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GPR Antenna Standards and Catalogue for ACE-VCE

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Abstract
This report provides a description and an interface to the WP2.3-3 catalogue on GRP antennas and test facilities identified or developed during ACE-1.

Keyword List:
GPR antennas, imaging radar antennas

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1 Introduction

1.1 Background

Ground and (more generally) surface penetrating radar (GPR) has many important applications – Landmine Detection, Buried Utility Detection (pipes, cables) and Breast Tumour Detection being particular examples. These radars use ultra wideband technique and place special demands on the antenna design due to the bandwidth and the soil electrical properties. GPR antennas operate close to or in contact with high dielectric media and often make use of high dielectric loading materials.

In ACE-1, a catalogue of available GPR antenna designs has been created and a joint GPR antenna test facility has set up at the Technical University of Denmark allowing antenna patterns to be measured in soil. A second complementary test facility with dry sand became available to the partners of the Work Package when Delft University of Technology joined ACE. This report summarises the GRP antenna designs and the antenna test facilities with links to the PDF documents of the catalogue. When more capabilities are added to the VCE, the information of this document and the links to the catalogue PDF documents will become available to the members of the ACE Community.

The catalogue will be further developed during ACE-2 with more antenna types and other information including catalogues of dielectric and resistive loading materials, antenna test procedures and test results. The standard situation is likely to be affected by the adoption of European UWB masks and regulations being investigated, e.g. in CEPT ECC TG3, and should take into account the very different operational and technical characteristics of GPRs and other imaging radars compared to communication systems.

1.2 Document Organisation

Section 1: Background

Section 2: GPR Antenna Catalogue

Section 3: GPR Antenna Test Facilities

1.3 Abbreviations

Acronym	**Meaning**
AUT	Antenna Under Test
CEPT	Conférence Européenne des Administrations des Postes et des Télecommunications
CPU	Central Processing Unit
CPW	Coplanar Waveguide
DAA	Detect And Avoid
DED(A)	Dielectric Embedded Dipole (Antenna)
EBG	Electromagnetic Band Gap (structures)
ECC	Electronic Communications Committee
EM	ElectroMagnetic
EMC	ElectroMagnetic Compatibility
EFIE	Electric Field Integral Equation
ESA	European Space Agency
ETSA	Exponentially Tapered Slot Antenna
FDTD	Finite-Difference Time-Domain
FEM	Finite Element Method
FSS	Frequency Selective Surface
GPIB	General Purpose Interface Bus (An IEEE 488 standard parallel interface between instruments and a PC)
GPR	Ground Penetrating (or Probing) Radar
GPS	Global Positioning System
GSM	Groupe Système Mobile
GUI	Graphical User Interface
IE	Integral Equation
IFFT	Inverse Fast Fourier Transform
LAN	Local Area Network
LDC	Low Duty Cycle
LPT	Line Printer
MB	Multiband
MFIE	Magnetic Field Integral Equation
MoM	Method of Moments
NF	Near Field
PC	Personal Computer
PCMCIA	Personal Computer Memory Card International Association
PDA	Personal Digital Assistant
PEC	Patch Excited Cup
PIN diode	Diode with large, neutrally doped intrinsic layer sandwiched between p-type and n-type doped layers
PRF	Pulse Repetition Frequency
PVC	PolyVinyl Chloride (thermoplastic that is a polymer of vinyl chloride)
RAM	Radar Absorbing Material (or Random Access Memory)
RCS	Radar Cross Section
RFC	Radio Frequency Compatibility
RMS	Root Mean Square
ROS	Rapport d’Ondes Stationnaires (French for VSWR)
RX	Receive

SMA	SubMiniature version A (coaxial connector operating from DC to 18 GHz)
S/W	Software
TBD	To Be Defined
TEM	Transverse Electromagnetic
TG3	ECC Task Group on conditions for UWB devices in bands below 10.6 GHz
TX	Transmit
UMTS	Universal Mobile Telecommunication System
UWB	Ultra Wideband
VCE	ACE Virtual Centre of Excellence (www.antennasvce.org)
WB	Wideband
WG	Waveguide
WLAN	Wireless LAN
WPAN	Wireless Personal Area Network
WPR	Wall Penetrating (or Probing) Radar
VSWR	Voltage Standing Wave Ratio

2 GPR Antenna Catalogue

The survey of GRP antennas available to the partners revealed a wide range of antenna designs. The ten antenna designs identified fall in seven classes with bowtie dipoles being the most popular one. Tables list for each class the names of the antenna including the originating institution, the bandwidth (typical corresponding to 10 dB return loss or VSWR less than 2), and some commentary. Links point to PDF documents describing in more detail each antenna design - typically giving antenna definition, principle of operation, intended application, typical performance, publications with more information, pictures and/or drawings, and physical characteristics of antenna. In several cases, the documents cover multiple designs for different frequency bands or requirements. The catalogue covers a wide range of frequency bands (and corresponding wide ranges of antenna size and mass). The partners have agreed to share the design information and make their antennas available to each other.

2.1 Bowtie Antennas

IDS TR600 bowtie antenna	0.36-1.41 GHz	Bowtie dipole with RAM loading
IDS TR1600 bowtie antenna	1.1-2.9 GHz	Bowtie dipole with RAM loading
TU Delft RC loaded bowtie antenna	0.495–5.155 GHz	RC loaded bowtie dipole
Univ. Bristol bowtie antenna	0.8-1.8 GHz	Bowtie dipole with RAM loading

2.2 Corner Reflector Antennas

ICCS/NTUA corner reflector antenna	1.39-1.58 & 4.69-4.97 GHz	Monopole in corner reflector

2.3 Dielectric Embedded Dipole Antennas

TU Delft dielectric embedded dipole antenna		"Butterfly" dipole in dielectric

2.4 Dielectric Wedge Antennas

TU Delft dielectric wedge antenna	0.8-5 GHz	Similar to dielectric loaded TEM horn

2.5 Patch Antennas

ICCS/NTUA E-shaped patch antennas	2.62-2.95 GHz	E-shaped patch with resonators
Univ. Bristol stacked patch antenna	4-9.5 GHz	Breast cancer tumour detection

2.6 TEM Horn Antennas

Univ. Liverpool TEM horn antenna	0.47-14.5 GHz	Dielectric loaded

2.7 Vivaldi and Tapered Slot Antennas

Univ. Nice/CNRS Vivaldi antenna	0.43-8.32 GHz	ETSA_A3 & other antennas reported

3 GRP Antenna Facilities

Most of the radiation patterns presented for the GPR antennas in the previous sections have been measured in free space and not in the ground or the medium where the antenna is intended to radiate. During ACE-1 a joint GPR antenna test facility was set up at Tech. Univ. Denmark to allow the radiation into the ground to be measured under realistic conditions to provide a better characterisation of the antennas in their intended mode of operation. This facility measures the radiation into soil of controlled humidity by means of a buried probe while the antenna under test is moved by a planar scanner. A second test facility became available when Delft University of Technology joined ACE. This second facility complements the joint facility as it uses dry sand, which is more homogeneous and simpler to characterise than soil. Furthermore, tide-domain measurements are available in addition to frequency-domain measurements.

The tables below provide links to PDF documents describing in more detail the two facilities and to joint paper presented in the special ACE session at APS in Washington, D.C., in July 2005. During 2005 a measurement campaign was carried out in the joint facility measuring most of the antennas in the catalogue. The report is under preparation and will be added to the VCE version of the catalogue.

3.1 Description of GPR antenna test facilities

Joint ACE facility at Tech. Univ. Denmark	http://www.asc-consult.dk/ace/WP2.3-3/The_Facility/facility.pdf
Facility at IRCTR Delft Univ. Technology	http://www.asc-consult.dk/ace/WP2.3-3/The_Facility/IRCTR_GPR_Antenna_Test_Facility.pdf

3.2 Paper presented at APS 2005 in Special ACE session

Joint ACE WP2.3-3 presented at APS	http://www.asc-consult.dk/ace/WP2.3-3/The_Facility/ACE_APS05.pdf