Antenna Measurement Facility Comparison Campaign within the European Antenna Centre of Excellence

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Abstract This paper gives an overview of the *Antenna Measurement Techniques and Facility Sharing* activity of the *Antenna Centre of Excellence* (ACE) within EU's 6'th framework program for research - in particular, the facility comparison campaign with the DTU-ESA 12 GHz VAlidation STandard antenna (VAST12).

Introduction

Antenna measurements constitute an indispensable part of the development of any wireless system. The accuracy and efficiency of computational tools are ever increasing and some stages of the development of some antennas may be based on simulations alone. However, increasingly stringent requirements and the consequential complexity of most modern antennas mean that a complete characterization cannot be achieved by even the most advanced computational tool. Hence, measurements of antennas are important whether for analysis, validation, or calibration. The purpose of the *Antenna Measurement Techniques and Facility Sharing* activity is to facilitate the consolidation and expansion of European expertise in research and development of antenna measurements. With 15 European universities, research laboratories, or companies, this activity is organized in 4 Work Packages (WP) led by different institutions as listed below:

WP 1 *European Measurement Expertise Mapping,* University of Calabria
WP 2 *First Facility Comparison Campaign,* Technical University of Denmark
WP 3 *Facility Sharing, Feasibility Study and Initial Test Cases,* France Telecom
WP 4 *Recommendations for Measurement Procedures,* SATIMO

WP 1 has established, by December 2004, a database over European antenna measurement facilities which is publicly available from the *ACE Virtual Centre of Excellence* (www.antennasvce.org) using the *ACE Community* module. From the outset, the database includes some 40 facilities and it will be regularly updated with more facilities and new functionalities. In WP 2 a facility comparison campaign has been initiated in mid-2004 and results from this are reported below. WP 3 has the objective to promote the sharing of advanced antenna measurement facilities and expertise to make more effective use of such resources. Finally, WP 4 aims to develop recommended practices for near-field measurements and smart antenna measurements on basis of the experience and expertise of the participating institutions; a part of this work is done in cooperation with the IEEE Antenna Standards Committee.

Facility Comparison Campaign with the VAST12 Antenna

The objective of this work is to conduct a comparison of antenna measurement facilities employing the DTU-ESA VAST12 antenna. This will serve to benchmark the participating facilities, to document the advantages and disadvantages of different measurement techniques as well as the practical implementations of these, and to provide inputs for the standardization of validation of antenna measurement facilities. Obviously, comparison campaigns with other antennas have been carried out and reported previously; e.g. [1]-[2].

The VAST12 antenna was developed by the Technical University of Denmark (DTU) for the European Space Agency (ESA) in the 1990s as a specially designed reference antenna [3]-[4]. The CFRP/foam structure ensures thermal and mechanical stability against differences in temperature and gravity orientation, respectively, between the participating facilities. The offset shaped-parabolic reflector, with different focal points in the two principal planes, and the corrugated circular feed horn provide a pattern with elliptical main beam and several challenging characteristics. The operating frequency is 12 GHz. For the present campaign, the polarization is linear and the gain about 30 dB, but with replaceable orthomode transducers and attenuators on the horn it is possible to change polarization and gain. The overall size of the antenna is 0.51x0.84x0.94 m^3, and the weight is about 20 kg.

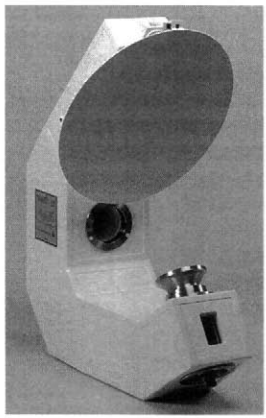

Figure 1. *The DTU-ESA VAST12 antenna.*

The first step of the campaign is to determine the Verification Test Plan that defines not only the radiation pattern parameters to be measured, but also the coordinate systems and the data formats to be used for the reporting of the measurement results. Thus, three different coordinate systems are defined: (1) the mechanical system using the flange of the antenna mechanical interface and a spirit level, (2) the electrical system using the peak directivity direction and the polarization of the radiated field, and (3) the optical system using a mirror cube mounted on the antenna. The Euler angles (ϕ, θ, χ) for the electrical and optical coordinate systems, as measured in the mechanical system, are (228.4, 0.6, 131.4) deg. and (228.3, 0.2, 132.0) deg., respectively. The second step of the campaign is then to make the first reference measurement at the DTU-ESA Spherical Near-Field Antenna Test Facility [5]. Third, the VAST12 antenna is shipped to the 6 participating institutions and measured at 8 different facilities. Finally, the second reference measurement is conducted at the DTU-ESA Facility. The data collection and processing is conducted by DTU in cooperation with the other participants and documented in an ACE report to be released by mid-2005; a few examples from this are shown in the next section.

Measurement Results from DTU, UPM and FTDR

The measurement results presented below are from the DTU-ESA spherical near-field facility at the Technical University of Denmark (DTU), the spherical near-field facility at the Technical University of Madrid (UPM) [6], and the far-field range at France Telecom R&D, La Turbie (FTRD) [7]. Figure 2 illustrates the importance of the coordinate system definition. It shows the co- and cross-polar patterns (Ludwig's 3rd definition) in the ϕ= 0/180 deg. plane for the 3 different coordinate systems from measurements at the DTU-ESA Facility. It is seen that both patterns are significantly dependent on the coordinate system employed. It is noted that the mirror cube coordinate system is intentionally oriented to make the co-polar peak and the cross-polar minimum occur away from the θ= 0 deg. axis.

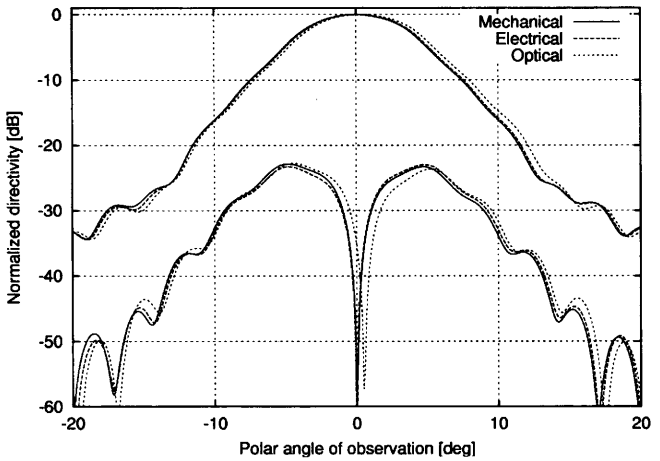

Figure 2. *Co- and cross-polar radiation patterns in the ϕ= 0/180 deg. plane for the mechanical, electrical, and optical coordinate systems.*

Figure 3a and 3b show the ϕ = 0/180 deg. and ϕ = 90/270 deg. planes, in the mechanical coordinate system, for the DTU and UPM results, while figure 4a and 4b show the similar cuts, in the electrical coordinate system, for the DTU and FTRD results. These patterns are all normalized to 0 dB with the directivity/gain values summarized in the adjacent table.

	Directivity	Gain
DTU	30.71	30.35
UPM	30.62	30.36
FTRD	31.1	30.4

Generally, there is good agreement between the measurement results of the 3 facilities; e.g. the deep sidelobe minima in the 90/270 deg. plane are recovered excellently in all 3 sets of results. However, a number of small differences can be noted at low levels which might be due to e.g. range reflections; in particular, there is a quite noticeable difference at a -36 dB level around θ= 25 deg. in the ϕ= 90/270 deg. plane, and the cross-polar patterns in the same plane are also quite different, but at a very low level.

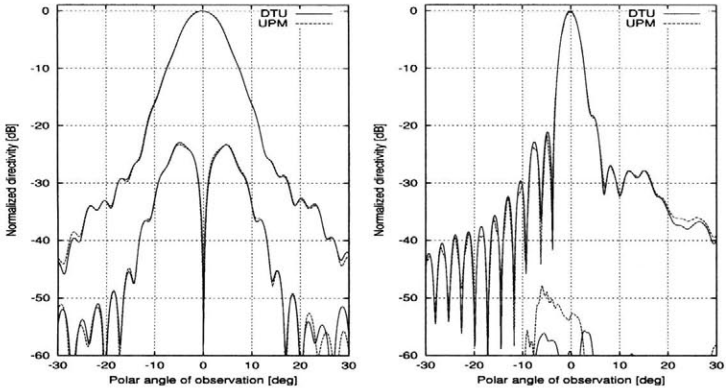

Figure 3. *DTU and UPM results for (a) the $\phi = 0/180$ deg. plane and (b) $\phi = 90/270$ deg. plane in the mechanical coordinate system.*

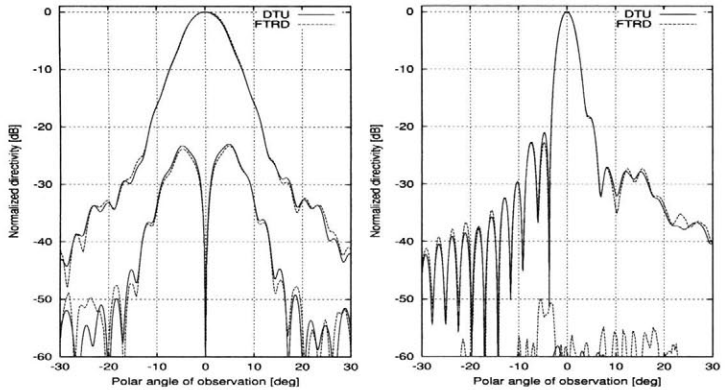

Figure 4. *DTU and FTRD results for (a) the $\phi = 0/180$ deg. plane and (b) $\phi = 90/270$ deg. plane in the electrical coordinate system.*

References

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[6] Homepage: www.gr.ssr.upm.es

[7] Homepage: www.rd.francetelecom.com/en/prestations/articulation_radio.php