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RESERCH AND DEVELOPMENT STRATEGY OF CIEAC and LMN FOR THE PERIOD 2005-2010

Motto: *"Think big!"*
Anonymous

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This document is dedicated to:

- Potential research partners
- Potential funding bodies
- Industrial partners itrested to use our researchresults
- Researchers intrested to be involved in our research/training
- Members of our administrative or research team
- Scientists, profesionals, students and administrators from PUB or outside
- General public intrested in development of scence and technology

Note: Until the end of the competition this is a **confidential document**.

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EXECUTIVE SUMMARY

Romania is today in one of the most favourable moments of its history. The access to the European Union opens new opportunities towards a necessary modernisation and a sustainable, well-balanced, long-term development. Of course, this is not an automatic process; it requires coherent efforts of all social categories and groups. Fortunately, these efforts will be fully rewarded, the European project opening perspectives that were unbelievable two decades ago. This effort concerted by the strategies and programmes of European Commission is supported also by **Politehnica University of Bucharest (PUB) - Romania, its CIEAC research Centre (Computer Aided Electrical Engineering) and the Numerical Methods Laboratory (LMN).** For the first time these structures define their medium-term strategy, specifically for the period 2005 - 2010. This was not possible during the "communist era" or during the endless transition period. Now, the opportunities provided by the coherent construction of a structured European Research Area (ERA) and of the European Higher Education Area (EHEA) allow us to define our development strategy in a realistic manner [1-14]. It is an excellent opportunity for us to clarify our mission, to identify and to declare our domain of competence at European level. In this way may we bring our modest contribution to achieve the Lisbon strategic objective of making Europe a knowledge based society. Thus ERA and EHEA are coherently structured and extended toward East.

The first section of the present document is an introductory one, describing the **state-of-the-art** in the domains of LMN competence and in other related areas. It presents the basic principles for the medium-term development strategy as well. The domains analysed are:

- **CSE** - Computational Science and Engineering, an interdisciplinary domain at the intersection of Applied Mathematics, Information Technology and Engineering Sciences.
- **SCEE** - Scientific Computing in Electrical Engineering, branch of CSE associated to Electrical Engineering, and related to the modelling and simulation of electric, electronic and electromagnetic devices and systems.
- **ITRS** - International Technology Roadmap for Semiconductors.
- **HPC** - Impact of High Performance Computing (HPC cluster and grid) to CSE and SCEE.
- Development of **communication based on CMOS technology** and its societal impact.
- **EDA** - Electronic Design Automation, the case of Radio Frequency Integrated Circuits - RFIC.
- Challenging of EDA technology in the **nano-electronics** era
- **Commercial solution** and their limits.
- State of the art in **Electromagnetic Modeling**
- State of the art in **parametric Reduced Order Models**
- **New business EDA model**

Principles of the proposed strategy are related to their **general objectives:** reinforcement of the capacity to provide training, research and innovation, strongly connected to the European industry requirements. Actions and methods to achieve these strategic objectives are identified. The proposed research domain: ***nEDA - nano Electronic Design Automation, based on SCEE and CSE*** has an inter- and multi-disciplinary character. The considered research methods are: theory, simulation and experiment, while the activities comprise: research, training and innovations. A characteristic of the strategy is its inter-sectorial aspect, other two important actors namely the industry and professional associations, being involved together with the academic community. The LMN vision integrates all these domains, activities, methods, and sectors in a coherent entity, which aims the strategic targets defined by the key words: attractivity, competitivity and culture of excellence.

The second section of the document describes **eight European complementary projects**, aiming the implementation of the proposed strategy. Most of these projects are in the first or the second phase of FP6 competition:

- **FP5/IST/CODESTAR** - *Compact modelling of on-chip passive structures at high frequenc.y*
- **FP6/IST/STREP/CHAMELEON RF** - *Comprehensive and Highly Accurate Models for EM Effects of Nano-blocks RFICs.*
- **FP6/HRM-MC/RTN/COMSON** -. *Coupled and Multiscale Simulation and Optimisation in Nanoelectronics.*
- **FP6/HRM-MC/EST/EST3** - *Early Stage Training in an Eastern European Site with Tradition in CSE and SCEE.*
- **FP6/ HRM-MC/TOK-DEV/TOK-4nEDA** - *High Performance Computing Knowledge for nano-Electronic Design Automation.*
- **FP6/ HRM-MC/SCF/SCEE** - *How to start a successful career in the interdisciplinary area of Scientific Computing in Electrical Engineering - SCEE.*
- **FP6/ HRM-MC/TOK-IAP/ETASIP** - *Electromagnetic and Thermal Analysis of Systems in Package.*
- **FP7, CEEX** - *Methods and tools for nano Electronic Design Automation. FP7 proposals.*

Each project has a specific role in research and/or training. Moreover the complex of projects has an added value due to the synergy, mutual amplifying their impacts. The main technical open problems, the innovative techniques and the potential scientific solutions are identified, as well as the original results expected to be obtained during the activity. The **research aims** to the development of adequate mathematical models, numerical schemes and their implementation in a demonstration software platform dedicated to the complex nanoelectronic problems. The platform will allow the coupled simulation of semiconductor devices, interconnects, circuits, electromagnetic field and thermal effects, all in one single conceptual framework. The nEDA platform will also allow the comparison between results of simulation and measurement, in order to validate the new developed methodology, using suitable benchmarks. The outcome of the studies on the platform will be a better methodology for automatic extraction of compact models for functional RFIC nano-blocks, valid up to 60 GHz.

A part of outstanding value of the strategy is the **European partnership**, built by the LMN team with long term efforts. These projects involve leader European semiconductor companies (Philips, ST, Infineon and AMS), three SMEs (MAGWEL-NL, Synapto-I and CST-D), nine universities in Netherlands, Germany, Belgium, Italy and Portugal (three of them belonging to Cluster organisation), and two research institutes in Belgium and Portugal [76-141]. Besides LMN, the consortium comprises also other research groups belonging to less favoured regions: Sicily, Calabria, and the former DDR.

The bunch of projects composing the nEDA strategy agglutinates a **critical mass of resources,** with a total budget of more than **8 600 000 Euro** (over 2 millions for PUB-LMN), which allows the hiring a total of 1466 person-months (746 person-months in PUB-LMN). The total number of full time persons who will carry on the activity within nEDA projects in LMN will be over 20, most of them foreign**. The critical resources of the proposed strategy are the two key persons, funds and the 200 square meter (rooms EB 206, 211 and 212)** necessary to carry out the proposed activities within PUB. The main **benefits** of the projects are:

- set-up in PUB of a **Doctoral School** in SCEE area, connected in a European network;
- **development of human resources** and the capability to provide research, training and innovation, at the highest qualitative level;
- development of **infrastructure** by building a grid dedicated to CSE, SCEE and nEDA, as well as contribution to the competitiveness of the European industry.

The third section of the document is dedicated to the description of the **host capacity** and the justification of its quality. Politehnica University of Bucharest is the biggest technical Romanian university. Numerical Method Laboratory (LMN), which will host the research activity belong to the Electrical Engineering Department. It has a long tradition in international co-operation, running sine 1990 a series of successful research and training projects. The **key persons** of the strategy are Prof. D. Ioan, head of the LMN and director of CIEAC and Assoc. prof. Gabriela Ciuprina, a LMN experienced researcher [15-75]. A series of prominent groups are also involved in the projects. Such groups are: Department of Mathematics headed by de Prof. C. Udriste, BCUM CoLaborator headed by Prof.V. Cristea, EDIL at Electronics Faculty headed by Prof. M. Profirescu, IEM at Department of Bioengineering and Biotechnology headed by Prof. Al. Morega, REROM at Power Faculty, headed by Prof. C. Balan and other groups covering complementary domains. The appointed researchers will have access to the local hardware, software and connectivity resources, as well as to the shared high performance European resources through the grid technology. The experimental works will be carried out abroad, using the most advanced equipment of our European partners.

The project management, presented in section 4 is based on modern principles and best European practice. The project director co-ordinates the project management unit (comprising an assistant manager and a project accountant) and chairs the International Steering Committee. The management structures of the projects have new responsibilities, not encountered hitherto:

- Set-up of the management procedures and appropriate plans;
- Co-ordination and organisation of training activities;
- Co-ordination and organisation of research;
- Researcher and staff recruitment [8];
- Quality assurance;
- Day-to-day management of scientific, technological and administrative activities such as organization of training, travels, meetings, events etc
- Resource management, acquisitions and payments;
- Risk management and contingency measures;
- Independent Financial Audit;
- Progress monitoring and reporting;
- Dissemination and exploitation of the research results;
- Management of Intellectual Property Rights;
- Disputes and corrective actions;
- Communication management, set-up and maintenance of a web site, with both public and private areas;
- Publicity, public image and branding
- Partnership reinforcing and extension.

To fulfil the contract commitments in the best conditions, the management structures will manage the available resources and all funds provided by contracts in an efficient way. The **CIEAC** research centre will carry out the administrative management, while **LMN** will carry out the scientific and technological management. They have competencies in these domains, proven by previous successful international projects. These projects guarantee the feasibility of the new proposals.

The last section describes the **European relevance and added value** of the proposed strategy. It presents the synergetic and structuring aspects, contribution to the European attractiveness and competitively as well as national and regional aspects related to the accessing of Romania to the European Union. The **reference list** with over 170 titles is structured in: European documents, publications of LMN members, publications of our partners and other publications.

SUMAR EXECUTIV

Romania se afla intr-unul din momentele cele mai favorabile ale istoriei ei. Integrarea in Uniunea Europeana ii va deschide caile spre o necesara modernizare si o dezvoltare echilibrata, sustenabila pe termen lung. Bineinteles ca acest proces nu se va petrece in mod automat, ci el presupune eforturii coerente din partea tuturor categoriilor si grupurilor sociale. Din fericire eforturile vor fi rasplatite din plin, proiectul European deschizand perspective de neimaginat in urma cu doua decenii. In acest effort concertat de strategiile si programele Comisiei Europene isi aduce contributia si **Universitatea Politehnica din Bucuresti (UPB), Centrul de Inginerie Asistata de Calculator si Laboratorul sau de Metode Numerice (LMN).** In premiera aceste structuri isi definesc strategia pe termen mediu, si anume pentru perioada 2005-2010. Ocaziile oferite de constructia coerenta a **Ariei Europene de Cercetare** (ERA) si a celei a **Invatamantului Superior** (EHEA) ne permit sa ne definim pozitia si strategia de dezvoltare in mod realist [1-14]. Este o excelenta ocazie sa ne conturam mai clar misunea si sa ne asumam si declaram domeniile de competenta si de excelenta la nivel European. In acest fel aducem modesta noastra contributie la realizarea obiectivului startegic de la Lisabona de transformare a Europei intr-o societate bazata pe cunoastere.

Primul capitol al prezentului document are un caracter intoductiv, fiind dedicat analizei stadiului actual al cunostintelor in domeniile de competatnta ale LMN si cele conexe:

- **CSE** - Stiinta si Ingineria Computationala, domeniu interdisciplinar aflat la intersectia Matematicilor aplicate, Tehnologiei informatiei si a Stiintelor Ingineresti.
- **SCEE** - Stiinta Computationala in Ingineria Electrica, subdomeniu al CSE asociat ingineriei electrice, care se refera la modelarea matematica si simularea cu calculatorul a dispozitivelor si sistemelor electrice, electronce si electromagnetice, precum si la rezolvarea problemelor cuplate.
- **ITRS** - Caile de dezvoltare a tehnologiei electronice a semiconductoarelor in urmatorul deceniu.
- **HPC** - impactul sistemelor de calcul de inalta performanta (cluster si grid) asupra CSE si SCEE.
- Dezvoltarea tehnologiei **comunicatiilor bazata pe tehnologia CMOS** si impactul ei social.
- **EDA** - Proiectarea Electronica Automata, cazul circuitelor integrate de radio frecventa RFIC.
- Provocarile tehnologiei EDA in era **nanoelectronicii** (interconexiuni si cuplarea prin substrat)
- Solutii EDA disponibile **comercial** si limitarile lor.
- Starea cercetarilor in **modelarea electromagnetica** si problemele deschise**.**
- Starea cercetarilor in **reduceea ordinului modelelor parametrizate** si problemele deschise**.**
- **Noul model de afaceri in domeniul EDA.**

Strategia proposa are ca **obiectiv general** dezvoltarea capacitatii si a nivelului de a oferi servicii de caliatate in educatie, cercetare si inovare, ghidata de o legatura stransa cu industria europeana de varf. Sunt identificate caile si metodele de indeplinire a acestui obiectiv startegic. Se evidentiaza caracterul inter- si multi-disciplinar al domeniului de cercetare propus: ***nEDA- Instrumente si Metode de Proiectarea nanoElectronica Automata,*** bazate pe SCEE si CSE. Metodele de cercetare avute in vedere sunt: teoria, simularea cu calculatorul si experimentul, iar activitatile nu se rezuma doar la cercetare ci in mod organic sunt cuprinse si formarea si inovarea la cel mai inalt nivel. Specific strategiei propuse este caracterul sau intersectorial, pe langa comunitatea academica intervenind activ in startegia propusa alti doi importanti actori: industria si aociatiile profesionale. **Viziunea LMN** integreaza aceste domenii, activitati, metode si sectoare intr-un intreg coerent, care urmareste atingerea tintelor strategice definite de conceptele cheie: atractiviate prin diversificarea fondurilor, competitivitate prin restructurare si excelenta impreuna cu partenerii nostri europeni.

Documentul descrie pe scurt in capitolul al doilea cele **opt proiecte europene** complementare, care au ca scop implementrea strategiei propuse (majoritatea aflate in faza I sau II a competitiei europene):

- **FP5/IST/CODESTAR** - Proiect de cercetare dedicat modelarii compacte a componentelor pasive integrate la inalta frecventa.
- **FP6/IST/STREP/CHAMELEON RF** - Proiect de cercetare dedicat modelarii comprehensive si de inalta acuratete a efectelorEM din nano-blocurile RFIC.
- **FP6/HRM-MC/RTN/COMSON** - Retea europeana de cerceatre si formare in domeniul simularilor cuplate multi-scala si optimizarior in nanoelectronica.
- **FP6/HRM-MC/EST/EST3** - Proiect european de cerceatre si formare a tinerilor cercetatori in domeniul CSE cu aplicatie in nanoelectronica.
- **FP6/ HRM-MC/TOK -4nEDA** - Proiect european pentru transferul cunostintelor in domeniul HPC catre echipa de cercetare nEDA din LMN.
- **FP6/ HRM-MC/SCF/SCEE** - Proiect european de formare si sprijin a evenimentelor stiintifice in domeniul SCEE. Conferinta SCEE 2006 va avea loc in Romania, organizata de PUB-CIEAC-LMN.
- **FP6/ HRM-MC/TOK -IAP/ETASIP** - Proiect european pentru transferul cunostintelor in domeniul analizei electromagnetice si termice a SiP, dinspre PUB/LMN catre un IMM italian.
- **CEEX/nEDA** - Proiect de "cercetare pentru excelenta" in domeniul "Instrumente software pentru proiectarea electronica automata a nano-sistemelor" si pregatirea propunerilor de proiecte pentru FP7

Fiecare proiect are un rol specific in cercetare sau educatie, iar in plus sinergia adauga o valoare suplimentara, de exemplu prin folosirea rezultatelor experimentale a le unui proiect in celelalte sau prin imbinarea cercetare-formare doctorala. Documentul identifica principalele probleme tehnice nerezolvate, tehnicle inovative si potentialele solutiile stintifice ale acestor probleme, precum si rezultatele originale astepate. **Cercetarea urmareste** dezvoltarea unor modele matemetice adecvate, scheme numerice si implementarea lor intr-o platforma software de demonstratie, dedicata problemelor complexe de nanoelectronica. Platforma va permite simularea cuplata a dispozitivelor semiconductoare, interconexiunilor, circuitelor, campului electromagnetic, si a efectelor termice, toate intr-un cadru conceptual unitar. Platforma nEDA va permite deasemenea si comparatia intre rezultatele simularii si cele ale masuratiorilor, cu scopul de a valida noile metodologii dezvoltate folosind structuri de test bine alese. Rezultatul studiior pe platforma nEDA va fi o noua metodologie de extragere automata a modelelor compacte ale nano-blocurilor functionale din RFIC, valabile pana la frecvente de 60 GHz.

O valoare deosebita a strategiei propuse o are **parteneriatul European,** pus la punct cu eforturi de lunga durata de colectivul din LMN. In proiecte sunt implicate cele mai mari companii industriale din domeniul nanoelectronicii europene (Philips, ST, Infineon si AMS), trei IMM-uri (MAGWEL-NL, Synapto-I si CST-D), noua universitati din Olanda, Germania, Belgia, Italia si Portugalia (dintre care trei din Cluster), si doua institute de cercetari din Belgia si Portugalia [76-141]. Pe langa LMN, consortiul mai contine si alte grupuri din regiuni europene defavorizate: Sicilia, Calabria si fosta RDG.

Complexul de proiecte ce alcatuiesc strategia nEDA coaguleaza o masa critica de resurse, cu un buget total de peste **8 600 000 Euro** (din care peste 2 milioane pentru PUB-LMN), care permite angajarea a unui total de 1466 persoane-luna (din care 746 in PUB-LMN). Numarul total de persoane ce isi vor desfasura activitatea in LMN va fi de peste 20, din care majoritatea lor doctoranzi din strainatate. **Resursele critice ale strategiei sunt cele doua persoane cheie, suportul financiar si cei 200 metri patrati (salile EB 206, 211 si 212)** necesari desfasurarii activitatii in UPB. **Beneficile** desfasurarii acestor proiecte sunt atat la nivel Eropean cat si la nivel local, ca de exemplu:

- infiintarea in UPB a unei Scoli doctorale in SCEE, conectata intr-o retea europeana,
- dezvoltarea resurselor umane si a capaciatatii de a oferi cercetare inovativa si training de calitate,
- dezvoltarea infrastructurii prin realizarea unui grid dedicat proiectelor in CSE, SCEE, si nEDA.

Al treilea capitol al documentului este dedicat descrierii **capacitatii unitatii** gazada a proiectelor si **justificarea calitatii** sale. Politehnica bucuresteana, persoana juridica gazda este cea mai importanta institutie de invatamant superior tehnic din Romania. Laboratorul de Metode Numerice (LMN) in care se vor desfasura cercetarile apartine Facultatii de Inginerie Electrica si are o competenta recunoscuta.

LMN are o lunga traditie de cooperare internationala in proiecte de succes, atat pentru educatie cat si cercetare demarate inca din 1990. **Personele cheie** ale strategiei sunt Prof. D. Ioan, seful LMN si Conf. Gabriela Ciuprina, ambii cu o deosebita experienta [15-75]. In proiectele de formare sunt implicate pe langa LMN si alte grupuri de cercetare din UPB cu rezultate stiintifice remarcabile, si anume: Departamentul de Matematica condus de Prof. C. Udriste, BCUM CoLaborator condus de Prof. V. Cristea din Catedra de Calculatoare a Facultatii de Automatica, EDIL din Facultatea de Electronica condus de Prof. M. Profirescu, IEM din Departamentul de Bioinginerie si Biotehnologii condus de Prof. Al. Morega, REROM din Facultatea de Energetica, grup condus de Prof. C. Balan dar si alte echipe care acopera domenii complementare. Cercetatorii angajati si doctoranzii vor avea acces la o serie de resurse hardware, software si de conectivitate din UPB dar si la resurse europene de foarte inalta performanta prin intermediul tehnologiei grid. Masuratorile vor fi efectuate in strainatate pe echipamente de varf.

Managementul proiectelor prezentat in capitolul 4 este bazat pe principii moderne si pe cea mai buna practica din proiectele europene. Directorul de proiect conduce atat echipa mangeriala alcatuiata din asistent si contabil, cat si Comtetul international de monitorizare. Structurile manageriale ale proiectelor au o serie de **responsabilitati** de mare importanta, neuzuale pina in prezent:

- Elaborarea procedurilor manageriale si a planurilor de coordonare;
- Coordonarea si organizarea activitatilor didactice;
- Coordonarea si organizarea activitatilor de cercetare;
- Selectia si angajarea personalului [8];
- Asigurarea calitatii;
- Conducerea activitatii scientifice, tehnice, adminstrative, cum sunt: oganizarea eficienta a deplasarilor, cursurilor, intrunir, evenimente, etc
- Managementul resurselor, achizitiilor si platilor;
- Managementul riscului si incidentelor;
- Audit financiar independent;
- Monitorizarea progreselor si raportarea lor;
- Diseminarea si exploatarea rezultatelor cercetarii;
- Managementul proprietatii intelectuale;
- Rezolvarea disputelor si masuri corective;
- Managementul comunicarii, realizarea unui site web dedicat cu o parte publica si una privata;
- Publicitate, imagine, relatii publice, branding;
- Intarirea si extinerea parteneriatului.

Pentru a indeplini clauzele de contract in cele mai in bune conditii, structurile manageriale ale proiectelor au responsabilitatea de a gestiona integral bugetele proiecteleor puse la dispozitie de finantator. Centrul de cercetari CIEAC, care asigura managementul administartiv si LMN, care asigura managenmentul stiintific si tehnologic au competente dovedite in domeniile lor de responsabilitate prin mai multe proiecte anterioare de succes. Acestea garanteaza fezabilitatea noilor propuneri.

Ultimul capitol descrie **importanta proiectelor din perspectiva europeana**: sinergia si coerenta la nivel european, contributia la atractivitate si competitivitatea europene, dar si aspecte nationale si regionale, ca integrarea Romaniei in Uniunea Europeana. **Lista bibliografica** are peste 170 de titluri, structurate in: documente ale Comisiei Europene, lucrari LMN, ale partenerilor si alte publicatii.

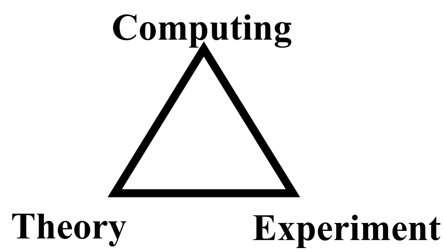
1. LMN VISION FOR 2010

1.1. STATE OF THE ART

Computational Science and Engineering - CSE

The understanding of phenomena and processes in science and engineering is no longer based on theory and experiment, but more and more on computations, as well. Mathematical models and numerical simulations supplement experiments, and sometimes even allow the studying of technical systems and natural phenomena that would be too time-consuming, expensive, or even dangerous to be studied only by experiment. The fast development of hardware and software has significantly increased the importance of computation in the scientific and engineering community, and numerical simulation is nowadays regarded as a third paradigm in combination with theory and experiment.

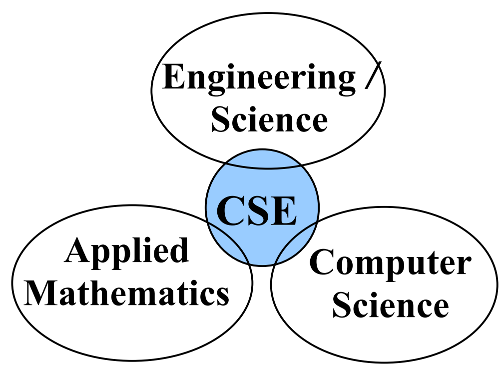
The explosive development of hardware and software (e.g. multiprocessing) has significantly increased the importance of computation in knowledge based economy. By means of computer simulation and optimisation of mathematical models, the time of design and development of new products and processes can be substantially reduced. Today, only products designed this way are **competitive on the global market.**



The increasing request for higher levels of detail, accuracy and realism in simulations requires higher and higher computational resources, advanced programming skills and sophisticated models and algorithms. Due to progresses in each of these fields, computational scientists and engineers can now approach large-scale problems that once were thought to be insoluble.

Computational Science and Engineering (CSE) is by definition a broad **inter-disciplinary** field based on applied mathematics, computer science and scientific or engineering applications. Details about CSE may be found on the web site of Society of Industrial and Applied Mathematics - SIAM Working Group on CSE Education http://www.siam.org/cse, or on the paper in *Graduate Education in CSE* published by SIAM Review 2001, No 1. Although it includes elements of applied mathematics, computer science, and engineering, however CSE is focused on the integration of knowledge and methodologies from all these disciplines, but it is a subject in itself, distinct from any of the former. CSE focuses on the development of problem-solving methodologies and powerful and robust tools for numerical simulation.

The importance of CSE in academic and industrial research is growing rapidly. We believe (as SIAM Working Group on CSE Education equally does) that CSE will play an important, if not a leading, dominant role in the future scientific discovery and engineering design. The successful way from application area problems to useful computational results requires domain expertise, as well as skills in mathematical modelling, numerical analysis, efficient algorithms, software design and implementation, validation and visualisation of results. CSE involves all these aspects and therefore, education is required and necessary in order to meet these demands. Many of the major Computer Science or Engineering departments, including, for example, Caltech, Rice University and Stanford University, ETH Zurich, Eindhoven University of Technology, KTH Stockholm, HUT, Oxford and Manchester Universities **host very successful postgraduate programmes in CSE.**



Scientific Computing in Electrical Engineering - SCEE

An important branch of CSE is Computational Science in Electrical Engineering (also known as SCEE – Scientific Computing in Electrical Engineering). Traditionally, the two theoretical pillars of electrical engineering are EM (electromagnetic field theory) and CAS (circuit and system theory). However some issues are still open, such as effective analysis of coupled field-circuit systems. Advanced and timely topics of SCEE include also:

Computational Electromagnetics (CE)
- Modelling and parameter extraction
- Discretization and Solution Methods (FDTD, FIT, FEM, BEM, FDS, TLM, PEEC)
- Applications (Antennas, Microwave, Interconnects and on-chip passive structures)

Circuit Simulation and Design (CS)
- Reduced Order Modelling
- Fast Simulation
- TCAD/EDA tools and techniques
- Applications (RF, Nano-electronics)

Coupled Problems (CP)
- Field-circuit coupled problems
- Multi-physics (Substrate coupling, electrical, thermal and mechanical coupling)
- Application (Co-Simulation, Electromagnetic Compatibility, Bio-engineering)

Mathematical and Computational Methods (CM)
- Inverse Problems
- Optimization
- Multi-Scale and Multi-Resolution Schemes
- Solutions methods for large linear systems
- Differential-Algebraic Equations (DAEs)
- Parallel and Grid Computing

The state-of-the-art in the SCEE area is described in detail by monographic books [76] and periodicals such as Compel, SIAM, IEEE Trans.on MAG, CAD-VLSI and others encountered in the Reference list. Overview presentations in conferences dedicated to this particular domain, such as Compumag, IEEE CEFC, PIERS, and ISEF. A series of conferences and events were dedicated ti this domain:

- First SCEE workshops held in Darmstadt (1997) and Berlin (1998), both under the auspices of the DMV (Deutscher Mathematiker Verein), as national German meetings;
- The international SCEE workshop organized in 2000, at Warnemunde, by the University of Rostock, Germany (***http://www.scee-2000.uni-rostock.de/***);
- The 4th SCEE conference jointly organized in 2004 by the Eindhoven University of Technology (TU/e) and Philips Research Laboratories Eindhoven - Netherlands (***http://www.win.tue.nl/scee2002/***);
- The SCEE 2004 event held in Capo D'Orlando, Italy, organized by Universita di Catania (***http://www.dmi.unict.it/scee2004/);***
- The summer schools organized by the Catania University, jointly with the Fraunhofer Institut for Techno-Wirtschaft Mathematik, Kaiserslautern will be held in Capo d'Orlando, in September 2005 (***http://www.dmi.unict.it/sceeschools***).
- Politehnica University of Bucharest - CIEAC Research centre will organise in Romania the next SCEE event in 2006 (***http://www.scee06.org***).

Nanoelectronics is a typical example of a key technology, application of SCEE, which can not be imagined without the use of intensive computations. Performing the step from micro- to nano-electronics, the semiconductor industry is confronted with very high levels of integration introducing coupling effects that were not encountered before. The electromagnetic coupling is accentuated in the frequency range beyond 10 GHz. The complexity of modelling and optimization problems for such devices is beyond the possibilities of the design software currently used in industry. The above subject requires knowledge from a **broad range of disciplines** from mathematics, physics, electronics, material and computational science. The strategic importance of nanoelectronics for next decades is presented in "Vision2020: Nanoelectronics"[9].

International Technology Roadmap for Semiconductor - ITRS

The state-of-the-art and the trends until 2018 of nanoelectronics is presented in the *International Technology Roadmap for Semiconductor* (*ITRS - Modeling and Simulation*, 2003, www.itrs.org).

Besides other areas, Technology CAD (TCAD) covers modeling of: interconnect and integrated package, passive and active element of circuit, materials as well as numerical methods - algorithms needed to implement the models, including grid generators, (parallel) solvers for (partial) differential equations, and optimization routines. According ITRS, "the development of new modeling capability requires long-term research, and increasingly interdisciplinary activities, which can be carried out best in an academic or a laboratory settings. For this reasons, a vigorous research effort at universities and independent research institutes is a pre-request for success in the modeling area, together with a close cooperation with industry, along the simulation food chain mentioned above".

The list of difficult challenges for 2010 and beyond comprise:

- High frequency Circuit Modeling for 5-40GHz applications (with harmonics up to 120GHz).
- Thermal-mechanical-electrical Modeling for Interconnection and Packaging.
- Nano-scale and opto-electronics modeling.
- Efficient extraction and simulation of full chip delay.
- Accurate and yet efficient 3D interconnect lines and integrated passives..

Interconnects play an increasingly important role as a limiting factor for staying in pace with Moore's low to double the maxim clock frequency every 1.5 years. A series of physical effects are responsible for the limitation of the maximum allowed frequency. Besides aspects considered already at larger feature size, such as resistance, capacitance and inductance, there are "high frequency effects": skin effect, proximity effect, current crowding at corners, and substrate induced losses. Accurate modeling of high frequency electromagnetic properties like inductive coupling is key. The ability to predict the electrical and parasitic properties of complex interconnect structures continues to be a challenge.

Of high priority are the coupled thermal and mechanical performance properties of thin multi-layer films. The change to low-k dielectrics with low thermal conductivity has placed more emphasis on combined electrical and thermal modeling.

Numerical methods and algorithms need improvement to support the growing complexity of physical phenomena to be addressed by TCAD. Meshing, although always important for the efficient and accurate solution of differential equations, has became a major issue because device architectures are now essentially three-dimensional. The linear solvers are often the bottleneck in the computation. Many millions of algebraic equations need to be solved simultaneous by a two-fold iterative scheme. The outer nonlinear loop may be improved by intelligent forward guessing strategies, while inner loop may be improved considerably by re-ordering strategies, optimal pre-conditioning, and partitioning of the equation set. Research is also needed on developing robust and efficient parameter extraction algorithm. Simulators loose their practical values without a well-calibrated parameter set. Some algorithms, such as GA- genetic algorithms may be good candidates, but if a remarkable improvement of their efficiency is realized. Other trends are presented in 171.

ITRS identifies following requirements for the Modeling and Simulation Technology up to 2010:

- Delay accuracy: 5% of maximum chip frequency,
- Accuracy of the temperature distribution 1-5C,
- Linear solvers: 800 000 equations/minute.

High Performance Computing (HPC) solutions for CSE, SCEE and EDA

ITRS identifies parallel computations in modelling and simulation an important and timely research area, the key of further developments in the nanoelectronics.

The evolution in the *TOP500* list of the fastest computers shows that supercomputers trend to be replaced with distributed systems, because today "the computer is the network". This is why EC financed within FP6-IST a series of European projects and centres around the concept *"eInfrastructure: a fundamental building block of the ERA",* aiming to promote the shared European research infrastructures, Grid computing, and collaborative working, such as *I3, GEANT,* and *GRIDS.*

According to [169], a grid is a standard-based computing architecture able to share computing and storage resources on heterogeneous systems and applications in a transparent manner. There are three types of grid deployments: departmental, inter-departmental, and -enterprise. The usual grids are: compute grids, data grids, and collaborative grids. The most important grid standards organizations are: The Global Grid Forum (GGF) and The Organization for Advancement of Structured Information Standards (OASIS). The grid allows the access to Virtualized Resources (LAN, WAN, Grid connections - distributed computing environments) through web services (program-to-program) and data sharing (XML), when additional resources are needed. Grid software can automatically to acquire these additional resources. Common infrastructure has been developed (.NET and J2EE). The elements used to build a grid solution are structured in layers: application, grid middleware (web services and other program-to-program software), data management, operating environment and system/network hardware. Nowadays, there are three methods to build a grid:

- Acquiring grid freeware, shareware, toolkits, or point products and build their own grids (as GT3, gSOAP, www.grids-center.org, and www.SourceForge.net).
- Purchase integrated grid toolkits, midddleware software environments from third party ISVs, such as AVAKI, Data Synapse, Platform, or United Devices;
- Purchase complete turnkey grid solutions from an OEM or a system integrator, such as Dell, Hewlett-Packard or IBM.

. The grid technology has as main advantages a more easily collaboration with internal and external organizations and reducing complexity and cost of system/storage/network management. Electronic Design Automation - EDA is one of the industries which benefits from this advance (see partnership of Platform Computing).

The general conclusions describing the present state are [168-170]:

- Multiprocessing, connectivity and tera-size (teraflops, terabit/s, terabytes storage) are now the key words in IT. Performances of hardware platforms continue to rise, but supercomputers trend to be replaced by distributed systems.
- Grid represent a huge advance in a new computing era, by overcoming the obstacle such as operating systems, infrastructure or database incompatibilities encountered in hybrid networks (Proc. of IEEE, no 3, 2005, special issue on Grid computing).
- Mathematical modelling and computer simulation carried out especially by parallel computation are important, timely research areas, the key of further developments in the nanoelectronics.
- Increasing parallelization demanded new programming models, methods, tools, environments, and libraries, such as HPC-Netlib, PETSc, MPI, OpenMP etc.

The increased sophistication of physical and mathematical modeling tools combined with the never ending advances in computer technology and information sciences made possible unprecedented simulation capability, with a great industrial impact.

Emerging Communication Technologies

Wireless multimedia streaming, such as 3D graphics, video, audio on hand-held, mobile or other battery operated devices will be a major technology underlying the next generation of information and entertainment appliances. From watching small video clips on your mobile device to playing live games with other people or looking at the latest news bulletin on your Palmtop as you wait for your plane or bus to arrive, the possible user applications are almost limitless. Our own home is slowly but steadily becoming a networked environment, in which devices can talk to each other in either a wireless or wired manner, and when we are on the move, so-called hot-spots will give us the possibility to retrieve the content we want wherever we are: anywhere, anytime, any device.

The workhorses for these applications are RF devices. Ever since the emergence of AM radio (one of the very first examples of electronics in the home), the range of RF applications has steadily increased and, especially in recent years with the development of the mobile telephone, the number of consumers

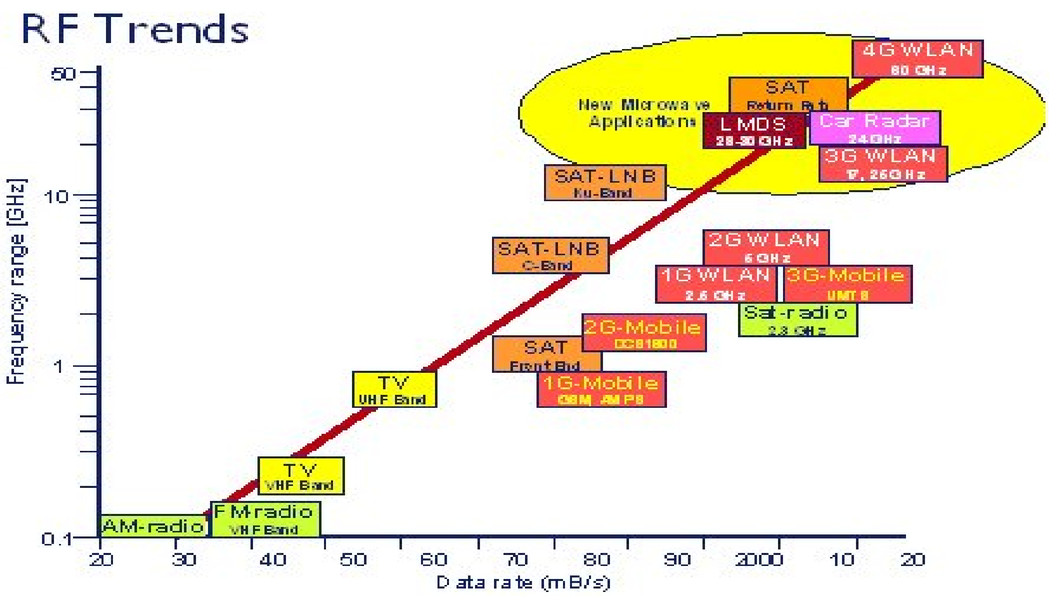


Fig. 1. RF consumer applications [http://www.research.philips/technologies/]

using RF devices has exploded. The estimated number of mobile handsets in use worldwide in the year 2005 is 700 million, whereas the number of wireless local area (computer) networks installed worldwide in 2005 is estimated to be over 80 million.

The RF CMOS and SiGe BiCMOS technologies are placed at the leading edge of present explosive extension of telecom marketplace. Both wireless and wired application areas of telecom require the use of state-of-the-art RF/mixed-signals process technologies and advanced design automation environments. Examples of applications in the wireless area include cellular telephone radios with protocols such as GSM (Global System for Mobile Communication) and WCDMA (Wideband-Code Division Multiple Access), location systems such as GPS (Global Positioning Satellite System), and wireless connectivity applications such as Bluetooth (2.4 GHz low power connectivity standard) and 802.11x (IEEE wireless LAN standards). Examples of the wired applications are synchronous data transmission over optical networks using various protocols such as SONET (synchronous optical network transmission standard) SDH (synchronous digital hierarchy).

A major trend in RF consumer applications is that of ever increasing data rate. Exploiting more bandwidth has the attractive property that the channel capacity rises in direct proportion with frequency. The increased level of congestion at relative low frequencies is the driver force that will push RF consumer applications into frequency band beyond 6 GHz (Fig 1). Another reason for this frequency shifting is the tight data rates required in application such as video streaming. Emerging high frequency RF applications include direct TV distribution via satellite in the 10,7 to 12.75 GHz (Ka-band) and 19.7 to 20 GHz (Ku-band), high speed internet services utilizing return channels in the 29.5 to 30 GHz region, as well as proposed WMAN (Wireless Metropolitan Area Networks) operating at frequencies up to 39 GHz. And motor-vehicle proximity sensing, currently at 24 GHz but soon to be moving to 77 GHz to avoid clashing with an important radio astronomy band.

Today, most of microwave solutions use discrete GaAs building blocks which is neither a low-cost nor a high volume process technology. Semiconductor companies targeting high-volume consumer application are therefore seeking silicon solutions manufactured ether in BiCMOS or in emerging RF CMOS technologies. It is likely that BiCMOS solutions will continue to dominate high-end applications, while RF-CMOS will gain its first foothold in applications where RF performance is less critical. These offer significant cost and size reduction compared with GaAs (fig.2).

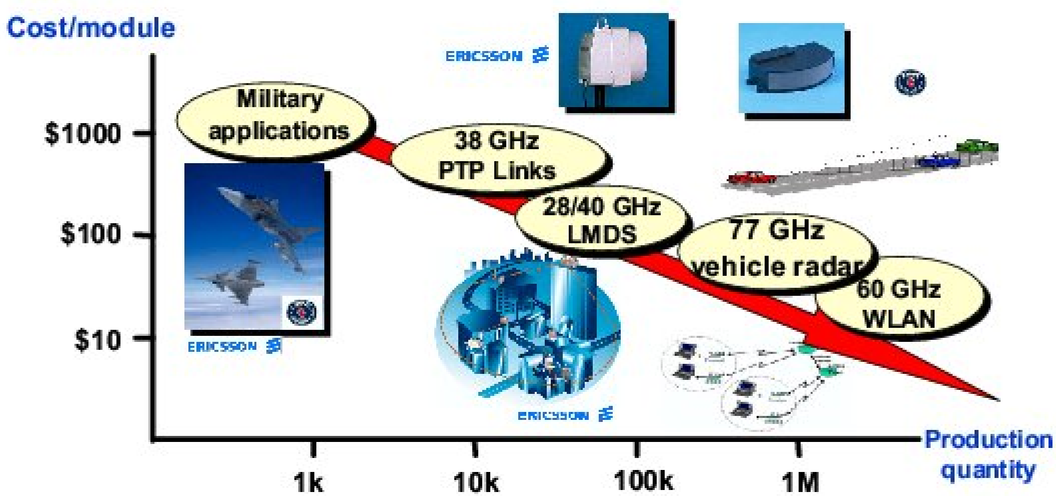


Fig. 2. Cost per RF IC vs production quantity [www.imec.be/impact]

A considerable amount of research is therefore currently carried out or planned to develop silicon-based solutions for emerging microwave applications. The exciting challenge to convert microwave designs based on discrete components into low-cost solutions on silicon is currently addressed by research directed along three axes (http://www.research.philips/technologies/ics/rf_icd/):

- *Frequency axis* from 5 up to 77 GHz to support higher bandwidth and data rates;
- *Technology axis* - stretching the limits of silicon based processes (both RF-CMOS and BiCMOS, including characterization and optimization of RF performances of the very-high-frequency transistor that can be produced in a 65-nm CMOS process), together with the exploitation of new passive components such as BAW and MEMS devices;
- *Architectural axis* - focusing on increasing digitization, low-voltage operation and re-use of RF circuits.

Design of RF IC

The state of the art in the design methodology of Radio Frequency Integrated Circuits (RFIC) is shortly presented below, briefing the perspective of the review papers [142] and [143].

Since the release of the first RF design kit for the (semi)custom circuit design (e.g. Cadence based BiCMOS kit of IBM) in the early of nineties, its components, such as: model libraries, symbol libraries, model/layout call-back tool, application extension language (SKILL in the Cadence case), parameterized cells for layout, layout versus schematic (LVS) checking, design-rule checking (DRC), parasitic extraction and custom graphic user interface were permanently developed and improved. This required the development of new methodologies and the work continues not only within the large semiconductor companies, manufacturers or major EDA software providers, but with an important scientific and technical contributions of SMEs, researchers from several institutes, and scientists from universities. The present days design frameworks allows the modularity and integration of different vendor tools, if they comply the EDA standards [144].

Two key components are necessary to successfully enable a silicon chip design: the silicon process technology described in a dedicated data base (allowing the device modeling) and the design automation environment (containing CAD tools, integrated in a design framework, allowing physical verification and simulation). As integrated circuit design becomes more complex, driven by shrinking technology from micro-scale toward nano-scale, and application frequencies continue to rise, these components must be highly integrated together, in order to get the success of the final product.

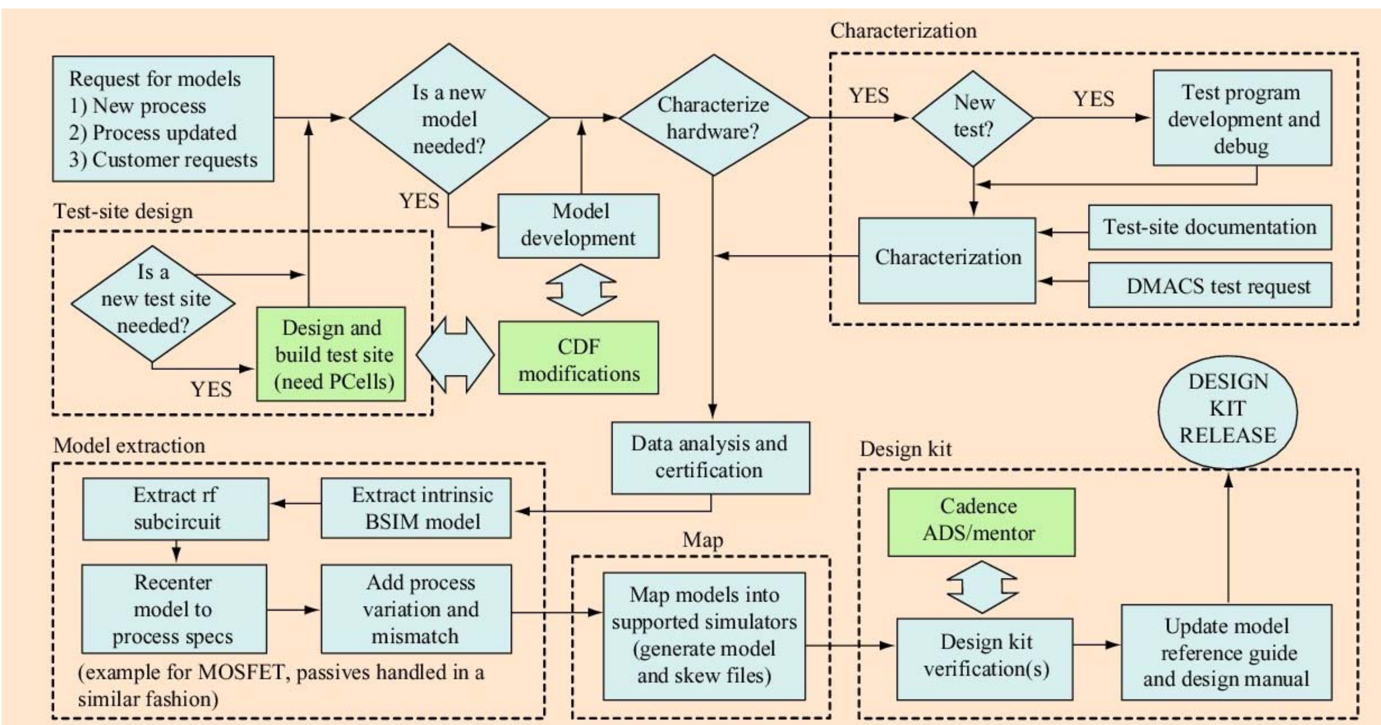


Fig. 3. Compact model development process at IBM [142]

These research and development effort was structured in four major directions:

- *Predictive modeling of semiconductor devices*, covering Technology CAD (TCAD), process simulation and semiconductor device simulation. The state of the art in this area is presented in [142].

- *Characterization* (view as an important step in the development of the device compact modes) consisting of on-wafer test structure measurements, such as DC, capacitance-voltage, AC S-parameters, large-signal and distortion noise characterization. The RF noise (both 1/f and thermal noise) in 180nm CMOS technology has been measured and modeled within the FP5/IST/IMPACT project [145].

- *Compact modeling* consisting in the development of a mathematical model as simple as possible (in order to maximize simulation efficiency), but enough accurate to predict the electrical behavior of the device as a function of the condition and constrains applied to it, including temperature or bias. The model extraction is based on the first-principle or on the measured data. Different methodologies are applied to build compact models for active (MOSFET, npn) or passive (inductors, varactor, resistor) components. The primary goal of compact model development effort is to provide hardware-validated, physics-based, scalable models that are fully integrated into the design kit. That means the direct parameter extraction must be employed rather then empirical or numerical optimization, whenever possible. It is important to make use of process information, such as vertical profile of doping concentrations. The extracted compact models should support parameter variability analysis (statistical analysis - Monte Carlo, process corner and wafer-specific simulation). Fig 3 shows the overall flow of steps used by IBM, for the compact model development process. The compact models of passive on-chip structures at high frequency vas the subject of the FP5/IST/CODESTAR project [147].

- *Design automation* consisting in development of tools to be integrated in design environments, aiming to allow an effective design flow. A typical RF design flow (fig. 4) starts from the design specification and continues with the successive use of following tool categories:
  - **schematic entry tools** (symbolic representation of active and passive components, connected by ideal wires),
  - **simulation tools** (time-domain, mixed-signal, and Harmonic Balance - RF/HB frequency-domain simulators, such as Spectre

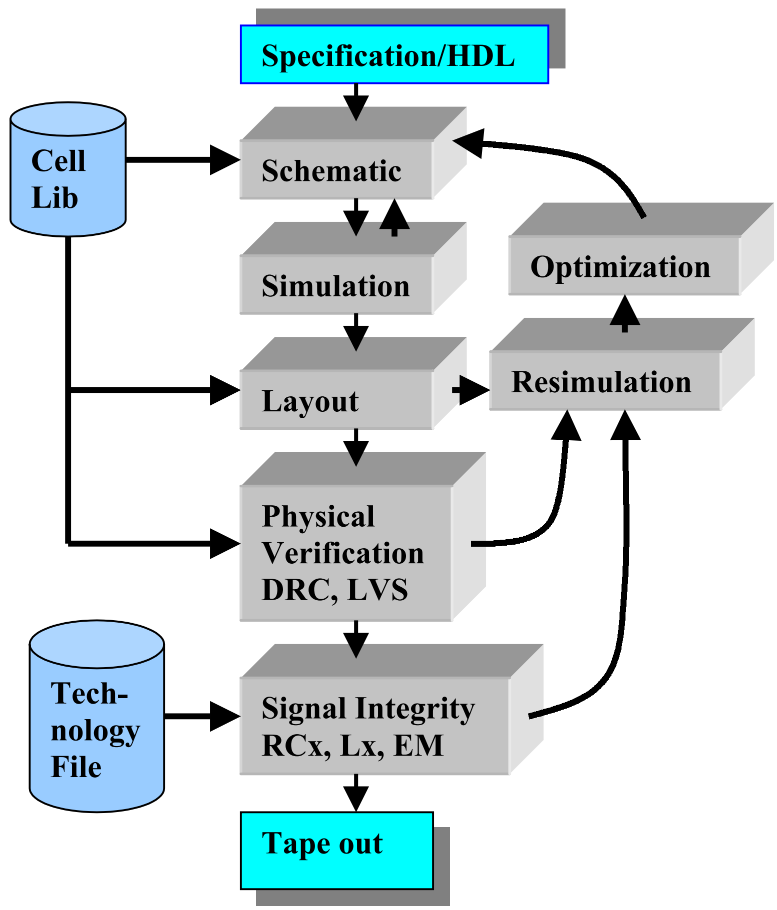


Fig.4. A typical RF IC design flow

- the main simulator used by RFIC designers, and HSPICE - considered as the "gold standard" for transient "anvelope" analysis or PLL design),
- **layout design** (using library of parameterized cells/primitives, e.g. BJT, MOSFET, resistors, inductors, diodes, and transmission lines with device options, such as: ground planes, trenches, and guard rings combined with schematic-driven layout tools for manual or auto-wiring connection of cells/primitives, and design of guard rings for noise isolation and latchup protection, with manual or automatic procedures written in the interpretative framework language),
- **physical verification** (tools for DRC and LVS, which process the layout with device-recognition and parameter extraction routines that should tolerate parametric design style, moreover present complexity requires higher-performance tools which accept "hierarchical" approach) plus **re-simulation**,
- **signal integrity** (tools for parasitic extraction which should cover the key areas of concern of any RF IC designer: interconnect delay, substrate noise coupling and interaction with package/PCB) plus **re-simulation**,
- after each stage the designer reiterates with previous ones (using tools for **back-annotation** of parasitic to schematic view), until the design requirements are reached (eventually in an automatic way as it is the present trend, driven by **optimization** tools, which justify the "automation" attribute from EDA).

An extremely important RF design activity is the post-layout verification step. At the recently held DATE 2005 conference, the largest and most comprehensive European conference in the fields of Design, Automation and Test of electronic circuits, this was voted the most important challenge for the next generations of ICs. It entails the accurate prediction of the behavior of the chip after each design iteration, but before actual production. Within the verification process, physical design issues related to parasitic couplings, handling of variability and design robustness are among the most prominent. The findings of the verification steps are used to improve the design, so that the first silicon implementation can be fully functional. This is absolutely necessary; the alternative of trying to correct a design through trial and error of silicon implementation is far too costly and far too slow in view of the economics of decreased time to market. Therefore, it is crucial to have a state-of-the-art system for the design verification of future RFICs up to 60GHz. Unfortunately such a design-verification system does not exist at present. Only partial solutions to the problem are available, and require a significant amount of non-design work from the designers. Clearly, this is not an acceptable situation [private communication with researchers from Philips].

Electronic Design Automation - EDA technology and their challenges in nano-era

Performing the step from micro- to nanoelectronics, the semiconductor industry is confronted with very high levels of integration introducing coupling effects that were not observed before. The complexity of this problem is beyond the possibilities of the software and design environments used within the microelectronics industry at present. Furthermore, it places additional requirements on the researchers of the future, since they must be able to understand all aspects of the problems faced by the industry. The design of complex integrated circuits requires adequate optimization and simulation methods. The current design approach involves optimizations and simulations in different physical and electrical engineering domains (electric, electromagnetic, electronic, thermal, system, circuit, device). To limit the complexity of the design task, in a kind of 'divide and conquer' approach, these domains are currently treated in isolation, and dedicated simulation and optimization programs have been developed for the individual domains. However, this design approach is nearing the limits of its validity. The design and fabrication of modern integrated circuits requires that the different domains are treated in their mutual dependencies as well. Performing the step from micro- to nano-electronics, high levels of integration of the different physical effects are needed.

Unlike digital design, nowadays RF/analog or RF/mixed signals digital-analog chips have typically required several fabrication iteration, resulting longer design schedules and slower time to market. The overall goal is to decrease the time and cost to market, reducing or eliminating intermediate trial chips and design iterations, through the use of optimal tools and design methodologies. Early detection of an error or a design weakness significantly reduces design cycle time. Complexity and diversity of EDA tools explain why the innovation and advances in this domain can be made only by interdisciplinary, highly qualified research teams, spread all over Europe, and considering the state of the art at word-wide level.

An effective RF design kit integrates in the design framework a coherent database of hardware-characterized and modeled cells and device primitives. For each component are stored data for schematic representation, terminals, geometric and electric parameter definitions, and procedure to create netlist entry of the component for a given circuit simulator.

Transistor models used to support the today digital CMOS technology do not provide sufficient accuracy in predicting the device characteristic in RF regime. In addition, analog circuit designers require scalable devices to remove limitation imposed by device libraries. These requirements define the direction for the development of more advanced analog modeling technology of active devices.

Solving the **interconnect modeling** problem is the first priority for signal integrity over the full range of frequencies of interest. Four key changes have led to the critical need for designers to consider interconnect effects early in the design process:

- a more complex and varied metal /dielectric stack with denser pitches,
- higher level of integration, leading to larger IC and longer chip-wide interconnects,
- higher signal frequencies with shorter wavelength and therefore increasing the electrical lengths of interconnects,
- lower supply (Vdd) voltages, driven by low power dissipation requirements.

In a way of other, all these effects are driven directly or indirectly by the shrinking of technology from micro to nano-scale.

There is a well known, generally tradeoff between accuracy (model complexity) and speed (simulation capacity). A series of modeling alternatives for interconnect and passive structures materializes this tradeoff:

- lumped RLC parameters (based on 2D or 3D static field problems) - inaccurate for high frequencies (the very fast tools being inaccurate even for low frequency);
- transmission line model (1D distributed parameter model, RC, RLC, frequency dependent p.u.l. parameters, requiring solving of 2D static or quasi-static electromagnetic field problems) - skin effect and other frequency-dependent effects become significant in GHz frequency range, and 1D transmission line models are not accurate in the case of 2D/3D non-straight wires, vias or passive structures;
- planar EM models (2.5D, quasi-static, based on integral approach - MoM) - successfully applied in many cases, but inaccurate for 3D and fringe effects;
- EM models (3D, based on integral approach PEEC, or differential FDTD, FIT, FEM, with quasi-static or full-wave field) - very slow and often difficult to set up.

Dimensions of the modeled structure, operating frequency, geometrical complexity, and noise-isolation requirement play an important role in determining the best modeling approach. For example, a quasi-

static solution is accurate up to a quarter wavelength of the signal (which is the case of most components in a nano-scale ICs, excepting long interconnects, such as ground, power and clock tree).
Currently available tools do not provide following features, expected from the further parasitic tools:

Pre-layout estimation of interconnect parasitics. Designers frequently need tools to estimate interconnect parasitics early in the design process, prior to layout.

Check and control of extraction accuracy. Questions naturally arise about whether such tools are accurate for a given structure. The acceptable range, for instance in the capacitance calculation is typically 10%, bigger errors up to 25% can be accepted only for the unusual geometrical structures, that are seldom encountered in practical design layouts.

Parasitic within devices and through the boundaries between interconnects and devices. This is important for designers when investigating the parasitic effects in key circuit structures, such as the output stage of power amplifiers and compensation or optimization of parasitic effects through layout adjustment.

Substrate coupling is another major parasitic coupling concern. It represents the effect of digital parts (other analog parts or bond pads, antenna, etc) of the design to the critical analog parts, affected by the current noise flowing through the semiconductor substrate. Substrate coupling occurs frequently in RF and mixed-signal design, but until recently has no had much of an effect on sensitive signals. With very complex new designs, such as WCDMA, there is a need to design proactively, with the substrate isolation in mind. In same cases there is a need for up 100dB isolation between transmit and receive chains, requiring an accurate understanding of the substrate coupling. On-chip insulation is becoming increasingly important due to the higher integration level, higher frequencies, and tighter specification for next generation products, such as 3G cellular [148].

Substrate, ground, power supply and package noise injection are interlinked effects from designer point of view. Process technology options, grounding strategies, guard rings, shielding, decoupling capacitance, and package parasitics all play an important role in isolation. However, it is a combination of them that ultimately determines whether the final design will meet the product specification. Since both novice and experienced designers are facing difficult substrate noise today, studies have been performed on this issue. However, currently available commercial tools give no satisfaction to designers. They are restricted to use good design practices.

For the analysis of the isolation effectiveness of the substrate, with and without isolation structures such as deep-trenches (DT), a combination of TCAD simulations and test structure characterization are continuously being developed [142]. Many hardware-validate simulations are required to understand the substrate coupling effect at several frequencies (e.g. DT doesn't provide an effective isolation at high frequency, being transparent for signals above 1 GHz) and to develop process-specific guidelines for designers. Chameleon RF project aims to contribute to the solution of this very challenging problem also (providing tools for the evaluation of ac point-to-point impedance between any two layout "terminals" or to ground and supply structure).

In summary, new coupling and loss mechanisms, including EM field coupling and substrate noise as well as process-induced variability, are becoming too strong and too relevant to be neglected, whereas more traditional coupling and loss mechanisms are more difficult to describe given the wide frequency range involved and the greater variety of structures to be modelled. All this will cause extra design iterations, over-dimensioning or complete failures, unless appropriate solutions are found to resolve these design issues.

Commercial solutions and their limitations

Most important EDA frameworks for RF IC design are: the industry-leading Virtuoso from Cadence [149], Galaxy Design and Discovery Verification platforms from Synopsis [150] and IC Nanometer Design from Mentor Graphics [151]. All these companies promote programs and technologies for open interoperability of EDA tools provided by the third party vendors, if they comply to the industry standards [152]. Examples of such programs are such as Cadence's Connections (with over 120 member companies), Mentor's OpenDoor (with 95 member companies) and Synopsis In-sync (with 44 member companies).
The most important RF EDA tools are:

- ***Microwave Office*** (MWOffice) from Applied Wave Research (AWR) includes linear and nonlinear circuit simulators (HB or in time domain, embedding HSPICE) as well as EM analysis tools, LVS, statistical design capabilities, and parametric cell-libraries with built-in DRC [153]. It was designed around a single, object-oriented database that is inherently synchronized with schematic, simulation and layout data. The data model is high-frequency aware permitting extraction and modeling of active and passive devices, as well as interconnect lines or other components custom-described in Verilog-A. A library of transmission line elements and discontinuities was mapped into equivalent time-domain representations. The solution is built on an open, standard-based software platform enabling integration of the best-in-class tools for schematic, simulation, layout, physical verification or optimization. The EM analysis capability integrates a 3D planar simulator (actually 2.5D) based on method-of-moments for full-wave frequency-domain. The EM Socket open standard interface enables users to access virtually any EM simulator from leading vendors, combining the integrated EM analysis with FEM, FDTD or full 3D MoM, such as Sonnet, IE3D from Zeland or EM3DS from MEM. So-called "dynamic EM extraction" capability allows manual selection of layout part and target it for simulation using any of EM solver supported. MWOffice tends to became a low-cost independent framework for RF design, rather than a modeling tool (because the integrated tools are not the best on the market).

- ***Star-RCXT*** from Synopsis is, according to the vendor, the EDA industry's leading parasitic extraction solution for 130nm IC processes [150]. It has completed thousands of tape-outs including ASIC, microprocessors memory and high-speed analog designs. According to vendors, it provides accurate parasitic parameter extraction with QuickCap (errors under 5% compared with the reference solver Raphael) and 3D interconnect modeling for advances process such as copper, low-k and in-die process variation with very high speed (5 million of gates in less than 5 hours). At this speed it can't be appropriate for the accuracy required by custom RF designs. The more accurate Synopsis' ***Raphael*** parasitic extractor, based on finite-difference + boundary-element methods for electrostatic 2D or 3D field (capacitance) and 3D quasi-magneto-static field (R, L) is much more time consuming and doesn't provides full-wave models.

- ***Q3D*** from Ansoft embeds 3D and 2D electromagnetic solvers to extract the parasitic RLCG parameters and to produces an equivalent SPICE-compatible equivalent circuit model [154]. It can be integrated in Cadence, Mentor, Synopsis or other EDA frameworks. The tool is based on static field solution, without considering quasi-static or full-wave high frequency effects, nether substrate couplings, or influence to the active devices.

- ***VeloceRF*** from Helic enables an inductance-aware RF IC design flow, complementing other tools as DRC, LVS and RC extraction (RCx) with parasitic and intentional inductance extractor feature. It is an electromagnetic modeling tool that extract RLCK (resistance, inductance, capacitance and mutual inductance) netlist for spiral inductors, transformers, arbitrary shaped inductive elements and RF interconnect lines, working with existing RC extraction tools [155]. VeloceRF is appropriate mainly for the design of spiral inductor-heavy chips. It requires less than 4 sec per spiral inductor (therefore it can't be very accurate) and it not requires parameter fitting against measurement (that means it is not tuned to the technological parameters, by hardware-verification and it has no controlled accuracy).

- ***Momentum*** from Agilent is a planar (2.5D) elctromagnetic (EM) simulator based on Method-of-Moments (MoM) that computes S-parameters for general passive circuits, included microstrip, striplines and other topologies [156]. Vias and airbridges connect topologies between layers are accepted so RFICs may be simulated. The tool enables the modeling of spiral inductors identifies parasitic coupling between components and interconnects as well as radiation and checks signal integrity. The embedded dual modeling engines allow full wave analysis of dispersion/radiation (Microwave mode) and quasi-static EM analysis (RF mode) for fast modeling of larger circuits from DC to quarter wavelength. The simulation uses Green's functions computed for the substrate, their physical properties coming from the Technology File of the given process. Finite-thickness is considered in modeling. The simulation is speed-up by adaptive frequency sampling based on rational fit model. The simulation results may get back-annotated to the schematic for the nonlinear circuit simulation. Although Momentum is a reference for EM modeling in RF IC design, it has as main limitation the absence of hierarchical approach, which make it inappropriate for complex geometries.

- ***APLAC RF*** design tool from Aplac contains "RF IC Module", which is a circuit simulator based on Harmonic Balance method and "ElectroMagnetic Module", based on FDTD method , which is not appropriate for RF nanostructures having sizes deep under wavelength [157]. The same difficulty is encountered with ***CST Microwave Studio***, developed in Germany, offered in USA by Sonnet and based on time-domain Finite Integrals Techiques -FIT [159].

- ***Colubus-AMS*** from Sequence provides RLC parasitic extraction for analog designs, supporting IBM 5- through 8-series SiGe and CMOS technologies [158]. Input files are process library, device library and layout file (in GDS II format), while output files are SPICE and parasitic description (in SPEF, DSPF formats and back-annotated parasitics). Columbus benefits from its proprietary NTX engine (Nano Technology eXtraction), which is a library builder which computes RLC "primitives", using field solvers, and stores them in the process library. One library applies for all extraction applications, support costs and eliminating "tuning" to achieve accuracy. During extraction, the NTX engine converts geometry to parasitics. Using patented topological decomposition algorithms that rely on these pre-computed primitives, NTX accounts for how each target net interact with its surroundings to determinate accurate RLC. NTX models also interconnect-to device parasitics and contact capacitance around contacted FETs. The vendor claims that even in full-custom layouts, NTX routinely achieves sub-10% errors in parasitic values. NEC, Toshiba and Matsushita adopted Columbus for their 90nm designs. It can be considered as a reference EDA tool for the most advanced solutions.

The overview of the commercial solutions is ended with the conclusions of an experienced RFIC designer in using them [160]:

- Without simulation, the building of a RF IC is wasting of time and money (a 130nm CMOS prototype cycle takes 3 months and costs over 500 000 Euro for a small batch run).
- Inadequate simulation and modeling is a key reason why RFIC designs are failing.
- It is not uncommon to need 8-10 run-time hours for a single simulation. Hundreds of simulations are necessary to understand the behavior of a modern wireless device under all operating conditions.
- In an attempt to save precious design cycle times, engineers will often remove simulations or segments of components from schematics, producing prototypes that do not meet specifications.

These conclusions explain the relevance of the proposed projects for the community of the RF IC designers.

State of the art in scientific literature dedicated to EM modeling

From the analysis of available commercial solutions it is clear that effective Electromagnetic (EM) modelingis the key of progress. Electromagnetic coupling effects in RF IC, due to substrate occurs at the component level, as well as at the block scale, and represents a significant limitation of circuit performances. The efficiency of isolation techniques, such as deep trench and guard rings is generally evaluated from measurement and have not met, up to now, proper design tools for their simulation. The problem difficulty resides in the discrepancy between active layer thickness (1-2 μ) and substrate thickness (300-500μ) exceeding many hundreds requires large mesh for discretization of differential equations in approaches such as FDTD, FEM, FIT or LG. This leads to huge computational resources required for simulation, even when subgridding technique is associated with time or frequency interpolation procedures. On the other hand, integral approaches are inappropriate for structures with nonuniform doped diffusion.

The hybrid differential-integral approach [164] seems to be the only one suitable for multilayer structures including nonuniformly doped diffusions (fig. 5). This approach in association with transverse wave formulation (TWF) offers a natural framework for multiscale (MS) and multiresolution (MR) full-wave analysis. The MS approach, based on optimal spectral expansion of integral operators provides indications for appropriate choice of meshing cell size. While, the wavelet-based MR analysis in the spatial domain (DSP inspired) allows the sensitive topological details to be investigated, using suitable "layout approximations". In the past, wavelets were principally directed toward performing a thresholding procedure to render the MoM matrix as sparse as possible. At each iteration loop, TE and TM modes may be computed, splitting the TWF solution in the spectral domain, into solenoidal and non-curl parts (coupled at high frequencies only by boundary conditions). At low conditions, the two modes are de-coupled, and as in PEEC the magnetostatic (TE part) and electrostatic (TM part) fields may be computed independently. While PEEC-based approaches leads to exact decompositions of the two parts at zero frequency, in MoM

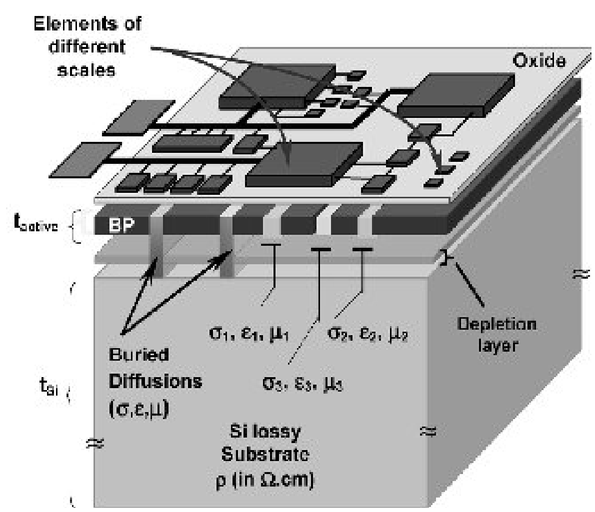


Fig.5. Typical layered structure with components and blocks [164]

formulations, numerical instabilities are observed at low frequencies. To improve the spectral properties of the MoM impedance matrix, loop-star, loop-tree or loop-charge DOF transforms were proposed. In TWF approach, numerical instabilities related to the matrix poor condition number are solved in a natural manner, using transverse waves instead of tangential electromagnetic fields, that allows to handle scattering operators in place of manipulating unbounded impedance or admittance operators. Although its advantages, the relatively high computational effort required even in simplest geometric configurations limits TWF approach at the complex structures. Moreover there are still open problems in EM modeling, e.g. how to handle IC complexity (the answer is of course the hierarchical approach of EM modeling) and how to bridge in a natural/automatic way the low and high frequency behavior.

Therefore we may say there is a lot of space for improvement in EM modeling and a generous series of research topics with important industrial impact. It is well known that EM modeling should be followed by effective procedures for order reduction, aiming to extract models as compact as possible.

State of the art in scientific literature dedicated to variational order reduction

Manufacturing variations are random in nature, and generally classified into two categories : temporal and spatial. Temporal variations are due time-varying equipment conditions, incoming wafer or characteristics of consumable materials. They manifest as lot-to-lot or wafer-to-wafer variations. On the other hand, spatial variations can occur on the wafer-to-wafer scale (e.g. due to non-uniformity in deposition or etch chamber) within wafer (die-to-die), or within die. Therefore variations can be classified in global (at the wafer scale) and local (at the die scale). Typical examples of manufacturing variations are variations in critical dimensions (CD) and inter-level dielectric thickness (ILD). These fluctuations cannot be eliminated, moreover hey continuously increasing in relative magnitude as new generations of nano-technologies are introduced. Without variation analysis, robust design of nano-structures cannot be conceived.

The effects of process variations can be captured by a set of worst-case SPICE model parameters. The impact on circuit performance may be then estimated via multiple circuit simulations to explore the "worst-case corners". This approach, as the interval analysis technique are known to create overly pessimistic results. Better results are obtained with Monte Carlo statistical method, but this analysis requires large number of simulations.

Although interconnect reduced order modeling is now a mature subject, the parameterized reduced order modeling is still at its infancy stage. A few reports have been made of algorithms that seek to apply model reduction in the context of process variation or for more generally parameterized passive component and interconnect models. Last context is encountered in the parametric cell libraries, where geometric variations of geometric parameters are relatively large. The two basic approaches presented in the literature are to use perturbational techniques to capture small deviations around the nominal circuit parameters [161], or to use multidimensional analogs of moment-matching (or Krylov-subspace) approach [162] to extend them to the parameter varying case. A difficulty with the first approach is that the accuracy is limited. The scheme breaks down for large deviations from nominal. The difficulty with the second approach is that tradeoff of errors versus order is hard to control, as moment matching in high dimensional space leads to projection space, thus models, whose size becomes exponentially large. Uniformly increasing the number of moments matched in each dimension leads to large jumps in model order.

A promising approach in this context is Truncated Balanced Realizations (TBR) and its approximation "Poor Man's TBR" (PMTBR), extended to the case where the matrices are described by statistical varying parameters [163]. They are able to produce remarkable accurate at relatively low order models, even in high dimensions (many process parameters). The problem still open is the high overall complexity of algorithm, and it will be addressed by proposed projects. An original multilevel parametric model order reduction (mpMOR), integrating electromagnetic analysis and order reduction into unitary methodology will be evaluated.

New EDA business model

Microelectronics has become a foremost driver of social and economic progress worldwide. With an average annual growth of 15% a year for the past three decades, its industry has made massive investments and is heavily rooted in Europe, creating thousands of jobs. The move to nano-scale devices, called nanoelectronics, will further revolutionise applications while demanding increasingly heavy investment in research and production to remain competitive.

Microelectronics underpins almost every single industrial sector. Its value chain currently represents 1% of global gross domestic product. More generally, the electronics sector receives 30% of industrial investment in the developed world and results in a global annual market of nearly €800 billion. Taking into account the many other industries that depend on electronics, the global value leverages some €5 000 billion. Electronics also generates highly skilled employment.

In the past years, the main European semiconductor companies generated about 10.000 direct and indirect jobs each year. Most of these jobs require a high level of education resulting in a great impact to expertise, expertise for local and regional engineering schools, universities and institutes. The semiconductor market is entering a new area of growth, which will propel it to a 500 B$ market in 2006. However, the large investment in nanoelectronics process technology and the development of advanced transistor and interconnect technologies is obsolete without accompanying design tools.

Although there has been a long tradition that the design tools are provided by US-based companies (CADENCE, SYNOPSYS, AGILENT and others), new opportunities arise at every technology generation. Start-up companies (SMEs) address design concerns that are difficult to address by established software providers because the overall tool sets are too rigid to deal with the fast increase of design demands. This explains why the traditional software vendors acquire the modern tools by purchase more than by in-house development. Their role shifts from software development to software integration. As such, those companies forego part of their role as technology leaders and lose partial control over the pace of tool development and innovation. **This shift allows a new business model** in Electronic Design Automation (EDA) industry, which generates great opportunities for European companies. Helic, CST and Aplac are European companies, success stories within this business model.

The nanoelectronics industry has a vital role in meeting the Lisbon challenge for a knowledge-based economy. Maintaining leadership in areas such as communications, medical and automotive electronics requires access to key intellectual property and leading-edge technologies implying an efficient knowledge transfer between R&D and manufacturing centres. Without this, Europe is left vulnerable – not only in chip manufacturing itself but also in the systems industries that rely on the components. Synergy between industrial strategies, scientific objectives and funding priorities must be optimised to meet goals for industrial exploitation and public benefit [9].

For Europe to achieve world leadership in R&D and maintain high value-added, next-generation production processes, it must provide [9]:

- An environment and infrastructures capable of supporting industrially relevant research activities;
- Strategic public-private partnerships in which strong user industries share their long-term visions with research partners and mobilise a critical mass of resources;
- An education system delivering a skilled, multidisciplinary research, design and production workforce.

1.2. PRINCIPLES OF THE STRATEGY

General objectives

The goal of the proposed strategy is the **reinforcing of training, research and innovation capability of PUB - CIEAC - LMN**. The strategy for **sustained and coherent progress** of these structures is based on following general objectives:

- human resources development,
- support for the mobility activities of different types,
- support for the dissemination and exploitation of intellectual property rights,
- improvement of environment and working conditions for research activity,
- upgrading of research infrastructure,
- strengthening the link with industry,
- increasing the number of doctoral candidates and postdoctoral fellows,
- extension toward new timely scientific and technological interdisciplinary areas,
- improvement of public and international image.

These objectives are subordinated to the reinforcement of the entrepreneurial component of the university, as it is defined in the Commission document: *Mobilizing the brain power of Europe: enabling universities to make their full contribution to the Lisbon Strategy COM(2005)/.* Thus, following challenges are considered: diversification of funding (attracting European and national financial support for training-research, as well as from industry) and governance improvement (by internal restructuring and more effective management), aiming to achieve a world-class quality of our activity. The tendency to uniformity and egalitarism in Romanian national system, noted in above document is a bottleneck. PUB as many other universities continue to offer same mono-disciplinary programs and traditional methods reducing this way the career opportunities for the young researchers.

One of the institutional effects of the internal reform and restructuring is the set-up of the Doctoral School in PUB, networked with similar European structures. It will have a dual function: a peak of higher education in PUB and a place for the first stages for researchers. In order to obtain the promised support from the European Commission [14] following criteria will be met through the proposed strategy:

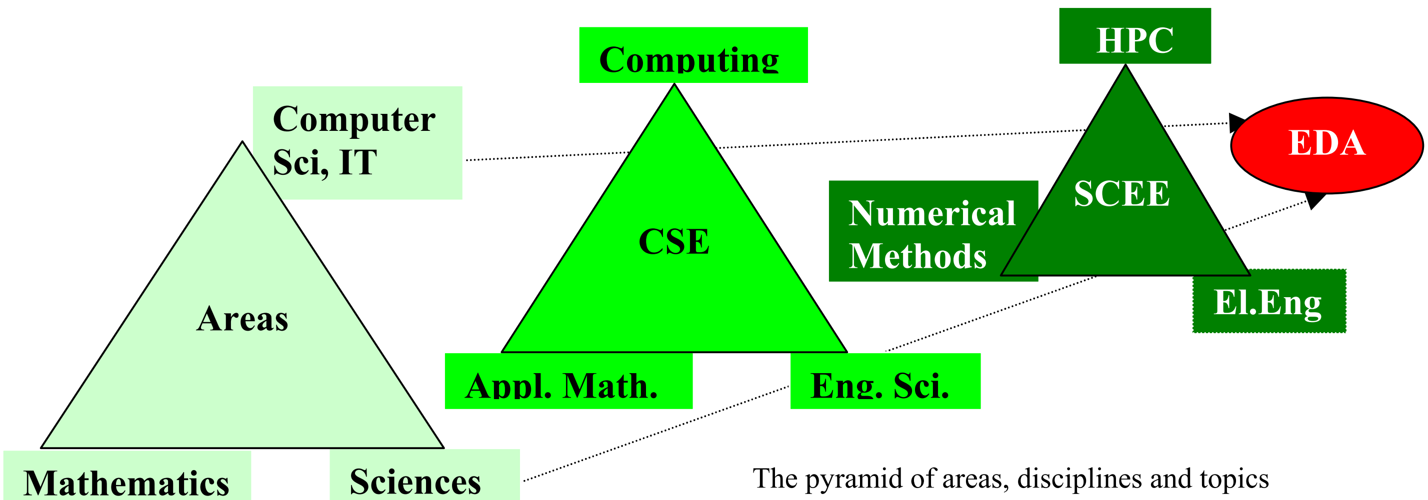
- Agglutination of the critical mass of resources ;
- Inter- and multi-disciplinarity of the activity;
- Strong European dimension;
- Backing from regional/national authorities (CEEX);
- Direct involvement of industry;
- Identification and declaration of the excellence areas.

The strategy will be implemented by a series of research-training European projects. All these synergic projects will emphases on the previous principles and will share the general objectives of the strategy.

Inter- and Multi-disciplinary approach. Areas, disciplines and topics

Many of modern developments in scientific research come through the interaction of individuals at the interface between scientific disciplines. Clearly this requires researchers capable of flexible thinking and with the necessary skills to communicate across traditional boundaries. This is the fundamental idea behind all research groups involved in the proposed strategy. The complementarily and the multidisciplinary of backgrounds, the experience and techniques of these groups are well reflected by their name (please see sections 2.3 and 3.2).

The set of subjects encountered in the section 1.1. are related to a broad range of disciplines from mathematics, physics, electronics, material and computational science.



The pyramid of areas, disciplines and topics

In a natural structure, at the background level there are basic areas, such as: mathematics (partial differential equations, ordinary differential equations, functional analysis), sciences (electromagnetics, condensed mater physics), computer science and Information technology (algorithms, data structures, object oriented design, programming languages).

The next level is occupied by applied mathematics (mathematical models of physical systems, qualitative analysis of solutions), Engineering Sciences (mechanical, thermal systems, material sciences, electronics), Computing Science (programming models, mathematical libraries), and interdisciplinary discipline of Computational Science and Engineering CSE.

At the upper level is placed the interdisciplinary topics of Scientific Computing in Electrical Engineering - SCEE and the related disciplines, such as:

- Numerical Methods (theoretical background for discretisation methods of differential and integral method, as well as for the numerical solutions of linear and non-linear system of equations),
- High performance Computing (parallel and distributed hardware and software solutions for large size, complex models and simulations), and
- Electrical Engineering (models based on electromagnetic field, circuit and systems).

The pinnacle of the discipline pyramid is the nano-Electronic Design Automation, with focus on advanced techniques for compact model extraction, signal integrity verification and optimisation.

Disciplines from low levels are subject of training for Bachelor, Master and Doctoral studies, while these at higher levels are subject mainly for research. Each researcher will cover with several level of deepness a particular area of the pyramid. It is not expected from them to become experts in all above mentioned disciplines, but it is important for them to have specific competencies, to understand the multidisciplinary overview, and to have the necessary skills to communicate with other member of the research team.

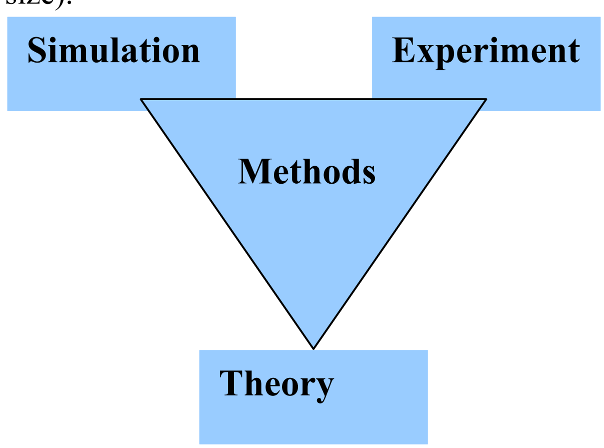
Unfortunately, the present educational system, based on training in narrow disciplines doesn't encourage the interdisciplinary approach. In PUB, the structure of electrical faculties: Electronics and Communication, Control and Computers, and Electrical Engineering became obsolete, when computer and communication technologies are merged and the modern electrical engineering is based on the unifying concepts of "digital and continuos circuits and systems" and "electromagnetic field and waves". Moreover the today PUB chairs have a conservative effect, their tribal behaviour being driven by quantitative reasons, not by interdisciplinary challenges. In this context is extremely difficult to attract the talented early stage researchers trapped in mono-disciplinary domains of interest toward a multidisciplinary context. Lack of mobility will affect their careers. The solution promoted by the proposed strategy is to build the kernel of the research team from foreign researchers and to keep the door open for new arrivals, including Romanian researchers. Hopefully in the next five years PUB will be restructured by merging the three electrical faculties in an EECS department, having as basic units laboratories and research centres. Thus the artificial walls between disciplines might be eliminated, allowing the match between the technology progress and the university structure.

Methodology of the proposed strategy

To solve the challenging problems encountered in the domains listed above the first method considered is the theoretical one. Effective mathematical models of passive and active electronic devices should be developed. That means analysis of well formulation: uniqueness, existence and continuity theorems. The models are based on a combination of PDE with ODE. Reformulation as a system of integral equations is also considered. Analysis of the convergence, consistence and numerical stability of numerical models are not easy theoretical tasks. Several effects of electromagnetic field, thermal and mechanical stress as well as material behaviour at high frequency should be analysed. The goal is to obtain an optimal trade-off between accuracy and model complexity, with the possibility to control the accuracy of solution.

The complexity of these models make not possible their solving without numerical methods by computer simulation. Therefore, simulation is the second crucial method promoted by the proposed strategy. That suppose the development of appropriate computer code based on the previous developed theory. The goal of this method is to develop reliable, flexible, easy-to-be-used code, with optimal computer resources requirements (CPU time and memory size).

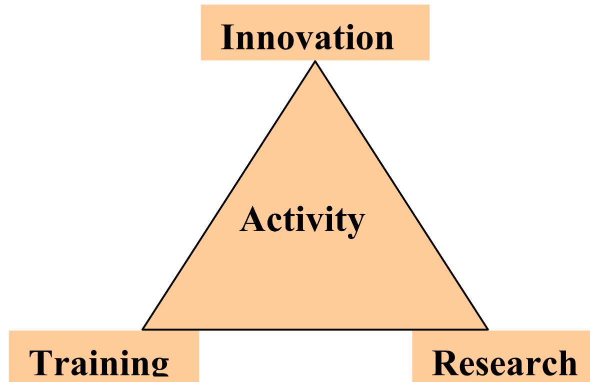
The only credible validation of the theoretical and simulation results is the comparison with the experimental results. Unfortunately, the state-of-the-art (on-wafer at 100GHz) measurements are extremely costly and therefore it is not profitable to be done in Romania. This is why the experimental work is proposed to be done by our industrial partners, whith suitable equipment and know-how. However, the researchers of LMN team will be involved in the selection and design of benchmarks, as well as in the post-processing of measured data (e.g. de-embedding).



The three basic methods in nowadays research, promoted also by the nEDA strategy comprise the "methods triangle" depicted in the above figure.

Activities of the proposed strategy

Belonging to a university, the host is involved not only in the pure research activity, as frequently happen in research institutes or industrial companies.



Training of early stage researchers, members of the nEDA research team at the Doctoral level is a key activity in the proposed strategy. This research-training activity has a double outcome, the human resource development at the highest level, meanwhile provide human resources necessary for the research activity.

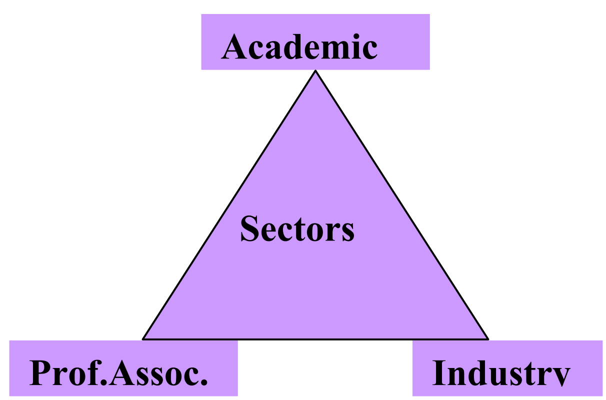
The planned training covers the scientific subjects described in the previous section, as well as complementary knowledge related to professional communication and scientific project management. The most part of the curricula is covered by the local teaching staff, however the shortage will be covered by knowledge transfer and inviting foreign scientists.

The goal of both training and research activity is the innovation and progress in the state of the art. Therefore the creative activity is the third equal important one, which close the above "activities triangle" (called also the "knowledge triangle"). The innovative results should be disseminated by typical techniques in academic community, mainly by publication. IPR and transfer of knowledge toward industrial partners, including SMEs are methods for their exploitation.

Researchers will be treated as professionals from the early stage of their career. Physical and virtual mobility (whether across boundaries or between universities and industry) and innovation leading. Following Commission recommendation [8], the university spin-off will be encouraged and rewarded. Compensation will reward quality and achievements in performance of all tasks, including a share of income of research contracts, consultancies, IPR, patent, etc. This kind of additional income for researchers is a must in a country as Romania where salaries are ten times lower then European average.

Inter-sectorial aspects of the proposed strategy

The activities of the proposed strategy are planned to be carried on not only in the academic sector, comprising universities and research institutes, but also through European partnership within industrial sector (e.g. by internships or other co-operation methods.



To obtain maximal impact in the European industry, the leader companies in semiconductor technology shall be included in the partnership. They are Philips, ST Microelectronics and Infineon (please see the Commission document entitled *Vision 2020: Nanoelectronics).* It is also important to include between industrial partners as well the SMEs, in order to improve the efficiency of the knowledge transfer, in the benefit of the European competitiveness. Industry is the target sector of the proposed strategy

Nowadays, the advanced research activity may not be carried out without a significant contribution of the Civil Society, comprising NGO-s such as Professional Associations and standardisation organisations (IEE, IEEE, ACM, SIAM, International Compumag Society - ICS). They control the professional communication means, publishing the most important periodicals in the area and organising the most prestigious international conferences (see the Reference list). The researchers will be encouraged to join these associations and to participate actively to the professional community life (as reviewers, editors, or event volunteers), taking important advantages for their careers.

The three main actors encountered in the proposed strategy comprise the above "sectorial triangle". Another important stakeholder supposed in the background is the government sector, which is expected to provide the financial support for our strategy. Actually the European competition within FP6 and FP7 inspired the proposed strategy, which exploits the great opportunities, provided by these framework programs.

Financial sources provided by Romanian government, through competition such as "Research for Excellence - CEEX" will be also accessed. However it is not clear how a large national partnership, imposed by this scheme may increase our chances in the next FP7 calls (we guess, on the contrary). Moreover, the application review is not compatible with that of EC (e.g. for "partnership structure" are given maxim 3 credits from 100 in total, however the threshold is 2, that means a proposal with 98 credits from 100 may be rejected ! Seems to be gambling).

Integral vision of the proposed strategy

Proposed strategy is based on following general expected achievement (meantime commitments and goals):

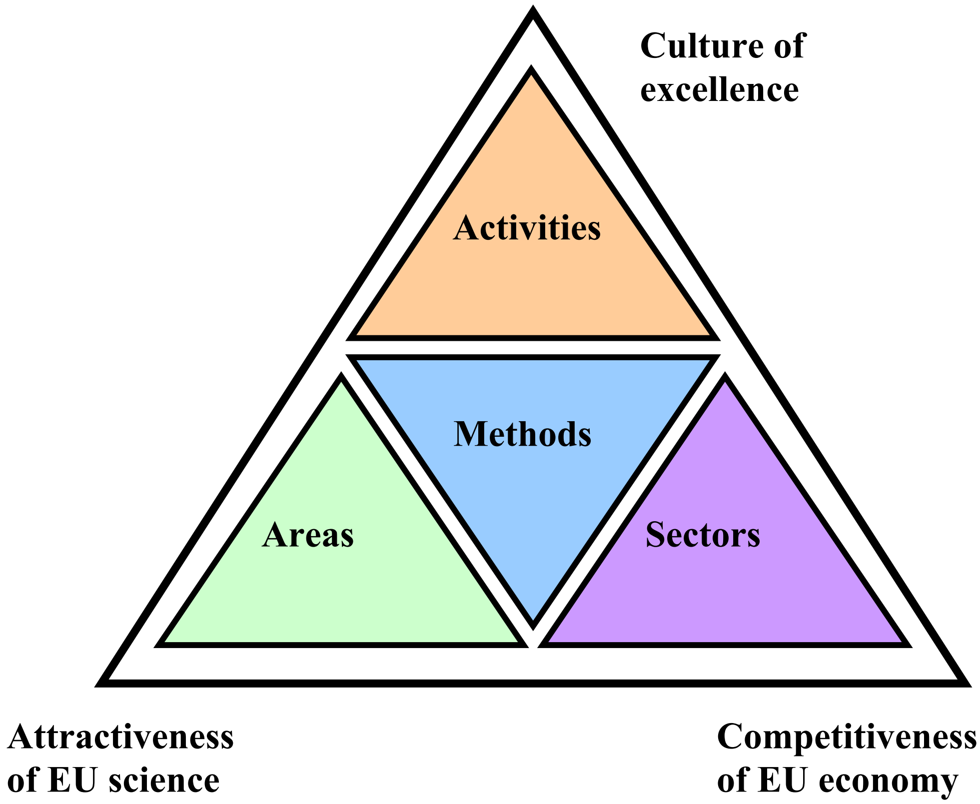
- increased attractiveness of the European science, and in particular that in Romania and PUB (by attracting funds and solving challenging problems),
- contribution to the competitiveness of European knowledge based economy (by a strong industrial partnership),
- permanent promotion of the Culture of Excellence (together with our prestigious European partners).

Attractiveness means besides others the increasing of the researcher income, including from the Romanian researchers at least at the level of Monthly Living Allowance of Marie Curie fellowship in Romania: 1331 Euro for less than 4 years experience, 2158 Euro for 4-10 years of experience, and 3237 Euro for more than10 years of experience [4],[7]. These are our targets. Under these levels can't be expected achievements at European level.

A new attitude related to IPR and their exploitation in the benefit of industry represents the method to achieve this target.

We know very well that "outstanding quality can only emerge from a terrain with an across-the-board "culture of excellence" - excellence being never a permanent achievement - it always need to be challenged. It can exist in a few entire universities, but much more widely in individual faculties or teams" [14]. It is exactly our case.

These three unifying principles integrate the LMN vision about the proposed strategy, as it is depicted in the figure below.



LMN vision for 2010 within nEDA strategy

Other important keywords of the proposed strategy are:

- Human resources development
- International scientific quality
- Better training and research environment
- Academic freedom and openness
- Mobility
- Inter and multi disciplinary approach
- Creativity
- European partnership and cohesion
- Visibility
- Result dissemination
- IPR exploitation
- Support for knowledge society

2. RESEARCH -TRAINING - INNOVATION PROJECTS AND THEIR SYNERGY

2.1. DESCRIPTION OF THE PROJECTS AND THEIR OBJECTIVES

2.1.0. FP5/IST/CODESTAR

CODESTAR is a European FP5/IST research project entitled *"Compact modelling of on-chip passive structures at high frequencies" (www.imec.be/codestar)*. The main goal of the **CODESTAR** European research project was the development of a computer code dedicated for the electromagnetic simulation of passive on-chip structures (such as spiral inductors, meander resistors and MIM capacitors up to 20 GHz) resulting in a small simulation network. Thus was developed an improved Electronic Design Automation - EDA tool dedicated to the signal integrity design verification of passive on-chip structures, including interconnects on RFICs. The code is a path from layout (cif or GDSII file) to circuit (SPICE format). Design, fabrication, and characterization of dedicated test structures was carried out, in order to validate the CODESTAR-code. The matching between experimental and simulation results had proven the project success

First, a detailed electromagnetic analysis of each passive structure is carried out. The outcome of the field solver is a full net list or a semi-state detailed description of the structure. Usual, the size of the model is too large to be useful and therefore a systematic order reduction must be done. The resulting compact model is inserted back into the full design scheme and the design cycle can be pursued.

The project was sub-divided in five major building blocks (work-packages). Two of them, i.e. the "Maxwell solver" and "Reduced order modeling" have a strong interdisciplinary. "Implementation" aims the software development itself, while "Test structures" deals with the input from industrial users and code benchmarking. Finally, "Exploitation and dissemination" aims to use in a commercial and non-commercial manner the research results.

The following solvers have been selected for an in-depth study and for being applied to on-chip integrated passives and interconnect: The Lattice-Gauge Solver (LG) by MAGWEL; The Finite-Integrals Technique Solver (FIT) by LMN; The Finite-Difference Time Domain Solver (FDTD) by RUG; and The Partial-Equivalent Electric Circuit Solver (PEEC) by TU/e. To solve real complex problems, an original methodological approach called ALROM (All Level Reduced Order Modeling) has been developed by PUB-LMN. The ALLROM strategy consists of four stages: macro-modeling, a-priori ROM, on the fly ROM and a-posteriory ROM. A dedicated software platform called ROM Work Bench was developed aiming to find the most appropriate order reduction method.

The Codestar project started in 2002 and successfully ended in 2004. The success of this project encouraged us to define (between November 2004 and May 2005) the present strategy to be carried on between 2005 and 2010, in co-operation with our European partners.

2.1.1. FP6/IST/STREP/CHAMELEON RF

The Specific Targeted Research Project - IST/STREP called CHAMELEON RF is entitled *"Comprehensive High-Accuracy Modeling of Electromagnetic Effects in Complete Nanoscale RF blocks"*. The goal of the CHAMELEON RF project is to develop methodologies and prototype tools for a comprehensive and highly-accurate analysis of complete next-generation RF functional blocks that will operate at RF frequencies of up to 60 GHz. The CHAMELEON RF project addresses the IST objective 2.4.1 (Nanoelectronics), more specifically: research on methods and tools for verification of advanced nanoelectronic circuits. It has a planned duration of 30 months, 322 man months and it has 7 partners from 5 countries.

The general objective of the consortium is that of developing a methodology and prototype tools that take a layout description of typical RF functional blocks and transform them into sufficiently accurate, reliable electrical simulation models taking variability into account.

The models, when presented to typical circuit level simulators should be able to accurately predict the electrical behaviour of the RF functional blocks in terms of their specifications such as noise, linearity, dynamic range and frequency range. The RF blocks that we will consider consist of typical functional RF blocks containing only one or two hands full of active devices and about the same number of designed passive devices such as integrated inductors and up to 10 metal layers. Examples include VCO, LNA and mixer structures, to be operated at frequencies as high as 60 GHz. Today, no consistent solution for physical design verification of such circuits exists, while their need is inevitable given the current trends in RF integration. This solution has to be developed 'in-house' since the commercial CAD tool suppliers are too distant from the new technologies involved.

2.1.2. FP6/HRM-MC/RTN/COMSON

COMSON is a FP6 - Marie Curie - European Research and training Network (RTN) on *"Coupled Multiscale Simulation and Optimization in Nanoelectronics*". This project merges the know-how of the three major European semiconductor industries with the combined expertise, in all fields of interest, of specialized university groups for developing adequate mathematical models and numerical schemes, and realizing them in a common demonstrator platform. This platform allows on the one hand, to test mathematical methods and approaches, so as to assess whether they are capable of addressing the industry's problems; on the other hand, to adequately educate young researchers at Doctoral level, by obtaining immediate hands-on experience for state-of-the-art problems.

The network has an interdisciplinary content that can easily be explained by its title: the task of *coupled multiscale simulation in nanoelectronics* has to combine the expertise of applied mathematics/numerical analysis and computer science ("multiscale simulation") with physical modeling experts ("coupled") and electrical engineers ("nanoelectronics"). The intersectorial dimension of this project is stressed by the participation of the three main European semiconductor companies working closely with specialized university groups to develop a demonstrator platform.

The main S&T objectives of the COMSON project are to develop new descriptive models that take these mutual dependencies into account, to combine these models with existing circuit descriptions in new simulation strategies, and to develop new optimization techniques that will allow for new designs. The scientific and technical domains of interest for research are detailed below.

Mathematical Modeling and Analysis (MOD)

Mathematical research up to now was mainly focused on models of one single domain, like. The aim of this project is to include besides semiconductor equations, the effects of other domains like thermal and electromagnetic coupling and high frequency modeling aspects to improve the accuracy of the models. This results in so-called *Partial Differential-Algebraic Equations*, which couples differential-algebraic models describing the lumped (network) part with partial dfferential equations for the spatially distributed elements and effects via right-hand sides, source terms or boundary conditions. This requires new analysis with respect to consistency and validity of the overall PDAE model that links different domains and levels of physical description, existence of solutions, and robustness and effciency of the numerical methods being applied for solving the extended sets of equations.

Simulation Techniques for Coupled Domains (SIM)

New, robust and effcient methods will be derived to solve the resulting equations. Depending on the type of coupling and accuracy to be achieved within simulation, two approaches are feasible to cope with these coupling effects:

a) Simulator coupling for systems of Partial Differential-Algebraic Equations (PDAE). Here all *dynamic* effects (for circuits, devices, thermal effects etc.) are modeled and simulated separately using their own simulation package which is based on their own time stepping algorithm in the numerical kernel. Assuming the packages are equipped with appropriate interfaces, the coupling of the PDAE model via right-hand sides, source terms or boundary conditions can be done by coupling the simulators at communication time points. As the PDAE systems are coupled dynamically, an outer iteration process (dynamic iteration) has to be performed until getting convergence within a macro time step from one communication time point to the next one. Equipped with adequate relaxation and overlapping techniques, dynamic iteration schemes have to be derived which can guarantee a stable error propagation from one macro time step to the other, thus ensuring rapid convergence as well as robustness and stability of the overall scheme used for coupling the models and simulators, respectively. This *distributed time integration* approach can quite naturally exploit the multirate, i.e., multiscale behavior in the time domain, as the different time stepping algorithms can use different time step sizes in accordance with the different time constants of the single models.

b) Model order reduction (MOR) for distributed effects. Being only interested in an adequate input-output behavior, distributed effects are described by behavioral models. While in the last 10 years, based on a sound mathematics, impressive results in model reduction have been made in deriving and optimizing methods for linear problems (for example, interconnects), model reduction for nonlinear problems is still in its mathematical infancy. In the present project, the focus will be on generating adequate low-order circuit models, both for the linear and the nonlinear case.

Optimization (OPT)

We aim at optimizing a realistic, medium size coupled problem of industrial relevance. This implies that optimization will be done in a multiple domain space with a large number of design objectives and restrictions (say between 10-100), and works in a very complex parameter space (several hundreds to thousands of parameters). As far as manufacturability requirements are concerned, optimization will have to deal with discrete as well as continuous variables. And finally evaluations of functions and of constraints will be very costly (each requiring a coupled simulation), and possibly noisy. How to exploit transient sensitivity analysis will be an additional point of attention. Finally, the reliability and robustness of a simulator depends on the accuracy of the implemented models and, in particular, the model parameters. In fact each separate model already has several hundreds of parameters. Therefore, in order to calibrate the models, new advanced and efficient parameter extraction techniques will be developed.

2.1.3. FP6/HRM-MC/EST/EST3

The Marie Curie Host Fellowship project entitled *"**E**arly **S**tage research **T**raining at an **EaST**ern **E**uropean **S**ite with **T**radition in Computational Science and Engineering - **EST3**"* has two components: training and research and is dedicate to the development of human resources and mobility. The structural training component is related to the broad and interdisciplinary area of Computational Science and Engineering (CSE) in which will be involved the early stage researchers (ESRs) appointed in the EST3. The blended research component of the proposal is a project has as objective the development of an original nano-electronic design automation methodology. The research project requires solid knowledge and competencies in CSE, motivating the proposed training.

The host of the ESRs, "Politehnica" University of Bucharest (PUB) is the largest entity of engineering education in Romania. It offers opportunities of research training at highest level for 6 doctoral candidates (three years stay for each) as well as for 12 short stays (four months each). The proposal exploits the Joint European Network in SCEE (Scientific Computations in Electrical Engineering) developed together with our traditional industrial and academic partners since 1991.

Several research groups from PUB with a prominent scientific role at national and international level jointly provide research training within the proposed project. All involved groups, together with early stage researchers - ESRs, will contribute to the success of above-mentioned pilot interdisciplinary research project in nanoelectronics. The subject of this project is close to but not overlap the subjects of other European projects we are involved in, such as RTN-Comson and IST/STRP/Chameleon. However, the impact of EST3 research training is expected to be broad, in thematic areas such as: computing and software technologies, electronic design automation, micro-systems, micro-, and opto-electronics, bio-engineering, ecosystems, water cycle, operational forecasting, system modelling, optimisation and simulation. All these areas insistently require scientists with professional skills provided by the research training programmes such as EST3.

2.1.4. FP6/ HRM-MC/TOK -4nEDA

Marie Curie Host Fellowships for the Transfer of Knowledge (ToK) entitled *"High Performance Computing Knowledge for nano-Electronic Design Automation - **4nEDA"**,* belongs to Development Host Scheme. The ToK - 4nEDA project aims to reinforce the competence in the area of High Performance Computing (HPC) hardware, software, and Grid solutions at 'Politehnica" University of Bucharest.

The transferred knowledge will be exploited by the local scientific community involved in a series of European research projects and multisectorial partnerships in the area of nanoelectronics. This interdisciplinary community committed to create an innovative platform for nano-Electronic Design Automation (nEDA). The local scientists have excellent results in their area of competence, however they need additional competencies in the complementary area of HPC, in order to fulfill their commitments with a relevant industrial impact. New-transferred technology will allow the local researchers to solve realistic problems for the benefit of the knowledge-based economy. Since the leader Silicon European companies are involved in these projects, the IPR generated, will contribute directly to the increase of the European industry competitiveness. Tok will reinforce not only research, but also the capability of the host to provide training at the highest scientific quality. The research training in domain of Scientific Computation in Electrical Engineering (SCEE) and in broader area of Computational Science and Engineering (CSE), at all levels: Bachelor, Master, Doctoral, and post-doc will be improved. The proposal was designed to have optimal size: project duration of 4 years, providing in this period 3 fellowships. The incoming experts will cover the local need of HPC-ToK, during their stay of 2 years each. The content, methodology and management of the ToK are defined considering the state-of-the-art, real need and feasible expected outcome.

The strategic goal of the proposed project is to increase the contribution of the host in strengthening of the scientific and technological bases of industry, in order to increase the international competitiveness of European knowledge-based economy. To reach this goal, the proposal is driven by the following objectives:

- development of the research activities in Romania and reinforcement of the research and training potential of the host in its need of new and timely areas of competence in HPC and CSE areas;
- overcome fragmentation of the European Research Area by encouraging synergies and structuring effects at European level, by exploitation of results of programs such as FP6-IST-GRID;

- enhancing inter-sectorial collaborations, interdisciplinarity and links between academic and industry, including SMEs, with a positive effects on host projects and partnerships such as nEDA.

These objectives will be implemented through the recruitment of external experienced researchers, who will be hosted by Politehnica University of Bucharest (PUB). The carefully selected fellows will be hired for the transfer of knowledge, research competencies and technology in the precise defined areas. Thus shortage of knowledge will be covered, for benefit of the host and Community.

2.1.5. FP6/ HRM-MC/SCF/SCEE

Marie Curie action dedicated to Conferences and Training Courses Series of Events (SCF) entitled "*How to start a successful career in the interdisciplinary area of Scientific Computing in Electrical Engineering - SCEE"* is an activity dedicated to development of Human Resources and Mobility (HRM). The project is targeted to the European Early Stage Researchers (ESRs) interested in a career in the challenging area of SCEE from academia or industry, preferably during their Doctoral study, who work on simulation, design or fabrication of modern integrated circuits or other innovative electromagnetic devices. It aims by its relevant training to amplify the dissemination and impact of the results obtained in the complementary projects described above, and to make SCEE more attractive for young generation.

A series of coherent events is planned within the SCEE SCF project, such as conference, workshops, hands-on, summer schools and Internet forum. The idea of project is to use the **International Conference on Scientific Computing in Electrical Engineering - SCEE 2006,** which will be held at Sinaia, Romania as an atelier for the early stage European researchers. Just before the conference, the selected fellows will participate at a Workshop, dedicated to effective techniques for dissemination of research results in the SCEE community. The participants will learn how to write a successful scientific paper, how to make an attractive poster, and how to present them using appropriate slides. After the SCEE 2006 conference, an **Internet Forum** will be launched, where participants are encouraged to analyze and to present their conclusions, as well as to discuss the scientific content and communication effectiveness encountered in the SCEE 2006 professional community. Each fellow should commit to submit a contribution for the next event - SCEE 2008, making all efforts to win "the best poster award" or "communication of the most promising researcher". In order to understand how the paper selection works, they will simulate the SCEE 2006 reviewing process. Thus, SCEE SCF leads to a significant step forward in the area. All aspects will be supported: education (state of the art, events 2-3), research (step forward, events 4-7) and innovation (results dissemination and use, events1,8). ESRs will be assisted in their scientific efforts by a series of coherent events of the proposed project all planned in the time interval 2006-08, in-between two SCEE international conferences. The events number 4-7 provide knowledge difficult to be found, from several areas from mathematics and theory, through computing toward electrical engineering applications, such as microwave and nano-electronics. They are: **FIT 30** event dedicated to fullfiling of of 30 years of research in Finite Integrals Technique, **PDAE network models** - a summer school dedicated to modeling and numerical analysis of systems described by Partial Differential Algebraic Equations (DPE), Workshop on **Parallel Computing for Electromagnetic Simulations, a**nd the Summer School dedicated to **Coupled Multiscale Simulation and Optimisation in Nanoelectronics.**

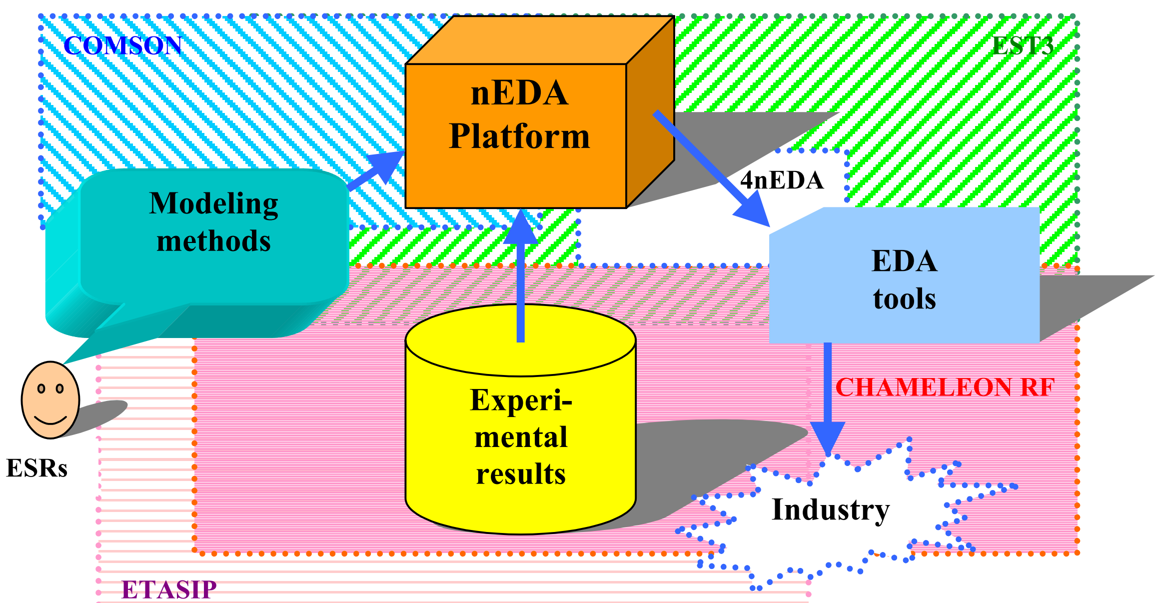
2.1.6. FP6/ HRM-MC/TOK -IAP/ETASIP

Marie Curie Host Fellowships for the Transfer of Knowledge (ToK) entitled "*Electromagnetic and Thermal Analysis of SIP - ETASIP"***,** belongs to Industry-Academia Partnership

Scheme. The ToK - ETASIP project aims the knowledge transfer between two universities (PUB-LMN-RO and TU/e-CASA-NL) and a SME (Synapto-Italy), in order to increase the European competitiveness in the area of SiP. From the technological point of view, the 1System-in-the-Package (SiP), which is the integration at the package level of various components, like semiconductor devices, resistors, inductors, capacitors, sensors, antennas, using advanced printed circuit technologies, represents a viable and flexible alternative with respect to other integration approaches. The high integration achieved in SiP technologies creates a highly dense three-dimensional circuit, in which active semiconductor devices are interconnected among themselves and to a network of thin conductors and embedded passives. The close integration of active and passive devices requires a careful study of the couplings inside the SiP structures at the development stage and this is the research topic of the present proposal. The correct estimation of electromagnetic and, at a later stage, also thermal and mechanical effects, in this project is dedicated specifically for sensors used for environmental applications. It not only enhances the overall quality of the SiP, but also provides mandatory information to the designer who needs to integrate the SiP in an even more complex system. The research topic is multidisciplinary in character, requiring knowledge from the fields of electronic engineering, manufacturing, electromagnetic analysis and numerical mathematical methods.

2.1.7. Other projects within Romanian National Program CEEX and FP7

The previous described projects were detailed defined and submitted to European Commission as result of several calls within FP6. The defined strategy is open to a series of complementary projects not yet defined in details. As an example, within Romanian National Scientific and Technological Program CEEX (www.mct.ro) will be submitted a project entitled "New methods and tools for nano-Electronic Design Automation - nEDA", aiming to build a consortium ready to submit applications for the next European Frame Program FP7. These new projects will be submitted in 2007, in order to cover the period 2008-2010. Thus, the strategy started with detailed defined projects will be continued in a smooth manner, assuring a sustainable development of the host.



Coherence between proposed projects

2.2. COHERENCE OF THE PROJECTS AND THEIR SYNERGY

2.2.1. COMPLEMENTARY ROLES OF THE PROJECTS

The strategic role of each project in the strategy is presented in the above figure and the following table.

PROJECT NAME	PROGRAM	ROLE OF THE PROJECT
Codestar - *Compact modeling of on-chip passive structures at high frequency*	FP5-IST	• Provided new knowledge, a competitive EDA methodology for signal integrity of the CMOS design verification, as a result of an advanced research (competitive methodologies and tools, such as ALLPROM based on dFIT and ROM Work Bench). • The innovative approach increased the credibility of LMN-PUB and • Generated a very valuable solid partnership.
Chameleon RF *- Comprehensive and Highly Accurate Models for EM Effects of Nano-blocks RFICs*	FP6-STREP	• Provides valuable results of "on-wafer" measurement for a series of benchmarks in advanced deep sub-micron technology (<100nm) at highest frequencies (60GHz), for hardware validation of the developed codes. • Challenging problems (RFIC blocks) with direct industrial impact by integration of developed tools in present design frameworks. • New theoretical approach (automatic domain decomposition, hierarchical EM analysis, parametric order reduction) and extension of ALLPROM. • Stronger partnership with leader scientists (Delft UT-NL, IST-PT). • Better IPR exploitation in order to increase European competitiveness. • Financial support for 2 full time experienced researchers working in LMN-PUB
Comson - *Coupled and Multiscale Simulation and Optimisation in Nanoelectronics*	FP6-HRM-MC RTN	• Openness to European companies, leaders in the Silicon industry (Philips, ST, Infineon), in order to preserve the fair competition on the European market. • Definition and implementation of standard API for a nEDA platform able to integrate and validate several modeling methods (ROM Work Bench will be developed and integrated in the new platform). • Extension of the scientific interest toward new advanced topics, such as PDAE, Thermal modeling and Optimization. • Reinforce training at Doctoral level. Contribution to the diploma recognition through the Comson Research and Training Network. • Development of the e-learning instruments for nEDA, CSE, SCEE, which will be exploited also by other projects. • Provides human resources for the research, 2 PhD foreign students working in LMN-PUB.
EST3 - *Early Stage Training in an Eastern European Site*	FP6-HRM-MC EST	• Reinforce the training capability of PUB, to provide high level structural training by design and implementation of new curricula for Doctoral studies in CSE/SCEE. • Facilitate the openness to the local research teams from Mathematics, Computer Science, Electronics, allowing structuring

with Tradition in SCEE		of PUB for interdisciplinary research. • Reinforce the capacity of PUB to select and host foreign PhD students. • Connection with third party countries (Moldova, Ucrain, Russia, China, India, Serbia) to increase the attractiveness of science and training in Europe and especially in Romania. • Set-up of a Doctoral school at PUB, connected to the Comson European Research and Training Network. • Provides human resources for the research, 6 PhD foreign students working in PUB. • The short stages will act as a glue with other LMN-PUB traditional partners, such as Politecnico di Torino, INPG, Imperial College, HUT, KTH, as well as the technical universities from Sofia, Athens, Budapest, Graz, and Warsaw, by joint PhD degrees, amplifying the impact at the European level.
4nEDA *High Performance Computing Knowledge for nano-Electronic Design Automation*	FP6-HRM-MC ToK-DEV	• Transfer of HPC knowledge and know how (including those in management area) necessary to make step forward in nEDA, according to ITRS. • Development and updating of research infrastructure, such as a cluster of PCs - Beowulf type, using financial support of the ToK project; a functional hybrid (intra)Grid, and an (extra)Grid (with the appropriate software) in the benefit of nEDA research. • Development of virtual organization (partners, topics, connectivity), able to submit successful FP7 proposal aiming to extend research beyond the currently defined strategy. • Bridging the existing gap between Computer Science and Computational Science will reinforce the PUB capability to provide structured training in HPC, CSE and SCEE areas at European level. • Provides human resources for the research, 2 experienced researchers and one more experienced researcher in the area of HPC, working in LMN-PUB for the benefit of the nEDA research.
SCEE *How to start a successful career in the interdisciplinary area of Scientific Computing in Electrical Engineering - SCEE*	FP6-HRM-MC SCF	• Enforcing long term collaborations at European level based on periodic events (such as SCEE conferences) open to both academic and industrial communities. • Development of professional communication and mobility actions, aiming to enhance international collaborations and overcome research fragmentation. Project will facilitate dissemination of the research results. • Improvement of public image of PUB, and in general of Romania. • Increase the public awareness about beneficial impact of science and, in particular, of CSE and nanotechnologies on everyday lives. • Human resources development and training in emerging areas, aiming to encourage synergies and structuring effects at European level.
ETASIP -	FP6-HRM-	• Transfer of knowledge from a technology (SoC- system on chip) to

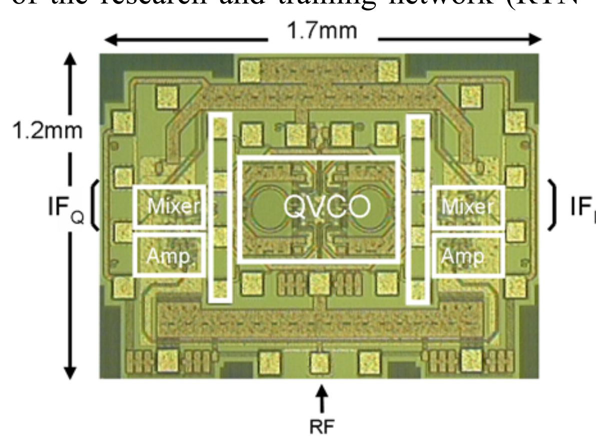
Electromagnetic and Thermal Analysis of Systems in Package	MC TOK-IAP	another (SiP - system in package) and adapting them accordingly. • Provides valuable experimental results for a series of benchmarks in SiP technology, for hardware validation of the developed code • Exploitation of the research results, using SME, in the benefit of European competitiveness.
NEDA *Methods and tools for nano Electronic Design Automation*	RO/MCT/CEEX	• Provides financial support for the Romanian PhD students and postdocs for the research activity in PUB-LMN. • Complementary support for the infrastructure development. • Networking with new partners, for a stronger National and regional impact.
NEDA	FP7	• Sustainable development of the host. • Dissemination and exploitation of the research results. • Set-up of a spin-off company (a local SME), aiming to exploit the results in a commercial manner. • Support for European Doctoral School, with a regional impact

2.2.2. COHESION OF THE PROJECTS

The above presented research projects will develop adequate mathematical models, numerical schemes, and their implementation in a software demonstrator platform dedicated to this complex problem of *nano-Electronic Design Automation (nEDA)*. The platform will allow the coupled simulation of semiconductor devices, interconnects, circuits, electromagnetic fields and thermal effects in one single conceptual and software framework. The nEDA platform will also allow the comparison between results of simulation and measurement, in order to validate the new developed methodology, using suitable benchmarks.

The nEDA platform plays a double role. It allows testing of mathematical methods and approaches, so as to assess whether they are capable of addressing the industry's problems; on the other hand, adequately education of young researchers by obtaining immediate hands-on experience for state-of-the-art problems. The nEDA platform does not aim at replacing existing industrial or commercial codes. However, it will be capable of analyzing medium-sized coupled problems of industrial relevance, thus offering a chance to develop advanced mathematics for *realistic* problems. Such a platform is urgently needed for academic research, since it provides a natural test-bench with state-of-the art models and parameters from different domains rather than scholastic simplifications. This way, another benefit of such a platform will be the collection and comparison of the knowledge about models and methods, which are widespread distributed over the different nodes of the research and training network (RTN Comson combined with SCEE joint European Network). Thus gives excellent opportunities for transfer of knowledge and mutual stimulation of new research.

The main expected outcome of the EST3 research project comprises methodologies and prototype tools for a comprehensive and highly accurate analysis of next-generation nano-scale functional IC blocks that will operate at RF frequencies of up to 60 GHz. That is also one of the S&T objectives of IST/STREP/CHAMELEON research project.



The figure above displays a 32 GHz device developed at the Philips Research Laboratories (one of the partners in the Comson and CHAMELEON RF projects). Currently, it is not possible to perform such analyses of complete RF blocks. Therefore the expected results of EST3 and of the complementary Chameleon RF projects is that of developing a methodology and prototype tools that take a layout description of typical RF functional blocks that will operate at frequencies up to 60 GHz and transform them into sufficiently accurate, reliable electrical simulation models taking variability into account. This transform from layout (GDSII file) to circuit (SPICE file) should be done in an automatic manner for a large class of RF blocks. We developed a similar tool within the IST/Codestar project. This tool is able to do successfully (with the accuracy control) this difficult transform. Current version of this tool may be applied only for a restricted class of on-chip components with distributed parameters, such as: passive devices (meander resistors, MIM capacitors, spiral inductors), and interconnects over non-uniform doped Silicon substrate.

To extract the compact model of RF blocks, both active and passive devices (including interconnects and Silicon substrate) should be hierarchically modeled, reduced, and simulated using multi-scale (MS) and a multi-resolution (MR) hierarchical approach. The nEDA platform will be an important instrument in the development and validation of these new design tools. The efficient ALROM (All Level Reduced Order Modeling) strategy dedicated to compact model extraction for passive devices, developed in a previous European project (IST/Codestar) will be integrated in the new nEDA platform.

An important advantage of planned synergy is that the expensive step of design and fabrication of test structures (benchmarks), necessary for hardware verification of new modelling methodology will be made within the CHAMELEON RF project and they will be fully used in the EST3. Meanwhile, Comson RTN will provide for EST3 the nEDA framework. These results of two complementary projects will be exploited within EST3 project, where new modelling tools will be developed and evaluated. They will be integrated in the nEDA platform and validated using the experimental result of measurements made on the CHAMELEON benchmarks structures. The validated algorithms and the resulted modelling methodology represent a very valuable knowledge, the kernel of the new design tools, to be integrated in the next generation Electronic Design Automation (EDA) flow of RF nanosystems with RF re-usable blocks.

Besides other objectives, the long-term intersectorial collaboration with our partners aims to set-up a European doctoral degree in CSE (in the frame of RTN-Comson project). The present strategy allows Romanian RTD community to be strongly involved in this challenging initiative, with mutual benefits for all partners. The long stages planned within EST3 project provide a critical mass of highly trained human resources, an essential ingredient for the success of other joint research projects (such as IST/ STREP/ CHAMELEON), while the short-stay EST3 stages act as "glue" for the consolidation of European partnership. High quality of the training within EST3 programme provided together with our European academic and industrial partners, as well as the use of ECTS and Diploma Supplement will facilitate the international recognition of the awarded diplomas and certificates. The short-stay of the EST3-ESRs will facilitate the awarding of the Joint Doctoral degrees, by PUB and their origin universities. The European Doctoral school planned to be set-up in 2008, within Comson-RTN would foster the support for Doctoral programs at European level, and it offers to the EST3 log-stay ESRs the opportunity to obtain an European Doctoral Degree in CSE, recognised by all RTN nodes.

2.2.3. ORIGINALITY AND INNOVATIVE ASPECTS OF THE PROJECTS

Technical problems:	Innovative techniques and scientific solutions:	Original expected results:
- Increasing geometrical and topological complexity - Increasing frequency - Smaller device and interconnect size - New materials (Lowk) with unknown RF behavior - Larger parameter variability - Complex nonlinear PDE equations for EM, DD and TH phenomena - Coupling and parasitic effects - Excessive simulation and optimization time - Lack of cohesion between several EDA tools - Low simulation accuracy - Lack of robustness of the present design methodologies - Lack of relevant experimental data	- Fast parameter extraction - New highly accurate transistor and interconnect models - Coupling TH and high frequency EM, DD effects - Coupling circuits with field - Parametric model reduction - Fast simulation - Parallel algorithms for large linear and nonlinear system - Link individual tools in a Demonstrator Platform - API framework for nEDA platform for industrial problems - Validation of numeric solution by symbolic computations - Multi-objective optimization - Accounting for costly and noisy objective functions - Suitable benchmarks - Experimental validation	- Phenomenon based reduced order models (PROM) - Correct formulation of math model (existence, uniqueness and solution stability) - Analysis and control of solution accuracy, convergence rate and numerical algorithm complexity - Design of suitable objects OOP (algorithms and data structures) - Hierarchical EM+DD modeling and new methods (MS and MR) for solving these coupled eqs. - Adaptive algorithms for PDAE discretization with accuracy control and automatic domain decomposition - Hierarchical multi-level pMOR - Fast co-simulation algorithms with multi-rate time integration or multi-frequencies approach

According ITRS, the challenging requirements of EDA domain lead to a transition to a completely new level of complexity, such as atomistic modeling instead of continuum diffusion equations, and accurate solution of Maxwell equations instead of traditional lumped circuit approach. These advanced methodologies require the development of new problem-specific and efficient algorithms, as the application of standard algorithms would result in prohibitive time and memory requirements, to mention only a couple of new approaches. Not only the linear solvers as stand-alone libraries demands continuos improvement, but also research is required on how the set of discretized equations are scheduled and organized before submission to the linear solver is done. In consequence, the state-of-the art of the numerical methods available or being developed mainly in other domains of science must be permanently checked from the point of view of the application requirements of all domains of simulation, described in this roadmap, and be used to influence and kick-off developments required. All these open problems will be addressed by proposed projects.

2.3. EUROPEAN PARTNERSHIP

2.3.1. INDUSTRY LEADERS

- Philips Research, Eindhoven (PHI), Electronic Design & Tools Analogue Simulation, Netherlands (Prof. W. Schielders, Wil.Schilders@philips.com, jan.ter.maten@philips.com)
- ST Microelectronics Catania (STM), Electronic Design and Manufacturing Automation Group–CAD Area, Italy (Dr. Salvatore Rinaudo, salvatore.rinaudo@st.com)
- Infineon Technologies Munich (INF), Product Development & Test Computer Software, Germany, (Dr. U. Feldmann, uwe.feldmann@infineon.com)
- AustriaMicroSystems (AMS), Austria (Dr. E. Seebacher, ehrenfried.seebacher@austriamicrosystems.com)

2.3.2. SMEs

- MAGWEL Leuven (MAG), Belgium (W. Schoenmaker, wim.schoenmaker@magwel.com)
- Synapto, Catania (SYN), Italy, (Dr. R. Ene, rene@synapto.com)
- CST, Darmstadt (CST), Germany, (Dr. Irina Maunteanu, irina.munteanu@cst.com)

2.3.3. UNIVERSITIES

- Technical University of Eindhoven (TUE), Centre for Analysis, Scientific Computing and Applications (CASA), Nedherlands (Prof. J. Maubach, maubach@win.tue.nl)
- Technical University Darmstadt (TUD), Institute for Theory of Electromagnetic Fields (TEMF), Germany (Prof. Th. Weiland, Dr. E. Gjonaj, thomas.weiland@temf.tu-darmstadt.de)
- Politehnica University of Bucharest (PUB), CIEAC - Numerical Methods Laboratory (LMN), Romaia (prof. D. Ioan, lmn@lmn.pub.ro)
- Delft University of Technology (DUT), Netherland (Prof. N. van der Meijs, nick@cas.et.tudelft.nl)
- Rostock University (ROS), Electrical Engineering and Computer Sci. Dpt (IWF) - Institute for General El. Eng. (IAE), Germany (Prof. Ursula van Rienen, ute.schreiber@uni-rostock.de)
- University of Wuppertal (WUP), Chair of Applied Mathematics & Numerical Analysis, Germany (Prof. M. Gunter, guenther@math.uni-wuppertal.de)
- Royal University of Gent (RUG), Belgium (Prof. D. de Zutter, daniel.dezutter@intec.rug.ac.be)
- University of Catania (CAT), Department of Mathematics and Computer Science (DMI), Italy (Prof. M. Anile, anile@dmi.unict.it)
- University of Calabria (CAL), Evolutionary System Group, Italy (Prof. Pietro Pantano)

2.3.4. RESEARCH INSTITUTES

- Interuniversity Micro Electronics Centre - IMEC Leuven (IMEC), Belgium (Dr. Geert Van der Plas, vdplasg@imec.be)
- Institute for Systems and Computers Engineering - (INESC/IST), Portugal (Prof. L. M. Silveira, lms@inesc.pt)

2.3.5. LONG TERM PARTNERSHIP

The following table shows how the academic and industrial partners are joined in several European research and training projects.

PROJECT	PROGRAM	PROJECT COORDINATOR	ROMANIAN COORDINATOR	INDUSTRY LEADRS AND SMEs	ACADEMIA UNIVERSITIES INSTITUTES
CODESTAR	FP5-IST	W.SHONEMAKER IMEC - B	D. IOAN PUB/LMN	PHILIPS-NL, IMEC (B), AMS (A) MAGWEL(B)	TUE (NL), RUG (B), PUB (RO)
CHAMELEON	FP6-STREP	W. SCHIELDERS PHILIPS - NL	D. IOAN PUB/LMN	PHILIPS (NL), MAGWEL-B, AMS (A)	DUT (NL), INESC (P), PUB (RO)
COMSON	FP6-HRM-MC RTN	M. GUNTER WUPPERTAL UNIVERSITY, GERMANY	D. IOAN PUB/LMN	PHILIPS-NL, INFINEON D, STM (I)	WUP (D), PUB (RO) TUE (NL), CATANIA (I) CALABRIA(I)
EST3	FP6-HRM-MC EST	D. IOAN PUB/LMN	D. IOAN PUB/LMN	-	PUB (RO)
4nEDA	FP6-HRM-MC TOK-DEV	D. IOAN PUB/LMN ROMANIA	D. IOAN PUB/LMN	-	PUB (RO)
SCEE	FP6-HRM-MC SCF	G. CIUPRINA PUB/LMN ROMANIA	D. IOAN PUB/LMN	CST(D)	PUB (RO) TUE (NL), TUD (D), WUP (D), CATANIA (I) ROSTOK (D)
ETASIP	FP6-HRM-MC TOK-IAP	R. ENE SYNAPTO, ITALY	D. IOAN PUB/LMN	SYNAPTO (I)	TUE (NL), PUB (RO)

The long and solid European partnerships between the academic and research teams from **the leading European companies** in the Silicon industry: Philips, Infineon and ST is proven by the following table:

	PUB	ROS	WUP	CAT	TUD	TUE	PHI-LIPS	INFI-NEON	ST
SCEE since	2000	1997	1997	2002	1997	2002	1997	1997	2004
ECMI since	-	2000	1994	1994	2000	1994	1994	1994	2000
MACSI net	+	-	+	+	+	+	+	+	+
FP5/Codestar	+	-	-	-	-	+	+	-	-
FP6/Chameleon	+	-	-	-	-	-	+	-	-
FP6/Comson	+	-	+	+	-	+	+	+	+
Handbook XIII	-	-	+	+	-	+	+	+	-

Where SCEE means the international Conference in Scientific Computation in Electrical Engineering (http://www.scee06.org), as well as involvement in the SCEE-SCF European project. **ECMI** means European Consortium for Mathematics in Industry (http://www.ecmi.dk/) and **MACSI net** is the Euro-net on Mathematics, Computing and Simulation for Industry (http://www.macsinet.org/). **Handbook XIII** means authorship at "Handbook of Numerical Analysis, Volume XIII, Numerical Methods in Electromagnetics", Editor P.G. Ciarlet, a reference for CSE, SCEE and Computational electromagnetics communities. As may be noted PUB/LMN has a strong and long term European partnership in the area of CSE, SCEE, nEDA, being involved in many important projects.

2.4. PROJECT RESOURCES

For a successful completed of the above-mentioned projects, a critical mass of resources is necessary. They may be classified in:

- Human resources: experienced researchers, students, teaching, managerial and technical/ administrative staff;
- Infrastructure and facilities: appropriate rooms, hardware, software, networking, libraries.
- Financial support for the research training, to cover staff cost, travels, consumable, upgrading, managerial cost and overheads.

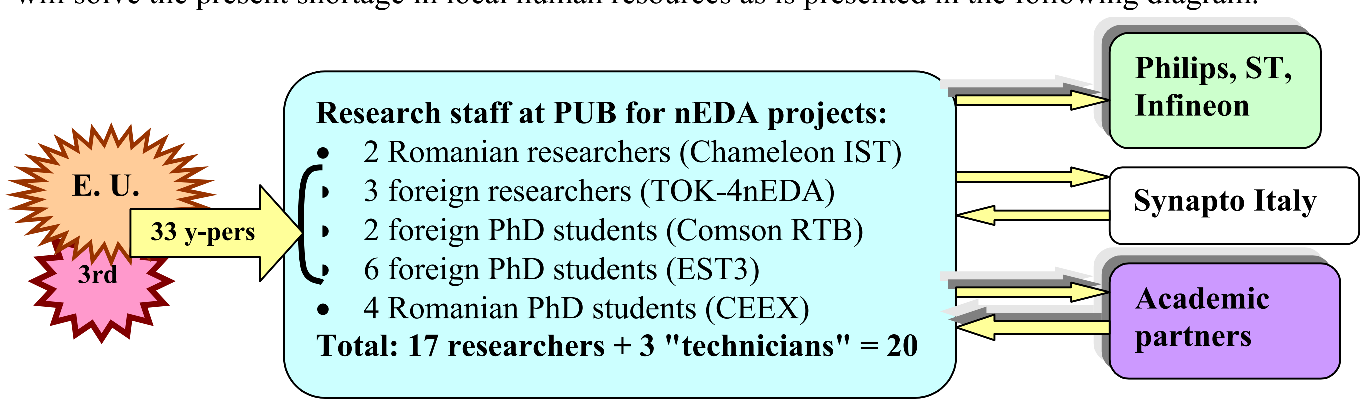
Of course time may be considered a also crucial resource, from management point of view.

2.4.1. HUMAN RESOURCES

They are described in sections 3.1-3.3. Following table shows the shows the level of the human and financial resources involved in the projects of nEDA strategy.

SHORT NAME	PROGRAM	STAFF-PUB PERS X MONTHS	STAFF-TOTAL PERS X MONTHS	PUB BUDGET (EURO)	TOTAL BUDGET (EURO)
CODESTAR	FP5-IST	*30*	*300*	177 000	2 631 594
CHAMELEON	FP6-STREP	*60*	*341*	257 400	2 150 595
COMSON	FP6-HRM-MC RTN	*72 (ESR)*	*360*	167 692	1 650 000
EST3	FP6-HRM-MC EST	*264 (ESR)*	*264*	587 000	587 000
4nEDA	FP6-HRM-MC ToK-DEV	*72 (ER)*	*72 (ER)*	343 068	343 068
SCEE	FP6-HRM-MC SCF	*2*	*6*	57 266	155 200
ETASIP	FP6-HRM-MC ToK-IAP	*48*	*123*	457 933	1 172 000
TOTAL		***746***	***1 466***	**2 047 359**	**8 689 457**

The key idea of the proposed strategy is to blend in an organic manner the research with the training at the Doctoral level. The research training indicated in the previous table is dedicated to the foreign PhD students (a restriction imposed by Marie Curie fellowship). Thus the mobility within European projects will solve the present shortage in local human resources as is presented in the following diagram.



2.4.2. Infrastructure and Financial resources

Infrastructure and facilities are described in section 3.5. Considering 10 square meter per a researcher, to host the nEDA research team are necessary at least 200 square meters (rooms EB 206, EB211, EB212).

According to previous table, the average financial support for a member of nEDA team is of about 100 000 Euro, which is enough for at least three years of research.

Normally, PUB should bring its financial contribution to such project, but taking into account the present state it is realistic to count only on contributions "in kind" as well as allowance for CIEAC to handle the managerial cost and the project overhead.

To conclude, the **critical resources** for the defined strategy, are:

- Two key persons, able to control the defined strategy from scientific and managerial point of view;
- The necessary rooms, estimated at 200 square meters, with access to the PUB infrastructure;
- The financial support from European Commission, estimated at 2 million Euro.

The rest of the necessary resources may be hired or acquired from the European "market".

2.4.3. Time Schedule

The schedule of projects is shown in the following Gantt chart:

Project	Months	**6**	**12**	**18**	**24**	**30**	**36**	**42**	**48**
CODESTAR	30								
CHAMELEON	30								
COMSON	48								
EST3	48								
4nEDA	48								
SCEE	30								
ETASIP	36								
CEEX/nEDA	36								
FP7/nEDA	30								

The T0 moment is expected to be 1st January 2006 +/- three months.

2.5. Expected Impact

2.5.1. Benefits for the host

Besides the impact on local research, the research-training projects will generate benefits for Politehnica University of Bucharest by **reinforcing its capability to provide structured training** in timely areas such as: High Performance Computing (HPC), Computational Science and Engineering (CSE), and Scientific Computating in Electric Engineering (SCEE). The new educational programs build upon ToK in these areas will have the capacity to graduate each year: 24 Bachelors, 12 Master and 6 Doctoral degree, students coming from Romania and abroad. The present structure of PUB encourages mainly the non-numeric applications of IT. Our plan is to change this structure, **bridging the existing gap between Computer Science and Computational Science**, and restructuring and enforcing the second pillar. The expectation of local community of researchers is to have access to training, consulting, tools and knowledge as in the European HPC centres, necessary to make their scientific effort more efficient.

The outcome of the ToK-4nEDA, RTN-Comson, and EST3 projects, such as the manuals and the course support material (slides, demos, tutorials, lab exercises, design specifications, user's guides, best practice guides, etc) will be electronically archived. These results will be exploited, considering IPR, after the end of project in the newly established Doctoral School, in the benefit of Romanian and foreign students and post-doctoral fellows within virtual classrooms (EST3 and RTN-Comson projects). It is the main institutional outcome of the proposed strategy. Moreover, a significant impact of the proposed project is expected within Romanian higher education system, **at national and regional level,** not only by developing the regional human resources, but also by dissemination in other Romanian universities, at Iassi, Cluj, and Timisoara.

As effect, young generation of researchers will understand the local opportunities to achieve excellence in science and engineering, and to transform the present migration (brain drain) of talented peoples into a successful mobility process, with positive **societal impact.**

Briefing the beneffits to the host, it results following selective list:

- European network to support research and training in SCEE, EDA at PhD level;
- Partnership with leader European industrial partners and top researchers;
- Challenging inter and multi-disciplinary topics requested by industry;
- Advanced scientific and technological results, key knowledge and related IPR;
- Valuable experimental results, benchmarks in advanced technology;
- Transfer of created knowledge in EDA toward European industrial companies;
- Curricula development for joint Doctoral studies in CSE and SCEE;
- Transfer of HPC knowledge for the benefit of research-training in CSE, EDA;
- Development of infrastructure and facilities in cluster-grid technology;
- Organisation of several event such as SCEE 2006 with international impact;
- Enforcing the capability to submit successful FP7 proposals;
- Other benefits, such as spin-off, funding diversification, papers and book publishing, better image, and competent people.

2.5.2. Interest at the European level

The planned projects contribute also to the expanding of the structured ERA toward East, thus increasing the attractiveness of science for the Romanian young generation. It is of European interest the **development of abundant human resources** highly educated in coherent manner, with interdisciplinary competencies in nanaoelectronics, combined with those of computational science. Both topics belong to the **thematic priorities of the next 7th framework** research programs. The project will bring so its contribution to this development objective. We are definitely willing and able to innovate, reform and deliver higher quality in teaching and research at world-class level.

Another leverage effect of the proposal is expected by turning the existing investment in HPC at the host in an efficient one. PUB invested recently about 1 million Euro in hardware (a HPC system with shared-memory architecture and 32 processors) and in the appropriate software. Unfortunately, it is mainly a study subject not an effective tool in computational research, and therefore the impact of this investment in the advanced IT technology outside Computer Science Department is deep under our expectation. The explanation is the shortage of local competencies in the exploitation of these expensive resources, for the benefits of researchers in science/engineering (other then IT), with suitable support for numerical software developers. The proposed ToK-4nEDA is directed to solve exactly this problem. Moreover a suitable management of our HPC resources will have not only a broader local impact, but also one at European level, by their integration in the shared continental grid, and increasing in this way the **available computational power in Europe**. It is understandable why the priority of HPC management (controlled by computer scientists) is Computer Science with topics such as data mining, computer vision or security (see e.g. ACM curricula in SE). As it happen in other EU universities, the development of innovative numerical software solutions for challenging problems of Computational Science is not one of their priorities, and barriers between disciplines are generated. ToK may eliminate them.

2.5.3. Breaking through achievements for a sustainable development

Three potential achievements of the proposed strategy are breakthroughs for the host organization:

- Set-up of Doctoral Scholl at PUB, having as topics (beside others) CSE and especially SCEE,
- Publishing a book dedicated to "Compact modeling of electomagnetic devices", in a prestigious publishing house such as Springer,
- Set-up of a high-tech SME as a PUB-LMN spin-off, dedicated to sell on global market and to maintain the developed "nEDA tools for signal integrity verification".

The success of these three initiatives depends very much of independent factors, such as:

- Local support in PUB for the Bologna process, and for the "Berlin Declaration of European Education Ministers" of 19 September 2003, to enforce structural training at doctoral level in a 3 years cycle, instead of the present system, based on individual tutoring. For the moment, seems to be not yet a critical mass in the favour of this approach, especially in the Faculty of Electronics.
- The spare time and energy remained to write a book depends on how fine works other priorities in management, training and research activities of such innovative strategy as nEDA.
- The success of the spin-off depends on the value of obtained research results, but also on the local economic environment (support for SME in Romania, know-how for a successful run of SME, accessibility to venture capital, motivation of highly trained talented young people to be hired in such a company, and support for a knowledge based high-tech SME from PUB technology park).

Despite of these risks, the activity within nEDA strategy will be carried on with perseverance, aiming to find solutions and to fulfill the targeted objectives.

3. DESCRIPTION OF THE HOST CAPACITY AND JUSTIFICATION OF ITS QUALITY

3.1. POLITEHNICA UNIVERSITY OF BUCHAREST

The host institution is the "Politehnica" University of Bucharest (PUB), Romania (www.pub.ro). It is not only the oldest technical university, but also the largest one in Romania. With over 180 years of existence, PUB represents one of the reference institutions for the Romanian higher education, being the main source of engineers trained at Bachelor, Master and Doctoral levels. As a member of EUA (European Universities Association) and CESAER (Conference of European Schools for Advanced Engineering), PUB pays special attention to international co-operation, unfolding more than 85 agreements with similar universities, mainly from Europe and the United States. The university is structured in 14 Schools (Faculties) covering fields of electrical, mechanical, chemical, bio engineering, material and computer science. Foreign languages (English, French and German) are used in teaching, within one of the Schools.

PUB has a high capacity to provide mentoring and tutoring of ESRs in CSE, at international level. The number of professors authorised to supervise PhD is 307 (133 in fields of electric engineering, 25 in computer science, 4 in mathematics, 4 in physics, 46 in applied chemistry, the rest covering mechanics, bioengineering and materials science). The total staff number is 3150 in teaching and research, 1846 administrative and technical staff. More than 20,000 undergraduate students are enrolled in PUB and 2678 postgraduate fellows are preparing their Master and Doctoral thesis here. Financial

reasons restrict the number of ESRs supported full-time for Doctoral studies at only 290. PUB is placed in a green campus, having more than one million square meters, on both sides of the Dambovita river which cross Bucharest, 150,000 square meters of buildings and 12,000 places in student hostels (please see the image gallery above).

The Numerical Method Laboratory (LMN) is located in a modern building, having enough space for our visitors, such as rooms EB 206, EB212 and EB 213 with over 200 sqm, dedicated to the present projects.

3.2. DEPARTMENTS AND GROUPS

The research groups within PUB, related to this proposal have an established track record of providing excellent research training and supervision to both Romanian and international postgraduate students, appreciated as highly trained in their post doctoral stages in Europe, USA or Japan. The scientific quality of research groups involved in our project, as well as the research infrastructure/facilities they have access to guaranties the success of proposed training (plese see sections 4.6 and 4.7). The heads of research groups involved in EST3 project have the following skills and experience in research:

Name	**Dpt./Group**	**Expe-rience**	**Competences and skills**
Prof. Dr. ***Udriste*** *Constantin,* udriste@mathem.pub.ro	Mathematics Group (Applied Mathematics, Symbolic and Numeric Meth.)	42 years	Algebra, Differential Eqs, Calculus, Operational Researches, Numerical Methods, Differential Geometry, Convex functions and optimization methods, Maple, Mathematica
Prof. Dr. Ing. ***Cristea*** *Valentin* Valentin@cs.pub.ro	Computer Science Group (HPC - CoLaborator)	36 years	Parallel Algorithms, Advanced Programming Techniques, Computer Network Software, Communication Protocols, Input/Output Systems, EGEE, RoGRID
Prof. Dr. Ing. ***Ioan*** *Daniel* lmn@lmn.pub.ro	Computational Electromagnetics Group (CIEAC - LMN)	35 years	Numerical Methods, Computational Electromagnetics, Electric Circuit, CAD-EM, EDA, Maple, Matlab, C++
Prof. Dr. Ing ***Profirescu*** *Marcel* Profires@edil.pub.ro	Electronics TCAD Group (EDIL)	41 years	Electron Devices and Circuits, TCAD, Software Tools in Microelectronics, Integrated Circuits Simulation and Design, Simulation, Continuum education and distance learning
Prof. Dr. Ing. ***Morega*** *Alexandru* amm@iem.pub.ro	Bio-engineering Group (IEM)	25 years	Data networks, Numerical Models in Bio, Electrical and Mechanical Engineering, FEMLAB, FIDAP/GAMBIT, Mathematica, FORTRAN, Matlab/Simulink
Prof. Dr. Ing. ***Balan*** *Corneliu* balan@hydrop.pub.ro	Computational Fluid Dynamics Group (REOROM)	23 years	CFD, Fluid mechanics, Continuum mechanics, Rheology and rheometry, Mathematica, FemLab, Fluent
Prof. Dr. Ing. ***Albu*** *Mihaela* mialbu@pcnet.ro, savu@ctanm.pub.ro	Experimental and Measurement Group	18 years	Distributed measurement systems, simulation techniques, virtual and Internet-based laboratories, remote experimentation, Matlab, LabVIEW, PSpice.
Prof. Dr. Ing. ***Meghea*** *Aurelia* a_meghea@chim.pub.ro	Complementary Group (Management, Communication)	40 years	Biophysical chemistry, Environment and Quality Management Systems, Project Management, Strategy for sustainable development in knowledge-based society

3.3. KEY PERSONS

The CVs of the key persons are briefed below.

IOAN Daniel Constantiu

Position: Professor at "POLITEHNICA" University of Bucharest, Electrical Eng. Dpt.

PhD supervision area: Electrical Engineering **Tel/Fax :** +(4021) 4111190

Gender/Date of birth/Nationality: Male / January 1, 1948 / Romanian,

Foreign languages: English, French

e-mail/URL: lmn@lmn.pub.ro / http://www.lmn.pub.ro/~daniel

Education and training: 1954-1961 Elementary school, Braila; 1961-1965 High School Nicolae Balcescu, Braila; 1966-1970 Polytechnic Institute Bucharest, MSc in El.Eng.; 1972 -1978 Polytechnic Institute Bucharest, PhD in El.Eng

Professional skills and competencies: teaching courses at university levels in: Theoretical Background of Electrical Engineering (Circuit theory, Electromagnetics), Computer Aided Design of Electromagnetic Devices, Computer Aided Electric Engineering, Industrial Electronics, Numerical Methods, Computational Electromagnetics.

Computer skills and competencies: FORTRAN, PASCAL, BASIC, Assembler, C, C++, MATLAB and operating systems: Windows, Unix.

Work experiences: 1970-1978 Teaching assistant at Polytechnic Institute Bucharest, El. Eng. Dpt.; 1978-1990 Lecturer at Polytechnic Institute Bucharest, El. Eng. Dpt; 1990-1994 Associate professor at Polytechnic Institute Bucharest, El. Eng. Dpt; 1994- present Professor at "Politechnica" University Bucharest, El. Eng. Dpt; Since 1984 head of LMN (Numerical Method Lab.); Since 1995 Chair of CIEAC research center.

International research projects: Coordinator and partner PECO/CAEE, TEMPUS/JEP2717 COPERNICUS/MANODET, JSAEM/ENDE, WB/BCUM/CoLaborator, FP5/IST/Codestar, FP6/STREP/CHAMELEON. Program Comm. Member: CAEE, JSAEM, SCEE, DATE.

Publications: Six university textbooks; two books; over hundred papers and communications published in Romania and abroad: 21 in ISI kernel journals, 49 - INSPEC, 29 in ISI Proceedings.

Visits and stages abroad: EdF/DER (F), INPG (F), SUPELEC (F), Politecnico di Torino (I), University of Bath (UK), London University (UK), CALTECH (USA), ISU (USA), CMU (USA), T.U. Graz (A), T.U. Budapest (H), EPFL (CH), Tokyo University (J), T.U. Eindhoven (NL), etc.

Awards: Romanian Academy - "Gh. Cartianu Award", IEEE Millenium Medal

Relevant Papers:

1. Irina Munteanu, Tilmann Wittig, Thomas Weiland şi **Daniel Ioan.** *FIT/PVL circuit-parameter extraction for general electromagnetic devices*. **IEEE Trans. Magn.** vol. 36, nr. 4, pp. 1421-1425, iul. 2000.
2. **Daniel Ioan**, Irina Munteanu. *Models for capacitive effects in iron core transformer.* **IEEE Trans. Magn.** vol. 36, nr. 4, iul. 2000, pp. 990-994.

3. **Daniel Ioan**, Gabriela Ciuprina, Cătălin Ciobotaru. *Hybrid algorithms for nonlinear equations of the magnetic field.* **IEEE Trans. Magn**. vol. 36, nr. 4, iul. 2000, pp. 1553-1556.
4. R. Albanese, A. Bossavit, R. Fresa, **D. Ioan**, G. Rubinacci, A. Tamburrino, F. Villone. *Identification of B-H curve from external measurements using complementary formulations.* **Physica B (Condensed Matter),** vol. 275, pp. 228-232, Elsevier, 2000.
5. **Daniel Ioan,** Anton Duca. *Use of MTANN Systems to Solve Inverse ENDE Problems.* Electromagnetc Nondestructive Evaluation (IV), vol. 17, pp. 159-166. S.S. Udpa and T. Takagi and J. Pavo and R. Albanese (Ed), **IOS Press**, Amsterdam, 2000. ISBN 90 5199 445 5.
6. Irina Munteanu, Silvia Drobny, Thomas Weiland şi **Daniel Ioan**. *Triangle serch method for nonlinear electromagnetic field computation.* **COMPEL, Int. J. Comput. and Math. in Electr. and Electron. Eng.,** vol. 20, nr. 2, pp. 417-430, Emerald, 2001.
7. Irina Munteanu şi **Daniel Ioan.** *Symbolic Computation with Maple V for Undergraduate Electromagnetics.* **IEEE Transactions on Education**, vol. 44, nr. 2, pp. 217, may 2001.
8. **Daniel Ioan**, Mihai Rebican, Anton Duca. *Use of Evolutionary Agents to Solve ENDE Inverse Problems.*Electromagnetic Nondestructive Evaluation (V), vol. 21, pp. 59-66. J. Pavo and G. Vertesy and T. Takagi and S.S. Udpa (Ed), **IOS Press**, **Amsterdam**, 2001. ISBN 1 58603 155 4.
9. **Daniel Ioan**, Irina Munteanu. *A Survey on Parameter Extraction Techniques for Coupling Electromagnetic Devices to Electric Circuits.* Scientific Computing in Electrical Engineering, vol. 18, pp. 337-357. Ursula van Rienen and Michael Gunther and Dirk Hecht (EDS.), **Springer Verlag**, Berlin, 2001.
10. **Daniel Ioan** şi Mihai Rebican. *Numerical Model for Eddy Currents Testing of Ferromagnetic Steel Parts.* **IEEE Trans. Magn**., vol. 38, nr. 2, pp. 1037-1040, march 2002.
11. B.Trapp, I. Munteanu, R. Schulmann, T. Weiland şi **D. Ioan.** *Eigenvalue Computation by Meen of Tree-Cotrec Filtring Technique.* **IEEE Trans. Magn**., vol. 38, nr. 2, pp. 445-448, march 2002.
12. Irina Munteanu, C. Ciobotaru, **D. Ioan.** *Reducing the complexity order of the algorithms for magnetic field nonlinear problems.* **COMPEL, Int. J. Comput. and Math. in Electr. and Electron. Eng**., vol. 21, nr. 2, 2002, pp. 286-295.
13. **Daniel Ioan**, Mihai Rebican. *Extraction of B-H relation based on the inverse magnetostatic problem.* **Japan International Journal Applied Electromagnetics and Mechanics**, vol.13, no.1-4 : 329-34,.
14. **Daniel IOAN**, Gabriela CIUPRINA "*Improved Algorithms for Solving Nonlinear Equations of the Magnetic Field*", **Revue Roumanie de Sciences Techniques Electrotechn. Et Energ.** Vol. 44, no 2-3, pp 209-220 , 2003;
15. **Daniel Ioan,** M.Radulescu,G.Ciuprina - *Fast Extraction of Static Electric Parameters with Accuracy Control*", in Scientific Computing in Electrical Engineering (W.H.A. Schilders et al Eds), **Springer**, 2004, pp.248-256
16. **D. Ioan,** Gabriela Ciuprina, M. Radulescu and M. Piper – *Algebraic Sparsefied Partial Equivalent Circuit (ASPEEC)* in Scientific Computing in Electrical Engineering, vol 2 (M. A. Anile et al Eds), **Springer**, 2005, under press

Other relevant papers and communications are listed in the Section 6.2.

CIUPRINA Gabriela

Position: Associate Professor at "POLITEHNICA" Univ. of Bucharest, Electrical Eng. Dpt.

Tel/Fax : +(4021) 4111190

Gender/Date of birth/Nationality: Female / November 6, 1967 / Romanian,

Foreign language(s): English, French

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Education and training: 1974-1982 Elementary school, Galati; 1982-1986 High School Vasile Alecsandri, Galati; 1986-1991 Polytechnic Institute Bucharest, MSc in El.Eng.; 1991 -1999 Polytechnic Institute Bucharest, PhD in El.Eng

Professional skills and competencies: teaching courses at university levels in: Numerical methods for Electrical Engineering, Optimization techniques, Electromagnetic waves.

Computer skills and competencies: FORTRAN, PASCAL, BASIC, Assembler, C, MATLAB, Scilab, Latex and operating systems: Windows, Unix.

Work experiences: 1991-1999 Teaching assistant at Polytechnic Institute Bucharest, El. Eng. Dpt.; 1999-2002 Lecturer at Polytechnic Institute Bucharest, El. Eng. Dpt; Since 2002 Associate professor at Polytechnic Institute Bucharest, El. Eng. Dpt;.

International research projects: FP5/IST/Codestar, FP6/STREP/CHAMELEON

Publications: Three textbooks; over forty papers and communications published in Romania and abroad, out of which 7 in ISI kernel journals, 6 in ISI Proceedings.

Visits and stages abroad: University of Bath (UK).

Recognition: Romanian Academy - "Gh. Cartianu Award".

1. Gabriela Ciuprina, **Daniel Ioan**. *Evolutionary Strategies used in Optimisation of Electromagnetic Field Devices*. **Journal of Electrical Engineering,** vol. 1, nr. 2, pp. 14-18, 2001.

2. Gabriela Ciuprina, **Daniel Ioan** şi Irina Munteanu. *Use of Intelligent-Particle Swarm Optimization in Electromagnetics***. IEEE Trans. Magn**. , vol. 38, nr. 2, pp. 1037-1040, march 2002.

3. Gabriela CIUPRINA, **Daniel Ioan**, Irina Munteanu, Mihai Rebican, Radu POP. *Optimizarea numerica a dispozitivelor electromagnetice.* **Printech,** Bucuresti, 2002.

4. Peter Meuris**, Gabriela Ciuprina**, Ehrenfried Seebacher, "High Frequency Simulations and Compact Models compared with measurements for passive on-chip components", **International Journal of Numerical Modelling: Electronic Networks, Devies and Fields**, Vol. 18, no. 3, **John Wiley,** 2005.

Other relevant papers and communications are listed in the Section 6.2.

3.4. INFRASTRUCTURE AND FACILITIES

The host institution and particularly the support research groups provide our early stage researchers access to excellent computing facilities. These include our HPC system (shown in figure below): a Sun Enreprise 10k server with 32 processors Shared Memory System - Symmetric Multi-Processing - SMP architecture, providing 22 GFlop/s with 16 GB RAM and 527 GB Storage Array. Giga Ethernet Fibre Optic connects it to the terminals in LMN. Software resources include: Solaris OS, Sun Forte Compilers for C, C++ and Fortran, Sun Performance Library, NAG SMP Library, Matlab with all toolboxes, ANSYS multiphysics, PetSc, NAG, MPI, OpenGL and other software tools from public domain. The ESRs have access also to a Local Area Network of high-end PCs, the first Fast Ethernet LAN installed in PUB, as well as Sun, HP, and SGI workstations. A distributed system, **cluster of PCs** (Beowulf type with minim 32 nodes Intel CPU at 3GHz, 1GB RAM and a low latency interconnect at minim 1 Gbps) **will be installed** in PUB-LMN within ToK-4nEDA project.

A valuable resource of our University is the fast speed broad band Internet access. The main node of the national academic network (RoEduNet) is located in our campus. When they need it, scientists have access to more powerful computing resources using the grid technology.

The proposed ToK project plans to exploit the Grid technology developed during the FP6-IST program as well as to promote the use of shared European research infrastructures. The ToK fellows will contribute to the interconnection of these valuable resources with local computing systems (Sun 10k and PC Cluster), in the benefit of the host research in nano-electronics, and training in CSE, and SCEE.

The proposed project plan to exploit in the benefit of ESRs several specific FP6 actions that aim to promote the shared European research infrastructures, such as:

- Integrated Activities within I3 - Integrated Infrastructure Initiative (to support integral provision of infrastructure related services to the research community at European level);
- Communication Network Development (GEANT - high speed net for all researchers in Europe, and GRIDS - high performance Grids and test-beds), and
- Trans-national Access (access to major research infrastructure).

Another important facility provided to our ESRs is the "Politehnica" University library. It is a long tradition institution, established on 16 February 1868, having now more than 1.5 million books and periodicals. Each research group will also provide access also to their laboratories, experimental facilities and measurement systems. The access to the virtual libraries (collection of IEEE, ACM and SIAM publications) through Internet complements in an efficient manner the library on the paper.

However there is still a lot of space for improvement, and we have a clear strategy for a sustainable development, nEDA projects will contribute to implement this strategy. After the ToK-4nEDA project the following advances in the HPC (High Performance Computer systems) technology are expected for the host capabilities:

- A functional cluster of PCs, Beowulf type described above;
- A functional hybrid (intra)Grid, which interconnects a system with a distributed architecture (PC cluster) and an existing system with parallel (SMP) architecture;
- The connection of the local HPC resources with international ones, using shared-resource model and (extra)Grid technology, resulting a virtual organization acting as resourse for nEDA project.

3.5. RELEVANT INTERNATIONAL COLLABORATIONS

"Politehnica" University of Bucharest has participated in all European important programmes dedicated to human resources development, such as: TEMPUS, SOCRATES, ERASMUS, TEMPRA or LEONARDO. It is an active partner in many international research projects in the frame of the COPERNICUS, PECO, FP5 and FP6 programmes. The World Bank has supported a series of infrastructure development projects in the "Politehnica" University of Bucharest.

A relevant early European co-operation was within TEMPUS JEP 2717/1991-93 and JEN 2717/1993-95 projects, dedicated to the set-up of postgraduate training programmes in Scientific Computation in Electrical Engineering (SCEE), at Master and Doctoral level. The curricula and first textbooks of these programmes were elaborated with precious assistance from our European partners. The main outcome of this project was the opening in 1992 of the first international postgraduate programme in SCEE at the "Politehnica" University of Bucharest. Some of the most prestigious European Universities from France, Italy, Greece, Austria, Germany and United Kingdom were involved in this project (considered by the European Commission as one of "model" TEMPUS I projects). A dedicated Joint European Network (TEMPUS JEN) followed it. This network was extended and now it supports, among other European projects, the present strategy. It includes research groups from the universities listed in the section 2.3.

The first High Performance Computing (HPC) system was installed in our university in 1999. The World Bank financed this project, and using that opportunity, we established a bridge and a communication channel with the HPC American community, in particular with research groups from University of Illinois, George Washington University, San Diego State University, Stanford University, Berkeley University, CALTECH, University of Iowa, University of Maryland, Arizona State University, Carnegie Mellon, Columbia University, Cornell University and Duke University. All of them are running training programmes in CSE at MSc or PhD level.

Another opportunity to establish world-wide co-operation was due to our positive answer to the invitation to get involved in the research and higher education projects with the Japan Society for Applied Electromagnetics and Mechanics. In this way, we have established a partnership with advanced research groups from Tokyo University, Hokkaido University and Tohoku University. All these international co-operation relationships have given us a clear understanding of the global trends, research opportunities and limits of CSE. Many members of our groups have been invited for research or teaching stages in above-mentioned universities.

Our research expertise in several aspects of CSE started in 1982, when the Numerical Models Laboratory (LMN) was established in "Politehnica" University of Bucharest. Since 1992, when the Graduate School in Scientific Computations in Electrical Engineering was opened, more than 250 ESRs have received research training at Master and Doctoral level. All graduates of our school become top specialists, able to cover excellent open position, available all over the world.

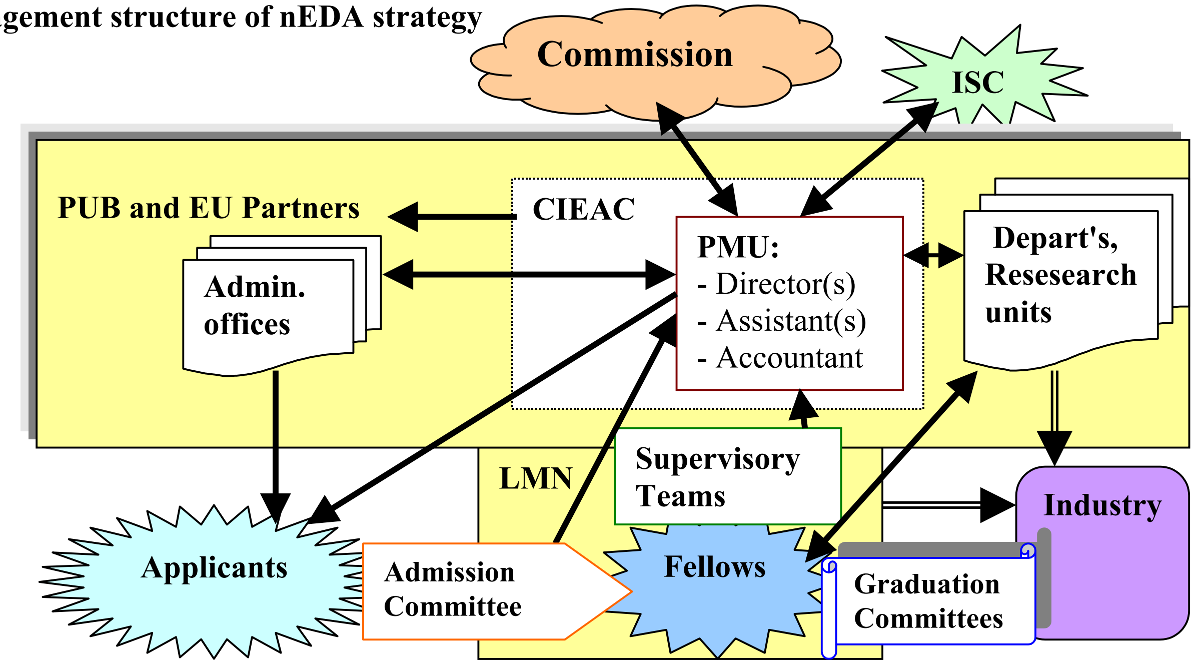
A selected list of relevant research and training projects we were involved are presented in the section 4.7.

4 MANAGEMENT AND FEASIBILITY

4.1. ORGANIZATIONAL STRUCTURE AND MANAGEMENT PRINCIPLES

The contractor of the proposed projects is **"Politehnica" University of Bucharest (PUB)**, the biggest technical Romanian University, with a solid tradition in international co-operation, and management of research-training national or international projects and programs.

Management structure of nEDA strategy



The structural unit that provides the management of the proposed strategy is **the Research Center for Computer Aided Electrical Engineering (CIEAC)** of PUB. A series of laboratories from different departments, such as Electrical Engineering, Electronics, Power Engineering are affiliated to the research center CIEAC, aiming to shared exploit of the administrative services and its infrastructure. The research activity itself is carried on within these laboratories. The Numerical Methods Laboratory (LMN) will coordinate the research/training/innovation activity within proposed projects, while the financial and administrative activities will be carried on within CIEAC.

In order to take care of all the day-to-day practical arrangements required for a successful run, a **Project Management Unit (PMU)** will be set-up within PUB-CIEAC Research Centre. This executive team comprises the Directors (projects co-ordinators), assistant manager(s) and a representative of the PUB financial department (project chef accountant). The PMU will be in charge of any matters related to financial, administrative and secretarial tasks including:

- progress monitoring, quality assurance, and the day-to-day management of scientific and technological activities
- set-up of the management procedures and appropriate plans;
- resource management, acquisitions and payments;
- preparation of the periodic reports to the European Commission or other funding bodies (such as progress report, cost statement and the audit certificate);
- corrective actions;
- staff recruitment;

- organization of training, travels, meetings, acquisitions, day-to-day business;
- set-up of a detailed dissemination and exploitation plan of the research results and newly created knowledge;
- communication management;
- set-up and maintenance of a web site, with both public and private areas;
- publicity, public image and increase of the general public awareness for the European science and in special for FP6, FP7, Marie Curie actions, CSE, SCEE, and nanoelectronics.

This implementation team will co-operate with research groups, teaching staff from several departments and with several **PUB administrative offices**, such as:

- International Relationships;
- Graduate Studies;
- Foreign Students;
- Financial and accounting;
- Public Relations.

The **General Director** (coordinator with most valuable projects) will provide the overall policy and direction for the projects from both administrative and scientific perspectives, including:

- chair of the International Steering Committee;
- monitor the quality assurance of the projects;
- risk management and suitable contingency measures;
- nominate the members of the Admission Committee and Supervisory Teams;
- will act as a knowledge manager, coordinating protection, publishing and exploitation of the generated knowledge and associated IPR as exploitation manager.

Other management bodies will be organised within the EST3 project, such as:

- **Admission Committee** will select ESRs, based on The Code of Conduct for the Recruitment of Researchers (2005/251/EC),
- **Supervisory Teams** (with minimum three members for each doctoral candidate, and one-two members for a short visit ESR);
- **Doctoral Graduation Committees** (headed by the Dean, doctoral supervisor(s) and 3 independent reviewers, at least 2 from other universities than PUB, according to the Romanian law).
- **The International Steering Committee** (ISC) includes representatives of academic and industrial partners. It will be in charge with the following tasks:
  - to monitor the work progress and check the achievement of the results;
  - to evaluate the annual reports on the scientific results;
  - to take all formal decisions regarding strategy amendments, planning and budget related issues;
  - to solve any disputes.

The decisions will be taken by the bodies mentioned above and disputes will be solved using traditional academic procedures, including voting procedures, and virtual meetings.

The strategy complies to the best FP6 management practices, including dedicated management staff, with the appropriate professional background (PMU), as well as a management board (ISC) with a certain degree of independence from the day-to-day project management and operation. The management will put emphasis on a strategic monitoring of outputs rather than on the detailed monitoring of inputs. PMU and ISC will take care of projects priorities balance and integration using the best practice of FP6/IP. There are considered: vertical integration (stakeholders and knowledge producers: teaching staff, senior and ES researchers), horizontal integration (several multidisciplinary areas: mathematics, computing, electronics, CSE, SCEE, IST, nanotechnologies), activity integration (training, research - theory, simulation and measurements-, innovation, exploitation and dissemination), sectoral integration (university, research units, industry, SME) and financial integration (public, private).

Active monitoring procedures will be defined aiming to avoid loss of projects control. If one or more groups or individuals do not fulfil their obligations, the project will have the mechanism to warn them, impose sanction on them, and reject them eventually from the partnership, if necessary.

The overhead and management expenses (including co-ordination and audit cost) will be managed by PUB-CIEAC, according to the PMU statute and the contract. The financial management of the project will comply very strict the contract and best practice in the area**.** Autonomy and independence in the resource management according to the contract is the only method to avoid bureaucracy and to fulfil successfully the project objectives. The projects will be assessed based on outputs and not monitoring inputs, thus eliminating the bureaucratic structures. After the contract signature, the director has the exclusive accountability in front of financing body. Quality assurance issues will be on the agenda of the PMU and ISC meetings, and preventive and corrective actions will be taken correspondingly.

For other management principles, please see section 4.7.

4.2. Researchers Recruitment

Recruitment strategy of the researchers involved in nEDA research-training projects is based on the principles of *The Code of Conduct for the Recruitment of Researchers* (2005/251/EC) about selection, transparency, openness, correctness, systematic apply of the equal opportunity principle and recognition of mobility experience.

Applicants should have an appropriate academic background. It is important for them to have knowledge in mathematics and experience in solving problems with computers. Experience in nanoelectronics or EDA is not required. Professional work experience in related fields will be considered merit, and they should fulfil the conditions to be an eligible researcher for Marie Curie fellowship. The advertising campaign will start as soon as possible, in the first month of the project. The Tok-4nEDA fellows should be graduate in Computer Science or Software Engineering.

The **selection** of fellows will be namely on the basis of: aptitude to carry out individual projects, potential for excellence, scientific quality, impact and the benefit of the proposed research to the individual fellow's research career. The internationally comparable assessment procedure based on applications and interviews will ensure transparency, impartiality, and equal supportive treatment of all applicants. The principle of equal opportunities will be applied, in particular between men and women. At same qualification, women will be preferred. The best practice will be applied to inform and convince talented people, especial women about the advantages to do research in Romania. The selection committee will comprise at least 50% women, in order to understand better the woman's applications.

The **open positions (vacancies) will be advertised openly** world-wide, using inexpensive electronic communication means, such as web and e-mail vacancy databases (http://improving.cordis.lu/mc, Pan-European Researcher's Mobility Portal: europe.eu.int/eracareers, or mailing lists of kind www.job) and the web-sites of our European partners. The National Contact Points NCPs will be also advertised as well as Informal of Liaison Offices (www.iglortd.org). The best practice such as: web sites of EST in Advanced Genetic Analysis at University of Leeds (www.fbs.leeds.ac.uk/agape), or International MSc Programme at TU Munchen (www.cse.tum.de/course) will be used as models. More extensive but targeted methods such as letters, posters and visits to our partner universities aiming to personal discussion with potential candidates are also planned. Advertising in professional publications and during international conferences will be also used. Since the quality of the project outcome is dictated mainly by the value of the appointed fellows, all active "head-hunting" techniques will be intensively used in the recruitment.

Candidates from any EU member or Associate State are welcome to join our research team. A maximum of 30% of the number of funded researcher-months could be appointed for third country researchers, e.g. from China, Japan, Russia, or India. Thus, the international dimension of the European Research Area will be enforced, with positive long-term effects. We expect to attract ESRs mainly from Greece, Bulgaria, Hungary, Israel or Moldavia. Therefore, to be efficient and feasible, our recruitment strategy will focus on these target groups, but according to the equal opportunities principle not restrict choice to them.

We learned that the recruitment procedure is determinant for the level of scientific success of any research-training project, therefore we will treat it very carefully.

4.3. Dissemination and Exploitation of the Results

It is of fundamental importance to the host and for consortium of European partners that the knowledge generated in the proposed projects is shared with other research groups and companies in order to:

- Generate broader acceptance for the developed technology and its applications
- Inspire more research projects in the area
- Generate interaction and feedback from other groups and learn from their experience
- Generate other positive benefits to the consortium or the European Community

Therefore, the dissemination program includes:

- Organisation of a seminars, workshops, e.g. SCEE events.
- Participation in conferences and workshops, such as the Compumag, IEEE CEFC, SCEE, DATE, and PIERS.
- Results that are of interest to the various research communities will be published in top-level research journals. For example: IEEE Trans. CAD of integrated circuits and systems, IEEE Trans. Magnetics, Compel, IEEE Journal of Solid-State Circuits, etc.
- Information will also be published in the popular press and posted on web.
- Publication of the results in the various web sites of the European Commission, especially CORDIS PROJECTS and CORDIS RESULTS.

Results will also be demonstrated and explained to visitors and to industry representatives from companies and research institutions all over the world.

Exploitation of the results will be done in the higher education process and IPR licensing for the developed software tools and methodology. The opportunity and feasibility of spin-off - set-up of a local SME aiming the commercial exploitation will be investigated.

4.4. Publicity

The results of the proposed project will be disseminated using several methods, aiming to rise public awareness of the IST and Marie curie actions and of the FP6 and FP7 in general.

Each published paper as well as PhD thesis, will acknowledge the financial support of European Commission. In order to disseminate their knowledge and exploit the research results, the researchers will be encouraged to use IPR-Helpdesk and Gate2Growth.We expect an important impact of the nEDA dedicated web site. Banners, posters and recruitment adverts will be posted in PUB and abroad at our European partners, during the international conferences, seminars and workshops.

The "Image and Public Relations" office of PUB will be involved in the promotion of following events: start-up of PC cluster and beginning of Doctoral studies in CSE. The interest of the media (television, radio, newspapers) and science communicators will be focused on this important events for Romania. The mechanism and channels through which the general public and especially the young one are exposed to science related information, such as press and science centres, will be exploited. Particular attention will be paid to factors within the professions involved, such as scientists, educators, science commentators, science journalists and science policy makers, in order to shape perception of science, its role in Romanian society and the importance of EU policies in the field. It is well known that the lack of visibility of Europe’s often excellent research leads excellent human resources to move out of research or out of Europe;

The publicity is treated as an important component of the project aiming to bridge the gap between the European dimension of science and the national public. In this way, citizens are encouraged to better understand the beneficial impact of science and, in particular, of HPC, CSE, SCEE and nanotechnologies on their everyday lives. The publicity efforts will be focused through three brands: Romania, PUB and LMN.

4.5. Intellectual Property Rights

As was mentioned just from beginning, the **strategic goal** of the proposed strategy is to increase the contribution of the host in strengthening of the scientific and technological bases of industry, in order to increase the international competitiveness of European knowledge-based economy. This goal can not be reached without an appropriate attitude about Intellectual Property Rights (IPR). This is why the host organisations of proposed projects have an active patenting and licensing policies.

The Intellectual Property Rights (IPR) will be managed using the FP6 basic principles and the European laws in this domain. Ownership resides, as is stipulated in the agreements, with person generating the knowledge. All participants will be encouraged to keep record of knowledge created during the project (who invented/discovered, what and when), to protect it and to inform PMU about them and their level of confidentiality. A detailed plan for IPR management (as a part of dissemination and exploitation plan) will be set-up by the PMU, during the preparatory stage of each project (www.ipr-helpdesk.org). The PMU and supervisory teams will help ESRs to disseminate and to exploit in a professional manner all new knowledge, created during the project. The ESRs will be informed that, according the contract it is obligatory to provide any knowledge, which "could be industrially or commercially applicable" with "adequate and effective" protection through the different intellectual property rights.

The researchers involved in nEDA project have access to the confidential data and know-how coming from our industrial partners. PMU is in charge to take all necessary measures to preserve the confidentiality. Since the Grid will be extended outside organization, enhancement of computer and data security is an important concern of the project.

The project coordinator will be the exploitation manager for the project, who will co-ordinate all aspects that have an influence on the exploitation of the results, such as patents, licenses, diffusion activities, as well as negotiations concerning exploitation issues with third parties. When the contractor will grant or transfer the knowledge ownership to the third parties, the Commission will be informed about planned transfer, asking for an agreement. The Commission will be notified also for the intention of publication of sensitive issues 60 days in advance.

4.6. SCIENTIFIC COMPETENCE

The Numerical Methods Laboratory (LMN) belongs to the School and the Department of Electrical Engineering of PUB and it is affiliated from the research point of view to CIEAC. It was established in 1982 as an advanced research and higher education unit, aiming to promote the use of information technology in electrical engineering areas at world quality level. Expertise areas of LMN cover: computational electromagnetics, numerical techniques, coupled field-circuit problems, optimization and inverse problems, soft computing, EDA, non-destructive evaluation, computer aided education.

Due to its multi- and inter-disciplinary approach, LMN is one of the few research groups with competencies in both computational electromagnetics as well as in the circuit and systems modeling and simulation. Only in the last years, the LMN group published more than 20 papers related to coupled field - circuit problems and automatic extraction of compact circuit models for passive devices at high frequency. LMN has a wide experience in developing hardware validated EDA tools for effective EM modeling, based on innovative discretisation techniques of Maxwell equations with accuracy control, such as *dFIT (dual Finite Integrals Techniques*), the basic technique of the original ALROM modeling strategy. LMN is one of the first promoters of ROM techniques in computational electromagnetics, including nonlinear models. An evaluation platform for Reduced Order Models methods named *ROM Work Bench* was developed within Codestar prject at LMN. Hybrid deterministic-stochastic (simulated annealing, genetic, evolutionary algorithms, "intelligent particle swarm") approaches were developed for optimization and inverse EM problems. The research results are rated as excellent by the academic community of SCEE (by the way, the next SCEE 2006 event will be held in Romania), as well as IEEE CEFC, ENDE and Compumag. More details are presented in sections 3.2, 3.3, 3.5. and 6.2.

4.7. MANAGEMENT COMPETENCE

LMN and CIEAC from PUB have an excellent record in the management of international research and training projects, totaling budgets over 6 million Euro (an annual average of 500 000 Euro). A list of relevant projects for present proposal contains:

- TEMPUS JEP/JEN/2717 - Postgraduate studies in Computer Aided Electrical Engineering;
- TEMPUS JEP 9122 - Use of IT in AV communication;
- PECO/CAEE93 - Organization of the International Conference on Computer Aided Education of Engineers;
- INCO/COPERNICUS/Euroeast - Extension of EUROCHIP services to Eastern European countries
- INCOCodestar/Manodet - Non-destructive testing based on a new principle to measure magnetic field;
- FP5/IST/Codestar – Compact modeling of on-chip passive structures at high frequencies;
- ENDE - El-mg. Non-Destructive Evaluation with Japan Society for Applied Electromagnetics;
- RJJSAEM - The first two Romania-Japan Joint Seminars in Applied Electromagnetics and Mechanics.

The **feasibility and credibility** of the proposed strategy is guaranteed by past successful events organized by CIEAC/LMN as well as those organized with our European partners, such as:

- First SCEE workshops held in Darmstadt (1997) and Berlin (1998), both under the auspices of the DMV (Deutscher Mathematiker Verein), as national German meetings;
- The international SCEE workshop organized in 2000, at Warnemunde, by the University of Rostock, Germany (***http://www.scee-2000.uni-rostock.de/***);

- The 4th SCEE conference jointly organized in 2004 by the Eindhoven University of Technology (TU/e) and Philips Research Laboratories Eindhoven - Netherlands (***http://www.win.tue.nl/scee2002/***);
- The SCEE 2004 event held in Capo D'Orlando, Italy, organized by Universita di Catania (***http://www.dmi.unict.it/scee2004/);***
- The summer schools organized by the Catania University, jointly with the Fraunhofer Institut for Techno-Wirtschaft Mathematik, Kaiserslautern will be held in Capo d'Orlando, in September 2005 (***http://www.dmi.unict.it/sceeschools***).

The main contractor, Politehnica University of Bucharest - CIEAC Research centre will organise in Romania the next SCEE event in 2006 (***http://www.scee06.org***).

The **lessons learned from the previous projects** are:

- Emphasis on institutional constructions (e.g. the Postgraduate School developed within JEP 2717, one of the TEMPUS projects declared as a models from European Commission was ceased by local administrative decision of Faculty/Department);
- Sustainability is difficult to be achieved, but it is the ultimate goal;
- Intra-university communication is more difficult to be achieved then international one, with teams which share the same scientific approach or system of values;
- The scientific/technological quality of the European partners is essential. To get and maintain the credit from first rank partners is necessary a long term investment and a continuos effort.
- The most valuable resource is the human resource, the highly trained people, their organizations and long term partnerships may not be substituted by infrastructure, equipment or books, contrarily they can attract financial support and material resources for their activity;
- The selection of the involved staff must be done very carefully, taking into consideration development potential and also the ethical issues;
- Challenging problems need motivated people. Appropriate research environments, employment advantages and opportunities in professional career motivate the researchers;
- The low level management/secretarial tasks must be delegated to professionals;
- Excessive complexity of management structure generates overhead, bureaucracy and unnecessary additional steps in the communication structure.
- The management of generated knowledge and associated IPR is the key of the knowledge-based society, allowing the increasing European competitiveness.

4.8. MONITORING THE IMPLEMENTATION OF THE PROJECTS

Quantitative indicators

The following indicators monitor the success of the project implementation:

- number of candidates who will submit applications;
- number of ECTS credit points acquired by EST fellows;
- value of new acquired equipment to be used for research by EST fellows;
- the number of total actual fellow-months.

Qualitative indicators

- articles published during the research projects and the rate of joint publications;
- participation and communications at international conferences and training actions;
- success of the organized events, number of events/participants;

- quality of web-site and other publicity means;
- quality and efficiency of the recruitment advertising;
- gender balance of ESRs.
- success of knowledge transfer in HPC area and appropriate management know-how;
- development of infrastructure (hardware, software, middleware, connectivity);
- curricula development at Doctoral level, new courses, lab-exercises and textbooks;
- institutional impact and their European extension;
- success of e-learning, complementary training and career development;
- number and quality of joint Doctoral degrees;
- activity of the Project Mnagement Unit and the International Steering Committee;
- internships in industry and SMEs;
- IPR transferred toward industry;
- Value of the developed software and methodologies;
- Number of FP7 submitted proposals and the success rate;
- Scientific and technological advances in state-of-the-art, such as nEDA platform functionality and matching between simulation and measurement.

4.9. Risk Management and Contingency Plans

Risk	Probability	Consequence	Contingency plan
A project proposal is not approved	Medium	Lack of resources for entire strategy	The proposal will be improved and it will be submitted to the next call
Low number of candidates or not appropriate trained	Low	Shortage in research personnel	Improve the recruitment strategy, and reiterate
Fellows does not comply the individual training plan or contract	Low	The contract with EC can't fulfill	Hire another fellow
Difficulty to find a suitable teacher for a certain course	Medium	Degree requirements aren't fulfilled	Invite an appropriate foreign teacher
The PhD students doesn't finish thesis in due time	High	Difficulties in their careers	Find new sponsorships to prolong their stages
Not matching between simulation and measurement	Low	Research results aren't attractive for industry	Development of more accurate models
One of the European partner falls in sleep	Low	The correspondent project suffers	It is warned and in the worst case it is substituted with other
Low level of result dissemination	Medium	Low impact of the strategy	Additional complementary training and consulting
Low level of result exploitation	High	Not expected social impact	Build appropriate organization (spin-off)

5. ADDED VALUE AND RELEVANCE TO THE OBJECTIVES

5.1. RELEVANCE FOR THE OBJECTIVES OF ERA AND MARIE CURIE ACTION

<table>
<tr><th>Framework and action objectives and policies</th><th>Objectives and impact of proposed strategy</th></tr>
<tr><td>FP6 strategic objectives:
• Strengthening the scientific and technological bases of industry,
• Promoting research activities in support of other EU policies, encouraging the international competitiveness of European industry</td><td>Advanced research projects (nEDA) with an important industrial expected impact.
Training in HPC-CSE, SCEE and EDA.
Contribution to the increasing of the science attractiveness in Europe and the European competitiveness.</td></tr>
<tr><td>Objectives of block activities:
• Focusing and integrating the European research
• Structuring the European Research Area - ERA - aiming to decrease the fragmentation of the research and development in Europe (including development of human resources and mobility)
• Strengthening the foundation of ERA</td><td rowspan="2">Encouraging synergies and structuring effects at European level. Enhancing inter-sectorial collaborations and overcome research fragmentation.
Maintaining of long term collaborations at European level based on mobility and ToK.
Excellent European partnership, excellent achievements and joint projects.
Development of entrepreneurial university.
Contribution to improving the gender balance, promoting women in science.
A series of practical measures to implement and facilitate the mobility, personal circumstances related to mobility (family, career development, language/ cultural diversity).
Other community regional or national aspects, cohesion and regional policy including the contribution to the development of the research activities in Romania, a EU Candidate country.
Inter-/Multi-disciplinar and inter-sectorial aspects (including SMEs).</td></tr>
<tr><td>General objective of Human Resources and Mobility Action:
Development of abundant and dynamic world-class human resources in the European research system, taking into account the inherent international dimension

Marie Curie Actions:
• Mobility for successful creation of ERA
• Transfer of research competencies
• Consolidation and widening of researchers' career
• Promotion of excellence in European research
• Gender balance (>40% selection of women)
• Development of the research activities in less-favoured regions of EU and Candidate Countries
• Interdisciplinarity and links between academic and industry, including SMEs</td></tr>
<tr><td>Specific objectives of
• Information Society Technologies (IST) -Specific Targeted Research Project (STREP), objective 2.4.1
• Marie Curie TOK-DEV Fellowships: Transfer of knowledge for development;
• Marie Curie TOK-IAP Fellowships: Transfer of knowledge for Industry-Academia Partnership;
• Marie Curie RTN - Research Training Network
• Marie Curie EST - Host for early stage training
• Marie Curie SCF Fellowships - Series of events</td><td>For design technologies (methods, tools, architectures), the focus is on: Research for mastering the technological shortcomings of nanoelectronics such as unreliable device behaviour, dispersion of circuit parameters, parasitic and interconnect effects, and leakage currents.
Developing new areas of competence and new research capabilities.
Challenging excellence.
Full contribution to the Lisbon Strategy.</td></tr>
</table>

5.2. ENCOURAGING SYNERGIES AND STRUCTURING EFFECTS AT EUROPEAN LEVEL

The present proposal is conceived as a chain of complex planned and current activities. It is a pilot action for future RTD activities of Romanian academic community, allowing its smooth integration in the ERA. Our previous experience in European mobility projects shows that a stage of a foreign fellow in a Romanian host has positive effect on the education improvement of at least 3 Romanian students or researchers. In the future this leveraging effect is expected to be increasing up to 6, by an improved management. After a stay in the Romanian host institution, and return to their origin countries, it is expected that the fellows bring their contribution to the strengthening of our network, as members of the European research community, or perhaps as employees of one of our industrial partners. During their stay in Romania they will be strongly involved in local research teams and therefore an important contribution to their career development is expected. Their membership in Alumni Association will also contribute to the long-term impact of the project. After the work at nEDA projects, the researchers will become scientists with experience in nano-electronic design automation, with excellent CVs records (work for leading companies in advanced domains), able to disseminate their knowledge in other research groups, contributing to the desired scientific and technological European cohesion.

Our previous experience in European co-operation shows an outstanding synergy between mobility and joint research projects. The mobility programmes generate more trust and confidence between partners and create conditions to launch new successful European research projects. This virtuous cycle generates an efficient way of overcoming fragmentation of the European Research Area. The nEDA strategy was conceived based on a series of complementary European projects covering both aspects: training (RTN, SCF, EST, ToK-DEV) and research (ToK-IAP, STREP). By synergy, these projects will bring a contribution to the building of a Europe of knowledge, based on two pillars: research (ERA) and higher education (EHEA), having an anti-fragmentation effect at European level. Moreover, the ToK in the both senses, in the advanced area of HPC for CSE in general, and in particular for SCEE and nEDA contributes to a research structuring at European level. The strategy objectives perfectly fit with several strategic objectives of the FP6 priority thematic areas, such as IST (e.g. 2.4.1 - Nanoelectronics) and NMP (e.g. 3.4.1. - Nanotechnologies), as well as those of the next FP7.

5.3. RELEVANCE FOR THE EUROPEAN COMPETITIVENESS AND ATTRACTIVENESS

It is obvious that in order to be competitive on a global market, computers must be used at any stage of product life cycle: engineering, design, manufacturing, testing and marketing. Only truly innovative products and technologies can be competitive. But this is not enough. For leadership on the market, the life cycles of high end products must be controlled. This is not possible if the development of software packages for engineering and design is not also controlled. This is the job of CSE/SCEE experts. Without such experts, the European competitiveness will suffer on medium and long terms. By training young researchers in this sensitive field of CSE, and in particular, by R&D in advanced area of nanoelectronics (nEDA) the proposed project will contribute to the European leadership in science and technology. In this way, the project brings our contribution to reach the target of spending 3% of GDP on research, having the necessary highly trained human resources for this goal, and to “make Europe the most competitive and dynamic knowledge-base economy by 2010”.

With Asian technology coming up and the US government funding massively nanotechnology, one should be aware that new developments are going fast. To keep both the industry and the academic world in Europe strong and competitive a larger number of scientists in nanotechnology have to be trained, and we may do it successfully.

Another opportunity exploited within proposed startegy is the "Access to the European Research Infrastructure", through FP6/IST projects, such as GEANT and GRID, which provide access to advanced HPC hardware, software and know-how. The best IST results will be transferred and exploited in another thematic priority: nanotech, and geographically from West to Eastern Europe. The access to the most advanced supercomputers located in Europe and USA, and the opportunity to do research in the benefit of leader companies (Philips, Infineon, and ST Microelectronics), provided by our research and development strategy will increase the attractiveness of European science to young researchers. Thus, the proposed projects will stimulate the return of Romanian scientists established outside Europe, willing to contribute to enhancement of the European scientific excellence.

Research in CSE involves the development of state-of-the-art computer science, mathematical and computational tools, directed towards the effective solution of real-world problems of science and engineering. Consequently, CSE is an interdisciplinary, emerging discipline with great impact on science and industry. Domains where CSE has played and is expected to continue to play a pivotal role include electronic design automation, simulation, design and control of vehicles, aircraft design, weather and climate forecast, pollution dispersion and many others. CSE tools are vital in physics, chemistry, materials, molecular biology and bioengineering.

The EST3 and Comson projects give to the ESRs a unique opportunity to combine the structured academic training in CSE, available in many European universities with their involvement in an advanced research project of outstanding importance for the European semiconductor industry. IC design automation tools developed in this project are indispensable for RF designers in this transition to the nano-scale era. These tools are needed to develop nano-scale designs of unprecedented complexity and performance and, in addition, enable the achievement of single-pass design success to avoid costly re-spins and the loss of market opportunities.

The results proposed research projects will facilitate the design of RFICs (e.g. for wireless applications) by cost-effective integration on silicon. This is urgently needed for applications in wireless communications. This will cause even more changes in our future society due to mobility and communication, changing the lives of the European citizens drastically, boosting applications of which only a few are mentioned: Learning, Working, Healthcare and Aids for disabled people.

5.4. Other Community, Regional, National and International Aspects

It is of European interest the **development of abundant human resources** highly educated in coherent manner, with interdisciplinary competencies in nanaoelectronics (NMP), combined with those of computational science (part of IST). Both topics NMP and IST belong to the **thematic priorities of the next 7th framework** research programs. Moreover, the field of nanoelectronics is considered by EC as an "edge technology" (see *Vision 2020: Nanotechnology [9]*). The proposed project will bring its contribution to this development objective. There are a number of factors, which indicate the **demand for postgraduate degree** in SCEE and in general in Computational Science and Engineering. Studies of employment demand show that employers prefer people with multiple specializations, since they can hire fewer of them and can retain them for longer periods of time. The conclusion of the "*Globalizing European Higher Engineering Education*" (GEHEE), is that over "the next few years, Europe will suffer from a very serious shortage of engineers in key areas, such as Information and Communication Technologies" (*www.cesaer.org*). According to *EITO (European Information Technology Observatory)*, the IT jobs represent 13.4 % of total employment in Western Europe. Apparently, this is an ideal situation, but Europe is actually facing a serious problem, high demand for workers with unique combination of IT skills and experience. This skill shortage is expected to increase from 1.3 million (10

%) in 2001 to 1.7 million (12 %) by 2005. In some specific areas such as computational science, the situation is worse. On the other hand, in the high-tech sector, Telecommunications and Microelectronics are **leading industries** and key enablers of jobs and economic growth in the European Union. The development of micro- and nano-electronics is at the very heart of future economic developments in products and services of the ICT sector, and it can not be conceived without highly trained human resources. There is no area of modern life untouched by the progress of microelectronics. Thanks to advances in microelectronics, new market opportunities are emerging in Europe characterised by the needs of products and services offering both mobility and connectivity. Europe has a solid industrial base, especially in Telecom, Home Car Electronics. It is relevant that top 300 firms spent in the last year: 45GE +2%/y on IT hardware, 37GE +12%/y on automotive 22GE +8%/y on electronics, 13GE +32%/y on software and 5GE +1%/y on telecom, where GE = billion Euro, %/y = annual increasing rate (Source*: DG Research Key Figures 2004)*.

Specific measures of **Lisbon strategy** have been agreed to fight against poverty, discrimination and social exclusion. In this respect, some programs are supported at a European and national level in order to reduce the differences in performance between Member States and the **Acceding States**. However, the differences remain important and are often acute in the case of the Eastern Europe countries. Notably impact is expected as a contribution of this ToK projects for long time results in the **cohesion** of EU countries by progressive reduction in the initial gap between EU and Eastern Europe region in unemployment levels, in high qualified labor work employment and the performance of the whole economy. The project of ToK toward an Acceding State - Romania fits perfectly the declared interest of the European Community in creating the European Research Area, which intends to correct the main deficiency in the European Research: "**the lack of an environment to stimulate research and exploit results, and the fragmented nature of activities and the dispersal of resources**".

Since the very beginning of the Sixth Framework Programme, Romania, as candidate country, have participated in EU research schemes on an equal footing with EU Member States. Statistics show a success rate of only 13% for acceding countries, while for Member States it is 19%. Improvement of the success rate for the proposal and development of the participation in Community Framework Programmes represents the focal point of the Romanian national policy.

All relevant demands for European higher education: quality assurance, mobility, ECTS, degree recognition, Diploma Supplement, joint degree and credits for livelong learning are addressed by our proposal, and the approval of the project will contribute to their achievement in Romania. Moreover the proposed strategy has additional specific objectives, such as the support for Bologna process, based on the following key-concepts: quality, recognition, transparency, mobility, convergence, employability, European dimension, attractiveness of European education and diversity saving.

In conclusion, the proposed strategy was conceived to bring its maximal contribution to the **synergy and structuring effects of ERA (Romania hopefully included) and fully support for the Framework and action objectives.**

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