# EVALUATION OF A HEMI-SPHERICAL WIDEBAND ANTENNA ARRAY FOR BREAST CANCER IMAGING

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## ABSTRACT

Using similar techniques to Ground Penetrating Radars, microwave detection of breast tumours is a potential non-ionising and non-invasive alternative to traditional body-imaging techniques.

In order to develop an imaging system, the team at Bristol have been working on a number of antenna array prototypes, based around a stacked-patch element - starting with simple pairs of elements and progressing to fully populated planar arrays.

As the system commences human subject trials, a curved breast phantom has been developed along with an approximately hemi-spherical conformal array. This contribution will present details of the conformal array design and initial results from this unique experimental imaging system as applied to an anatomically-shaped breast phantom.

## 1. INTRODUCTION AND BACKGROUND

Breast cancer is the most common cancer in women. X-ray mammography is currently the most effective detection technique, however it suffers from a relatively high missed- and false-detection rates, involves uncomfortable compression of the breast and also entails exposure to ionizing radiation.

Microwave detection of breast tumours is a potential non-ionising alternative being investigated by a number of groups [1]. In these microwave-based systems, in a similar fashion to Ground Penetrating Radars, microwaves are transmitted from an antenna or antenna array, and the received signals, which contain reflections from tumours, are recorded and analysed.

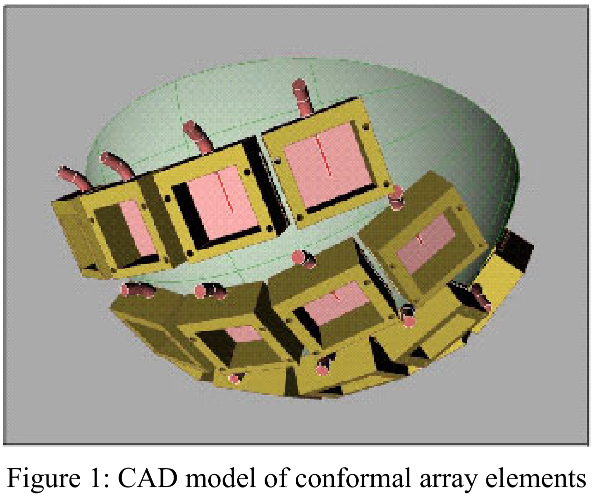

Figure 1: CAD model of conformal array elements

A pre-requisite for all of these systems is a suitable antenna array. Initial work concentrated on developing a simple but low-profile and wide-band antenna that would cover the 4-10GHz frequency range. A stacked patch element was designed that broadly meets the design criteria [2]. The stacked patch design was initially employed in a mechanically-scanned system that used stepper motors to move a pair of antennas over a 4 x 4 grid of element locations. This arrangement was superseded initially by a planar fully-populated array, and then by the conformal array described herein.

## 2. CONFORMAL ARRAY DESIGN

Given the effort in designing a constructing a conformal array, the intention from the outset was to design not only an array for laboratory use on a realistic, curved phantom, but also one that would serve as an initial clinical prototype.

Approximately 20 female volunteers came forward from the University and the fit between their breasts and various plastic spherical sections was assessed with them lying in a prone position – the prone (face-down) position being felt to offer the best chance of the breast forming a gently and uniformly-curved shape.

Following this assessment, the dimensions of the array were input into a 3D CAD model, along with the antenna elements and all supporting metalwork. A view of the CAD model is shown in Figure 1, the array being formed around approximately the lower third of a 78mm-radius sphere.

As will be seen in Figure 1, each element is positioned tangentially to the spherical surface. The microstrip feed to the reverse of each element is retained, and clearly visible, however due to the curved construction a transition to semi-rigid coaxial cable is required.

A staggered arrangement of elements seen in Figure 1 is employed, this giving – barely – enough clearance for the cables and connectors, which pass between the elements of adjacent rows. The use of the 3D CAD modeling was found to be vital, given the tight geometrical clearances and the difficulty in foreseeing, in a curved geometry, potential clashes between cables, connectors, antennas, screens and supporting metalwork. Even in Figure 2 it may be seen that the right-most feed on the second row (numbered from the top) will not clear the adjacent element – and this required a small modification to the feed arrangement for that individual element. For laboratory tests the array stands-off 20mm from a skin phantom and the radiating face is submerged in a tank of liquid breast-fat equivalent medium [2].

Figure 2 shows the fully-operational system, as set up for clinical measurements at the Oncology Centre in Bristol. The arrangement for phantom measurements is similar except for the addition of an external tank that contains the phantom materials. The RF switching between the array and the network analyser is clearly visible, as is the RAM between the antenna elements which is intended to damp reverberations between the phantom (or person) and the array.

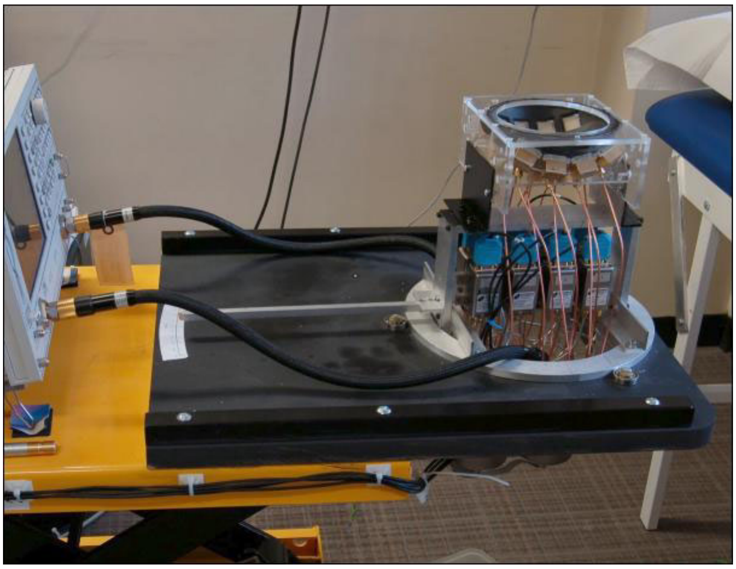

Figure 2: Clinical experimental set-up

## 3. IMAGING RESULTS

The imaging technique employed at Bristol is a simple and robust multistatic time-domain delay-and-sum method (although various refinements are applied to the basic method).

An experimental image of a 6mm-diameter phantom tumour is presented in Figure 3. A linear colour scale is employed, with the maximum normalised to unity in the slice from the 3D dataset presented, relative values less than 0.1 (i.e. lower than the limit on the colour bar) are displayed as "white". The larger object is the tumour and has a value of 1.0 as described in the legend. The smaller point is an artefact with an amplitude of 0.15. This result was obtained in the presence of a high dielectric, curved, skin phantom.

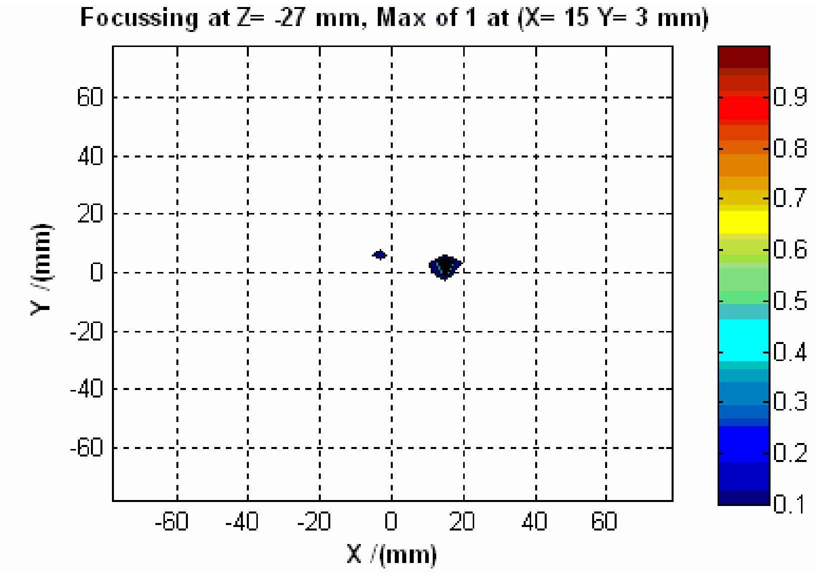


Figure 3: Focused image of a 6mm tumour located at x=15mm, y=0.

Many more datasets are available and a number of different focusing approaches have been examined. Results for these scenarios will be available for presentation.

## 4. CONCLUSIONS

A 16 element conformal antenna array has been described. The antenna elements populate the inside of a section of a hemisphere, this being a suitable geometry for clinical application.

Preliminary imaging results are encouraging and other challenging imaging scenarios are currently under consideration. For example, detection of 4mm-diameter tumour phantoms in the presence of the breast+skin phantom has also been successful – although there is insufficient room herein to present those results in full.

## REFERENCES


[1] E. C. Fear, "Microwave imaging of the breast," Technology in Cancer Research and Treatment, vol. 4, pp. 69-82, 2005.

[2] R. Nilavalan, I. J. Craddock., J. Leendertz, A. Preece, and R. Benjamin, "Wideband Microstrip Patch Antenna Design for Breast Cancer Tumour Detection" to be published IET Proceedings, Microwaves Antennas and Propagation, 2007.

[3] J. Leendertz, A. Preece, R. Nilavalan, I. J. Craddock and R. Benjamin, A liquid phantom medium for microwave breast imaging, 6th International congress of the European Bioelectromagnetics association, Budapest, Hungary, Nov 2003.