The European School of Antennas: The New Model of Distributed PhD School of the Antenna Center of Excellence

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1. Introduction

The European School of Antennas (EsoA) is a new model of a geographically distributed PhD school, which aims to improve the advanced antenna training and research in Europe. The school is organized in the framework of the Antenna Center of Excellence (ACE), a "Network of Excellence" financed by the sixth framework program of the European Union. The school is constituted as a highly qualified integrated set of advanced courses at the PhD level, distributed in the most accredited European research centers on antennas.

The general objectives of the school are: i) strengthening the European excellence on antennas; ii) completing the individual PhD curricula of students in electrical and information engineering by offering interaction with the best trainers in Europe; iii) increasing the link between European universities and industries in antenna research and development; and iv) facilitating the interchange of ideas among early-stage researchers and teachers, thus increasing the future mobility and synergy.

The school is furnished with centralized Web support, and this is coordinated so that the courses have the same format and apply common basic rules for exams and credits.

2. Training Activity on Antennas in Europe

The explosion of research and technology development in the antenna area has not been followed in Europe by an equivalent growth of advanced-level educational activity. Many universities are changing their curricula, in view of delivering new Bachelor-Master degrees at the 2006-2007 horizon, to comply with the new European rules codified by the Bologna declaration. The countries that have already changed their university structure have concentrated their resources on Bachelors and Masters degrees, without adequately restructuring the PhD. Therefore, PhD courses are now often concerned with interdisciplinary subjects, in order to group students of various scientific background to save financial resources. Even though this can broaden the basic knowledge, it also leads to a lack of specialized training. Moreover, we see a reduction of the educational background in the electromagnetic (EM) area, mostly due to the increasing needs of communication and computer science teaching. This imposes a need to recover part of the educational EM background at the PhD stage.

3. The New Model of a Distributed PhD School

The new model of a geographically distributed European School of Antennas (Figure 1) is motivated by the need for a high-level scientific qualification, accompanied by the demand of increased interaction in European research, and by the lack of high-level training offered on antennas. The European School of Antennas is a coordinated and integrated set of PhD courses, distributed in the most accredited research centers on antennas in Europe.

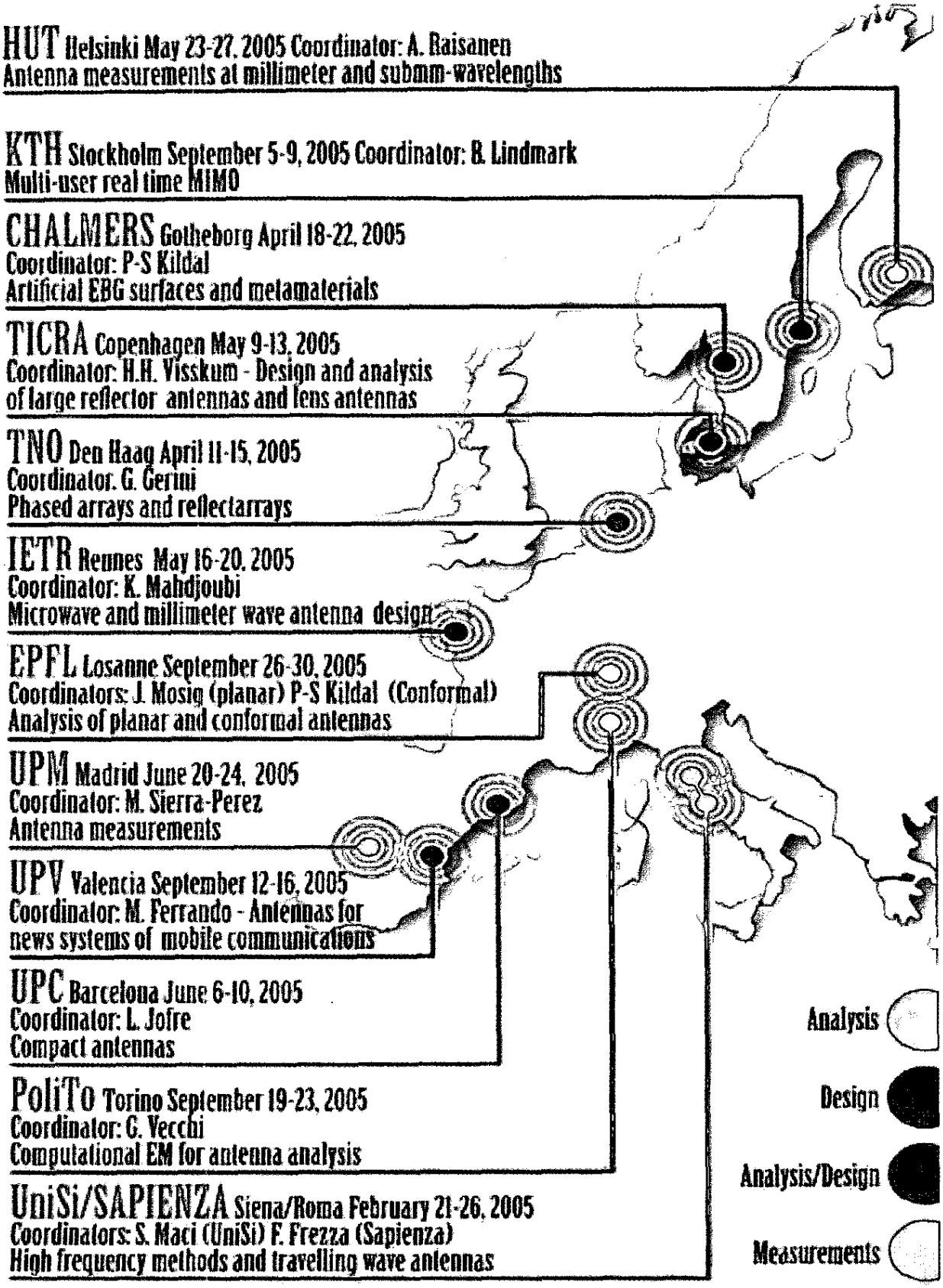
The school was conceived to:

- Cover uniformly antenna theory, analysis, synthesis, design, and measurements, with emphasis on the industrial needs and on the state of the art technological innovations.

- Complete the individual PhD curricula of students in electromagnetics, telecommunication, and electronics by offering interaction with the best teachers in Europe.

- Increase the links between universities and industry on a European scale.

- Identify the best students with the prospect of retaining their talent in industry or in universities different from that of their origin after graduation.


HUT Helsinki May 23-27, 2005 Coordinator: A. Raisanen
Antenna measurements at millimeter and submm-wavelengths
KTH Stockholm September 5-9, 2005 Coordinator: B. Lindmark
Multi-user real time MIMO
CHALMERS Gotheborg April 18-22, 2005
Coordinator: P-S Kildal
Artificial EBG surfaces and metamaterials
TICRA Copenhagen May 9-13, 2005
Coordinator: H.H. Visskum - Design and analysis
of large reflector antennas and lens antennas
TNO Den Haag April 11-15, 2005
Coordinator: G. Gerini
Phased arrays and reflectarrays
IETR Rennes May 16-20, 2005
Coordinator: K. Mahdjoubi
Microwave and millimeter wave antenna design
EPFL Losanne September 26-30, 2005
Coordinators: J. Mosig (planar) P-S Kildal (Conformal)
Analysis of planar and conformal antennas
UPM Madrid June 20-24, 2005
Coordinator: M. Sierra-Perez
Antenna measurements
UPV Valencia September 12-16, 2005
Coordinator: M. Ferrando - Antennas for
news systems of mobile communications
UPC Barcelona June 6-10, 2005
Coordinator: L. Jofre
Compact antennas
PoliTo Torino September 19-23, 2005
Coordinator: G. Vecchi
Computational EM for antenna analysis
UniSi/SAPIENZA Siena/Roma February 21-26, 2005
Coordinators: S. Maci (UniSi) F. Frezza (Sapienza)
High frequency methods and travelling wave antennas
Analysis
Design
Analysis/Design
Measurements

• Facilitate the interchange of ideas among researchers.

The geographically distributed model exhibits some advantages with respect to a conventional PhD school concentrated in one single place. First of all, while the conventional courses are organized by only one professor and a few assistants, a distributed and coordinated structure insures several teachers and specialists for each course. This makes it possible to share a larger number of activities. On the other hand, an excellent research center has specialists on various subjects who participate in more than one course. Other advantages are summarized below:

• A distributed structure intrinsically and naturally facilitates the interaction among teachers, students, and specialists, thus offering a new research potential.

• The distributed organization is rich in laboratories, equipment, and measurement instruments of different types. Correct planning allows the optimal use of the best facilities in Europe.

• The distributed structure offers to the students the possibility not only to participate in some specific courses, but also to spend a period at the host institution after the course, to perform research and to exchange ideas.

• Currently, the recognition of credits achieved by a student outside the home university is complicated and uncertain. The involvement in the school of a large number of teachers of various institutions helps to get such work acknowledged and to achieve a common basis for the amount of credits accredited.

4. Training Objectives and Courses

The European school of Antennas uniformly and exhaustively covers the antenna topics required to complete the individual PhD curricula. The school itself cannot yet be thought of as a self-consistent individual PhD course, but it is an adequate complement to the PhD curricula individually offered by universities in electromagnetics, telecommunications, and electronics. However, it lays the basis for developing a European-wide PhD program, involving both academic and industrial organizations. The 2005 edition of the school has involved a coherent series of eleven courses. Figure 1 summarizes the title, location, period, and coordinators of the events. (Note that the course at EPFL was presently moved to March 2006 for logistic reasons).

4.1 Participants

The hosting institutions are chosen according to their excellence in the subject of the course. The resulting wide geographical area covers eight different countries. The following universities, all belonging to the ACE community, have been involved in organization and teaching:

• Università degli Studi di Siena (UniSi), Italy (S. Maci, European School coordinator)

• Kungliga Tekniska Högskolan (KTH), Sweden (B. Lindmark, ACE training and education activity coordinator)

• Università degli Studi di Firenze, Italy (A. Freni, Virtual Antenna Laboratory coordinator)

• Danmarks Tekniske Universitet (DTU), Denmark

• Helsinki University of Technology (HUT), Finland

• Universite De Marnes La Vallee (LMV), France

• Institut National des Sciences Appliquees de Rennes (IETR), France

• Università degli Studi di Roma "La Sapienza," Italy

• Politecnico di Torino, (PoliTo) Italy

• Universidad Politecnica de Catalunya (UPC), Spain

• Univerisidad Politecnica de Madrid (UPM), Spain

• Univerisidad Politecnica de Valencia, (UPV) Spain

• Chalmers Tekniska Högskola, Sweden

• Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland

The increase in dialogue between industry and universities has been particularly considered by involving several people from industry and nonacademic research centers. The following institutions have participated in both the organization of the school and of specific courses:

• IDS (Italy)

• IMST (Germany)

• TICRA (Denmark)

• TNO (The Netherlands)

Other industrial research centers have contributed with teachers:

• ALCATEL (France)

• Ericsson (Sweden)

• Ericsson Microwaves (Sweden)

• ESA-ESTEC (The Netherlands)

• FOI (Sweden)

• SATIMO (France)

• THALES (France)

As a consequence of this large industrial involvement, a significant part of the special topics are strategic for the future and the competitiveness of the industry.

4.2 Course Format

Each course is given in one week. This format allows the organization of the students' mobility without sacrificing their own research activities, and leaves open the possibility for the students to extend their stay in the host institution for an additional research and/or training period. The typical format of each course consists

of five hours of lectures during the morning, and three or four hours of extra activities during the afternoon. These extra activities are concerned with exercises, reading of key papers on topical subjects, laboratory experiments, panel discussions, and student presentations. The total structure thus consists of 25 hours of lectures and 15-20 hours of extra activities. The lectures have been provided not only by people from the host universities, but mainly from external speakers. Each course, which includes a written assessment test, provides to the students three or four ECTS credits, depending on the additional home assignments.

4.3 Training Objectives

The school is structured around different typologies of courses on the basis of their prevalent content (Figure 1). The typologies are: analysis (A), design (D), and measurements (M). The courses where analysis and design aspects are merged together are labeled as A/D. The following training objectives have been established for each typology:

• Providing a basic background and advanced theoretical knowledge about the analytical and numerical methods for antenna analysis and synthesis, with emphasis on new computational EM modeling (courses of type A, A/D).

• Providing to the student an advanced knowledge of antenna measurement techniques in the range from microwave to sub-millimeter wavelengths (courses of type M).

• Providing design criteria for many typologies of antennas, and clarifying the applications for each type of antenna with the use of software, both available on the market or proprietary to partners (courses of type D and A/D)

The general training objectives are:

• Covering uniformly all the antenna topics, at the same time providing a self consistent framework for each course

• Illustrating the innovation and the state of the art in EM emerging technologies and methodologies to open to the students new research horizons

• Providing the opportunity to the students to take advantage of advanced topics of an international nature of the project, and of the presence of leading scientists, with the possibility of new research contacts

The analysis courses have as their main objective giving to the PhD students advanced concepts on the analytical and numerical methods useful for antenna and scattering analysis. These courses synthesize all the modern computational techniques, based on integral equations (Method of Moments) and on differential equations (Finite-Difference Time-Domain and Finite Element Methods), as well as on high-frequency and hybrid techniques based on asymptotic methods. The basic methodologies are completed by a course about antenna synthesis and optimization, and by two courses concerning measurement techniques at microwave and sub-millimeter-wave frequencies.

The courses of design, besides presenting the more appropriate design methods, illustrate the applications to radio wireless communication, radar, remote sensing, aeronautics and space, transport, security, and de-mining. They cover advanced issues in the classical antenna typologies, such as reflector antennas and feed horns, lens antennas, phased-array antennas, planar and conformal antennas, and traveling-wave antennas. Furthermore, they include emerging antenna technologies as a matter of research. Emphasis has been placed on some topical antenna types, such as multibeam and adaptive antennas, antennas with digital beamforming, EBG and metamaterial antennas, compact antennas, and fractal antennas.

4.4. Web Support

The school is supported by a dedicated Web site [1], which is a special section of the "Virtual Center of Excellence" (VCE) [2], the official Web site of ACE. The relevant items are:

• Centralizing and facilitating as much as possible the online registration of the students

• Organizing publicity and dissemination actions

• Collecting the electronic material to support the school, namely:

  – Electronic forms of the speaker presentations
  – Homework
  – Evaluation forms
  – Notes and reference to textbooks
  – Output of the exams

• Collecting the progress report and final documentation

• Establishing links with other Web centers, like those of COST 284, ESA, NASA, and large industrial research antenna centers

• Updating the list of the grants for the students

• Showing the availability of research positions in the EM research area within Europe.

• Creating and updating the Virtual Antenna Laboratory (VALab), with the purpose of rendering available free-ware educational software, or software developed by the partners (see next subsection).

4.5 Virtual Antenna Laboratory

For high quality in antenna design, the use of numerical simulation tools is of great value, since this provides increased understanding of the physics behind an antenna problem and reduces the need for expensive and bulky antenna measurement equipment. However, different antenna problems typically call for different software. Therefore, a comprehensive antenna education ideally includes the knowledge of different tools that today are developed with little coordination in several places. Since the different software programs are proprietary to the universities or industries that have developed them, sharing them directly is a problem.

The key feature of the VALab [3] is to develop something more than a regular Web site, where the student or/and the researcher can download only static pages, despite the fact that they can move from one to the other using hyperlinks. In the virtual laboratory, all the material that the partners have decided to share with the other participants (notes, slides, design tools,

executable modules, etc.) should be available for the researchers, according to the restrictions that the owners have indicated. Moreover, the idea is to provide to the researcher the possibility of integrating executable modules, already available among the partners, into their own codes.

5. Students and Speakers

The outputs of the evaluation form and the enthusiasm we have seen among of the students confirm the effectiveness of our model. The overall number of students registered in the courses was 240, with an average of 22 students per course. Most of the students have followed one course; some students have followed more than one, up to four courses. Due to the economic facility of the institutions belonging to ACE, about 80% of the students came from the ACE institutions. However, European students external to ACE have had exclusive access to 60 grants offered by ACE (five for each course), to cover entirely their mobility and fee expenses. An average of 50% of the students came from the host country. The data concerned with the number and origin of the trainers are very interesting: we had 99 teachers and assistants). Only 40% of these belonged to the institution hosting the course. This confirms the international character of the school. Tables 1-11 present, in chronological order, essential information on each course; the extended report is presented in [4]. Each table is completed by a photo of the course participants.

Table 1. "High-Frequency Techniques and Traveling-Wave Antennas."

Location and period:	Siena, February 21-23 Rome, February 23-26
Host institutions:	University of Siena, La Sapienza
Coordinators:	S. Maci, F. Frezza
Main trainers:	S. Maci, F. Frezza, P. Pathak, A. Toccafondi, G. Manara, M. Albani, A. Galli,
Total trainers and percentage from the host institution:	15, 80%
Students and percentage from the host country:	34, 91%

Table 2. "Phased Arrays and Reflectarrays."

Location and period:	The Hague, April 11-15, 2005
Host institutions:	TNO
Coordinators:	G. Gerini
Main trainers:	H. Legay, C. Renard, J. Johasson, L. Pettersson, G. Vecchi, G. Gerini, A. Neto, S. Maci, J. Encinar, M. Gillard
Total trainers and percentage from the host institution:	12, 16%
Students and percentage from the host country:	27, 55%

Table 3. "Artificial EBG Surfaces and Metamaterials."

Location and period:	Gothenburg, April 18-22, 2005
Host institutions:	Chalmers
Coordinators:	P.-S. Kildal
Main trainers:	P.-S. Kildal, S. Maci, S. Tretyakov, K. Mahdjoubi
Total trainers and percentage from the host institution:	7, 42%
Students and percentage from the host country:	21, 24%

Table 4. "Design and Analysis of Large Reflector Antennas and Lens Antennas."

Location and period:	Copenhagen, May 9-13, 2005
Host institutions:	TICRA
Coordinators:	H. H. Viskum
Main trainers:	H. H. Viskum, M. Lumholt, S. B. Sorensen
Total trainers and percentage from the host institution:	7, 57%
Students and percentage from the host country:	11, 18%

Table 5. "Microwave and Millimeter-Wave Antenna Design."

Location and period:	Rennes, May 16-20, 2005
Host institutions:	IETR
Coordinators:	K. Mahdjoubi
Main trainers:	K. Mahdjoubi, J.-M. Laheurte, M. Grzeskowiak, M. Himdi, M. Drissi, O. Lafond, R. Sauleau
Total trainers and percentage from the host institution:	11, 81%
Students and percentage from the host country:	13, 54%

Table 6. "Antenna Measurements at Millimeter and Sub-Millimeter Wavelengths."

Location and period:	Helsinki, May 23-27, 2005
Host institutions:	HUT
Coordinators:	A. Räisänen
Main trainers:	A. Räisänen, A. Lehto, J. Ala-Lauronhao, J. Mallat
Total trainers and percentage from the host institution:	8, 100%
Students and percentage from the host country:	14, 79%

Table 7. "Compact Antennas.

Location and period:	Barcelona, June 6-10, 2005
Host institutions:	UPC
Coordinators:	L. Jofre
Main trainers:	L. Jofre, J. M. Rius, A. Skrivervik, D. Manteuffel, W. Simon, S. Blanch
Total trainers and percentage from the host institution:	6, 50%
Students and percentage from the host country:	33, 21%

Table 8. "Antenna Measurements."

Location and period:	Madrid, June 20-24, 2005
Host institutions:	UPM
Coordinators:	M. Sierra
Main trainers:	M. Sierra, O. Breinbjerg, P.-S. Kildal, A. Räisänen, L. Foged, M. Calvo Ramon, L. de Haro Ariet, J. L. Besada Sanmartin, M. Sierra
Total trainers and percentage from the host institution:	10, 60%
Students and percentage from the host country:	24, 50%

Table 9. "MIMO Communication Systems and Antennas."

Location and period:	Stockholm, Sept. 5-9, 2005
Host institutions:	KTH
Coordinators:	B. Lindmark
Main trainers:	B. Lindmark, P. Vainakinen, C. Icheln, P. Suvikunnas, P. Zetterberg, E. Larsson, M. Bengtsson, C. Anton
Total trainers and percentage from the host institution:	12, 50%
Students and percentage from the host country:	19, 58%

Table 10. "Antennas for New Systems of Mobile Communications."

Location and period:	Valencia, Sept. 14-17, 2005
Host institutions:	UPV
Coordinators:	M. Ferrando
Main trainers:	M. Ferrando, A. Valero, L. Jofre, A. Cardama, S. Blanch, M. Sierra Perez, L. de Haro Ariet, M. Sierra-Castaner
Total trainers and percentage from the host institution:	9, 22%
Students and percentage from the host country:	24, 70%

Table 11. "Computational EM for Antenna Analysis."

Location and period:	Torino, Sept. 19-23, 2005
Host institutions:	POLITO
Coordinators:	G. Vecchi
Main trainers:	G. Vecchi, R. Graglia, A. Freni, S. Maci, R. Loison, R. Mittra
Total trainers and percentage from the host institution:	6, 33%
Students and percentage from the host country:	23, 65%

6. Future Development

The European school will also be structured for the years 2006 and 2007. Other universities will join the group for the 2006 editions. These are the University of Karlsruhe (Germany), University of Naples "Feerico II" (Italy), University of Birmingham (United Kingdom), Czech University of Technology (Czech Republic), and University of Zagreb (Croatia).

The topics of the 2006 school will cover those important antenna topics left out in the pilot year, such as ultra-wideband antennas, active antennas, and antenna synthesis. The structure of the 2006 edition will be made available in January, 2006, at http://www.antennasvce.org/.

7. References

1. VCE section of EsoA: htpp://www.antennasvce.org/education/ESoA/view.

2. Virtual Center of Excellence (VCE), official ACE Web site: htpp://www.antennasvce.org.

3. VALab Web site: htpp//valab.det.unifi.it/new/valab.

4. Contract FP6-IST 508009 ACE (Antenna Center of Excellence) "The European School of Antenna" final report, ACE Deliverable 3.1.D3.