Rick's talked about the overview of the entire PACS structure. Now let's talk specifically about integrating modalities. DICOM part three actually defines image objects, or information objects. They define them in two primary categories, large categories, both image and non-image objects. These objects define specific information inside what are called elements. The elements have specific value representation that defines their structure, format, information order, etc… And then they're grouped into both groups and into elemental numbers such that we have a group number, in this case for patient ID, the ID of a patient is number 20. So out of the current objects, in 2003 part three that are defined, there are 26 image objects, and 33 non-image objects. Notice that the

image objects can be sub-categorized, a secondary capture multi-frame, single bit object is a distinct object from a secondary capture multi-frame gray scale byte object for example. So they're going into very high detail on what an object is defined and for each one of those objects and they're going to very fine detail on what needs to be defined in that object by modalities and what the PAC vendors may have to utilize. All PACS vendors do have some methodologies for you to see the DICOM header, which spells out these elements. So for example, you can view in the DICOM header acquisition parameters such as the time of acquisitions. In this case, this is a series of images, so you have an acquisition time for the series and the individual image has a different time. So you can

utilize this to determine where the study was done, what time it was done, you can do QA of the technique factors, you can do dosimetry and in addition most PACS vendors use the DICOM headers to build annotation for display. So you can use them to display almost any tag as an annotation, also they include acquisition and processing parameters inside of the DICOM header. These processing parameters though are often stored in what's called private tags, which are proprietary to the vendor and may or may not be visible inside of your PACS system. So what does a physicist need to know? You need to know what your modality is using out of those elements. The DICOM committee understands that more mandatory elements are needed, but there are only specific elements that will be mandatory,

that the vendor will have to put in. The rest of them will be optional. In addition, you need to understand which elements your PACS system can utilize, because there are many optional elements. They may not use them all for each object, and objects are being retired and replaced as technology changes. As an example, the CT and MRI objects were defined ten years ago, and they were defined specifically for reviewing standard image series, and they did not handle advanced imaging or processing very well. Therefore, most of the processing parameters that vendors are using, as technology changes, they're storing in private tags. In addition, with the increased data size, hanging protocols and other methodologies of viewing the images are not handled well, if at all. The new

DICOM objects for CT and MRI are now going to be able to handle multiple slice data much more efficiently. They have much more mandatory elements, so for example in CT you notice there were only 18 elements in the original standard, none of them were required or mandatory. In the new standard there are 41 elements and almost all of them are mandatory now. Similarly in MRI we have a much larger number of elements and most of them are also mandatory. Rick mentioned modality work list, if we specifically look at the standard for modality work list.

There are currently about 50 elements defined in the modality work list and this defines what is communicated from the RIS system to the modality, and just showing you a couple of them, we see we can define specific start stop times,

Accession number which Rick was talking about, patient identifiers, the specific modality and other information can be included in the modality work list. Before PACS than, what was done is the technologist would order the study, or somebody at the front desk. They would print a form, put it in a folder, go get the patient, set up the study, acquire the data, submit for processing, that would mean film would be going to wet processor, CT would be reconstructed, MRI may have some other processing done to it, if it was film you would reload the cassette, review the images, do I need to repeat, if I do I have to go through the whole series again. If I don't have to repeat, then for CT and MRI I have to select which images I'm going to print, because I can't send all of those images on film to my

radiologist. I'll window and level those, and print them. I'll set up a file folder and then I will send a completion to the RIS to tell the system that yes I have done that study. With a fully functional PACS system you still have to order the study and obtain the patient, but the modality work list is going to handle all of the demographic data into the modality for you, and in addition at the end of the study, it will automatically inform the RIS, if it has performed procedure step, that the study has been done. So we're greatly improving the efficiency, plus as Rick says, we're decreasing any errors. I'm going to talk just briefly about some advanced things that are in modality work list, that are coming, that we need to start looking into whether we can have the vendors start supporting. One for

instance is scheduled procedure step description. **Do not advance slide yet** This is a standard that is generated by the institution, therefore it does not have highly restrictive VR for them and what it can be used for than is to send information to a modality, such that it can automatically setup the study for the technologist in addition to providing the demographics about the patient. **Advance to Utilization by Modality Slide here** So you can think of this as your automatic organ programming on your generators. Right now a technologist will select an automatic organ program to setup kV and mA for instance for a study, or whether you need to photo time. Well there is no reason why we cannot be doing all of that through the modality work list, if we send that information

from the RIS. So recommendations, insist on implementing modality work lists, as Rick says all vendors will do this and you need to insist that they do it. Carefully look at what they can send from your system and what you can pass through your PACS, also look at what your modality can utilize, if they can utilize the more advanced features, such as perform procedure step or for example the scheduled procedure step description, you can do a lot more efficient work, and have less errors. Unfortunately, most systems do not support these more advanced features yet, but again as a physicist we should start insisting and to make sure our administration insists also. Now once we have acquired the data, and we've used modality work list to make sure the data is correct, now we want

to have the PACS system, or the modality store the data, and send it to the PACS system. Most modalities can store raw or processed data, some will only store processed data, some will only

send processed data. Specifically, if we look at something like the CR and DX objects, and I'm going to talk mostly from now on about these objects, we can send for most modalities 8 or 12 bit data. We can send that data in optical density, in presentation values or in log exposures, and I'm going to talk a little more in detail about what those different things are. First let's define something that is termed a VOI or value of interest. For a value of interest the modality will process the raw data and convert it into a log exposure space. Then for a specific body part and view they will select a region of the

histogram for the values of interest in that data, and then apply to that a look up table, and after the application of the look up table they will present it in P values or optical density to the PACS system. So if we look at this idea when we are printing film from our modality, and we look at a film characteristic, a film will have an optical density range of about 0-3 + base + fog, and the optical density range sent from your modality, then can be mapped almost directly to that range, and then if you wanted to see dark areas, the radiologist would simply hot light those areas. For soft copy display on the other hand, we have luminance ration of about 350-1, which translates to about an optical density range of 0-2.5. **Advance to OD Values Softcopy (2) Slide here **Therefore, we cannot map

the entire range uniformly into there and so if we wish to see different areas ** Advance to OD Values Softcopy (3) Slide here** of the image similar to the film we have to window and level those. But, we need to understand that optical density sent to a printer produce luminance response with a log luminous proportional to the image value, ** Advance to Luminance Response Softcopy vs. Film Slide here** and therefore we get a linear response in the printer, from what is sent to it. On the other hand, on a DICOM calibrated soft copy display we have increased contrast build into the darker regions, such that if you send OD values to a soft copy display, you are suppressing those regions and you'll have decreased contrast in those dark regions. So what we want to do is insist that the

modality send OD values to a printer and send P values to a PACS system to produce an equivalent appearance. ** Advance to The DICOM VOI LUT Sequence slide here **An even better methodology that I'm going to recommend is to have the modality actually send the DICOM VOI, in this situation they will send the entire data to the PACS system and then use the VOI LUT on the PACS system. ** Advance to Using VOI/LUT with PACS side here (this should be 3 separate slides)** To give you an example why this is important, if the original raw data that is acquired a modality is this, and you pick the VOI, and look up table LUT from this area, that is all that is sent to the PACS system and this data is not sent to the PACS and you cannot get it back. You could send data over

here, or you could send the middle data, but you're not sending the entire data to the PACS system, and therefore you do not have that information stored in the medical record. But if you send the raw data and the VOI LUT, your PACS system now has to be able to apply that VOI and the LUT and therefore in that manner you could shift the VOI to look at regions that are darker and then shift the LUT to see in that area, and in that case you could get the entire data, and have more flexibility for the radiologist to see all the information. So the recommendation is to configure real modalities and PACS to send and utilize VOI LUT sequences and actually

Jeff's going to talk a little bit more about how to do that in a minute. However, most CR and DX modalities can't even send P values

as of yet, they can only send OD values, or log exposure. Several of them can send log exposure and VOI LUTS, but unfortunately most PAC systems cannot deal with VOI LUTS right now, and they're actually assuming you're sending P values. So we have a problem, and we need to be as physicists promoting to both the modality and the PACS vendors to solve this problem. I said before we're giving you an overview, and we're maybe going a little quickly with this, but there are a lot more people talking about this at this meeting, at the RSNA, SCAR, at SPIE, and I highly recommend that you go out there and see these talks, start getting more knowledgeable in all these different areas.