



Commission E Triennial Report 2021-2023

Dr. Virginie Deniau
Chair Commission E

This is a summary of the activities of Commission E on Electromagnetic Environment and Interference during this triennium. This report covers the two-year period between the URSI GASS in Rome in 2021 and the URSI GASS in Sapporo in 2023.

1 Officers of Commission E for this triennium

Chair: Dr. Virginie Deniau

Vice Chair: Prof. Carlo Carobbi

ECR 1: Dr. Chaouki Kasmi

ECR 2: Dr. Riccardo Trincherò

2 Terms of Reference

During this period a committee dedicated to the evolution of the Terms of reference was organized. The current Terms of Reference are as follows:

- ✓ Terrestrial and planetary noise of natural origin, seismo- electromagnetic fields;
- ✓ Man-made electromagnetic environment;
- ✓ The composite noise environment;
- ✓ The effects of noise on system performance;
- ✓ The effects of natural and intentional emissions on equipment performance;
- ✓ The scientific basis of noise and interference control, electromagnetic compatibility;
- ✓ Spectrum management

The proposed Terms of reference are still in discussion and a final list will be proposed during the business meeting of the URSI GASS2023.

But at this state, the work group dedicated to the new terms of reference established that:

The Commission deals with the study, modelling and characterization of:

- electromagnetic noise of natural origin;
- man-made electromagnetic noise, both intentional and unintentional;
- complex electromagnetic systems and environment;

by using measurement, deterministic, statistical, stochastic and machine learning techniques.

Further, the Commission promotes research and development in:

- the effects of noise on system performance;
- electromagnetic eavesdropping and EM cybersecurity;
- hardware and software techniques for the suppression and mitigation of electromagnetic interference;



- the scientific basis, standardization and metrology of electromagnetic compatibility;
- the efficient use and management of radiofrequency spectrum.

3 Commission E Working Groups

A number of Working Groups have been established to provide a focus for a number of activities relevant to the theme of Commission E. These are outlined below, together with the relevant contact persons

Commission E is organized into following Working Groups

WG Name	Title	Co-Chairs / Chairs
E1	Terrestrial and Planetary Electromagnetic Noise Environment and seismo-electromagnetic fields	C. Price (Israel), Y. Hobara (Japan), A.P. Nickolaenko and K. Hattori (Japan)
E2	Intentional Electromagnetic Interference	M. Bäckström (Sweden) , Richard Hoad (U.K.) and W. Radasky (U.S.A)
E3	High-Power Electromagnetics	R.L. Gardner (U.S.A) and F. Sabath (Germany)
E4	Lightning Discharges and Related Phenomena	V. A. Rakov (USA) and S. Yoshida (Japan)
E5	Interaction with, and Protection of, Complex Electronic Systems	F. Gronwald (Germany), J-P. Parmantier (France)
E6	Spectrum Management	J. P. Borrego (Portugal) and R. Struzak (Poland)
E7	Electromagnetic Compatibility in Wired and Wireless Systems	F. Rachidi (Switzerland), A. Zeddani V. Deniau (France), and F. Gronwald (Germany)
E8	Stochastic Techniques in EMC	L. Arnaut (UK), S. Pignari (Italy), and R. Serra (Netherlands)
EB	Chaos and Complexity in EM	G. Gradoni (UK), and A. Sihvola (Finland)
EHG	Solar Power Satellite	Chair: H. Matsumoto (Japan), Co-Chair for Commission E: J. Gavan (Israel), Co-Chair for Commission H: K. Hashimoto (Japan);
GEH	Seismo Electromagnetics (Lithosphere-Atmosphere-Ionosphere Coupling)	Co-Chair for Commission E: M. Y. Hobara (Japan), Co-Chair for Commission G: S. Pulinets (Russia), Co-Chair for Commission H: H. Rothkaehl (Poland)
GJFEH	Interdisciplinary Space Weather	Co-Chair for G: I. Stanislawski (Poland) Co-Chair for J: R. Fallows (Netherlands)
URSI/IAGA	URSI/IAGA VLF/ELF Remote Sensing of the Ionosphere and Magnetosphere (VERSIM)	Chair for URSI (Commissions E,G,H): M. Clilverd (UK), IAGA Chair: J. Bortnik (USA)



E1. Terrestrial and Planetary Electromagnetic Noise Environment

Co-Chairs: C. Price (Israel), Y. Hobara (Japan), A.P. Nickolaenko (Ukraine), and K. Hattori (Japan)

This WG deals with the study on the characteristics of natural electromagnetic noise taking place not only in the terrestrial, but also in the planetary environment. The most well-known EM noise is the atmospheric radio noise from the lightning discharges (so-called sferics in a wide frequency range from DC to VHF). Some examples of topical subjects on sferics are (1) monitoring of global lightning activity as studied by high frequency noise and Schumann resonance phenomena in the ELF band and (2) ELF transients related with the optical emissions in the mesosphere due to the lightning. Higher frequency lightning emission provides us with the information on the fine structure of lightning electrical structure, while lower frequency noise provides us with the macroscopic nature of lightning. The noise coming from the ionosphere/magnetosphere will be discussed as well; micro pulsations in the ULF range, VLF/ELF emissions and HF emissions due to the plasma instabilities in the space. The radio noise environment on other planets is also of interest to this group. We are particularly interested in using natural EM observations in monitoring, detecting and forecasting natural hazards, such as thunderstorms, severe weather, space weather and seismic events.

E2. Intentional Electromagnetic Interference

Co-Chairs: ~~M. Bäckström (Sweden)~~ Richard Hoad (U.K.) (rhoad@QinetiQ.com) and W. Radasky (U.S.A)

This WG studies the area of intentional electromagnetic interference (IEMI), which is defined by the IEC as the “Intentional malicious generation of electromagnetic energy introducing noise or signals into electric and electronic systems, thus disrupting, confusing or damaging these systems for terrorist or criminal purposes.”

Aspects of these studies include:

- the electromagnetic threat weapons and their characteristics,
- the coupling to electronic systems through both radiated and conducted transients,
- the vulnerability of equipment and systems including jamming, denial of service, upset and damage,
- the use of detectors to recognize and to mitigate attacks,
- and the protection of equipment and systems.

E3. High Power Electromagnetics

Co-Chairs: R.L. Gardner (U.S.A) and F. Sabath (Germany)

The objective is to encourage research in high power electromagnetics (HPE). The technical area of HPE consists of the physics and engineering associated with electromagnetic sources where nonlinear effects associated with high-field regions (and air breakdown) must be included in the analysis and design. This includes (but is not limited to) EMP simulators, high-power narrowband and meso-band sources and antennas, and hyperband (impulse) sources and antennas. It also includes the environment near lightning channels and in nuclear EMP source regions. In some cases it includes the high field regions on, or in targets because of local field enhancement.

E4. Lightning Discharges and Related Phenomena

Chair: V. A. Rakov (USA) and S. Yoshida (Japan)



The lightning discharge is one of the two natural sources of electromagnetic interference (EMI), the other one being the electrostatic discharge. Electric and magnetic fields generated by lightning represent a serious hazard to various systems, particularly those containing sensitive electronics. This WG focuses on the characterization of lightning and its interaction with engineering systems and with the environment, as well as on lightning detection and testing. It covers all aspects of lightning research, including observations, field and laboratory experiments, theoretical studies, and modeling.

E5. Interaction with, and Protection of, Complex Electronic Systems

Co-Chairs: F. Gronwald (Germany), J-P. Parmantier (France)

This working group studies the various electronic and electromagnetic aspects related to the interaction with, and protection of, complex electronic systems. The focus is the analysis of the various coupling paths and their associated transfer functions into complex electronic systems, as formalized in the framework of electromagnetic topology. Analytical, numerical, and measurement techniques are used to characterize the electromagnetic fields and currents in a complex environment. In the analysis, special attention is placed on the emergence of new technologies, and the inclusion of advanced materials and communication systems.

E6. Spectrum Management

Co-Chairs: J.P. Borrego (Portugal) and R. Struzak (Poland)

The E6 focus is on sound scientific spectrum management for improved utilization of the radio frequencies for protection wireless communications service and radio sciences. The goal is to assure further development of radio sciences and communication services, unobstructed by potential radio interference due to unwanted energy in the form of out-of-band and in-band encroaching and deleterious in-band and out-of-band emissions. The electromagnetic spectrum is treated as a limited natural resource with a multitude of competing demands for access to it and use of it. Spectrum management seeks innovative means and technologies for adequate co-existence of all of them taking into account the need of protection of new and incumbent wireless and wired communication services, systems and equipment, with special focus on science services and those that use passive technologies.

E7. Electromagnetic Compatibility in Wired and Wireless Systems

Co-Chairs: F. Rachidi (Switzerland), V. Deniau (France) ~~A. Zeddani (France)~~, and F. Gronwald (Germany)

The intensive use of the electromagnetic spectrum for communications has resulted in issues of compatibility and interoperability between different users. In addition the continual increase in operating frequency of products and higher frequency sources of disturbances (such as Ultra-Wide Band systems) resulted in an increase of potential EMC problems in communication systems and the use of power lines for carrying data is adding to interference problems. Potential remedies are also addressed.

E8 Stochastic Techniques in EMC

Co-Chairs: L. Arnaut (UK), S. Pignari (Italy), and R. Serra (Netherlands)



Commission E: Joint Working groups

EB Chaos and Complexity in EM

Co-Chairs: G. Gradoni (UK), and A. Sihvola (Finland)

Wave complexity underpinned by fully developed, partial and transient chaos is becoming permanent in multi-component electromagnetic systems operating at electrically large scales. Statistical methods have been developed to tackle those systems and their specific engineering structures occurring in electromagnetic compatibility, electronics circuits as complex sources of radiated emissions, wireless communications including massive MIMO systems, etc. Recent studies in wave chaos have attracted researchers in electromagnetic theory and universal statistical properties have been used to study large electromagnetic systems without solving the full-wave problem. Hybrid methods combining full wave algorithms with newborn statistical methods are emerging in the EM wave modeling arena. System specific components need detailed treatment while deformed and irregular parts of EM environments can be treated statistically because of their mixing behavior. Furthermore, statistical sources can be treated through semi-classical as well as random matrix theories. Novel theoretical models have been developed describing fields through complicated electromagnetic environments – including electromagnetic reverberation chambers - also accounting for coupling through apertures and including losses at both microwave and mmWave regimes, as well as complex placement of wires and cables within EM environments. Uncertainties arising within cabling and radiating systems can be described through the polynomial chaos method.

EHG Solar Power Satellite

Chair: H. Matsumoto (Japan), Co-Chair for Commission E: J. Gavan (Israel), Co-Chair for Commission H: K. Hashimoto (Japan)

GEH Seismo Electromagnetics (Lithosphere-Atmosphere-Ionosphere Coupling)

Co-Chair for Commission G: S. Pulinets (Russia), Co-Chair for Commission E: M. Y. Hobara (Japan), Co-Chair for Commission H: H. Rothkaehl (Poland)

GJFEH Interdisciplinary Space Weather

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URSI/IAGA VLF/ELF Remote Sensing of the Ionosphere and Magnetosphere (VERSIM)

Chair for URSI (Commissions E,G,H): M. Clilverd (UK), IAGA Chair: J. Bortnik (USA)

4 Commission E Related International Activities – Flagship Conferences

Besides the various national URSI activities, main focus of Commission E is put on the URSI flagship conferences.



URSI GASS 2023, Sapporo, Japan, August 19-26, 2023

Commission E received 112 submissions for the URSI GASS in Sapporo (2023). The presentations are organised in 8 sessions. In addition, there are six common sessions with other commissions, organized by commission E.

E01 : EMC Analytical & Numerical Modeling in complex systems (Riccardo Trincherro, Christophe Guiffaut, Chaouki Kasmi)

E02 : EMC Measurement techniques (Ramiro Serra, Carlo Carobbi)

E03 : Stochastic/Statistical Techniques in EMC (Luk Arnaut, Sebastien Lall  ch  re, Chaouki Kasmi, Sergio Pignari)

E04 : HPEM, Intentional EMI (Felix Vega, Nicolas Mora)

E05 : EMC and EMI in Wired and Wireless Communications (Virginie Deniau, Frank Gronwald)

E06 : Time Reversal in Electromagnetics (Farhad Rachidi, Marcos Rubinstein)

E07 : Lightning and related phenomena (Farhad Rachidi, Marcos Rubinstein, Takeshi Morimoto)

E08 : Electromagnetic interference at PCB, package, and chip level: Signal and Power Integrity (Francesco de Paulis, Riccardo Trincherro)

EAB : Wave Chaos of Complex Systems (Gabriele Gradoni, Steve Anlage, Luca Bastianelli)

EACFJ : Spectrum management and Utilization (Tasso Tzioumis, Jos   Pedro Borrego)

EBC : Wave modelling of novel wireless systems (Gabriele Gradoni, Luca Bastianelli)

EC : EM Security of Cyber-physical systems & Wireless Technologies (Yuichi Hayashi, Chaouki Kasmi, Virginie Deniau)

EFGH : Natural Electromagnetic Noise & Radio Sensing Applications in Terr. & Planetary Environments (Yasuhide Hobara, Colin Price, Martin Fullekrug, Tomoo Ushio)

EJGF : Machine learning & signal processing to analyze & mitigate EMI and RFI (Virginie Deniau, Riccardo Trincherro, Kevin Vinsen, Kaushal Bush, Hariharan Krishnan, Paolo de Mattheais)

In addition, Commission E also offers a tutorial on **Migration Methods for Ground Penetrating Radar Signal enhancement - a review tutorial with examples** presented by Prof. Felix Vega.

URSI AT-RASC 2022, Gran Canaria, Spain, May 30 – June 1, 2022

Commission E only received a relatively small number of paper submissions for this conference, with 43 papers accepted. For memory, in 2018, 40 papers were accepted.

As a consequence, the session structure was adapted in order to form larger sessions able to receive different topics.

The reason for the low submission rate was seen in competitive events centering on Electromagnetic Compatibility and a too large number of Commission E related conferences in general.

- Session E01: EMC measurement Issues
- Session E02-1: HPEM, Intentional EMI, Radiation Hazards, Lightning (Part 1 and 2)
- Session E03: EMC and EMI in Wired and Wireless Communications
- Session E04: Machine learning & signal processing to analyze & mitigate EMI
- Session E05-1: Time Reversal in Electromagnetics (Part 1 and 2)
- Session EABK-1: Wave Chaos of Complex Systems (Part 1 and 2)
- Session EACFJ: Spectrum management and Utilization
- Session EC: EM Security of Cyber-physical systems & Wireless Technologies
- Session EFGH: Natural Electromagn. Noise & Radio Sensing Apps in Terr.& Planetary Envir.
- Session JE-2: EMC issues in integration of digital and analog electronics (Part1 and 2)



Commission E organized also an **ECR tutorial**, presented by **Riccardo Trincherò** from *Politecnico di Torino (Italy)*.

- **Demystifying Machine Learning for EMC and SI/PI Applications**

Two papers of commission E were in the young Scientist competition:

- **An Efficient Iterative Scheme for HEMP Simulation with Consideration of Self-consistency**,
 - Ning Dong , *Xi'an JiaoTong University (China)*
- **Dynamic Adversarial Jamming-based Reinforcement Learning for Designing Constellations**,
 - Yizhou Xu (1), Haidong Xie (2), Nan Ji (2), Yuanqing Chen (2), Naijin Liu (2), Xueshuang Xiang (2), (1) *Tsinghua University (China)*; (2) *Qian Xuesen Laboratory of Space Technology, China Academy of Space Technology (China)*

URSI GASS 2021, Rome, Italy, August 28 – September 4, 2021 (planned as hybrid event)

The URSI GASS 2021 has been organized in a similar way as the URSI GASS 2020, resulting in a similar session structure with a very satisfying number of 89 paper submissions, distributed to 15 Commission E related sessions. The URSI GASS 2021 was planned as a hybrid event, allowing for both on-site and remote attendance.

Commission E also planned the following short courses:

Machine Learning approaches with GNU radio, presented by J. Villain,
Introduction to electromagnetic reverberation chambers – Theory, Applications and Research,
presented by Ramiro Serra and Philippe Besnier

Uncertainty quantification for electromagnetic applications, presented by Carlo Carobbi and Sébastien Lalléchère.

Commission E organized also the ECR tutorial **High Power Electromagnetics: Effects on analogue and digital electronics**, Lecturers: C. Kasmi, D. Martinez, F. Vega, N. Mora

Election: Carlo Carobbi was elected as Vice Chair and Riccardo Trincherò as ECR2.