area size:** With traditional film, cassettes of various size were used to image different body parts. The largest cassette had an imaging area of 14 in. x 17 in. With CR systems, a similar array of plate sizes are available. With DR systems, the imaging area is fixed. Some DR systems use image areas that are smaller than traditional film.

  Users of DR systems must be cognizant of the image area that is available to them.

- **Time of image acquisition:** The time of image acquisition tests how long it takes a digital radiography system to process an image and adjust the image to obtain a final result. With DR systems, this is the entire processing time. With CR systems, there will be an additional time to put the plate in the reader. The time to take the plate out of the table and put it in the reader was not tested at the SHOWDOWN as it is not an inherent system component.

- **How many mouse clicks to send to a remote server (c-store):** With most systems, at the completion of a study, images are sent to an archive. This workflow should be efficient and not cumbersome to the technician. The same routine is often used for teleradiology applications. The ACVR Teleradiology Guidelines recommend that 4 mouse clicks or less are required for sending images to a remote server.

  Cumbersome systems require excessive numbers of mouse clicks to accomplish mundane tasks. Sending to a remote server is one of these tasks. Users are encouraged to evaluate software efficiency when purchasing a system.

- **Type of acquisition system:** The type of acquisition system was recorded. The classes of systems represented at the SHOWDOWN are:

  1. CR: Computed Radiography
     - OPEN: an open system requires users to remove a flexible imaging screen from the CR plate before processing. This is an extra processing step
     - CLOSED: this is the most common CR system where the entire imaging plate is placed into the reader during processing.
  2. DR FP: DR Flat Panel Detector
  3. DR CCD: DR charge couple device detector using a single camera.

- **Embedded image data removal:** Many vendors will embed patient information, advertisements, and other information directly into the pixel data of the image. In some cases this can be beneficial. In other cases, this is bothersome graffiti on the image. Users should have the ability to include or remove this information.

- **DVM to manually configure destinations:** Sending to a remote server, workstation in your hospital, or radiologist for review will require users to enter the destination information into their digital system. Veterinarians should be able to enter this information without assistance from the vendor. This is essentially as vendor assistance can be costly and also allows for abuse as the vendor controls where the images are sent to . Allowing users to manually configure their own destinations is essential.

Part 2: PACS

In this section, we tested the basic functionality of the PACS (picture archiving and communication system) component of each digital radiography system. Users must understand that a digital radiography system is composed of several different parts. These are:

1. Digital detector and acquisition computer: The image acquisition component of the system is the hardware used to acquire the image (i.e. CR or DR machine) and the workstation attached to that hardware.
2. PACS: The software that allows users to distribute images around the hospital and archive images for future use and safekeeping.

Several vendors brought PACS software to the SHOWDOWN. Other vendors elected to simply bring their digital detector and acquisition software. For vendors that did not bring PACS to the SHOWDOWN their PACS offering was scored as N/A.

As was the case for the image acquisition software we evaluated the PACS offering for several items. Many of these items are repeat tests of the functionality listed above. With some systems, the acquisition may not provide this functionality but the PACS will. With other systems, the functionality is duplicated in the acquisition system and PACS.

- **Ability to autoroute images**: see section about autorouting images in PART 1

- **DICOM conformance statement**: see section about DICOM conformance statemtents in PART 1

- **Audit trail for DICOM header alterations**: see section about audit trails in PART 1

- **Backup Options:** Every computer will crash eventually. Too many veterinarians have already lost their digital radiographic database because of a computer malfunction. Some vendors provide users with methods to backup the system. Some do not. Vendors were questioned about their backup options.

- **Ability to store other modalities in PACS?** One function of PACS is to integrate all DICOM devices into a central location. Some PACS systems can accomplish this. Others cannot. If a vendor can store other modalities in PACS, it is likely that you will be able to feed your ultrasound machine, CT scanner, or MRI into a single archive. Contact your vendor to determine which modalities are supported.

  If you have or will have an ultrasound machine, CT scanner, digital dental unit, endoscopy unit, MRI etc. at your hospital this is very important information. If you will only have a digital x-ray machine and never have other modalities you would like to feed into your PACS, this is not important to your situation.

- **DICOM Q/R enabled?** DICOM is composed of several different service classes or functions. DICOM Query/Retrieve is one of them. DICOM Q/R allows for a vendor independent method of accessing the image database and pulling images from the database. DICOM Q/R functionality will allow you to use viewers from other vendors and may help with data migration in the future should you decide to switch PACS vendors.

  The ability to use viewers from other vendors can be extremely important if you need image manipulation tools that your vendor does not provide. For example, you may hire an associate that likes a viewer they used at a previous hospital; or you might have a specialist come to your hospital that wants certain functionality etc. There are also several free or inexpensive viewers that you can use if you need to add workstations to your hospital. Without DICOM Q/R functionality your vendor can charge you whatever they want for additional site licenses as they are the only ones who can access your database. If you are happy with your vendors image viewer and will never be expanding your system or migrating to another platform DICOM Q/R may not be important to you.

Part 3: Teleradiology

Recently, the ACVR Published a set of recommendations that outline essential software functions to facilitate teleradiology. These recommendations are:

Open Standards *The ACVR recommends the adoption of the DICOM format (DICOM.nema.org) for teleradiology applications. All systems should be able to generate a DICOM compliant image object and have software able to send images directly to a remote DICOM server.*

Open Access *ACVR recommends that the transmission system should allow the user to send cases to any remote DICOM server. Additionally, the user should be able to select and store multiple remote servers in the transmission system. The system should allow the end user to configure a remote DICOM destination without the need for administrative (vendor specific) privileges.*

Image Transfer:

- *ACVR recommends that digital radiography systems be equipped with the ability to automatically send all images and studies to a remote server (autorouting), which facilitates high volume teleradiology applications. ACVR recommends that digital radiography systems allow sending images to a remote server easily. From the basic listing of patients on the user workstation, 4 mouse clicks or fewer should be needed to send a complete study to a remote DICOM destination.*
- *ACVR recommends that the transmission system send images as a "background process" to allow users to work with the system during transmission.*
- *ACVR recommends that the transmission mechanism used for teleradiology should have error checking that alerts the user to any problems with transmission.*

Image Compression*: DICOM images are large files, so teleradiology generally requires a broadband internet connection. Data compression may be used to increase transmission speed and reduce storage requirements. Several methods, including both reversible (lossless) and irreversible (lossy) compression techniques, may be used, provided the resulting images show no clinically significant loss of quality. ACVR recommends that compression only be used under the direction of a qualified veterinarian. The types and ratios of compression used for different imaging studies transmitted and stored by the system should be selected and periodically reviewed by the responsible veterinarian to ensure appropriate clinical image quality.*

At the SHOWDOWN we tested some of the software functionality against the ACVR Teleradiology Guidelines.

- **Error Checking (including error indicator) during c-store?** Veterinarians expect that when they pushed the SEND button on their digital system, their images would be sent and the images would arrive at their destination. Unfortunately, some digital radiography systems fall short on that mark because they don't take measures to confirm that the images get sent.

  To test the error checking ability of each system, the internet cable was unplugged from the wall while images were being sent to a server. To satisfy this requirement, the system must 1) provide the user with an obvious error flag or alert telling the user that there was a problem with the transfer 2) Provide a log of which images were sent 3) The system must either auto retry sending or allow the user to restart the image transfer.

  It is recommended that veterinarians purchase systems from vendors who include functionality to monitor the sending process and alert users if there is a problem sending. Ideally users will be told how many images were sent and if there are any errors. If there are errors, the machine should automatically retry sending or allow the user to restart the sending process manually.

- **How many mouse clicks to send to a remote server:** See discussion of mouse clicks in Part 1.

Part 4: Distribution

The ability to distribute images on media such as a CD or DVD is an essential function of any digital system. However all CD burning utilities and portable viewers are not created equal. We tested some important features of the CD/DVD burning utilities included with digital radiography systems.

- **Ability to burn CD/DVD?** This test is self explanatory. The ability to burn a CD or DVD with patient images is an essential function of any system.

- **CD/DVD compliance with DICOM exchangeable media profile?** Many referral hospitals receiving DVD's from referring veterinarians import the images into their own PACS. Compliance with the DICOM exchangeable media will facilitate this process. The DICOM interchange media profile specifies that a CD/DVD should include DICOM images and a DICOMDIR file.

  The frustration many referral hospitals have with CD's and DVD's they receive from referring veterinarians cannot be overstated. Sending DVD's and CD's with patients that comply with the DICOM exchangeable media profile will help ensure a smooth referral. This is a feature that is recommended but not essential for day to day practice.

- **Viewer included with CD/DVD?** An autoloading viewer facilitates viewing images provided on a CD or DVD. Without an autoloading viewer, users are presented with the basic windows dialog box that says "what should I do with the DVD." This can be confusing to users who are not familiar with computers or viewing images. Furthermore, if the user does not have a DICOM viewer, they will not be able to view DICOM images on the DVD without first downloading a viewer.

  Including a viewer on the CD/DVD is a recommended feature. It should be noted, however, that all viewers are not created equal. Some viewers run off of the CD/DVD without loading software on the computer. Other viewers require users to load software on the computer. Requiring users to load software before they can view images can be very problematic as many IT departments do not permit software to be loaded on computers without administrator access. Users are encouraged to try the vendors DVD on many different computers at many different hospitals. The viewer included with your images is a reflection on your hospital. Be sure it works and has an appropriate look and feel for your situation.

- **Ability to export images as JPEGS?** DICOM images are large images and require special software to view the images. From time to time it will be necessary to export images as a JPEG or other non-DICOM format.

  The ability to export images in a JPEG format is beneficial as most practices will need to export images in a non-DICOM format from time to time.

Part 5: Integration

Integration with practice management is a topic that will become more and more important in the future. At the present time, non-proprietary mechanisms of integration with practice management are few and far between in veterinary medicine. This year we tested only a single element of practice management integration.

- **Modality worklist enabled?** DICOM provides a vendor independent method of communication between practice management and the digital radiography system. This DICOM functionality is called DICOM modality worklist. This DICOM service allows users to "order" a radiographic study in practice management. Once a study is ordered, technicians are presented with a list of studies at the acquisition station that were ordered. This allows them to select a study from a list rather than enter patient demographic information at the acquisition station. This increased throughput in radiology and prevents recordkeeping errors caused by typo's when the entering patient demographic information into the digital radiography system.

  DICOM modality worklist is an essential first step to non-proprietary communication with practice management and paves the way for automated billing between digital radiography and practice management.

Part 6: Conclusion

The software comparison performed at the SHOWDOWN tested basic system functionality. You must determine which functions are important to you to determine if the functionality is important to your situation.

The SHOWDOWN testing matrix is a first step in system evaluation. The testing matrix does not address image quality, vendor service, or other important considerations when purchasing a digital radiography system.

You will find that many of the systems satisfy many or all of the functions that we tested. This is because most of them are very basic software functions and many vendors improved their offerings to be able to be competitive at the SHOWDOWN. These vendors and all of the vendors who participated in the SHOWDOWN should be commended and supported.

For more information about purchasing a digital radiography system, or if you have any questions about the SHOWDOWN please visit www.animalinsides.com and drop us a line.