White Paper

Why is Softcopy QA important?

What's inside?

- The Softcopy QA belief.
- Why medical displays are not perfect.
- Real softcopy QA data from the field.
- Softcopy QA's vision from different users.
- Start with softcopy QA today.

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Medical facilities have quality programs and teams for a lot of equipment, but in many cases the medical displays used for diagnosis and reviewing are not part of any scheduled quality routines.

A perfect display still does not exist today, missed diagnoses still occur.
Life critical decisions on these displays imply a real need for softcopy QA. It is often forgotten but has never been so critical as it is today.

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1 MANAGEMENT SUMMARY

More and more medical facilities are moving to Picture Archiving and Communication Systems (PACS). Diagnosis and review happen without the use of film and people rely on the quality of the display system for making life critical decisions in a matter of seconds.

The image is generated at the acquisition site, runs through a central processing cycle and is finally shown on a medical display. In this image chain the data is vulnerable to all kinds of process deficiencies like look up tables, corrections, etc.
Softcopy QA only covers the last step in this process: the medical workstation retrieves the data and, with a viewing application, the image is shown on the display.

Every medical facility invests a lot in these workstations. Since they are crucial for diagnostic work, they should guarantee image quality throughout their useful lifetime. Inside display devices a lot of parameters change over time, and yet they should be DICOM (Digital Imaging and Communications in Medicine) Part 14) Grayscale Standard Display Function (GSDF) compliant (see reference 1). The DICOM GSDF is a standard contrast curve, against which different types of display devices can be calibrated. With it, softcopy displays can be calibrated in order to ensure that images look the same when viewed on different workstations and at different times.

Softcopy QA is the process of controlling and checking medical diagnostic and review displays towards medical standards.
The display should be calibrated to the DICOM GSDF curve. This process runs in the factory or it can be done in the field using an optical sensor to measure different luminance levels.

The DIN6868-57 standard (see reference 2) describes the performance of the acceptance test to determine the quality of image display devices. DIN describes the parameters and tools to be used for acceptance testing. Both the manufacturer and user/expert should perform such an acceptance test upon installation or after modifications that could influence image quality, and they should determine the reference values for the constancy tests using the described test equipment.
In July of 2002, the DIN6868-57 acceptance test became law in Germany, so compliance to this standard is mandatory for German medical facilities.

The American Association of Physicists in Medicine Task Group 18 (AAPM TG18) (see reference 3) document provides standard guidelines to practicing medical physicists, engineers, researchers and radiologists for the performance evaluation of electronic display devices intended for medical use. It outlines both acceptance testing and quality control.
Acceptance testing is required before the first use of a diagnostic imaging device, and each time after it has been repaired or replaced.

Quality control specifies periodic, recurring check-ups during the use of medical devices.

The Japanese Industry Standard (JIS Z 4752-2-5) is similar to the DIN6868-57 and specifies constancy testing.

2 THE QA SOFTCOPY BELIEF

In the pre-PACS era, QC technicians were responsible for running a fixed QA procedure for the film printers on a daily or weekly basis. If this test was not done, it resulted in no films, no production, no diagnosis, and no income.
And from the moment the first medical displays are used, it looks obvious that the investment will result in an excellent performance until the last day of economic life.
People in favor of PACS focused on advantages like the workflow improvement, the interactivity of the image data, faster throughput, … but since that day only a few people really considered image quality over the lifetime of a medical display.
There is no reason why a similar QA procedure (as on film) wouldn't be necessary on a device vulnerable to several deficiencies like phosphor aging, luminance instabilities, etc.
And these devices are used for making life critical decisions in a matter of seconds. Quality is ubiquitous in everything we do today, in everything we buy; it is really everywhere. And it is not for free, for quality you have to pay something extra, because it is worth the investment over its lifetime. And this is something you have to be convinced of. This is surely valid for softcopy QA: early adaptor PACS hospitals have Cathode Ray Tube (CRT) based displays that now are close to the end of their lifetime. They are aware of softcopy QA and realize that quality pays over time. The good news is that the belief in softcopy QA is growing every day.
And that's not all. The ubiquity of web-based viewers tied to today's PACS and teleradiology systems allows images to be read anywhere, anytime. And how can image quality be maintained and controlled on all these displays?

This document will focus on the importance of softcopy QA by the experience of talking to people. And not just people, but medical physicists, PACS administrators, service engineers, radiologists, IT staff and decision makers of a medical facility.

3 WHY MEDICAL DISPLAYS ARE NOT PERFECT

There are a lot of parameters influencing the image quality of a medical display. First of all there is the environment and secondly intrinsic parameters like the degradation process on CRT and LCD displays.
It is not the intention to go through all the details about display technology in this document. It will focus on the major deficiencies of LCD based displays. The real technical cause of these problems will not be highlighted here.

3.1 Controlling the environment

3.1.1 Ambient Light

The environmental light is quantified as the amount of ambient light (lighting, windows,…) hitting the display surface. It is easy to understand that in a room with a high amount of ambient light, it will be very difficult to see details in the dark area of an image shown on the display. Visualizing this will be dependent on the actual black level of the display device itself. A well-controlled reading room with a small amount of ambient light is always advised. Windows should be shaded and special dimmable lighting certainly improves this.
The ambient light – quantified as Illuminance – has the following impact on the contrast ratio of CRT and LCD based displays:

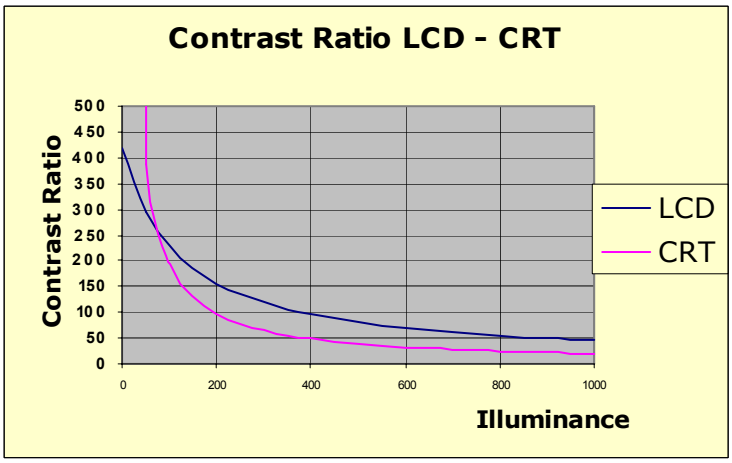

Fig 1: Influence of ambient light to the contrast ratio of medical displays

Be aware that the DIN6868-57 standard specifies a minimum contrast ratio of 100 and the AAPM TG18 a value of 250 for diagnostic displays.

3.1.2 Reflection

A display is sensitive to reflection because the ambient room light reflects on the device and generates an extra luminance to the user.
Figure 2 illustrates this:

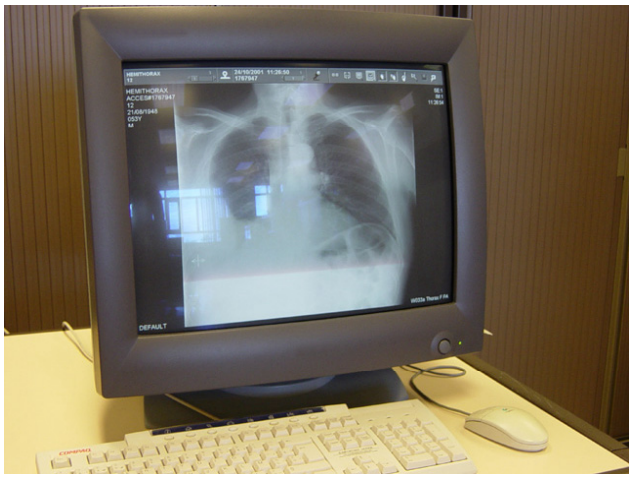

Fig 2: Visual reflection of a window on a CRT based display

3.2 The luminance degradation on LCD based displays

LCD-based flat panel displays basically differ from CRTs in the way the light is generated and modulated. With LCDs, the light generation is physically separated from the light modulation. The light generation is done by a light source, called the backlight, and is continuously on at full intensity.
This light source knows nothing about the image information. The light modulation is realized by shutting off the light flux from the source by means of the LCD panel. Only the LCD panel is driven by the video signal information, not the light source.

The backlight is an important source of instabilities. The efficiency of its lamps is extremely temperature dependent (fig.3).

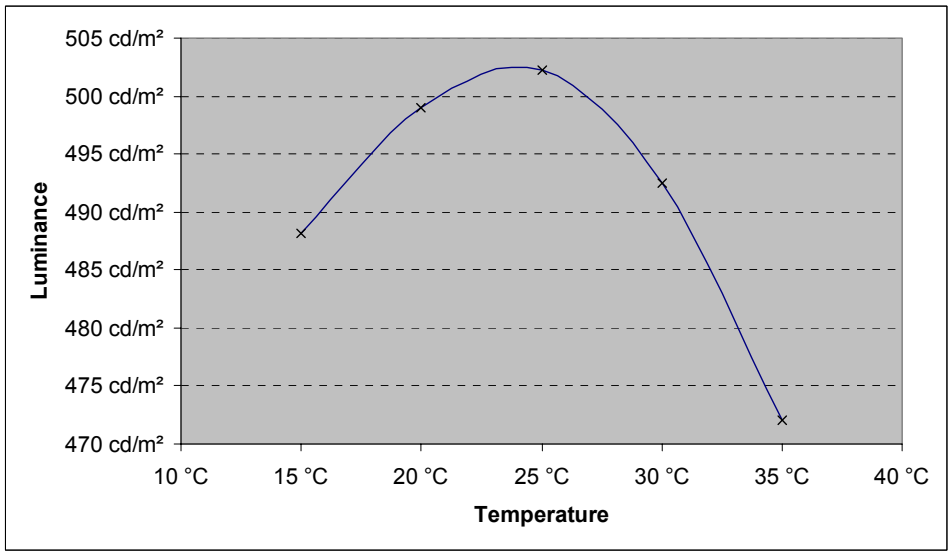

Fig 3: Influence of temperature on the luminance of LCD-based displays

The luminance can fluctuate drastically in a short time frame (minutes to hours) due to temperature changes at startup. When the display is switched on the backlight's and LCD panel's temperature change. This results in a luminance output shown in figure 4.
Over a longer time period – it's entire lifetime – the luminance slowly degrades because the phosphors used in the lamps wear out.
I-Guard, a tiny embedded optical sensor positioned at the front of BARCO's CORONIS displays, detects all these changes and continuously corrects both the short term and long term instabilities.
Since it is located at the front of the screen, it can correct for all instabilities caused by backlight and the liquid crystal display.

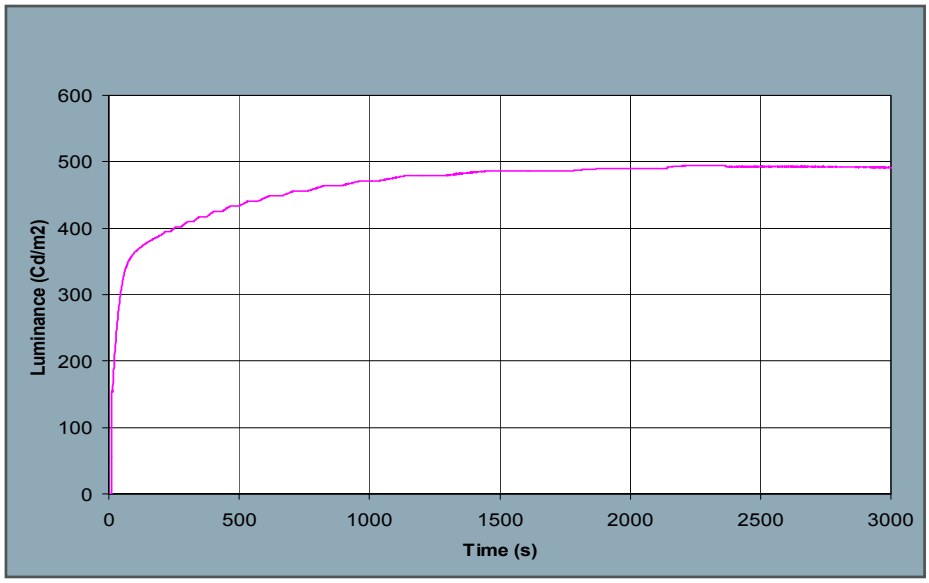

Fig 4: Influence of temperature on the luminance of LCD-based displays

3.3 Other deficiencies

There are a lot of other deficiencies for LCD based displays. The viewing angle, the luminance response, uniformity, noise, artifacts, … We refer to the AAPM TG18 document (reference 2), it covers these topics in a high technical level.

4 REAL SOFTCOPY QA DATA FROM THE FIELD

PIN, Barco's integrated Product Intelligence, is a revolutionary concept that ensures worry-free diagnostic reading and image distribution by means of "intelligent" medical display technology. The system's intelligence creates a smart background, which offers radiologists and administrators professional comfort by bridging the gap between people and technology.

All BARCO CORONIS displays contain an I-Guard, a built-in frontal sensor for stabilizing the backlight of the LCD. But this embedded, accurate luminance sensor is also used for doing a lot of QA measurements. These measurements are done by BARCO's MediCal Pro software, installed on every workstation. A central software package MediCal Administrator gathers all workstation, display and QA data and makes this accessible through an easy web interface.
On CRT based displays there is no embedded sensor so the measurements have to be done manually.

Figure 5 shows the results of measuring the white luminance on a number of CRT based displays over multiple days with an X-Rite DTP92 sensor.
The upper part of the curve covers displays (BARCO MGD521) that were calibrated to a white luminance level of 85 fL (footLambert), the lower part shows measurements on BARCO MGD221 displays calibrated to 65 fL.
The horizontal lines show warning (+/- 3%) and error (+/- 6%) levels. Over a period of 90 days several displays were measured. You can see that after a period of 70 to 80 days a couple of displays are running into the warning tolerances of the measurements. This means their white luminance is off by more than 3% but not more than 6%. This is not so bad, but it indicates a slight shift in luminance. At that time, it will not be disturbing for the radiologist, but giving you this signal at that time allows you to pro-actively solve this problem. The display has been recalibrated and this readjusts the white luminance of the display.

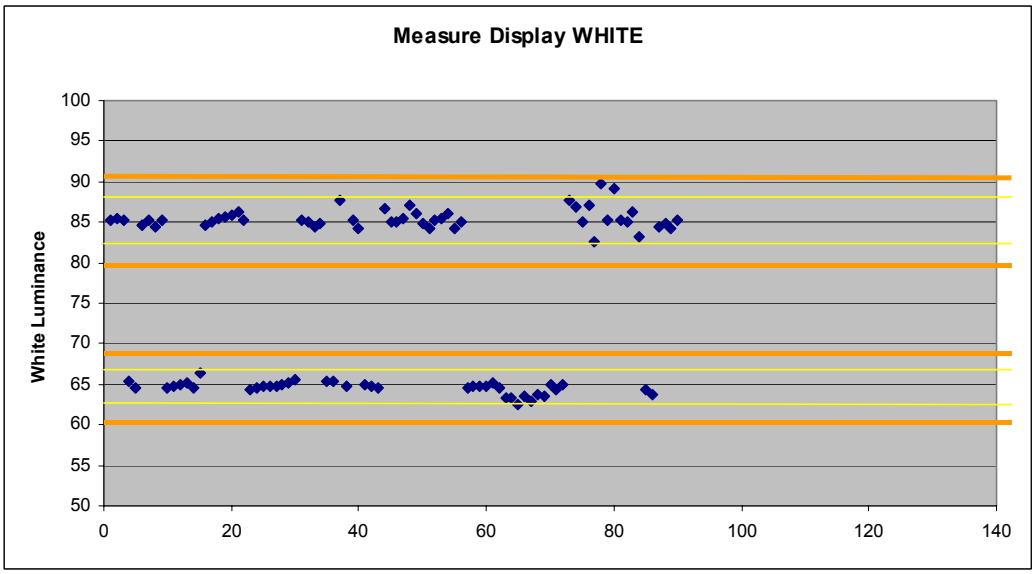

Fig 5: MediCal Administrator generates a graph of measuring white luminance

With PIN, I-Guard measurements can be taken transparent for the end-user. The QA tasks can also be scheduled during the night, the displays are taken out of PowerSave mode, the actual check is done and all results are sent to MediCal Administrator. One such set of results is shown in Figure 6.

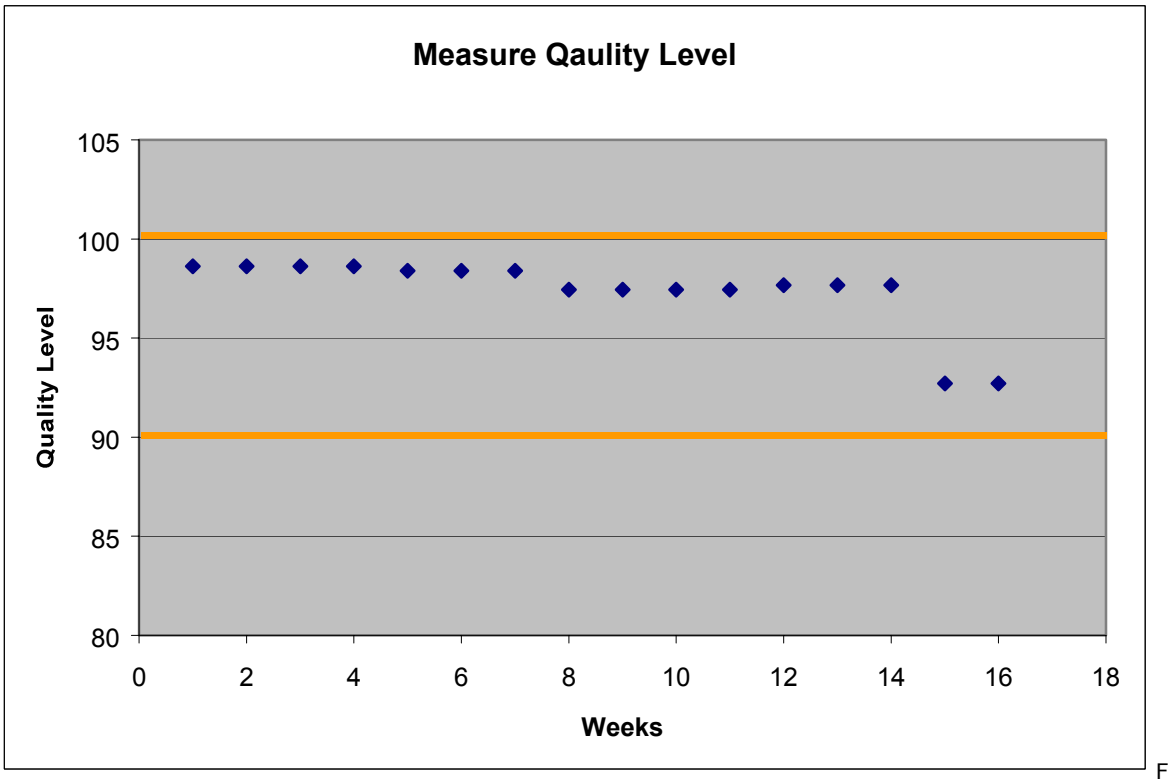

Fig 6: A graph of quality level measurements on a CORONIS display

A QA task "Measure Quality Level" measures how closely a display is calibrated towards the DICOM GSDF curve. GSDF is the accepted standard for the luminance behavior of medical displays. A number of different gray values are measured (from black to white) and for every value the error between measured and target value is calculated. Then all errors are combined to 1 percentage, a value of 100% means the measured values totally fit onto the target DICOM GSDF curve. The error level is set to 90%, as shown in figure 6. From the results you see that after 15 weeks the quality level is going down, but is still between the predefined tolerances.
If the measurements would go below the tolerances, the display can be recalibrated remotely using MediCal Administrator, the problem will be solved and the quality level will again be within tolerances.

5 HOW CAN YOU START WITH SOFTCOPY QA TODAY?

5.1 Separate calibration from QA

A lot of people now use a calibration tool to reset their display system to the DICOM GSDF curve. They do this, for example, twice a year and are confident the displays are always DICOM GSDF compliant.
In some cases this re-calibration is a corrective action because it was wrong, but it is also very possible that the re-calibration was not necessary.
Therefore we believe it is a good practice to learn from the softcopy QA process: only re-calibrate the display system when it is necessary. You can do this by doing a QA check twice a year, if the result of this check recommends a new calibration, it should be done at that moment.

5.2 Follow the guidelines

5.2.1 DIN6868-57

This standard describes the performance of the acceptance test to determine the quality of image display devices. DIN describes the parameters and tools to be used for acceptance testing. Both the manufacturer and user/expert should perform such an acceptance test upon installation or after modifications that could influence image quality and they should determine the reference values for the constancy tests, making use of the described test equipment.
In July this 2002, the DIN6868-57 acceptance test became law in Germany, so compliance to this standard is mandatory for German medical facilities.

In practice this standard is widely accepted in Germany. All new installed workstations are run through this test. On the existing workstations they still have until 2005 to make them compliant, but the test is often done on installed systems too.
The test itself does not really contain DICOM GSDF compliance in a quantitative way; it is covered by a visual test. But with other measurements that need to be done, it easily takes 15 to 20 minutes per display to run through this. Important to note is also that there is a report provided in the standard document, so for every test a signed report is necessary.
BARCO provides this standard as a plug-in into the MediCal concept. The wizard based user interface makes it easy to run the test; the result is stored locally on the workstation, but is also sent to MediCal Administrator, the central Softcopy QA management tool.

5.2.2 AAPM TG18

This document provides standard guidelines to practicing medical physicists, engineers, researchers and radiologists for the performance evaluation of electronic display devices intended for medical use. It outlines both acceptance testing and quality control.
Acceptance testing is required before the first use of a diagnostic imaging device, and each time after it has been repaired or replaced.
Quality control specifies periodic, recurring check-ups during the use of medical devices.
This standard is not commonly used yet. It is a guideline, not something mandated by law. But on the other hand this document gives a nice overview of deficiencies of displays and what can be done to observe them in an early stage.
The quality acceptance and control is divided into 3 levels: visual, quantitative and advanced. The first level is purely based on test patterns and visual checks. This is very easy to use, but can be subjective in some cases and does not always generate the same result when several people run the tests.
The second, quantitative approach is based on measurements for luminance uniformity (spatial uniformity over the screen), luminance response (DICOM GSDF compliance), etc.
An optical sensor is needed in this case. The sensor is not a very expensive device, but something that is used for calibrating and checking medical displays.
The third, advanced level is very technical and is based on – in some cases – complex measurements with dedicated equipment. It can be used for physicists during a selection process of a certain technology or partner when moving to PACS.
The novice end user can start using this standard at the first or second level. Visual checks and simple measurements can be taken and returns an appropriate level of acceptance for the displays. A report is not really specified in the document, however tables can be translated into reports.
BARCO also provides a plug-in for this standard. It generates a PDF report on the spot with all detailed results local on the workstation, as well as at the central server.

5.2.3 JIS

The Japanese Industry Standard (JIS Z 4752-2-5) is similar to the DIN6868-57 and specifies constancy testing.
It is not necessary to explain that Japan has always given an extra dimension to quality and efficiency. This is also the case for softcopy QA. This document describes the recurring tests that can be done on medical workstations.
Although it is only a guideline, it is often used. The test describes frequencies for these tests and is based on the DIN6868-57 standard.

5.2.4 Visual checks

If you do want to start with softcopy QA, it is certainly a good idea to start with visual checks. But be aware that these are very time consuming and do not always return the expected results. There are a lot of test patterns available. Some of them, like the SMPTE (Society of Motion Picture and Television Engineers) test pattern, can contain more than 10 specific detailed tests. The challenge is to lead the novice user through a process of evaluating through all of these… or not? This evaluation process if often implemented by popping up a question like "Is this pattern shown correctly?" In this case you overload the user with a lot of information and the result is that out of 10 users, 5 people pass the display, the other 5 have all seen a different defect.
In our opinion, the AAPM TG18 has spent most time on generating good test patterns for specific deficiencies. By running through them and popping up specific questions, the results with multiple people turns into a real success. BARCO's plug-in provides this functionality in an easy to use wizard. A PDF report is generated with all questions and answers.

5.2.5 What tools to use?

The tools available today are often bundled with the display systems. As already mentioned, a lot of these tools focus on the calibration process only and not really on QA.
Depending on the tools you have available, it is important to learn from QA and make a good plan to start using QA.
BARCO's MediCal Pro runs on a workstation and takes care of calibration and quality assurance, not only on BARCO displays but also on other display types. The standard based plug-ins for DIN6868-57 and AAPM TG18 simply install on top of MediCal Pro and extra QA tasks can be added.
MediCal Administrator is installed on a server on the network and enables the PIN concept for the installed display base.

6 SOFTCOPY QA VISION FROM DIFFERENT USERS

This section highlights feedback from different people active in a medical facility and certainly involved in digital medical imaging.
A typical statement is described for five different roles. However, that does not mean that every person in this role shares these thoughts. The intention is to give an average meaning of softcopy QA for these different roles. People in these roles who thoroughly believe and support softcopy QA should be encouraged to educate colleagues on this topic.

6.1 Medical physicist: a bare necessity

This person is convinced that quality on medical displays is very important. He/she is convinced of the life critical factor when decisions are made in a matter of seconds. He is always involved in the selection process of medical displays for diagnostic and review purposes. The physicist is very knowledgeable in the area of image acquisition and workflow management. The last process of popping up that image on the medical display is important, but deficiencies at this last step are not always known.
Explaining the things that can go wrong, giving a real demo of a certain scenario and showing how these problems can be solved turns our conversation into a real interesting discussion. He warns us of the fact that radiologists expect displays to work to an optimum level and the QA checks should not disturb their work.

6.2 Radiologist: softcopy QA should be non-intrusive to us

The radiologist is aware of the importance of a good, calibrated and controlled display for doing diagnosis, but he/she is not intended to spend time on checking this. The process of softcopy QA is something that should happen without disturbing the radiologist. A non-intrusive sensor like the I-Guard completely fulfills this task.
The whole group of radiologists is involved in the selection process of medical displays when a medical facility will move to PACS. They focus on the impression they get when looking to a study on displays from different display vendors and compare this to what they are used to seeing on film.
For some people this switch is not easy, the viewing angle on an LCD can be disturbing. Others have a kind of 'grainy' impression of the image, because they actually see the LCD cells when looking very close.
These people are convinced that softcopy QA is important for improving the quality of the whole medical imaging workflow, but it should not disturb their work. If manual actions need to be done, somebody else should do them at non-production time. Automated, intervention free QA during the night is very much appreciated, introducing this on flat panels is easy to understand.
On the other hand, in some medical facilities we receive a question if it is possible to do a quick test in the morning. It can be supported with MediCal Pro by setting up a visual check for the first person that logs on to the workstation. Some radiologists really encourage this and feel more confident with their diagnoses for that day. The majority still do not want to be bothered with this, even if this only requires a couple of seconds per display.

6.3 PACS Administrator: central QA management

The PACS Administrator has a big responsibility. She/he is gathering data about network traffic, workstations status, etc. She is often very much interested in similar features of the medical displays.
If the softcopy QA data can be gathered at a central server, the quality of network, workstations and also of all displays can be managed from one central point.
It is often necessary to lookup when a display was replaced with another one. From her desk, it is easy to look up when a display was calibrated the last time, when it was checked the last time, etc. If this technical and historical data is provided in a web interface, it is so easy that PACS administrators and service engineers use it on a daily basis.

6.4 Service engineer: only automated, intervention free QA works

Adding more workstations into a medical facility means extra work for the service engineer. Not only for installing everything, but also for controlling them over time.
Service engineers typically run into problems every day and reactively solve them. Planning ahead is very hard in these situations.
Most of the time is consumed by corrective maintenance. For example, the service engineer is contacted when an image is not shown correctly on the display. A new incident is initiated, just one incident of the corrective maintenance he is handling daily.

If automated, intervention free QA can be used on the displays, and the process of preventive maintenance is started automatically. In this case, problems can be solved pro-actively. The number of incidents of corrective maintenance will decrease.

Providing intervention free softcopy QA tools to service engineers is really a blessing. They can better plan their work, and detect issues before they cause problems.

This can be realized when the softcopy QA data is also stored at a central server, like BARCO's PIN concept. Softcopy QA management is available through a web interface from anywhere and the user can remotely solve problems.
The displays are controlled and checked automatically and when something goes wrong, the service engineer receives an email or a pager message. He logs on to MediCal Administrator (from where he is now) and remotely checks the display status. Through suggested solutions and remote calibration he has the ability to solve the problem remotely, without going to that workstation. Rather than running to this workstation, he can investigate and solve the problem remotely.

6.5 Staff member: if it is not for free, what is the cost? when will we earn something back?

An IT manager, a staff member of a medical facility, is first of all interested in the cost and the return on investment of softcopy QA. You can explain the importance of the quality of the softcopy process, they accept this, but are of course very cost conscious.

An advanced solution like MediCal Pro, MediCal Administrator based on the PIN concept, and I-Guard is not free. It initiates a startup cost that will be profitable over time. Its remote features decrease the number of interventions, and thus the travel time for maintenance of the medical displays.
Also scheduled, preventive maintenance can be started as an automated tool on Coronis displays, at nearly no cost. Over time this will result in less corrective maintenance, since some problems can be tracked pro-actively. Translating this into real numbers is difficult; a lot of medical facility specific data is need for this. But by explaining this unique concept it should be easy to convince the staff that selecting a PIN solution will return its profit over time.

7 CONCLUSIONS

Softcopy QA IS important, in the digital image chain as well as with the display itself. LCD based displays still suffer from major deficiencies like backlight deterioration, etc. Besides the bare necessity don't forget that quality as such is based on a certain belief. **Checking devices used for taking life critical decisions in seconds should be a no-brainer.**

You can start with softcopy QA today, even if you do not know all the technical details of it. The evolving standards like **DIN6868-57** and **AAPM TG18** help in explaining the concepts. The BARCO MediCal software allows DICOM GSDF calibration and provides an entire set of QA tasks, easy to set-up and understand. It is available today.
But do not underestimate it. You need an action plan to start with it. A good practice is that you plan to do things as automated as possible. You could also start with manual actions on all your diagnostic displays and later transfer it to your reviewing displays.

If you already do softcopy QA, you should learn from the data that is coming out of it. If a system fails on a check every time you run it, you may want to do the test more often. Use a system that returns that information for you. **This is much better than re-calibrating all your displays whether it is necessary or not.**

Automated, intervention free softcopy QA is available today. The AAPM TG18 luminance response test (DICOM GSDF conformance) can be run automatically during the night on BARCO Coronis displays. MediCal Administrator gathers results and alerts the service engineer when the test does not pass. This is just one example of how to turn reactive problem solving into pro-active display maintenance. **The move from only corrective maintenance to preventive maintenance** takes some time, but choosing the right tools makes it a small step with an initial investment and a return on that investment over time.

Last but not least, please **add softcopy QA to your RFP's** (Request For Proposals). It is often forgotten and is so important for the serviceability and the lifetime of the displays. It may introduce an extra initial cost but certainly will pay for itself over time.

8 REFERENCES

[1] DICOM Supplement 28: Grayscale Standard Display Function.
http://medical.nema.org/dicom/final/sup28_ft.pdf

[2] DIN6868-57
http://www.din.de

[3] AAPM TG18: American Association of Physicists in Medicine Task Group 18
http://deckard.mc.duke.edu/~samei/tg18

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