

---

This item was submitted to [Loughborough's Research Repository](#) by the author.  
Items in Figshare are protected by copyright, with all rights reserved, unless otherwise indicated.

## **The human factors surrounding system change in breast cancer screening: a case study**

PLEASE CITE THE PUBLISHED VERSION

PUBLISHER

© Human Factors & Ergonomics Society of Australia Inc. (HFESA)

LICENCE

CC BY-NC-ND 4.0

REPOSITORY RECORD

Brace, Charlotte L., Alastair G. Gale, and Matthew G. Wallis. 2019. "The Human Factors Surrounding System Change in Breast Cancer Screening: A Case Study". figshare. <https://hdl.handle.net/2134/3120>.

This item was submitted to Loughborough's Institutional Repository by the author and is made available under the following Creative Commons Licence conditions.



creative commons  
COMMONS DEED

**Attribution-NonCommercial-NoDerivs 2.5**

**You are free:**

- to copy, distribute, display, and perform the work

**Under the following conditions:**

 **Attribution.** You must attribute the work in the manner specified by the author or licensor.

 **Noncommercial.** You may not use this work for commercial purposes.

 **No Derivative Works.** You may not alter, transform, or build upon this work.

- For any reuse or distribution, you must make clear to others the license terms of this work.
- Any of these conditions can be waived if you get permission from the copyright holder.

**Your fair use and other rights are in no way affected by the above.**

This is a human-readable summary of the [Legal Code \(the full license\)](#).

[Disclaimer](#) 

For the full text of this licence, please go to:  
<http://creativecommons.org/licenses/by-nc-nd/2.5/>

## The Human Factors Surrounding System Change In Breast Cancer Screening: A Case Study

C Brace<sup>1</sup>, A Gale<sup>1</sup>, M Wallis<sup>2</sup>

<sup>1</sup>Applied Vision Research Centre, Ergonomics and Safety Research Institute, Holywell Way,  
Loughborough, UK LE11 3UZ, UK [www.esri.org.uk](http://www.esri.org.uk)

<sup>2</sup>Coventry and Warwickshire Hospital Breast Screening Unit, Coventry, UK.

*Keywords:* Mammography, film reading, digital, analogue, implementation.

### ABSTRACT

Screening for breast cancer involves examination of mammograms. Conventional film-screen mammography is being surpassed with the implementation of digital soft copy film reporting. However, little thought has been given to the human factors associated with the allied period of system changeover. This study considered the human factors implications with respect to comfort, performance and efficiency of work tasks. The purpose of this project was to examine the human factors issues surrounding the implementation of the new technology and prepare recommendations relevant to practitioners for improved implementation practice. A combination of techniques (expert walkthroughs, verbal protocol analysis, interviews, work station assessments) were applied to examine existing and revised working practices during mammography film reading. Eight Radiologists and Radiographer Advanced Practitioners within two Breast Screening Units participated to enable a thorough understanding to be gained of strategies adopted when using the different systems and the combination of systems. A variety of changes in working practices were recognised to have occurred with the new system (digital) implementation. There was an impact upon technique, comfort, performance and efficiency during digital soft copy reporting when viewing analogue priors. Subsequent recommendations for workstation design, working practices and training were produced to assist in improved implementation of digital processes in mammography. The project demonstrated that implementation of new technology needs to be thoroughly assessed to alleviate any potentially problematic human factors issues.

### 1. INTRODUCTION

Breast cancer is currently the most common female cancer in the UK with 1 in every 9 women developing breast cancer sometime in their lives (NHSBSP, 2005). Each year over 41,000 women are diagnosed with breast cancer in the UK and more than 1,000 women die from the disease every month in the UK (Breakthrough Breast Cancer, 2006). The National Health Service (NHS) Breast Screening Programme (BSP) is an effective part of the UK's efforts to reduce the death toll from breast cancer. A key element of the programme involves the all women in the UK aged between 50 and 70 being invited to have a routine mammography (breast x-ray examination) every three years. Statistics show that the screening programme had lowered mortality rates from breast cancer and the latest research shows that the NHS Breast Screening Programme is now saving 1,400 lives every year in England (NHSBSP, 2006).

Mammography is a specific type of imaging that uses a low-dose x-ray system for the examination of breasts. A mammography exam, called a mammogram, is used as a screening tool to detect early breast cancer in women experiencing no symptoms and to detect and diagnose breast disease in women experiencing symptoms such as a lump, pain or nipple discharge. Mammography plays a central part in early detection of breast cancers because it can show changes in the breast up to two years before a patient or physician can feel them. Research has shown that annual mammograms lead to early detection of breast cancers, when they are most curable and breast-conservation therapies are available.

Reading a mammogram is a skill that radiologists develop over time. They look for any signs of abnormality, including asymmetries (something on one side that's not on the other), irregular areas of increased density, clusters of small calcifications, and any area of skin thickening. Mammograms aren't perfect. Normal breast tissue can hide a breast cancer, so that it doesn't show up on the mammogram. This is called a false negative. Additionally, mammography can identify an abnormality that looks like a cancer, but turns out to be normal. This "false alarm" is recorded as a false positive. Most standard mammographic workups include two views of each breast taken from different angles. This is so the breasts can be compared, and so that both breasts can be checked for abnormalities. If a mammogram has been taken before, the radiologist will compare the old mammogram (prior) to the new one to look for changes.

With technological progress, conventional film-screen mammography will eventually be surpassed with the implementation of digital mammography and the associated soft copy reporting. Results of the Digital Mammographic Imaging Screening Trial (DMIST), one of the largest cancer screening trials ever conducted by radiologists (Pisano et al, 2005) are encouraging. This large-scale, multi-centre clinical trial was designed to measure differences in diagnostic accuracy between digital mammography and film mammography. DMIST results showed that, for the entire population of women studied, digital and film mammography had very similar screening accuracy.

Digital imaging may have many advantages over film – post-processing, image enhancement, better workflow and more efficient image transfer/ archival and retrieval processes. However, there may be human factors issues surrounding the implementation of this new technology that need to be managed in order to ensure that the potential advantages can be effectively realised and that the health and well being of staff are not compromised.

## **2. AIMS AND OBJECTIVES**

The purpose of this project is to examine the human factors issues surrounding the implementation of the new technology and prepare recommendations relevant to practitioners for improved implementation practice.

## **2. METHODS**

A variety of human factors techniques were applied to examine and understand existing working practices during the implementation of digital mammography film reading in UK NHS Breast Screening Unit. Techniques included expert walk through, verbal protocol analysis, interviews and work station assessment. Use of these methods enabled a thorough understanding to be gained of strategies adopted when using: routine conventional roller viewing of analogue (film) cases with analogue priors, and; trial Full Field Digital Mammography (FFDM) with analogue priors viewed on a multiviewer.

Particular attention was given to the following core human factors issues, encompassing comfort, performance and safety:

- Posture/hardware usability
- Task/changes in task
- Concentration/workload
- Software usability
- General room layout and physical ergonomics
- Long-term considerations

Participation was invited from radiologists and advanced practitioners based within two UK Breast Screening Units who routinely undertake film reading. The work was conducted as an audit and checked with the appropriate Ethics Committees, but full ethical clearance was not required to be sought. However, full participant consent was obtained prior to undertaking the evaluations.

## **3. RESULTS**

### 3.1 Participants

Eight participants were observed, including 5 radiologists and 3 advanced practitioners. The mean age of the 5 females and 3 males was 47 years (range 35-57 years). Stature was varied, allowing for anthropometric issues to be examined (mean stature 1.7m, range 1.5-1.8m). Between them, the participants had an average of 8.5 years experience in analogue film reading (range 1-17 years) but less than 1 year for reading digital film (range 8-12 months).

### 3.2 Observations and Equipment

Fourteen sets of observations were made during the employment of 2 different types of work practice (routine conventional roller viewing of analogue (film) cases with analogue priors [four different roller view workstations], and trial FFDM with analogue priors viewed on a multiviewer [one digital/analogue workstation]). The digital viewer in use was the Sectra system, with IDS5 data management software and Flexscan E1ZO monitors. The analogue viewers were a selection of Planilux Mammolux EL models.

The human factors issues with respect to general film reading practice are initially presented. This is followed by discussion of the salient human factors issues surrounding system change from analogue to digital film reading.

### 3.3 The Human Factors of General Film Reading Practice

The issues described in this subsection are independent of type of film reading medium, and were consistent observations throughout the investigation.

**Environmental conditions.** Extensive psychophysical research has established that radiological lesion detectability degrades when viewing conditions are not optimized. As a consequence, European Guidelines (EC, 1996) have been produced regarding the optimum viewing conditions required for film reading resulting in proper assessment of image quality and accurate reporting on the diagnostic information in the radiographs. It is suggested that a low level of ambient light in the viewing room is essential for good contrast within the image, and means for magnifying details in the displayed radiographic image should be available. Additionally, resources should be available to restrict the illuminated area to the area of the radiograph to avoid dazzling.

Generally, the fundamentals of these Guidelines were followed. Due to the fact that the ideal working environment with respect to human performance is that of a dimly lit location, it was common for equipment to be located in small cubicle areas, often with no natural light or ventilation. There were numerous reports of the working environment becoming uncomfortably warm, because of it being a small, enclosed space containing intense light emitting sources and computer equipment. If the temperature rises too high, monitor life expectancy and radiologist productivity decrease. Other larger working environments contained multiple workstations, and it was reported that they could become noisy with distractions occurring due to the presence of other team members.

**Job design.** In the radiology departments observed, there was a large degree of individual autonomy over when and how much film reading was undertaken. Although some individuals took regular breaks, the participants in this case study generally self-reported to be working for long periods at a time at the task, e.g. up to 3.5 hours at a time without a break. Time spent film reading over the course of an ordinary week ranged between 4.5 and 14 hours. Other predominant activities during a routine week varied for the different individuals but generally involved several hours of computer use and clinics. For advanced practitioners, this often required the physical operation of mammography equipment. Some participants stated that they preferred to film read at particular times of the day, e.g. "early morning when the eyes are fresh", and others stated no preference.

**Workstation and posture.** The chairs were of standard office variety with limited lumbar support and limited adaptability combined with non-adjustable workstations. Even if the chair is adjustable, unless the workstation is adjustable too, it can be impossible for an individual to be able to comfortably reach the foot pedals, whilst satisfactorily being able to view the top of the film display. The postures and specific workstation set ups are described in more detail for each work practice in section 3.4. Few participants adjusted their chairs when commencing the task. Despite this, few individuals reported

any symptoms of musculoskeletal discomfort. Those individuals that did report symptoms were advanced practitioners and their other routine weekly activities involved manual operation of mammography equipment, suggesting that this additional physical strain may be a contributor to their reported discomfort when undertaking film reading.

**Workload.** A high level of concentration is required during film reading. Individuals were spending from a few seconds up to 1 minute observing each patient's images. Numbers of patient records in each batch were between 5 and 50, and there is usually more than 1 batch of records that is waiting to be read. These batches are stored in piles of packets in different locations, dependant on the department. These can be very heavy and one of the radiology departments that was visited recommends that piles of packets are kept to manageable size and weight because they have to be moved routinely by staff. Even a pile of 20 packets can be very heavy if there are lots of old films included in patients' packets.

**Summary.** To summarise, an individual is often working in a small, hot, poorly ventilated darkened room that contains a selection of light boxes/VDU screens for long periods without a break. During the film reading task, they are tolerating high levels of mental workload as well as poor physical postures.

### 3.4 The Human Factors Issues Surrounding System Change

A variety of changes in working practice occurred with the implementation of digital film reading. Issues have been documented in the following subsections.

**Workstation and posture.** When reading current analogue film and analogue priors, the positions maintained by the individuals were generally fairly static with poor posture, leaning in very close to the viewer, with little lumbar support, maintaining a position directly in front of the analogue workstation. If not completely static during the task, the reader would be leaning and slightly twisting their torso from side to side (particularly if they had a short upper body) in order to read all of the films presented on the viewer and to enter data management information, Figure 1. For both types of set up, a data management screen was located close by the image display(s). Therefore, for pure analogue film reading, there was a roller viewer and a data management display screen and for the FFDM film reading, there were two large image displays, a data management display screen and a roller viewer. Eye strain was reported to be a problem for some individuals when using the digital system due to the use of the additional display screens to read images. This was a reason why some of the cohort chose to conduct film reading in the morning rather than later in the day because their eyes would be "less tired" and they would be "more mentally alert".

Comparing between films in the different mediums required substantial movement by the film reader, Figure 2. Generally, the individual would sit in front of the digital monitor and observe the most recent films before either stretching or twisting their torso or sliding their chair over to view the analogue priors which were positioned at the analogue workstation which was at a 45 degree angle to the digital workstation. There were reports of inefficiency in task performance due to the constant movement required to view the different images. However, there were no differences in reports of musculoskeletal discomfort between the two different types of workstations. It may be possible that the continuous, dynamic movement adopted when using the FFDM workstation may be beneficial in keeping the body from remaining in one static position for long periods of time. However, it is not ideal that such continuous movement is required for the task during the involvement of FFDM.



Figure 1. Example of a wholly analogue work station

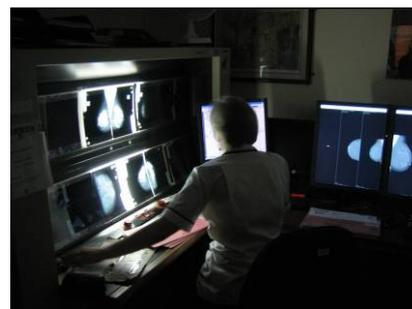


Figure 2. Example of a work station with digital current images and analogue priors

Hand controls were the only available mechanism for operating the FFDM and changing the images. However, both hand and foot pedals could be used for the viewing/retrieving of the analogue images. It appeared that individuals generally chose to use the hand controls, although the most efficient working practices were by those staff that combined the use of the foot and hand controls due to the flexibility that this achieved and the reduced physical effort incurred. When asked, some participants reported that they had not considered using the foot controls. Others reported using them, despite difficulties they encountered, due to the reduced physical work that resulted: "I'm short so it's difficult to reach the pedals... I usually use the hand controls on these analogue film viewers but I find that you have to twist round much further to reach them whilst examining digital display, so have adopted foot pedals instead. It would be better if they were raised up on a step so I could reach them more easily though..."

Bar code reading is often used with the analogue film reading, which is linked to the management information software, allowing the user to scan the bar code on the film and scan the appropriate results card dependent on the outcome of the film reading process. Bar code reading is not currently used with the FFDM system because another computer system would be required and there is not enough space.

**Working practice.** Magnification is commonly used to view the images during the reading task, as per the Guidelines (EC, 1996). A magnifying glass is used with the analogue film commonly resulting in the reader leaning closely in towards the film. The capability for zooming in as well as adjusting the background ('windowing') is available with the FFDM. Some individuals continued to use the magnifying glass when observing images on the FFDM medium, presumably due to habit. This cannot be the ideal way of magnifying the FFDM images due to the type of medium and the resolution, and therefore this practice may affect efficacy. The majority of individuals used the controls on the FFDM system to zoom in/out and window, and this was done routinely for each patient. These were managed with the input devices (mouse or keypad) associated with the FFDM. There were few problems reported with these input devices and they were generally well received.

It was observed that the user can increase/decrease the light behind the analogue priors and this was done fairly frequently when comparing analogue to analogue. However, it was not commonly done when comparing analogue with digital images. Additionally, it was clear from the observations that significantly fewer comparisons were being undertaken generally when having to compare films between the different mediums compared to pure analogue. This was doubtless due to the effort required in physically moving across from the FFDM to view the analogue priors. It may also have been due to the reported difficulties in conducting comparisons between the different mediums due to their different characteristics and presentation.

One participant noted that she "does not revisit the priors if there's nothing obvious on the new image". This may have implications for error, and specifically, false negative reporting, because of the potential to miss a new indicator as the prior is not being fully examined/compared to the current image. Although recent studies have shown no significant differences in efficacy between analogue and digital film reading (Pisano et al, 2005), it would be useful to have examined the actual practices of the participants in such trials and to observe their methods of film reading, e.g. were comparisons being continuously made between the images within the different medium? If continuous comparisons were being undertaken, it could be suggested that the trial results do not reflect the real-life situation of film reading practice and the results could be inconclusive in this respect.

**Efficiency and confidence in reporting.** It was reported that it took as long as 12 months to feel confident with reporting from FFDM. Intelligence from the cohort stated that digital was slower and less efficient to start off with, but when an individual developed their own mechanisms of working and had some experience of the system, they quickly speed and become more efficient. Therefore, although analogue film screen reading was still the preferred mode of choice amongst the majority of the group, more users were becoming accustomed to FFDM, and realising the benefits with respect to clear image, ability to window/zoom and easy movement between patient images. It was apparent from observations that, generally, the analogue reading process was more smoothly operated than the digital, simply because of additional experience. From the comments received, it was suggested that radiologists became habituated to the FFDM more quickly than the advanced practitioners. It was also suggested that radiologists became more confident with using FFDM more quickly than advanced practitioners. This could be perceived during the observations because, in this small study, advanced practitioners were more likely than radiologists to compare the prior images during FFDM reading.

Possible reasons for this difference in confidence may be that the radiologists were more likely to have been exposed, for some time, to using digital systems in their other specialities, e.g. CT, MRI scanning, and that, within this cohort, the radiologists had many more years experience in film reading than the advanced practitioners. This suggests that there may be implications for different training needs between the different staff groups.

**Reported difficulties and 'room for improvement'.** If more than the standard number of images have been recorded (e.g. for a woman with very large breasts, or for a reprint), the order of the films in the digital system can vary. This means that the film reader has to change them to the correct order within the FFDM management system, which is reported to be time consuming.

It was common for the digital and analogue film orders to be different, e.g. because the digital ones are recorded in time order of images being taken, and the analogues are put up according to the actual schedule of events for a screening session. The digital images may also change order if any of the information has been entered incorrectly, e.g. information on date of birth can affect order. In order for the film reader to work as efficiently as possible, it is imperative that the order against each is correct, therefore it would be useful for the person loading the images to have a copy of the digital list.

Currently, with the relatively new set up, there were some limitations in terms of the software efficiency of the FFDM system. When reports are entered onto the FFDM software (e.g. cancer detected, or no cancer observed), this information has to be transcribed into another programme required for the NHS BSP, which is then used to report to the BSP and to run mail merges for reporting the results to the patient. Ideally, the set up would be to have digital images on the FFDM system which can be linked directly to the BSP software.

It was suggested that, ideally, each film reading workstation would be placed in a separate, but identical room. This would cut down on the number of disturbances experienced, as well as containing the same workstation design with the same power points allowing equipment to be in the same locations etc., enabling the user population to be able to work in the same way independent of which workstation was being used.

Whilst the NHS is moving towards a fully digital age, there is still currently the necessity for paperwork and files and space is required at the workstation for "flipping over" documents and packets.

## 4 RECOMMENDATIONS

### 4.1 Film Reading Practice

**Environmental conditions.** Lighting should be provided in the correct spectrum coupled with appropriate lighting levels, dimming capacity, no flicker and direction of the source to avoid glare on a computer screen. As an imaging study may require reading the image from a monitor while referring to a paper requisition or medical record, some type of supplemental task lighting is often essential. A radiology department may include practitioners of all age ranges. Therefore, the amount and types of light must be adjustable, e.g. a 30-year-old film reader usually requires approximately half as much light as a 60-year-old film reader (Hedge, 2005).

Adequate ventilation should be incorporated into workplace design and if this is not achievable, cooling systems, fans etc. should be available. Attention should also be paid to noise levels within the working environment, as the task requires a high level of concentration to avoid errors being made. Sound absorbing materials, e.g. curtain, carpets, wall tiles, may help to dissipate high noise levels.

**Workstation and posture.** The general position of the body, height of the monitor, table and chair, combined with the film reader's interaction with a number of monitors and input devices, the size of the workstation, as well as placement of the wrist and elbow relative to equipment all play a vital role in effective and safe workflow. In many work sites there will be numerous personnel who work at each workstation, therefore all components must be adjustable to flexibly suit the specific anthropometrics of each team member. Monitor placement, the height of the monitor relative to the user with the position of the neck and back and the general overall height of the system is important. With improper positioning, there is increased eye, neck and back strain. Equipment should be placed according to frequency of use and excess equipment should be removed to allow for more space and flexibility in

the limited working environment. It has been suggested that the optimum number of visual display units for film reading is two and any more than that can result in little user benefit, despite significant additional economic cost in purchasing equipment (Siegel et al, 2004).

All devices should be positioned in such a way that the user can work in a neutral posture. The upper arms should be relaxed against the body, with lower arms no higher than a 90-degree angle to the elbow and preferably a little lower than that, with both hands and wrists straight out ahead (Hedge, 2005). It is difficult to say, without observing such a setup, whether it would be better to alter the existing FFDM workstation design from the 'L' shape to a straight run. It could be suggested that a straight run may result in a more static overall posture but with excess stretching of the torso along the length of the workstation, which may create additional discomfort for the user.

If an improvement in the requirement of computers/different pieces of software could be achieved, this may have implications for the renewed use of bar code reading with FFDM due to improved efficiency of information technology. This use, in turn, could have powerful implications for efficiency of FFDM.

#### **4.2 Staff health and wellbeing**

As a minimum, it is recommended that every 20 minutes the film reader should look away from the monitor for at least 20 seconds at a spot that is 20 feet (6 metres) away to minimise eye strain (the 20-20-20 rule, Hedge 2005). Due to the non-neutral physical postures adopted, it is also suggested that the individual takes a micro-break (a 60 to 90 second rest) and alters their position by standing up and stretching every 15 minutes, to reduce muscular fatigue and improve (physical and mental) performance (Hedge, 2006). Staff should also be persuaded to have regular eye checks so that changes in visual acuity etc. can be monitored and the appropriate countermeasures selected to avoid eye strain or discomfort.

It is suggested that individuals should be given the autonomy to decide when during the day/week they wish to undertake film reading so that they can choose a time that optimally suits their requirements and preferences.

Piles of patient files (packets) should be kept to a manageable size and weight (maximum 20 packets per pile) because they have to be moved routinely by staff. They should also be stored, e.g. on shelves, which are at waist height so that the user does not have to bend and lift to manoeuvre the paperwork.

#### **4.3 Training**

By observing a variety of users, it was clear that much good practice was occurring, and there were several examples of efficient and effective systems of working. It was also apparent however, that good practice can be shared within a team. Therefore, it can be suggested that periodic observations of fellow team members may be beneficial for continued learning and development of new system use. Specifics of the task suggest that there is a need amongst some staff for additional training in the use of the navigation and graphics tool with the FFDM software. Additionally, staff should be encouraged to explore and develop their own strategies during film reading, which may involve use of additional hand and foot control mechanisms. It can be suggested from this study that there needs to be some re-examination of training requirements for different staff groups, e.g. advanced practitioners, radiologists, to ensure that training is as tailored and appropriate as possible.

#### **4.4 Recommendations for future work**

The evaluation was unable to examine routine soft copy reporting with full field digital mammography (FFDM) priors because the implementation of the technology was too recent. Therefore, it would be useful to examine this set up once it is piloted.

Little discomfort was reported by the individuals despite their long periods of equipment use in one film reading session. Discomfort may develop over continued exposure and this should be monitored carefully. There is a need to examine the interplay between film reading and other routine tasks, e.g. physical work such as operation of mammography machines. Advanced practitioners, who may be more likely to undertake more physical work, are relatively new to film reading (which is part of their extended job role due to shortages in radiologists). Therefore, this comparatively new working practice needs examining in relation to existing work tasks.

Further research needs to be undertaken to examine the real-life situation of film reading practice and to assess whether it is commonplace to not make comparisons between the images within the different medium. If a larger study demonstrates that task behaviour really is changing to such an extent, the results of recent studies showing efficacy between analogue and digital film reading (Pisano et al, 2005) need to be reviewed.

An FFDM workstation design with a straight run rather than an 'L' shape should be examined to investigate if this workplace layout is preferred by the user. Further evaluations also need to be conducted examining a variety of digital systems with larger numbers of participants. It would also be useful to re-examine the work practices after a longer period of implementation to see if the individuals had overcome 'teething problems', as no-one in the cohort in this case study had been using the digital film reading system for longer than a 12 month period. This additional information would assist in the development of a full set of recommendations. Furthermore, it would be useful to examine working practice and error rates after a variety of conditioning periods to see if habituation has any effect.

## 5. REFERENCES

Breakthrough Breast Cancer (2006). Statistics available from:

[http://www.breakthrough.org.uk/about\\_breast\\_cancer/understanding\\_breast\\_cancer/statistics.html](http://www.breakthrough.org.uk/about_breast_cancer/understanding_breast_cancer/statistics.html)

European Commission (EC) (1996). European Guidelines on Quality Criteria for Diagnostic Radiographic Images.

Hedge A (2005). It's all in the Ergonomics: People-friendly Design for the Reading Room. Health Imaging & IT. August 1, 2005. Available from: <http://www.healthimaging.com/content/view/843/68/>

Hedge A (2006). Optimizing the reading room: Lessons on visual perception, ergonomics and design. SCAR/SIIM Daily News. April 29, 2006. Available from: <http://www.healthimaging.com/content/view/4281/142/>

NHSBSP (2005). One Vision: NHS Breast Screening Programme. Annual Report 2005. Available from: [www.cancerscreening.nhs.uk](http://www.cancerscreening.nhs.uk)

NHSBSP (2006). Screening for Breast Cancer in England: Past and Future, Advisory Committee on Breast Cancer Screening, 2006 (NHSBSP Publication no 61). Available from: <http://www.cancerscreening.nhs.uk/breastscreen/publications/nhsbsp61.html>

Pisano et al (2005). Diagnostic Performance of Digital versus Film Mammography for Breast-Cancer Screening. New England Journal of Medicine Volume 353:1773-1783

Siegel E et al (2004). Society for Computer Applications in Radiology. SCAR University 2004, Section 12. Digital eye for the analog guy. Presented by: Eliot L. Siegel, MD, and the Baltimore Research Team.

## 6. ACKNOWLEDGEMENTS

The authors gratefully acknowledge the funding for this project which is financed by the National Health Service (NHS) Breast Screening Programme, UK.