15 PhD positions in the Horizon Europe Marie-Curie Doctoral Network:

European Doctoral Network on In-Situ Monitoring of Electromagnetic Interference

Applications are invited for 15 PhD positions ("Doctoral Candidates", DCs) to be funded by the Marie-Skłodowska-Curie Doctoral Network "**iSense – European Doctoral Network on In-Situ Monitoring of Electromagnetic Interference**" within the Horizon Europe programme of the European Commission.

Niels Bohr once said, "*Prediction is very difficult, especially if it's about the future*". This is especially true when it comes to the high-tech electronic devices that we increasingly rely on and the electromagnetic environment they have to operate in. We are faced with having to anticipate what is likely to happen in the future, with the widespread use of even more advanced communication systems, the rise of highly automated technologies, like self-driving cars and robotic surgeries, complex systems and infrastructures, and our growing dependence on technology. This web of interconnected systems-of-systems creates a complex electromagnetic environment in which the seamless interoperability of electrical and electronic equipment must be guaranteed.

The **iSENSE Doctoral Network on In-Situ Monitoring of Electromagnetic Interference** has a clear mission: to train a new generation of experts who possess the skills and fundamental knowledge required to effectively address our intricate and ever-evolving electromagnetic environment to tackle the issue of electromagnetic interference. Specific innovations to be expected are innovative EMI sensors and monitoring methodologies, early warning tools for detecting EMI occurrences, the formulation of novel modelling and test strategies and, overall, a greater success in avoiding EMI issues.

The iSENSE Beneficiaries are 8 universities, KU Leuven (BE), TU/e (NL), UTwente (NL), ESEO (FR), UNILIM (FR), Universidad de Granada (ES), BRNO University of Technology (CZ), Technical University of Sofia (BG), 2 industry-oriented research organisations, WIS (DE), Fraunhofer (DE), and one company EMC Barcelona (ES). Together, these bring in top-class expertise in electromagnetic compatibility, electrical design, sensoring, anomaly detection and statistical modelling as well as domain knowledge of relevant application sectors. Furthermore, the inter-sectoral characteristic is guaranteed by the support of a series of industrial entities, such as Thales, Philips Healthcare, Valeo, Airbus, Barco, etc., forming a fully interrelated, integrated, and international consortium.

Key dates:

- **12 August 2024: Launch of 15 DC Positions**
- **October-November 2024: First selection procedure (screening received applications and first online interviews)**
- **10 December 2024: Deadline for online application**
- **11 December 2024 – 9 January 2025: Second selection procedure – screening received applications**
- **10 January 2025: Circulation list "iSense preselected candidates Recruitment Event"**
- **Beginning of February 2025: iSense Recruitment Event**
- **1 week after Recruitment Event: Circulation list "recruited iSense DCs"**
- **March – October 2025: Targeted starting date for DC contracts**

Key background info

EU FUNDING

This project has received funding from the European Union's EU Framework Programme for Research and Innovation under the HORIZON-MSCA-2023-DN Grant Agreement N°101168880 (MSCA-DN-iSense)

Number of positions available
15 PhD Positions

Research Fields
Electrical Engineering - System Engineering - Sensor Engineering - Computer Science – Signal Processing – Electromagnetic Compatibility

Keywords
Electromagnetic compatibility – Sensing – EMI Sensors – Electromagnetic disturbances – Electromagnetic interference – anomaly detection

Career Stage
Doctoral Candidate (DC)

Benefits and salary
The successful candidates will receive an attractive salary in accordance with the MSCA regulations for DCs. The gross salary includes a **living allowance** (approximately € 3400 per month[1]), a **mobility allowance** of approximately € 600 per month and, if applicable, a **family allowance** of approximately € 660 per month. ***These amounts are nominal (gross) amounts and certain deductions will apply for social security contributions and/or taxes according to the applicable national laws of the country where the recruiting beneficiary is located***. The exact (net) salary will be confirmed upon appointment and is dependent on local tax regulations and on the country correction factor (to allow for the difference in cost of living in different EU Member States). The guaranteed PhD funding is for 36 months (i.e. EC funding, additional funding is possible, depending on the local Supervisor, and in accordance with the regular PhD time in the country of origin). In countries where PhDs typically last longer than 36 months, beneficiaries foresee additional funding for the required time to finish the PhD if the DC fulfils all technical requirements at the end of the 36 months. In addition to their individual scientific projects, all fellows will benefit from further continuing education, which includes internships and secondments, a variety of training modules as well as transferable skills for the Jobs of Tomorrow as well as active participation in workshops and conferences.

On-line Recruitment Procedure (see Appendix 1 for full description)
All applications proceed through the on-line recruitment portal on the https://dn-isense.eu/ website. Candidates apply electronically **for one to maximum three DC positions** and indicate their preference. Candidates provide all requested information including a detailed CV (Europass format[2] obligatory), a motivation letter and transcripts of bachelor and master degree[3]. During the registration, applicants will need to prove that they are eligible (cf. DC definition, mobility criteria, and English language proficiency). For some positions, candidates must be eligible with respect to national and international regulations for knowledge transfer and export control. **The (final) deadline for the online registration is 10 December 2024**. However, candidates are encouraged to apply as soon as possible. In the period October-November 2024 a first selection procedure will take place where received applications so far will be screened by the respective beneficiaries and possible first online interviews might take place along with online personality tests. Additionally, after the online application deadline (10 Dec 2024), a second selection procedure will take place, similar as the one during the first selection procedure. Finally, the iSense Recruitment Committee selects between 20 and maximum 30 candidates for the Recruitment Event which will take place in Bruges (Belgium) (**Beginning of February 2025**). The selected candidates provide a 20-minute presentation and are interviewed by the Recruitment Committee. Candidates will be given a small scientific task (prior to the recruitment event) by their prioritized Supervisor and will be asked questions about this task during the interview to check if the candidate has the right background/profile for and a good view on the DC position. In order to facilitate their travel, selected candidates (from outside Belgium) receive a reimbursement of maximum 250 euro (paid by the prioritized Supervisor). In order to avoid delays in reimbursements, candidates are asked to keep all invoices and tickets (cf. train, plane, hotel...). The final decision on who to recruit is communicated shortly after the Recruitment Event (estimated **1 week after the Recruitment Event**). The selected DCs are to start their research as quickly as possible (target period: March – October 2025).

[1] Dependent on the applicable EU Country Coefficient
[2] https://europass.cedefop.europa.eu/documents/curriculum-vitae
[3] Master students who will graduate in the next coming months are welcome to apply. In that case, please provide an overview of the transcripts that are already available.

Applicants need to fully respect three eligibility criteria (to be demonstrated in the Europass CV):

1. **Doctoral Candidates** (DCs) are those who are, at the time of recruitment by the host, **not already in possession of a doctoral degree**.
2. **Conditions of international mobility of researchers**: Researchers are required to undertake transnational mobility (i.e. move from one country to another) when taking up the appointment. **At the time of selection by the host organisation, researchers must not have resided or carried out their main activity (work, studies, etc.) in the country of the recruiting beneficiary for more than 12 months in the 3 years immediately prior to their recruitment**. Short stays, such as holidays, are not considered.
3. **English language**: Doctoral Candidates (DCs) must demonstrate that their ability to understand and express themselves in both written and spoken English is sufficiently high for them to derive the full benefit from the network training.

The 15 available PhD positions

(see **Figure 2** for interactions between DCs/WPs)

DC1: Enhancing EMI detection in integrated circuits taking into account speed, precision, and adaptability
Host: ESEO (FR)
Main supervisor: R. Perdriau (richard.perdriau@eseo.fr)
Co-supervisors/mentors: M. Ramdani (ESEO - FR), T. Claeys (KU Leuven - BE), F. Lafon (Valeo - FR)
Duration: 36 months
Required profile: Master's Degree (or equivalent) in Electrical and Electronics Engineering
Desirable skills/interests: Skills: EMC, digital and/or analog integrated circuit design – Interests: machine learning.
Objectives: Develop integrated building blocks capable of the rapid and accurate detection of harmful EMI within integrated circuit. Investigate and assess various detection techniques, including digital, analogue, and advanced structures like neural networks, for their effectiveness in EMI detection. Strike a balance between enhancing structures within off-the-shelf integrated circuits and designing specific detection blocks.

DC2: Cost-effective and robust EMI detection systems for smart electronic devices using generic PCB structures
Host: Fraunhofer (DE)
Main supervisor: M. Lanzrath (marian.lanzarth@int.fraunhofer.de)
Co-supervisors/mentors: H. Garbe (LUH - DE), M. Ramdani (ESEO – FR), S. Hildebrandt (Lumiloop – DE)
Duration: 36 months
Required profile: Electrical Engineer, Physicist
Desirable skills/interests: PCB layout, electronics design, circuit technology, rf design, rf technology, rf measurements, programming.
Objectives: Investigate the adaptability of PCB structures for EM detection systems within Smart Electronic Devices (SEDs). Assess the feasibility of implementing standardized PCB layouts for EM detection systems within SEDs. Design, implement and validate an IEMI-sensor integrated onto a PCB.

DC3: Simultaneous radiated and conducted EMI characterization in multi-node sensor networks
Host: UTwente (NL)
Main supervisor: N. Moonen (niek.moonen@utwente.nl)
Co-supervisors/mentors: F. Leferink (UT - NL), D. Vanoost (KUL – BE), E. Tourounoglou (Thales, NL)
Duration: 36 months
Required profile: Electrical Engineering
Desirable skills/interests: Electromagnetic Compatibility, Data Processing.
Objectives: Develop advanced EMI sensors capable of capturing a wide range of electromagnetic disturbances (radiated and conducted, from low kHz to at least 40 GHz). Create monitoring devices that combine EMI sensors with existing logging and fault-detection mechanisms in electronic devices. Investigate database-processing techniques to manage and analyse the data generated by EMI sensors.

DC4: Advanced sensors for characterizing pulsed electromagnetic disturbances
Host: BUT (CZ)
Main Supervisor: M. Stumpf (stumpf@vut.cz)
Co-supervisors/mentors: P. Kadlec (BUT - CZ), G. Antonini (UnivAQ - IT), F. Sabath (WIS – DE)
Duration: 36 months
Required profile: The DC will analyze both theoretically and experimentally electromagnetic (EM) pulse effects using time-domain (TD) EM sensors. Attention will be paid primarily to the concepts of loaded loop and linear probes with an emphasis on their computational and analytical models. To meet the research objectives, the DC is expected to employ numeric computing environments (e.g., MATLAB, Python), analytical tools as well as modern EM-field solvers and TD measurement setups. Therefore, an ideal candidate possesses a MSc degree in Electrical Engineering, Applied Mathematics, or Physics from an accredited program and has demonstrable experience in EM field modeling.
Desirable skills/interests: Electrodynamic, antenna and circuit theory; Familiarity with basic analytical models of linear and loop antennas**;** Coding skills in modern numeric computing environments (e.g., MATLAB, Python)**;** Excellent interpersonal and communication skills**;** Strong written and verbal English communication skills**;** Excellent attention to detail**;** Ability to work well both alone and as part of a team
Objectives: Create new analytical and numerical models of time-domain EM sensors capable of characterizing both electric and magnetic-type impulsive EMP sources. Design a loaded loop sensor, measure its characteristics and validate its mathematical models. Utilize advanced analytical tools (e.g., the Cagniard-deHoop method) and numerical techniques (e.g., the Partial Element Equivalent Circuit) to enhance the accuracy of EMP assessment.

DC5: Optimizing EMI monitoring through compressed sensing: reducing sensor deployment for efficient data acquisition
Host: KUL (BE)
Main supervisor: D. Vanoost (dries.vanoost@kuleuven.be)
Co-supervisors/mentors: D. Pissoort (KUL - BE), T. Hartman (UT - NL), M. Azpurua (EMC Barcelona - ES)
Duration: 36 months
Required profile: Electrical engineering and/or computer science

Desirable skills/interests: Sensors, Electromagnetism, Artificial Intelligence, Measurement Techniques.
Objectives: Develop and implement advanced, compressed sensing techniques to reduce data stored and processed by individual EMI sensors. Determine the minimum number of sensors required for a more comprehensive view of the EMI environment. Develop practical solutions that incorporate compressed sensing for capturing, analysing, and managing EMI data.

DC6: Optimization of the parameters for monitoring and describing electromagnetic environments
Host: KUL (BE)
Main supervisor: T. Claeys (tim.claeys@kuleuven.be)
Co-supervisors/mentors: D. Pissoort (KUL - BE), A. Roc'h (TU/e - NL), R. Kleihorst (PHC - NL)
Duration: 36 months
Required profile: Electrical engineering
Desirable skills/interests: Electromagnetism, antenna theory, signal processing, measurement techniques.
Objectives: Identify and prioritize the EM parameters with the most impact on system performance and reliability. Develop a cost-effective methodology for EMI monitoring without sacrificing resolution and accuracy. Validate the proposed methodology by conducting measurement campaigns in smart-grid and medical environments.

DC7: In-situ evaluation of the EMI footprint of large interconnected systems
Host: TU/e (NL)
Main supervisor: A. Roc'h (a.roch@tue.nl)
Co-supervisors/mentors: G. Pemen (TU/e - NL), G. Andrieu (Unilim - FR), W. Ophelders (Canon - NL)
Duration: 36 months
Required profile: Electrical Engineering
Desirable skills/interests: Electromagnetism, Electromagnetic Compatibility, Metrology.
Objectives: Advance the concept of the EMI footprint to in-situ evaluations for complex interconnected systems. Explore advanced measurement setups such as the Vibrating Intrinsic Reverberation Chamber (VIRC), near-field scanning and distributed sensing. Incorporate cutting-edge algorithms, including machine learning, to the EMI footprint.

DC8: Non-linearities as the basis for electromagnetic health monitoring of critical information and communication systems
Host: WIS (DE)
Main supervisor: M. Schaarschmidt (martinschaarschmidt@bundeswehr.org)
Co-supervisors/mentors: H. Garbe (LUH - DE), T. Claeys (KUL - BE), R. Kebel (Airbus DE - DE)
Duration: 36 months
Required profile: Electrical Engineering, Physics
Desirable skills/interests: Electromagnetic Compatibility, RF Measurement Technology in Frequency and Time Domain, Statistics, Computational Electromagnetics, System Engineering, Risk Analysis.
Objectives: Investigate and describe the non-linear behaviours that manifest in the emission spectrum of ICT systems when exposed to HPEM. Conduct controlled EMI tests on representative systems with different complexities to quantify non-linearities. Develop an advanced diagnostic tool capable of pinpointing the subsystems most affected by external interference.

DC9: Enhancing the dependability of mission-critical system through an advanced anomaly detection methodology for electromagnetic disturbances
Host: KUL (BE)
Main supervisor: M. Verbeke (mathias.verbeke@kuleuven.be)
Co-supervisors/mentors: D. Pissoort (KUL - BE), D. Nikolov (TUS - BG), R. Deseine (Barco - BE)
Duration: 36 months
Required profile: Electrical engineering or computer science
Desirable skills/interests: Machine Learning, Artificial Intelligence, Electromagnetism.
Objectives: Create an anomaly-detection methodology tailored to identifying potential EMI, in order to reduce the number of false alarms in mission-critical systems. The objective is to adopt a semi-supervised strategy, starting from data representing normal electromagnetic behavior. Also the integration of the EMI-footprint concept into the anomaly-detection methodology will be studied (in collaboration with DC7).

DC10: Electromagnetic field characterization, coupling analysis, and signal integrity prediction in complex cavity environments for enhanced EMI assessment
Host: UNILIM (FR)
Main supervisor: G. Andrieu (guillaume.andrieu@xlim.fr)
Co-supervisors/mentors: A. Reineix (UNILIM - FR), A. Roch (TU/e - NL), F. Lescoat (Airbus FR - FR)
Duration: 36 months
Required profile: Electrical Engineering
Desirable skills/interests: Electromagnetism, Electromagnetic compatibility (EMC), antenna theory, signal processing, measurement techniques.
Objectives: Develop EM field models up to 18 GHz for use in diverse environments like aircraft fuselages, cars and satellites. Examination of the coupling effects between electromagnetic fields and cables within complex enclosures. Contribute to an improvement of the electromagnetic-shielding assessment of cable systems in complex cavities.

DC11: A digital twin for real-time electromagnetic compatibility assurance of an automotive wheel-speed sensor
Host: TUS (BG)
Main supervisor: D. Nikolov (d_nikolov@tu-sofia.bg)
Co-supervisors/mentors: M. Hristov (TUS - BG) D. Pissoort (KUL - BE), S. Krustev (Renesas - BG)
Duration: 36 months
Required profile: Microelectronic/System Engineering, Computer science
Desirable skills/interests: Model-Based Engineering, Software Engineering, Electromagnetic Simulations,
Objectives: Create a comprehensive system-level model that accurately predicts the functional behaviour for a wheel-speed sensor system when exposed to EMI. Use the developed system-level model to construct a parameterized EMI digital twin. Verify and validate the EMI-aware digital twin.

DC12: Impact assessment of the changing nature of a medical electromagnetic environment
Host: TU/e (NL)

Main supervisor: A. Roc'h (a.roch@tue.nl)
Co-supervisors/mentors: G. Pemen (TU/e - NL), S. G. Garcia (UGR - ES), R. Kleihorst (PHC - NL)
Duration: 36 months
Required profile: Electrical Engineering
Desirable skills/interests: Electromagnetism, Electromagnetic Compatibility, Metrology.
Objectives: Develop specialized machine-learning tools to extract and recreate essential features of a medical EMI environment. 2) Address both frequency-domain and time-domain variations to encompass both continuous and transient disturbances. 3) Establish a comprehensive framework for assessing the long-term impact of dynamic EMI environments.

DC13: Enhancing electromagnetic compatibility for evolving power grids and renewable integration through adaptive, distributed control
Host: UTwente (NL)
Main supervisor: T. Hartman (tom.hartman@utwente.nl)
Co-supervisors/mentors: F. Leferink (UT - NL), H. Garbe (LUG - DE), M. Azpurua (EMC Barcelona - ES)
Duration: 36 months
Required profile: Electrical Engineering
Desirable skills/interests: Electromagnetic Compatibility, Data Processing.
Objectives: Develop a methodology that integrates time- and frequency-domain measurements with statistical analyses for evolving power grid and distributed renewable-energy sources. Introduce adaptive, distributed control concepts to optimize the matching of load and supply within power systems. Analyze the dynamic interaction between supply and demand while predicting and managing EMI.

DC14: Electromagnetic simulation of incertitude in complex systems: applications to emissions from photovoltaic installations
Host: UGR (ES)
Main supervisor: L. D. Angulo (lmdiazangulo@ugr.es)
Co-supervisors/mentors: S.G. Garcia (UGR - ES), D. Pissoort (KUL - BE), R. Moreno (Ikerlan - ES)
Duration: 36 months
Required profile: Physicist, Electronics/RF/EMC Engineer, and/or Applied Mathematician.
Desirable skills/interests: Numerical methods, software development, computational electromagnetics, EMC.
Objectives: Develop innovative stochastic models for the unpredictable EMI aspects of electronic systems with a focus on photovoltaic systems. Integrate the stochastic models into the existing time-domain simulation frameworks at UGR. Enhance EMI simulation tools to more reliable and robust tools for assessing anomalies.

DC15: Monitoring electromagnetic emissions from large photovoltaic installations
Host: EMC Barcelona (ES)
Main supervisor: M.A. Azpúrua (marco.azpurua@emc-barcelona.com)
Co-supervisors/mentors: M. Quilez (UPC - ES), S.G. Garcia (UGR - ES)
Duration: 36 months
Required profile: Electronics/Telecommunications Engineering, Physics, Metrology.
Desirable skills/interests: Electronic Design, Electromagnetic modelling and simulation, RF measurements, Design of Experiments (DOE), Estimation of the measurement uncertainty, Computer Assisted Design (CAD).
Objectives: Develop advanced technology for continuously monitoring electromagnetic emissions in large photovoltaic installations during operation. Explore advanced sensing techniques considering time, frequency and statistics. Establish a validation process involving real-world scenarios like large photovoltaic installations with industry collaboration for practical testing.

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iSense project abstract and key project information

Niels Bohr once said, "*Prediction is very difficult, especially if it's about the future*". This is especially true when it comes to the high-tech electronic devices that we increasingly rely on and the electromagnetic environment they have to operate in. We are faced with having to anticipate what is likely to happen in the future, with the widespread use of even more advanced communication systems, the rise of highly automated technologies, like self-driving cars and robotic surgeries, complex systems and infrastructures, and our growing dependence on technology. This web of interconnected systems-of-systems creates a complex electromagnetic environment in which the seamless interoperability of electrical and electronic equipment must be guaranteed.

Only a few years ago, a mobile phone was exclusively used to make calls; today, it is a powerful, smart computer. Cars used to be purely mechanical, but now they're full of computing power technology. Even medical equipment has evolved from basic instruments to high-tech systems. These changes are transforming our lives. But for electronic engineers, it is a tough world, because more complex electronics are being positioned closer and closer to each other, creating the conditions for electromagnetic interference (EMI). The reality is that we cannot predict with any certainty what new technologies will emerge in the next decade. However, based on our experience of the last decade, we do know that they will introduce new forms of EMI – whether radiated or conducted, quasi-continuous or transient – amplifying the complexity of this issue.

Traditionally, the approach to addressing EMI has been "rule-based". This means that we take the existing standards, we read what the rules tell us to do and then we follow those rules. Unfortunately, standards evolve slowly, typically taking around 5 years to update, leading to them to lag technological progress. Additionally, it is challenging to ascertain if their requirements are sufficient, especially when addressing complex, invisible phenomena like EMI. For example, many EMI standards still use a 1 kHz Amplitude Modulation test signal, which is outdated for assessing electronic device immunity in modern communication systems with advanced modulation techniques. To overcome these challenges, the latest Blue Guide (which is about the implementation of EU product rules) mandates a "risk-based" approach for new electronic devices entering the European market. This approach prioritizes ensuring a device's reliability within its electromagnetic environment throughout its lifetime, demanding a detailed understanding of the environment to estimate interference likelihood and severity and implement effective mitigations. Unfortunately, the required skills and knowledge needed for this are lacking. We need to understand the precise flow of electromagnetic fields, currents, and voltages in settings such as healthcare facilities or electric vehicles, which are very different to textbook examples. The real world is more complicated, making it necessary to employ statistical methods, including the precise estimation of outliers, which has not been thoroughly investigated before in the context of EMI. Hence, there is a pressing need to attract and train researchers proficient in monitoring, understanding and modelling continuously evolving electromagnetic environments and extract in-depth insights into how new forms of EMI impact advanced electronic devices.

The iSENSE Doctoral Network on In-Situ Monitoring of Electromagnetic Interference has a clear mission: to train a new generation of experts who possess the skills and fundamental knowledge required to effectively address our intricate and ever-evolving electromagnetic environment to tackle the issue of electromagnetic interference. Specific innovations to be expected are innovative EMI sensors and monitoring methodologies, early warning tools for detecting EMI occurrences, the formulation of novel modelling and test strategies and, overall, a greater success in avoiding EMI issues.

The interdisciplinary needs required to realise iSENSE's overall mission are of such a complexity that we see a large training network involving some of Europe's flagship companies - such as Thales, Philips and Airbus – together with leading European universities in the field – like KU Leuven, UTwente and TU/e – and industry-oriented research organisations – Fraunhofer and Ikerlan – as the best way to tackle the related Science/Technology (S/T) **challenges**, which are briefly described as follows and which will be the aim of the project's **four Scientific/Technological (S/T) WPs**:

Challenge 1 (WP1 – Sense): Devise a diverse set of sensors that are both cost-effective and capable of detecting various types of electromagnetic disturbances. These sensors should be applicable at all levels of design, from small electronic components to complex systems. The aim is to have a toolbox of sensors that can effectively identify and measure EMI in different settings and across different frequency ranges.

Challenge 2 (WP2 – Monitor): Improving our ability to continuously monitor electromagnetic environments. It includes the development of methodologies for real-time and long-term monitoring of EMI, ensuring that we can identify and address new electromagnetic disturbances as they occur.

Challenge 3 (WP3 – Analyse): Deepen our understanding of evolving trends in the electromagnetic environment and how electromagnetic disturbances affect high-technology systems. This involves both anomaly detection and characterizing the various intermediate states that devices may experience when subjected to EMI, ranging from 'working perfectly' to 'actually failing'.

Challenge 4 (WP4 – Exploit): Get better at applying this knowledge when designing and testing such systems. This challenge focuses on translating the knowledge gained in the previous challenges into practical applications. It involves enhancing the design and testing processes of high-technology systems to make them more robust to EMI.

Figure 1: iSENSE Consortium overview

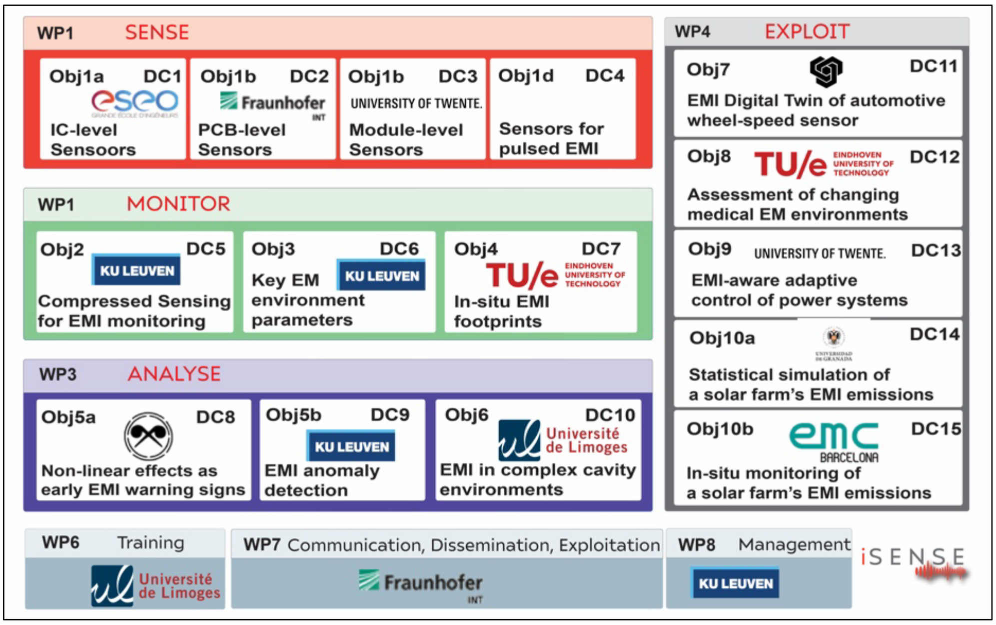

Figure 2: iSENSE WP structure

Together, these **four** challenges are referred to as the "*Sense – Monitor – Analyse – Exploit*" backbone of the iSENSE Doctoral Networks, see Figure 2. Details of the activities in the 4 research WPs are described below.

WP1: Sense - Cost-effective EMI sensors, from IC to system level

WP1 involves four DCs and focuses on the fundamental sensing technologies that underlie the characterization of an electromagnetic environment. When discussing EMI sensors, most people envision devices that quantify electric or magnetic fields in the air. However, an electromagnetic environment encompasses a broader spectrum of phenomena, including radiated and conducted disturbances, as well as continuous and pulsed interference. Moreover, as a disturbance couples from one design level to another, its key characteristics can change. As such, WP1 focuses on sensors from the top system level down to the integrated-circuit level. Given the wide diversity in electromagnetic disturbances to be considered, the characterization of an electromagnetic environment can only be successful if a large number of sensors at different locations and with different natures are used. So, making these sensors cost-effective is crucial. **DC1** focuses on the lowest level and will research *EMI detection in integrated circuits considering speed, precision, and adaptability*. **DC1**'s main challenge will be to find the right balance between improving existing structures found in off-the-shelf integrated circuits with the creation of specialized detection blocks. **DC1** will design a test chip with early EMI detection and adaptive methods for specific interference types, focusing on rapid detection in complex environments while minimizing false alarms. **DC2** will consider one design level higher and devise *cost-effective and robust EMI detection systems for smart electronic devices using generic structures at the level of the printed-circuit board*. The main goal of **DC2** is to determine if and how existing structures on printed-circuit boards can be adapted for EMI sensing, and create from that mitigation strategies for ensuring the continuous, safe operation of smart electronic devices, even when subjected to intentional EMI. Going again one design level higher, **DC3** will consider *multi-node EMI sensor networks for the simultaneous characterisation of radiated and conducted EMI*. **DC3** starts from the premise modern electronic devices already have valuable EMI-sensing capabilities through their existing logging and fault-detection mechanisms, often requiring only software updates to be used for that purpose. **DC3** will look for the best combination to cover both radiated and conducted disturbances. Finally, **DC4** acknowledges that many electromagnetic disturbances come in bursts and pulses and will devise *advanced sensors for characterizing pulsed electromagnetic disturbances*. To this aim, **DC4** will use advanced tools like the Cagniard-deHoop technique to design a near-field sensor based on loaded loops. This near-field sensor will simultaneously characterize electric- and magnetic-type impulsive sources as will be validated with practical time-domain measurements.

WP2: Monitor - From EMI sensor data to electromagnetic environment information

In its initial form, sensor data is a collection of measurements and observations, often complex and unstructured. To extract valuable information, we depend on sophisticated algorithms and analytical tools that can derive information from this data. WP2 is dedicated to addressing this transformation process, bridging the gap between raw sensor data and actionable, valuable information that informs decision-making and drives various actions. **DC5** will *optimize EMI monitoring through the application of compressed sensing to a large network of sensors*. Using compressed sensing, **DC5** will leverage the sparsity of EMI signals, enabling the filtering of noise and redundant data, resulting in cost savings and reduced power consumption. Furthermore, **DC5**'s efforts will guide the optimization of sensor networks by minimizing the total number of required sensors and strategically placing them. Complementary to this, **DC6** will look for the *optimal set of parameters for monitoring and describing electromagnetic environments*. **DC6** will identify key electromagnetic parameters, covering a broad frequency spectrum. Initial measurements in smart-grid and medical settings will serve as a reference, based on which **DC6** will refine parameter selection focusing on the use of lower-cost EMI sensors (WP1). This work will establish minimum requirements for resolution and accuracy. A second measurement campaign in the same environments will validate the methodology. While **DC6** takes the point-of-view of the environment, **DC7** will look at the devices and *expand the recently introduced concept of an EMI footprint to in-situ evaluation of large interconnected systems*. The EMI-footprint concept is a useful tool for understanding how electromagnetic energy behaves in products. Evaluating it in real-world situations, especially for complex systems, is important but far from easy. **DC7** will be working on improving this process. **DC7** will explore advanced methods like near-field scanning and distributed sensing systems to get detailed EMI data and construct the complete EMI footprint.

WP3: Analyse - Analysing evolving EMI trends and unusual events

In contrast to how current EMC standards deal with electromagnetic immunity, a device that is subject to EMI cannot be easily described as either operating correctly or not. There is a wide range of intervening states that describe the operating behaviour of a device that is neither in a perfect state, nor has it failed, but it is somewhere in between. A lot can happen in this grey transition zone: from nothing happening at all, over internal errors, to a disruption of critical capabilities/services at the system level. Therefore, **WP3** concentrates on the characterisation of this region in between to better understand the condition of the device, so that we can know whether it is just about to fail or whether it is capable of continued operation. **DC8** and **DC9** will be working closely on complementary projects. **DC8** will work on a technique to *monitor non-linearities in the EM behaviour as a warning for upcoming interference*. In the past, it has been concluded that subtle, non-linear changes in the emission spectrum of a digital system, i.e., the EM signals it generates itself, can be seen when that system is subjected to an EM disturbance. **DC8** will study in-depth the physical mechanisms behind the generated non-linearities, as this is essential for a correct interpretation of what those non-linearities can tell us about the EM health of the system. Second, **DC8** will disturb several digital systems of varying complexity in a controlled manner, while their emission spectra are carefully monitored. **DC8**'s final aim is to create a diagnostic tool that can identify subsystems affected by interference during operation, helping to ensure system reliability and safety. On the other hand, **DC9** will *identify anomalies in the occurring electromagnetic disturbances during operation of mission- or safety-critical systems*. Anomaly detection for EMI is challenging as electromagnetic disturbances can take many forms. As such, **DC9** will use a semi-supervised approach to build models of normal electromagnetic behaviour and investigate how these can be combined with the EMI-footprint concept of **DC7** (WP2). A key performance indicator for the anomaly detection of **DC9** will be the minimum number of false alarms. To conclude WP3, **DC10** will focus *on the electromagnetic field characterization, coupling analysis, and signal-integrity prediction in complex enclosures* with a particular interest in those with low Q-factor. **DC10** has two main objectives: developing precise electromagnetic field models for these enclosures and studying how electromagnetic fields interact with cables within them. This research aims to predict cable-system performance and assess the need for electromagnetic shielding in complex environments.

WP4: Exploit - Utilizing EMI knowledge within a risk-based approach

The S&T WPs conclude with WP4, which builds upon the previous 3 WPs to develop a risk-based EMC approach. In total, 5 DCs are working on case studies for 3 different industrial sectors: automotive, healthcare and an energy network infrastructure in the form of the power grid and a solar farm. These case studies will not only use the results of the DCs from WPs 1–3, but will also provide practical feedback for them. **DC11** will develop a proof-of-concept *EMI-aware digital twin for an automotive wheel-speed sensor system*, a case study that is representative of many other safety-critical systems. A digital twin is a digital representation (based on models) of a real physical system, which acts like the real system, helps in detecting possible problems, simulates all kinds of scenarios, monitors the performance and/or the environment, etc. **DC11** will consider the entire sensor system, cabling, microcontroller, and power supplies. The work consists of creating a system-level model, developing a parameterized EMI model, and verifying and validating the digital twin, with a focus on transient disturbances. Important questions to be answered are: What type of data is needed for the models? What is the required accuracy? How quickly do we need to do the calculations? Moving from automotive to healthcare, **DC12** will *assess the impact of the changing nature of the electromagnetic* *environment within a healthcare setting*. **DC12** will study how the electromagnetic environment changes in healthcare settings, which is particularly important because it is always changing with new medical equipment and infrastructure updates. **DC12** will be working on making a lab setup that mimics this changing medical electromagnetic environment, using data from various sensors. Both frequency-domain and time-domain variations are targeted to encompass both continuous and transient disturbances. **DCs 13-15** will all be working on use-cases related to the energy sector. As the first of these three, **DC13** will *enhance electromagnetic compatibility for evolving power grids and renewable integration through adaptive, distributed control*. **DC13** will introduce adaptive distributed control, using sensor data to balance supply and demand for an optimal EMC behaviour. **DC13** will also analyse interaction between supply and demand, predict and manage EMI, and employ digital signal-processing techniques. **DC13** will provide feedback to international standards committees. Next to that, **DC14** and **DC15** will both be working on EMI aspects of large photovoltaic installations, also referred to as solar farms. **DC14** will focus on simulations and will cover *how to deal with uncertainties and statistical variations in the electromagnetic simulation of large, complex systems such as photovoltaic installations*. **DC14** will integrate stochastic models into the state-of-the-art deterministic simulation tools that are currently available at UGR and use this to assess the electromagnetic emissions of solar farms. In parallel with this, **DC15** will focus on practical in-situ measurements to *monitor the electromagnetic emissions from large photovoltaic installations*. Based on this, **DC15** will establish installation guidelines to minimize emissions and mitigate EMI risks, ensuring smooth operation of large photovoltaic systems alongside other sensitive systems and the environment. Both **DC14** and **DC15** will be granted access to a recently installed extensive solar farm at IKERLAN.

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Appendix 1: Recruitment Procedure and Principles

Advertisement Process: The search for appropriate candidates will start as soon as the project is approved and is initiated through job ads published on ec.europa.eu/euraxess, Die Zeit/academics.de, LinkedIn and through personal contacts of the network partners. A preliminary iSENSE recruitment web page will be put on-line as soon as possible (July 2024). This speedy timing is chosen in order to be able to attract the best possible students, who by and large graduate in May-June. Postponing the the start of the search for candidates to September 2024 would mean that the best students have already found PhD positions in academia or jobs in industry. A special effort will be made to promote the vacancies at Central and Eastern European universities (e.g., KU Leuven's Central Europe Leuven Strategic Alliance – CELSA)).

All the recruitment is in line with the European Charter for Researchers, providing the overarching framework for the roles, responsibilities of both the researchers and employers. The Code of Conduct for the Recruitment of Researchers functions as a set of principles and ensures that the selection procedures are transparent and fair. The recruitment strategy for iSENSE will fully comply with the Code of Conduct's definition of merit. For example, merit is not just measured on researchers' grades, but on a range of evaluation criteria, such as teamwork, interdisciplinary knowledge, soft-skills and awareness of the policy and economic impact of science. The Recruitment Committee has members of each gender and considers the promotion of equal opportunities and gender balance as part of the recruitment strategy. Special efforts are made to attract women and researchers from new EU Member States. iSENSE aims at a participation of 50% female researchers in the network.

Selection Process: The pre and final selection will be made in a collective progress, led by the Recruitment Committee (RC), which consists of all the people who will be involved in the supervision process. Every member of the RC will receive 4 hours of training on recruitment procedures and will be made aware of factors like unconscious gender bias. The candidates can apply for a maximum of three projects and list their order of preference. The 30 most suitable candidate DCs are invited to a **Recruitment Event** (Bruges, Belgium, month 2). Each candidate gives a presentation and is interviewed. The committee selects the DCs (1) based on their scientific background and potential, (2) based on the expected benefit of the scientific exchange between the trainees' home countries and institutions and the hosts, and (3) in accordance with gender equality and minority rights. The candidates are ranked, and a collective decision is made, considering the order of preference. In this way a complementary team of DCs can be assembled. All non-selected candidates will receive a letter explaining the reasons why they were not selected (in line with the Code of Conduct). The DCs are employed on fixed-term contracts and are registered as staff candidates for their PhD degrees. Therefore, they are entitled to pension contributions, paid holidays, and other employment benefits, as governed by the universities, non-academic partners, and industrial companies.

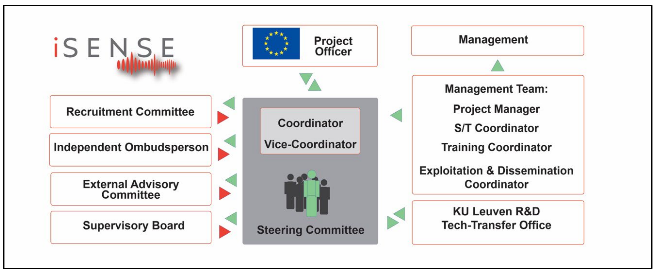

Figure 3: iSENSE Project Management Structure

Recruitment Committee (RC) = This committee involves the General Coordinator, the Vice-Coordinator and at least one representative per Beneficiary. Its goal is to oversee the recruitment of the 15 DCs during the collective recruitment event.

Gender considerations. The advertised positions will not contain gender-coded language and will describe the project, necessary qualifications, working conditions, entitlements, career development, timings and an overview of the selection procedure for maximum transparency. Where regulations allow, adverts will encourage female candidates.

In case not all 15 DCs can be recruited during the collective **Recruitment Event**, the recruitment procedure is "decentralised", meaning that the involved supervisors continue the search for good candidates. The GC is kept informed at all times when new eligible candidates appear. The GC makes an official complaint in case the Code of Conduct for the Recruitment of Researchers is breached. The involved supervisor is then expected to find another candidate. Recruitment problems are also, if still needed, discussed during additional RC meetings in order to deliver specific action plans to target specific networks relevant for the vacant DC positions. All details concerning the recruitment-procedure principles are communicated on the on-line application portal, so that potential DCs know exactly what to expect and are stimulated to apply.