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### Are Technical and Legal Standards for PACS too High?:

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#### Results from Mainz Meeting Indicate a Need for Change

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**PACS systems offer many proven benefits compared to filmbased services in clinical environments. However, have we set the benchmarks for its implementation and regulation too high? This question was discussed with PACS experts at the HIS/RIS/PACS/DICOM meeting June 6 – 7, 2007 in Mainz, Germany (<http://www.unimainz.de/FB/Medizin/Radiologie/agit/Welcome.html>). This article follows up by presenting the case for a relaxation of certain significant rules for PACS usage.**

Here are some examples of the regulations for PACS usage that were challenged at the Mainz meeting:

- PACS is the most critical application of an enterprise. The up-time must be more than 99.9% with a 24h/365d service.
- All aspects of storage, data security and availability of PACS images must be increased 100 times, if possible 1,000 times above film-based radiology.
- All images must be archived even if they are only for temporary use without clinical relevance.
- A PACS system is mandatory to store all thin slices if a Multi Detector CT (MDCT) is operated.
- Film-based use of MDCT is not allowed.
- No image may be lossy compressed, even if the difference between original and compressed image is less than the difference in quantum noise between two sequential exposures.
- Storage has to be done locally, with high security Storage Area Network systems (SAN) and Network Attached Storage (NAS). External archiving by Application Service Providers (ASP) is not an option.

#### Is PACS a Critical Application?

At the Mainz meeting, radiologists were asked "Do you classify PACS as a critical application?" Two answered with "yes", eight with "no". PACS vendors were asked "Do you provide a 24h/365d service in Germany?" One vendor provides this service in 5% of cases, all others in 0% of the installed base.

In our 2,500 bed hospital, the consensus of the Chairmen of thirty clinical departments was that PACS is not the most critical application. All agreed that the availability of HIS, network and laboratory data are critical, requiring a 24h/365d service. For PACS, we provide several fallback and security mechanisms. Most new radiological modalities are prepared to store image data from three to fourteen days. This time should be sufficient to fix any PACS problems. Paper or film-based printing is available in most hospitals. A quick film reading of emergency cases can be performed at the primary or secondary modality console. In our PACS system the web-server for all clinical departments can be accessed directly by all modalities. During the last six years, these methods have been more than sufficient.

On a typical 8 AM to 6 PM day with high PACS workload, any problems can be fixed within hours by the PACS vendor or IT department.

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Saturday, Sunday, on holidays and at night-time, the PACS workload is low and radiologists on duty can use prescribed fallback mechanisms. Critical applications in terms of patient safety are CT, radiography, ultrasound and in some environments, angiography. No service contract guarantees the 100% uptime of a CT scanner, hence these critical modalities must be doubly available.

## Are Safety Requirements too High?

It is often argued that PACS downtime may not exceed 0.1%. Solutions are often high-level expensive SAN systems with fast image access. Long-term archiving is performed with tape or optical robot systems or hierarchical storage management systems (HSM). Retrieval of these older images often takes up to a half hour depending on the daily workload, speed of the archive system and the quality of the prefetching and autorouting implementation.

The future is clearly fast online storage and access preferably for four to six years. This reduces access to images in the long-term archive far below 1%. At the Hospital Nuremberg we provide fast online storage with a less expensive solution over six years based on standard IDE and SATA RAID systems. This storage is installed in two independent server rooms with an automatic switchover of the IP address if one system fails. All images over six years are accessible in 1 - 2 seconds. The need for retrieval of images older than six years is nearly zero.

## Should we Archive all Images?

The answer is clearly no. The preferable system is as follows:

- Thick slices are sent to PACS by the modality; multiple thin slices go to a workstation. Here they are used for post-processing in a first-in, first-out (FIFO) buffer and are deleted after several days or weeks. If archiving of thin slices is necessary, storage in the PACS has to be done manually. This solution involves time-consuming interaction between technicians and physicians.
- New MDCT scanners provide scan protocols that include the reconstruction of angulated images without displaying the thin slices. Hence, thick slices go to PACS or workstations only if flagged by the scan protocol.
- These algorithms could be included in PACS rules, for example "if thin slice datasets (e.g. >200 slices, <1 mm slice thickness) were used for reconstruction of diagnostic datasets that are also stored in the same study, there was no access to this study for >6 month and no "don't delete" flag exists, images can be deleted automatically". This procedure keeps the online archive fast and small but does not exclude archiving of all images in the long-term archive that is normally done close to the exam date.

When asked "Do you want thin CT-slices to be archived if they are only used for reconstruction of diagnostic thick slices?", only one radiologist at the Mainz meeting answered yes, eight answered no, and there was one abstention.

## Why are we Afraid of Lossy Image Compression?

Lossless compression which reduces the amount of data by a factor of about 2.5 is not generally used and lossy compression is not used at all. There are various legal reasons for this. In Germany the "Röntgenverordnung" allows a compression (lossless or lossy) "as long as there is no loss of diagnostic quality". The responsible radiologist has to decide what is diagnostic or not. Hence PACS vendors provide lossy DICOM JPEG2000/Wavelet compressions but PACS users need a common consensus which lossy compression rates are safe and acceptable.

At the Hospital Nuremberg we compress all images after "no touch" for six months with intelligent PACS rules depending on modality and type of study with compression rates between 1:2.5 and 1:10. With this delay all film readings and clinical conferences are performed with original images as well as external longterm archiving close to exam time. This compression reduces online storage volume by a factor of eight, compared to uncompressed data, or 3.2 compared to lossless compression.

At the Mainz meeting radiologists were asked "If there is a consensus of radiologists on safe lossy compression factors, would you use lossy compression?" Ten answered yes, one said no and I was the only one actually using lossy compression.

## External Archiving by Application Service Providers

At our hospital, the concept to store everything online (EOL) between five to six years had a strong influence on the decision for long-term archiving. This reduces the slow offline archive from a "working archive" to a "depository under legal aspects" where images must be retrievable in "appropriate time" (legal regulation in Germany "Röntgenverordnung" < 24 hours). Hence, we decided to cooperate with an external ASP. The upload is not time-critical and the download of < 1% requires no high speed WAN connections. Of course the decision for ASP models depends on legal regulations which vary from country to country.

At the Mainz meeting radiologists were asked "Would you use ASP for long-term storage?" Ten answered yes. I was again the only individual present using ASP storage. Clearly the results of the Mainz meeting indicate that is time to think and act differently in future when planning or expanding a PACS system.

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