Newfocus Research Networking Program

R. Sauleau[1], O. Biro[2], J. Stiens[3], Z. Sipus[4], A.V. Räisänen[5], L.-P. Schmidt[6], C.A. Fernandes[7], J. Mosig[8], V. Fusco[9], S. Maci[10], A. Neto[11], A.I. Nosich[12], A.V. Boriskin[1,12]

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***Abstract*— This paper describes the scope and on-going activities of the ESF Research Networking Program entitled "New frontiers in mm / sub-mm waves integrated dielectric focusing systems" (acronym "NEWFOCUS").**

I. Introduction

At millimetre (mm) and sub-mm waves ($f > 30$GHz), moderate or high-gain radiating structures are key devices to establish point-to-point and point-to-multipoint radio links for far-field and near-field applications. In this frame, quasi-optical technologies, and in particular integrated dielectric focusing systems, are very attractive due to their promising figure of merit in terms of performance and cost.

To promote this rapidly developing research domain, a research and network project entitled "New frontiers in mm / sub-mm waves integrated dielectric focusing systems" (acronym NEWFOCUS) has been recently proposed to and supported by the European Science Foundation (ESF) under the Research Network Program (RNP) scheme. The running period of RNP NEWFOCUS is five years from June 2010 to June 2015.

The major goal of NEWFOCUS is to gather and share expertise and know-how on dielectric focusing systems (and feeds) spread all over Europe in order to strengthen and consolidate education and research in this field. More precisely, the twelve NEWFOCUS partners from Austria, Belgium, Croatia, Finland, France, Germany, Italy, Portugal, Switzerland, The Netherlands, UK, and Ukraine (Fig. 1) will focus their networking activities onto generic integrated dielectric focusing systems and their associated feeds / sensors.

II. Technologies in the Core of the Project

The main antenna technologies covered by NEWFOCUS are highlighted in Fig. 2. This includes any integrated dielectric focusing / collimating system built from arbitrary focusing devices combined with a set of arbitrary primary feeds (emitting mode, antennas) or detectors (receiving mode, integrated electromagnetic sensors):

- The focusing device is usually built from a set of dielectric or metal-dielectric lenses of various shapes and sizes, and made of different constitutive materials,
- The feeds and detectors are 2-D or 3-D, passive or active devices that can be integrated at the "system" base and arranged into arrays, e.g. for the design of reconfigurable, beam forming or beam steering antennas and high-resolution receiving / surveillance / diagnostic / imaging systems.

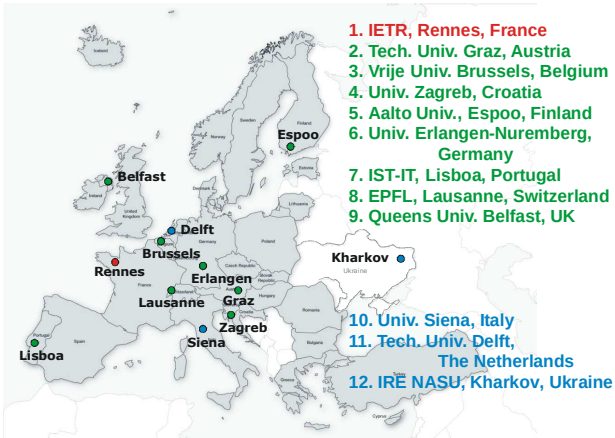

Fig. 1. Institutions involved in NEWFOCUS. The chair and the steering committee (SC) members' affiliations are indicated with red and green marks, respectively. The SC guest members are marked in blue.

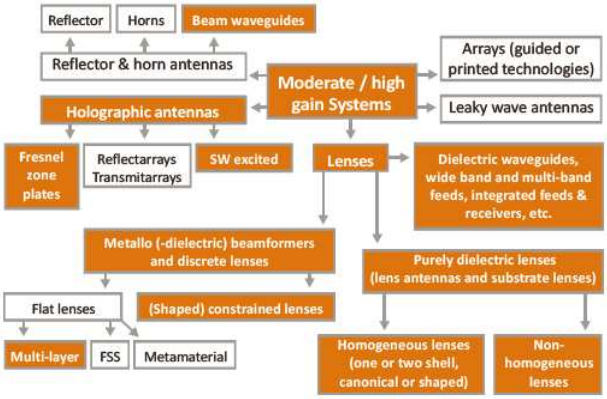

Fig. 2. Technologies covered by NEWFOCUS.

Such systems play important roles in a wide number of applications ranging from microwaves to THz and requiring beam shaping, beam switching, beam steering or multiple-beam capabilities. A non-exhaustive list of applications is given below:

- Broadband high data-rate indoor (smart home, gigabit offices) & outdoor wireless communication systems around 38 GHz and 60 GHz,
- Wireless Personal Area Networks (WPANs) in the 60-GHz band,
- Intelligent Transport Systems (ITS), e.g.:
  – Short range / long range / multi-function automotive radars at 77 GHz and, in the near-future, from 77 GHz

to 81 GHz for ultra wide band (UWB) high-resolution short range radars,
– Road Traffic & Transport Telematics at 63/64 GHz for communications between vehicles, as well as between vehicles and infrastructures,

- Communications with LEO, MEO and GEO satellites in Ku-, Ka- and Q-bands (domestic and professional users, communications with moving platforms like high-speed trains, etc.),
- Communications with high-altitude platforms (HAPs),
- Communications between satellites, aircrafts, and between ground and civil / military aircrafts in Ka band,
- Passive and active imaging / sensing, security and surveillance systems in public areas (airports, stations, etc.) at mm and sub-mm waves,
- Instrumentation (time-domain or frequency-domain spectroscopy, quasi-optical receivers and systems, reference antennas for time-domain measurements, diagnostic procedures, non-destructive testing applications, plasma studies).

III. Current status of research in Europe

The research in Europe in the field of interest of NEWFOCUS is active. Nevertheless, the research effort is spread among many research centres (universities, agencies, etc.). Many research studies are overlapping or duplicated; on the contrary, others are really complementary, and bridges between them must be built for creativity and innovation. On the other hand, due to the wide diversity of existing technologies (Fig. 2), a variety of complementary electromagnetic modelling techniques (modal decompositions, high-frequency and asymptotic methods, integral equations, time-domain approaches, multi-scale and multi-grid methods, etc.) and CAD tools has been developed over the past ten years.

Although there was a number of projects supported by national funding agencies and EU (e.g. under the FP7 program), they only gathered a limited number of partners and did not cover the whole spectrum of expertise and know-how that are required to promote research into the design and synthesis of integrated dielectric focusing systems.

IV. NEWFOCUS objectives

The main objectives are the following:

- Development of advanced electromagnetic modelling techniques using complementary formulations for the analysis, synthesis and optimizations of integrated dielectric focusing systems,
- Implementation of powerful CAD tools,
- Consolidation of research efforts aimed at innovations in the mm and sub-mm technologies with a particular emphasis on integrated dielectric focusing systems,
- Benchmarking measurement facilities at mm and sub-mm waves,
- Promotion of researchers' mobility.

V. NEWFOCUS activities

Several activities are carried out to reinforce research, researchers' mobility, and education in the field of NEWFOCUS, such as organization of scientific meetings, educational courses, and distribution of travel grants for exchange visits between research laboratories. These actions will be undertaken in close collaboration with the European Association on Antennas and Propagation (EurAAP) and the European School of Antennas (ESoA). A few examples of recent NEWFOCUS activities are provided below.

A. Scientific meetings

NEWFOCUS provides support for scientific meetings (conferences, workshops, schools, etc.) on topics within the scope of the Program and with a European or international dimension. A few examples of such meetings are the following:

- Workshop "New frontiers in mm/submm wave antennas" in the frame of International Conference on Applied Electromagnetics and Communications (ICECom-2010), Dubrovnic, Croatia, Sept. 23, 2010. This workshop consisted of 12 oral presentations given by authors from France, Italy, Turkey, Spain, Portugal, the Netherlands and Russia. The list of covered topics included new dielectric materials, novel radiation principles, and innovative UWB and reconfigurable dielectric and discrete lens antennas for mm-wave band applications with particular emphasis on 60 GHz.
- Convened session "Focusing systems, lenses, and reflectors" in the frame of 5th European Conference on Antennas and Propagation (EuCAP-2011), Rome, Italy, April 11-16, 2011. This session will consist of 10 oral presentations given by author from France, Spain, Portugal, Finland, Italy, Australia, USA, and Ukraine. The topics to be discussed design, optimization and fabrication of dielectric and discrete lens antennas as well as multi-element lens/reflector focusing systems for communication and imaging at mm and THz ranges.
- Special Session / workshop "New frontiers in mm/sub-mm waves integrated dielectric focusing systems" during the ESA Workshop on MM-Wave Technology and Applications and the Global Symposium on MM Waves held in the frame of MM-wave Days 2011 (23-25 May 2011, Espoo, Finland). This workshop consists of 8 oral and 1 poster presentations given by authors from Finland, France, Italy, Korea, Netherlands, Portugal, Spain, UK, and Ukraine. The topics covered include design and fabrication of advanced integrated lens antennas for communication and imaging systems.

Proposals for additional scientific meetings are welcome. Priority will be given to meetings taking place in countries that financially support the Program, and the applicants should be established researchers based in a country in which the ESF has a member organization.

B. Educational courses

A post-graduate course on integrated lens antennas and quasi-optical technologies and systems will be organized in the framework of ESoA in 2011. More details will become available soon at [1].

Contributions of NEWFOCUS to other ESoA courses are also planned (imaging systems, THz technologies).

C. Research & Researchers' mobility

NEWFOCUS offers travel grants for exchange visits between research laboratories working in the field of the Program. There are two types of travel grants available to support of researchers' mobility associated with NEWFOCUS:

- Short visit grants of up to 15 days,
- Exchange visit grants from 15 days to 6 months.

The grants are competitively awarded on the basis of the scientific merit of the proposed research projects and their relevance to the Program.

The recently supported projects are the following:

- D.M. Natarov (1-months exchange visit, finished). This is a joint project between IRE, Ukraine and IETR, France. It is entitled "Resonances in the scattering and focusing of waves by periodically structured ensembles of metal and dielectric wires". This is beginning of a complex work into the study of the 2-D wave scattering and focusing by discrete reflectors and lenses made of large collections of periodically structured sub-wavelength-size circular cylindrical scatterers, i.e. wires. Research efforts were concentrated on the analysis and characterization of the "grating resonances" in the linear grids of up to 3200 dielectric and imperfect-metal wires.
- A.V. Boriskin (6-months exchange visit, finished). This is a joint project between IRE, Ukraine and IETR, France entitled "Design of quasi-3D integrated lens antennas". The goal is to develop a synthesis-oriented CAD tool based on the Muller's boundary integral equations combined with the analytical regularization technique and to perform the preliminary synthesis of quasi-3D (shaped planar slab and cross-type) integrated lens antennas. Such antenna configurations promise a number of advantages including light weight and good aperture efficiency.
- M. Bosiljevac (6-months exchange visit, finished). Entitled "New focusing devices based on periodic surfaces", this joint project between Univ. Zagreb, Croatia and Univ. Siena, Italy aims at developing and characterizing new feeding and transmission structures for lens antennas which can simultaneously provide focusing properties. These devices are based on the modulation of the parameters of planar periodic surfaces that allows us to carefully control the path of electromagnetic waves and even focus them in the same manner as it is done with dielectric lenses. A great benefit of this concept lies in the fact that it can be realized on standard planar substrates, making the manufacturing process very simple and low-cost. One potential application of this concept is an H-plane horn housing a Luneburg lens designed using the mentioned principle.
- M.V. Balaban (6-months exchange visit, ongoing). This joint project entitled "The scattering and focusing of electromagnetic waves by a thin dielectric disk" is between IRE, Ukraine and IETR, France. It is aimed at the building of new analytical-numerical method of solving wave scattering by thin material disks. Full-wave consideration involves generalized boundary conditions, dual integral equations in spectral domain, extraction and full inversion of their singular parts, and eventually efficient discretization. The attention is concentrated on the scattering by a single uniform dielectric disk and two stacked disks and associated resonances.
- M. Beruete (2-weeks short visit, ongoing). This is a joint project between Univ. Navarre, Spain and Univ. Lille, France. It is entitled "Terahertz extraordinary transmission antennas".
- V. Bulygin (1-week short visit, scheduled for April). This is a joint project between IRE NASU, Ukraine and University Roma III, Italy entitled "Near field focusing and radar cross section for a finite paraboloidal screen".
- A.I. Nosich (2-weeks short visit, scheduled for April). This is a joint project between IRE NASU, Ukraine and University Roma III, Italy & IETR, France entitled "Mathematical and numerical modelling of dielectric lenses, resonators, and lasers using boundary integral equations".

The NEWFOCUS program will be presented in detail during the conference (objectives, partners, grants, application guidelines, etc.). Recent achievements obtained in the frame of some of the grants mentioned above will be also discussed.

VI. Conclusions

The program is open to everyone. Applications for all the activities are to be submitted online and will be considered on a continuous submission basis. Details of the calls and submission rules are available at the NEWFOCUS website [1].

Acknowledgment

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References

[1] NEWFOCUS homepage: www.esf-newfocus.org.