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The Strategic Research Agenda on EMC in the next (7th) European Research Framework Programme (2007-2013)

Frank Leferink

Thales Netherlands, P.O. Box 42, 7550 GD Hengelo, The Netherlands and
University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands
E-mail: frank.leferink@nl.thalesgroup.com or frank.leferink@utwente.nl

with

Christos Christopoulos (University of Nottingham, United Kingdom),
Marco Leone (Siemens, Germany)
Amaury Soubeyran (EADS, France)
Marcel van Doorn (Philips, Netherlands)

Introduction

The European Commission has published the research policy and the proposal for the next (7th) Framework Programme [1]. It is stated that, to be a genuinely competitive, knowledge-based economy, Europe must become better at producing knowledge through research, at diffusing it through education and at applying it through innovation, i.e. the “knowledge triangle”. Today the European Union (EU) devotes only 1.96 % of its Gross Domestic Product (GDP) to research and development, compared to 2.59% for United States, 3.12 % for Japan and 2.9% for Korea. In March 2002 the Barcelona European Council set the target of raising the European research effort to 3 % of EU GDP, two thirds of which should come from private investment.

European Technology Platforms (ETP) play an important role in the 7th Research Framework Programme (FP7) [2]. ETPs focus on strategic issues, bring together stakeholders, led by industry, to define medium to long-term research and technological development objectives and lay down markers for achieving them. ETPs thus play a key role in better aligning EU research priorities to industry’s needs.

A key objective of ETPs is the establishment of a strategic research agenda (SRA). Through the definition of a SRA technology platforms can influence policy in the FP7 programme and hence, in due course, lead to the development of specific projects which will be submitted through normal channels for EU funding.

The SRA reflects the needs as seen by industry, taking (emerging) social, economical and technological trends into account. A yearly workplan is generated from the SRA and submitted to the European Commission. The European Commission decides which part of the Work Plan will be converted into open Calls. Any (European) entity, including industry, universities or institutes, can then submit a research proposal which will be evaluated in an independent commission, before the research project is awarded (or not).

EMC: a horizontal issue

To date the European Commission has recognised or established 29 TPs [3]. Nearly all of these platforms cover vertical issues, such as eMobility (mobile communication), or ARTEMIS (embedded Systems) [3]. Electromagnetic Compatibility (EMC) is a horizontal issue, and underpins almost all engineering activities and influences our daily life more than ever, at a time when EMC problems are rapidly increasing. In the coming years the electromagnetic environment will drastically change. A high-speed digital lifestyle and an explosion of (wireless) devices will, without well-timed and properly informed action, result in an increase of interference problems in homes, vehicles, hospitals, factories, planes, etc. In addition to this ‘natural’ environment, intentional electromagnetic threats are also now emerging to which unprotected systems will be vulnerable.

Without a coordinated development program in which all stakeholders are involved, this increasingly complex electromagnetic environment cannot be controlled anymore and will lead to more and more interference problems and safety hazards, possibly aggravated by intentional malicious aggressions.

Europe's goal to achieve sustainable growth and competitiveness and homeland security can only be achieved through a better quality and cooperation of the entire EMC research and innovation community. This does not only include the capacity to create new EMC knowledge, but also an understanding of how the EMC knowledge might be used, applied and implemented by industry. Competitive advantage will also come from the existence of an effective know-how transfer from science to useful application in industry. In addition to that, the public fear of electromagnetic fields introduces often non-technical issues where a collaborative approach between researchers from different areas, including medical and psychological experts, is needed.

However, because EMC is distributed everywhere, in any product and environment, research and engineering activities are fragmented. This fragmentation poses a big disadvantage, that is EMC research and innovation does not receive sufficiently coherent attention to establish a determined push towards lower costs and higher social and economic benefits.

In our view, long-term fundamental work of strategic nature in EMC is required now to support emerging technologies and prevent new threats. A "European Technology Network on Sustainable Electromagnetic Environments (EMC including EMF)" (ETN-SEE) has been established to facilitate, coordinate, and accelerate the development and acceptance of technologies that will create in the future an electromagnetic friendly and secure society.

Discussions with the European Commissions are taking place to acknowledge the ETN-SEE.

The ETN-SEE has now approximately 150 stakeholders supporting the initiative. Efforts in establishing the ETN-SEE are led by a small team consisting of Christos Christopoulos (University of Nottingham), Frank Leferink (Thales), Marco Leone (Siemens), Amaury Soubeyran (EADS) and Marcel van Doorn (Philips). Secretarial support is provided by Chris van den Dries (cdr@fme.nl) who maintains a web page for the ETN-SEE at www.emc-esd.nl, under 'technology platform'.

The objectives of the Technology Platform Sustainable Electromagnetic Environments (EMC including EMF) are:

- establish a clear strategic vision on EMC
- strengthen EMC innovation
- enhance international cooperation
- improve cooperation between industry and research institutes
- alleviate fragmentation in research

In short: To facilitate, co-ordinate and accelerate the development and acceptance of technologies that will create in the future an electromagnetic friendly and secure society.

It may be argued that the necessary EMC related work can be done as part of other research programmes supported by the EU. Indeed, most research activities in high-technology areas have an element of EMC work. Several of the existing TPs should also cover some aspects of EMC although this is not evident from the published documents. However, as EMC is a "horizontal" issue affecting several technological areas, the danger is that work is fragmented and un-coordinated. The establishment of an ETP-SEE will coordinate and focus this work, exploit synergies, and give a strategic vision to an otherwise ad-hoc activity. The intention is not to replace but to support and lead in this crucial technological challenge.

Industrial orientation

The economic impact of electromagnetic compatibility is huge: EMC related costs count for 1 – 5% of the sales price of electrical and electronic goods. With a European sales volume in electronics around 530 Billion euro [4] the EMC financial impact is in the range of 5 to 25 Billion euro a year. Delay in product introduction or withdrawal of products are further substantial unaccountable costs [5].

This is the reason that many large industrial parties initiated and support the ETP-SEE, to facilitate, co-ordinate and accelerate the development of technologies that create a future electromagnetic compliant society.

Vision and Trends

The vision on the future, with an emphasis on EMC, is complex, but we can recognize some key elements [6],[7]:

1. Social trends.

We can see an increased awareness in the following areas:

a. Security and safety in our daily living environment

b. Safety anywhere, including transport (such as tracking, drive-by-wire, brake-by-wire, steer-by-wire)

c. Health and medicine, including the risks of Electromagnetic fields (EMF), and pollution, and an increased demand for better medicine

d. Just-in-time society, i.e. people are not willing to wait for unknown amount of time

e. Home automation, i.e. domotica (such as flexible infrastructure, mix of data and energy, media comfort, healthcare-at-home, air quality)

f. Connected anywhere, everywhere, anyplace, anytime, any network on any device, right content, secure, low energy, ubiquitous networks

2. Economical trends.

There is an increased need for:

a. More functionality

b. Less space

c. Less costs, and thus

d. Mass production in China

Many social and economical trends result in technological needs and therefore a market pull (instead of market driven) trend. For instance, the safety trend will put an emphasis on the need for hardened electronics and sensors (i.e. RFID) against Intentional EMI. The trend to reduce the air pollution will push the need for smart sensors in automotive applications. The trend for a healthy society will reduce the amount of psychoactive drugs which can(?) be replaced by nerve stimulators using radio-frequency signals. The nanotechnology will delivers us the means to develop a lab-on-a-chip, etc.etc.

3. Technological trends.

The technological trends are listed in the next section

a. Semiconductors technology

According to the International Technology Roadmap for Semiconductors 2005 [8], the communication speed between the chips is increasing and is projected to be 29 GHz with an on-chip clock of 33 GHz in the year 2015. To reach these higher speeds ICs are using increasingly lower voltages, e.g. 0.8 V in 2015. This means that their logic thresholds are lower, the noise margin is going down and they are becoming more vulnerable to interference. Radiated emissions will increase because of faster switching edges and hence more energy in a harmonic spectrum that extends to higher frequencies. Signal integrity problems will also increase due to the continuing reduction in rise times and the increase in clock frequencies. Over the coming decade the number and variety of potential disturbance sources and victims is set to increase exponentially. This will lead to an astronomical increase in the risk of interference. The question of how to control interference is becoming a key issue in system design [9], [10].

b. TFMPS concepts

The number of users of mobile systems is growing exponentially. The wireless and wired spectrum will get overcrowded with applications such as GSM (Global System for Mobile communication), UMTS (Universal Mobile Telephone system), BlueTooth, WLAN (Wireless Local Area Network), UWB (Ultra Wide Band), ADSL (Asymmetric Digital Subscriber Line, and PLC (Power Line Communication). Legislation by itself (e.g. spectrum trading) will not be able to cope with assigning the extra channels and capacity needed. Technological improvements will be key to a sustained and compatible diversification and parallel operation of communication systems [11].

TFMPS: time-frequency-modulation-power-space can be used at the same time together, resulting in an overwhelming openness of our frequency spectrum, compared to the conventional approach of singular Time or Frequency, other domains.

c. Smart Dust

Future generations of sensor systems (‘smart dust’) will rely on wireless systems, because of fragility and impracticality of fibre-optic-based channels. Such systems are characterized by large numbers of highly sensitive, low-cost and low-power sensor/actuator pairs. Both the integration of the sensor arrays in an existing EM ambient, as well as telemetrical aspects will require the associated EMC problem to be defined and tackled from the outset.

d. Transport

Cars, planes, vessels, and trains are more and more controlled by sensitive electronic systems, which make these transportation systems sensitive for electromagnetic interferences. The electronics inside the transportation systems are causing interference with radio communication systems.

New transport applications with an EMC impact are: automatic driving with fail safe technology, radar technology for sensing obstacles and objects, intelligent traffic/weather sensors, wireless networking technology in and between cars, etc.

Many systems, especially airplanes, are poorly screened against electromagnetic fields due to the replacement of metal by composite materials, resulting in many vulnerable systems.

e. Intentional EM interference (terrorism)

Intentional and/or high-power electromagnetic interference is increasingly seen as a potential weapon of mass malfunction and terrorism. A proper understanding of the threats and how to mitigate fall-out in a variety of critical systems and components is essential to tackling the problem head-on, and requires to be addressed at supra-national and governmental level. The fact that targeted systems are often situated in consumer rather than military markets, makes this a focus issue for the civilian sector as well.

f. Increasingly dense EM environment

Increasingly, co-existence and compatibility of electrical and electronic systems is an issue of complex and dynamically changing environment of partially known or specified sources of radiation. Therefore, traditional approaches based on (over) simplified models and isolated operation and performance are no longer adequate in today's increasingly dense EM environment. An integral systems approach rooted in sound electromagnetic principles and design and analysis techniques, as offered by EMC technology, offers the best guarantees for sustained benign electronic developments.

g. Innovative materials

New semiconductors will facilitate new products. If it would be possible to have power semiconductors which can withstand high temperatures, then these could be integrated in direct drive motors in hybrid cars, resulting in much more energy efficient and lower polluting systems. The disadvantages of these concept are many EMI issues due to the high level of current, switching very fast. The same materials can be applied in distributed and local power generating systems used in wind and solar energy systems.

Metamaterials can be developed which are enabling us to decrease the size of antennas considerably. Novel materials could be developed to embed passive components in integrated circuits and printed circuit boards, decreasing costs and improving reliability due to the decrease in number of interconnections.

h. EMC standardization

New EMC standards have to be developed for products with high clock frequencies, digital modulation techniques and wired & wireless communication devices [12]. There are enough changes taking place in the electrical environment to warrant reassessment of the present limits (digital services, consumer awareness, increase in amount of electronic equipment). We need to develop a database of defined protection levels for radio services that can be used as a basis for deriving future EMC limits. The current EMC test methods have their origins in analogue technology and the limits are based on the protection of analogue radio and TV services below 1 GHz. Digital radio services have different tolerances to broadband and narrow band interference than analogue radio services. Urgent investigation is needed into what the effect of this will be in terms of interference limits and test methods for digital radio/TV products. Resolving the digital EMC problem is going to be a major challenge in the coming decade. EMC of networks and installations is a missing link in the current mass of EMC standards. Many wired home networks use the existing power or telephone wiring and – without co-ordination – this will lead to EMC problems. Ever since the publication of the European Directive 89/336/CE on EMC of 03 May 1989 (enforced 1 Jan 1996), the interest of product committees in standards and their application has been growing. Several international standards related to EMC, often with European participants or organizers as key members have been, or are in the process of being developed. Progress has often been slowed by the shortages in concerted funded efforts related to some more fundamental research on specific test facilities and methods.

There is growing concern about the potentially harmful effects on human beings of exposure to electromagnetic fields (EMF). Standardization bodies in Europe – and worldwide – are developing standards to limit EMF exposure for humans. The goal is to prevent any known adverse effects on health caused by exposure to electromagnetic fields in the frequency range from 0 Hz to 300 GHz. Legislation requires compliance with the EMF standards. To comply with the new EMF standards, it is necessary to develop an EMF competence. Future applications in the fields of wireless connectivity, wearable electronics, on/in-body sensors, and healthcare add further weight to the EMF issue.

The EMC Research Agenda

Achieving the vision will require strategies to invest in EMC research and development. Four main EMC technology themes emerged from the vision and roadmapping process:

Theme 1: EMC Methodologies
Theme 2: EMC Standardization / Control
Theme 3: EM Safety / Security
Theme 4: EM Modelling & Simulation

These strategies are supported by a series of high-priority activities that will directly lead to their fulfillment. These activities were judged by the stakeholders to be achievable in the short (less than three years), medium (three to ten years) to long-term (more than ten years). The lists hereafter chart the strategic research agenda in more detail.

THEME I: EMC METHODOLOGIES

- Materials / meta-materials
  - Innovative materials for EMC applications
  - Incl. nanotechnology, shielding, and filtering
- Signal- & Power Integrity
- EMC impact of new technologies
  - Communication technologies
  - Automotive hybrid drives
  - Power electronics drives
  - Sensor technologies
- Interconnects
  - Wireless (antenna's, co-existence, …)
  - Wired (PLC, High-Speed buses, …)
- EMC of semiconductor devices
- Transients protection (ESD, lightning)

THEME II: EMC STANDARDIZATION / CONTROL

- New test methods
  - Test methods above 1 GHz: RVC, TEM,
  - Statistical vs. deterministic data evaluation
  - Diagnostic methods
  - IC/module testing for system characterization
  - Methodologies for translation of EMC requirements between various (sub)-system levels
  - In-situ testing (large systems)
  - Measurement / compliance uncertainty
  - Fast emission measurements in time domain
- Unification of standards
  - Multimedia, Defense, Automotive, Aerospace, Electro-medical devices
- EM spectrum control
  - Intentional and unintentional radiators

THEME III: EM SAFETY / SECURITY

- EMF: Human exposure to EM fields
  - Exposure assessment and mitigation techniques
- Product Safety (EMC for functional safety)
  - Risk based EMC
- IEMI: Intentional Electromagnetic Interference

THEME IV: EM MODELING & SIMULATION

- New computational techniques
  - Hybrid techniques for multi-scale problems (FDTD, TLM, PO, …)
  - Multidisciplinary techniques for concurrent engineering (EMC, thermal, mechanical, …)
- Modelling of novel materials
- Non-deterministic modelling
- Expert systems / design tools
  - For components, board, cables/connectors, and systems
  - EMC/SI/PI verification, analysis, synthesis
- Certification by simulation
- EM dosimetry

Eighteen working groups have been created, one for every topic, comprising at least 3 stakeholders. The working groups are describing the research needs for these topics which will be included in the workplan. The objective is to present the workplan mid 2006 to the European Commission.

Conclusion

There is considerable fragmentation of research with the current way of doing things. Is there sufficient interaction between practitioners in EMC, Signal Integrity and Communications to ensure that the linkages, compromises and optimization between different technologies (not forgetting the human factor) are all fully considered in a design? We believe that a long-term coordinated research effort is required to address these issues, which are central to the development and acceptance of new technologies, and products, where compatibility, inter-operability, co-existence and multi-functionality will be paramount.

The ETN-SEE Research Agenda outlines a view of where the electronics industry is today, a vision of where its stakeholders want to go tomorrow, and strategies on how to get there. It provides guidance to government, industry, and academia on the direction of future activities.

Working Groups are established for each strategic research topic. The task of the Working Groups is to create high-level brief project descriptions for their specific research topics. Through the definition of a strategic research agenda they will influence policy in the Seventh Framework Program (FP7) and hence, in due course, lead to the development of specific projects, which will be submitted through normal channels for EU funding.

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