16 PhD positions in the Europe Horizon Marie Skłodowska-Curie Project

Do you want to be trained to take up a key position mixing electronics and AI for medical electronic equipment? While being part of a prestigious MSCA doctoral network working on the embedding of existing AI technology into a the design for electromagnetic interference in medical equipment? **This is your chance!!**

PATTERN

Applications are invited for **16 PhD positions** (“Doctoral Candidates (DCs)”) to be funded by the Marie-Skłodowska-Curie Doctoral Network “**PATTERN – European Doctoral Network Enabling Artificial Intelligence for Electromagnetic Compatibility**”. The consortium groups 9 hiring Universities: Eindhoven University of Technology (NL), University of Twente (NL), KU Leuven (BE), Universiteit Gent (BE), Tomáš Baťa University (CZ), Technische Universität Hamburg (DE), CNRS (FR), NOVA University of Lisbon (PT) and De Montfort University (UK). Together, these universities have a proven track record in the management of Electromagnetic Interference (EMI), Artificial Intelligence (AI), material engineering, system-safety engineering, and risk management, and are the leaders in their field in Europe. Existing knowledge in sustainability management will be reinforced by connecting the industrial network of PATTERN’s 9 stakeholders across the complete lifecycle of medical products. Design solutions for the management of EMI represent one of the most extended value chains: stretching from switching events in ICs, at the heart of all our electronics (Nexperia), at one end, to diverse safety-critical applications MedTech Products: Philips with collaborative imaging systems, Barco with medical screens and the Plux with biosensing platforms and wearables) at the other. Many intermediaries are present: with components (Nexperia, Rosenberger), cables (SAFRAN) and innovative measurement and simulation platforms for EMI (Prana and Idiada, respectively).

PATTERN will create a long-lasting, multidisciplinary, academic-industrial network for doctoral training, with leading European industry and academia, to achieve a breakthrough in the design of innovative EMI solutions, throughout their lifecycle, with AI acting as the key enabler of a new design philosophy. For this inclusion to occur, each DC will develop through their research the missing dedicated components, tools and techniques, and apply them to a representative set of EMI solutions under development. This hands-on training is supplemented with several scientific professional courses and an immersive training where the DCs can fine-tune their skills for the Jobs of tomorrow, while addressing the societal challenges of the PATTERN program.

Specifically, Doctoral Candidates (DCs) in the project will be working on (more details can be found below):

- DC1: Physics guided model for learning and control for EMC
- DC2: AI to combine and model EMNF applied to cables
- DC3: Sensitivity propagation in AI-developed tools for EMI analysis
- DC4: AI to combine and model Electromagnetic Noise Footprint (EMNF) applied to PCB Tracks.
- DC5: ML-based Sequential Sampling Techniques for Accelerating EMC Measurements
- DC6: Adaptive Database with ML methods for EMI Prediction and Optimization of High-Speed Packages
- DC7: AI for EMI filter Design
- DC8: Assessment of electromagnetic compatibility of cabling systems through AI
- DC9: Enabling a trade-off between using physics- or data-based approaches for EMC prediction using AI tools
- DC10: Evolutionary Algorithms as a Tool for Electromagnetic Shielding Design
- DC11: Development of AI diagnostic tools to identify the origin of an EMI
- DC12: Development of AI tools to assess accurately the influence of EMI on biosignals
- DC13: Real-Time Anomaly Detection in the Electromagnetic Environment Using AI and EMNF
- DC14: Development of diagnostic AI tools to change from (post-design) analysis to (pre-design) synthesis
- DC15: Development AI tools for adaptive sampling in the in-situ near field of installation
- DC16: Human analogue training for neural networks

September 30, 2024: Deadline for online applications
End-October 2024: Notification of PATTERN pre-selected candidates
Mid-November 2024: PATTERN recruitment event
End-November 2024: Decision on recruited PATTERN DCs
January 1st 2025 to January 1st 2026: Start of the DC contracts

Key background info

EU FUNDING

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Number of positions available
16 PhD / Doctoral Candidate (DC) Positions

Research Fields
Electrical/Electronic Engineering – Materials Engineering – Safety Engineering – System Engineering – Sustainability Management.

Keywords
Electromagnetic Interference – Electromagnetic Compatibility – Electromagnetic Modelling - Artificial Intelligence - Medical Equipment – Risk Analysis – Risk Reduction.

Career Stage
Doctorate Candidate (DC) i.e., not already in possession of a doctoral degree at the date of the recruitment.

Benefits and salary
The successful candidates will receive an attractive salary in accordance with the MSCA regulations for Doctoral Researchers. The nominal (gross) amount includes (at least) a living allowance (€3400 per month, country coefficient applies to allow for the difference in cost of living in different EU Member States), a mobility allowance (€600 per month), and a family allowance (€660 per month, if applicable). Deductions will apply for social security contributions and/or taxes according to the applicable national laws of the country were the recruiting organization is located.
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). Position DC16 is an exception to these conditions and will be directly funded by UKRI (Public Body for Innovation and Research in UK).
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 acquired through a unique immersive learning.

Recruitment Procedure (see Appendix 1 for full description)
All applications proceed first through the on-line recruitment portal on the www.pattern-dn.eu website. Candidates apply electronically for one to maximum three positions and indicate their preference. Candidates provide all requested information including a detailed CV (Europass format[1] obligatory), a motivation letter and transcripts of bachelor and master's degree[2]. During the registration, applicants will need to prove that they are eligible (cf. DC definition, mobility criteria, and English language proficiency). The deadline for the on-line registration is **30 Sept. 2024**.
The PATTERN Recruitment Committee selects between 32 and maximum 48 candidates for the Recruitment Event which will take place Online (**Beginning November 2024**). The selected candidates provide a 20-minute presentation and are interviewed by the Recruitment Committee. Candidates will be given a domain-relevant peer-reviewed paper (prior to the recruitment event) by their prioritized Supervisor(s) and will be asked questions about this paper during the interview to check if the candidate has the right background/profile for the DC position.
Prior to the recruitment event, online interviews between the Supervisor(s) and the candidates are recommended, along with on-line personality tests. A good quality digital connection will need to be organised.
The final decision on who to recruit is communicated shortly after the Recruitment Event (estimated **Mid November 2024**). The selected DCs are to start their research as quickly as possible (targeted date: **1 February 2025**).

Applicants need to fully respect the following eligibility and mobility criteria (to demonstrated in the Europass CV):

- Supported researchers must be doctoral candidates, i.e. not already in possession[3] of a doctoral degree at the date of the recruitment.
- Recruited researchers can be of any nationality and must comply with the following mobility rule: they 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 36 months immediately before their recruitment date**.** For 'International European Research Organisations' (IERO), 'international organisations', or entities created under Union law, the researchers must not have spent more than 12 months in the 36 months immediately before their recruitment in the same appointing organisation. Compulsory national service, short stays such as holidays and time spent by the researcher as part of a procedure for obtaining refugee status under the Geneva Convention[4] are not considered.

[1] https://europass.cedefop.europa.eu/documents/curriculum-vitae
[2] 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.
[3] Researchers who have successfully defended their doctoral thesis but who have not yet formally been awarded the doctoral degree will not be considered eligible.
[4] 1951 Refugee Convention and the 1967 Protocol.

DC1: Physics guided model for learning and control for EMC
Host: TUe (NL)
Main supervisor: Dr. Amritam Das (TUe, NL)
Co-supervisors/mentors: Prof.dr.ir. Roland Toth (TUe, NL), Prof.dr.ir Tim Claeys (KUL, BE), Ir. Rob Kleihorst (Philips, NL)
Duration: 36 months
Required profile: Electrical Engineering
Desirable skills/interests: Machine Learning, Data-driven modelling, Control design, Electromagnetism
Objectives: Modelling EMC is challenging due to nonlinear behavior, frequency-dependent interactions, complex geometries and many uncertainties involved. Current technqiues are heavily limited due computational burden and are often too costly to enable optimization early in the design process. This DC will aim to capture the time-varying behaviour of components, connectivity, and operational conditions with machine learning methods, such as Physics-guided Neural Networks (PGNNs) and explore control strategies to design controllers efficiently based on the learnt models to suppress electromagnetic interference within electronic systems. The DC will also support capturing time-varying behavior of EMC and contribute to the desing of a medical collaborative system.
Secondments (2-4 months in total): KU Leuven (BE), Philips (NL)

DC2: AI to combine and model Electromagnetic Noise Footprint (EMNF) applied to cables.
Host: TUe (NL)
Main supervisor: Dr. Ir. Anne Roc'h (a.roch@tue.nl)
Co-supervisors/mentors: Prof. Philippe Besnier (CNRS. FR)/ Ir. Rob Kleihorst (Philips, NL)/ Prof.dr.ir. Roland Toth (TUe, NL)
Duration: 36 months
Required profile: Electronic Engineering
Desirable skills/interests: Electromagnetism, Electromagnetic Compatibility, Metrology, Artificial Intelligence.
Objectives: This DC first goal will be to unravel a structural understanding of the exchange of parasitic energy of cables with its environment using AI tools. The so-called EMNF (ElectroMagnetic Noise Footprint) comprises a set of characteristic curves obtained from stand-alone measurements on a device. A second goal will consist in exploring how to combine two or more EMNFs. The work will support an optimization (within the SSbD framework) of cable routing in a MedTech product by combining EMNFs. *Secondments (2-4 months in total): Safran (FR) and CNRS (FR).*

DC3: Sensitivity propagation in AI-developed tools for EMI analysis
Host: CNRS (FR)
Main supervisor: Philippe Besnier, (philippe.besnier@insa-rennes.fr)
Co-supervisors/mentors: Dr. Ir. Tom Hartman (UT, NL), Dr. Ir. Charles Jullien (SAFRAN, FR), Prof. Jean-François Dupuy (CNRS/ INSA Rennes, FR)
Duration: 36 months
Required profile: Electrical Engineering or Applied Mathematics
Desirable skills/interests: Electromagnetism, electromagnetic compatibility, statistics, machine learning, applied mathematics
Objectives: A very large number of variables is needed for analysis of the EMI propagation and some of the initial uncertainties can have a drastic impact on the obtained results. Uncertainty propagation has never been analysed beyond EMC unrealistically simplified scenario. A solution, customized to the reality of EMC scenarios, is needed.
This DC3 will explore, assess, and develop efficient preprocessing techniques for identifying the important variables in the EMI propagation mechanism. The aim is then to reach an efficient sensitivity analysis of these remaining factors using AI techniques. It opens the door to a refine prediction of a risk of EMI for a given safety-critical EMI scenario can be refined.
Secondments (2-4 months in total): SAFRAN (FR) and TUe (NL).

DC4: AI to combine and model Electromagnetic Noise Footprint (EMNF) applied to PCB Tracks.
Host: TUe (NL)
Main supervisor: Dr.ir Anne Roc'h (TUe, NL)
Co-supervisors/mentors: Prof. Davy Pissoort (KUL, BE)/ David Kuratko (IDIADA, CZ)/ Prof.dr.ir. Roland Toth (TUe, NL).
Duration: 36 months
Required profile: Electrical Engineering
Desirable skills/interests: Electromagnetism, Electromagnetic Compatibility, Metrology, Artificial Intelligence.
Objectives: This DC first goal will be to unravel a structural understanding of the exchange of parasitic energy a PCB Tracks with its environment using AI tools. The so-called EMNF (ElectroMagnetic Noise Footprint) comprises a set of characteristic curves obtained from stand-alone measurements on a PCB. A second goal will consist in exploring how to combine two or more EMNFs. The work will support an optimization (within the SSbD framework) of PCB routing by combining EMNFs. *Secondments (2-4 months in total): KU Leuven (BE) and Idiada (CZ).*

DC5: ML-based Adaptive Sampling Techniques for Accelerating EMC Measurements
Host: UGENT (BE)
Main supervisor: Tom Dhaene (UGENT, BE)
Co-supervisors/mentors: Ivo Couckuyt (UGENT, BE), Dirk Deschrijver (UGENT, BE), Dr.ir Anne Roc'h (TUe, NL)
Duration: 36 months
Required profile: Electrical Engineering
Desirable skills/interests: Machine Learning, Electromagnetic Compatibility, MW/RF
Objectives: By leveraging state-of-the-art, data-efficient Machine Learning (DE-ML) approaches and developing novel Bayesian active learning (BAL) techniques, the goal is to reduce the time of standard well-known, lengthy EMC tests, especially for radiated field sampling.
Secondments (2-4 months in total): TUe (NL), Thales (NL)

DC6: Generation of an Adaptive Database in Combination with Methods of Machine Learning for Signal Integrity (SI) and Electromagnetic Interference (EMI) Prediction and Optimization of High-Speed Packages for Discrete Devices
Host: TUHH (DE)
Main supervisor: Prof. Christian Schuster (TUHH, DE)
Co-supervisors/mentors: Dr.ir Stanislav Kovar (TBU, CZ) / Prof. Matthias Mnich (TUHH, DE) / Nexperia (DE)
Duration: 36 months
Required profile: Electrical Engineering, Physics, or Data Science
Desirable skills/interests: Electromagnetics, Electromagnetic Compatibilty, Machine Learning, Artificial Intelligence

Objectives: This DC project aims to extend the state of the art in application of methods of machine learning (ML) to the field of electronic computer aided design (ECAD). Specifically, it aims to develop, train, optimize and evaluate ML methods for simulation and optimization of high-speed packages for discrete devices in combination with generating and using an adaptive database. The main objective is to adapt ML methods which model and ultimately replace the existing design process in most steps and hierarchies.
Secondments (2-4 months in total): Nexperia (DE) and CNRS (FR).

DC7: AI for EMI filter Design
Host: TUe (NL)
Main supervisor: Dr.ir Anne Roc'h (TUe, NL)
Co-supervisors/mentors: Prof. Frank Leferink (UT, NL)/ Ing. Libor Valíček (Schneider, CZ)/ Dr. Ir. Roland Toth (TUe, NL)
Duration: 36 months
Required profile: Electrical Engineering
Desirable skills/interests: Electromagnetism, Electromagnetic Compatibility, Power Electronics, Artificial Intelligence.
Objectives: This DC first goal will be to unravel a structural understanding of the exchange of parasitic energy of EMI Filters with its environment using AI tools. The so-called EMNF (ElectroMagnetic Noise Footprint) comprises a set of characteristic curves obtained from stand-alone measurements on a device. A second goal will consist in exploring how to combine two or more EMNFs. The work will support the optimization (within the SSbD framework) of EMI filters within products by combining EMNFs.
Secondments (2-4 months in total): Schneider (CZ) and UT (NL).

DC8: Assessment of electromagnetic compatibility of cabling systems through AI
Host: CNRS (FR)
Main supervisor: Philippe Besnier, (philippe.besnier@insa-rennes.fr)
Co-supervisors/mentors: Dr. Ir. Anne Roc'h (TUe, NL), Dr. Ir. Charles Jullien (SAFRAN, FR), Prof. Jean-François Dupuy (CNRS/ INSA Rennes, FR)
Duration: 36 months
Required profile: Electrical Engineering or Applied Mathematics
Desirable skills/interests: Electromagnetism, electromagnetic compatibility, statistics, machine learning, applied mathematics
Objectives: Recently, different techniques have been introduced to estimate the response of wiring systems according to their stochastic uncertainties using various approaches such as reliability techniques (risk analysis), polynomial chaos, decision-tree algorithms / random forests, neural network, kriging. None addresses uncertainty distribution
This DC8 will work on the assessment of uncertainty distributions, which are key since governing the propagation. The work mainly aims at defining a practical and cost-efficient methodology to estimate the input distribution of uncertain parameters by design. This knowledge is a necessary condition to propagate them correctly for assessment of EMC output responses associated with cabling systems.
Secondments (2-4 months in total): SAFRAN (FR) and TUe (NL).

DC9: Automation of the Assessment of Physics-Based vs. Data-Based Approaches for Signal Integrity (SI) and Electromagnetic Interference (EMI) Prediction and Optimization of Cables and Connectors Assemblies
Host: TUHH (DE)
Main supervisor: Prof. Christian Schuster (TUHH, DE)
Co-supervisors/mentors: Dr.ir Tim Claeys (KUL, BE) / Prof. Matthias Mnich (TUHH, DE) / Rosenberger (DE)
Duration: 36 months
Required profile: Electrical Engineering, Physics, or Data Science
Desirable skills/interests: Electromagnetics, Electromagnetic Compatibilty, Machine Learning, Artificial Intelligence
Objectives: This DC project aims to make a contribution in the area of signal integrity (SI) and electromagnetic interference (EMI) prediction of electronic systems based on either "physics-based" or "data-based" approaches. Specifically, this project will try to establish algorithms that will allow assessing accuracy and complexity (speed) of each of these approaches in order to come to automated recommendations for the design process. The main objective is to enable an automated assessment of whether to use a physics- or data-based approach for prediction and optimization of SI and EMI of cable and connector assemblies.
Secondments (2-4 months in total): Rosenberger (DE) and CNRS (FR).

DC10: Evolutionary Algorithms as a Tool for Electromagnetic Shielding Design
Host: TBU in Zlin (CZ)
Main supervisor: Dr. Stanislav Kovar (TBU, CZ)
Co-supervisors/mentors: Prof. Davy Pissoort (KUL, BE)/ Ing. Libor Valíček (Schneider, CZ)
Duration: 36 months
Required profile: Electrical Engineering/ Mechanical Engineering
Desirable skills/interests: Electromagnetic Compatibility, Computational electromagnetism, Metrology, Artificial Intelligence
Objectives: This project aims to enhance electromagnetic shield designs using evolutionary algorithms. DC will start by analyzing existing designs to set benchmarks. Next, DC will create a mathematical model to predict design effectiveness. Finally, AI will be implemented to optimize manufacturability and effectiveness, ensuring practical, high-performing solutions across industries.
Secondments (2-4 months in total): Schneider (CZ), IDIADA (CZ)

DC11: Development of AI diagnostic tools to identify the origin of an EMI
Host: KUL (BE)
Main supervisor: Prof. Davy Pissoort
Co-supervisors/mentors: Prof. Frank Leferink (UT, NL), ir. Ronny Deseine (Barco, BE), Prof. Mathias Verbeke (KUL, BE)
Duration: 36 months
Required profile: Electrical Engineering or Computer Science
Desirable skills/interests: Electromagnetism, artificial intelligence, machine learning, product design
Objectives: DC11 will investigate the potential of AI as a tool for design engineers to identify the origin and optimal solutions for EMC issues in the post-deployment phase of safety-critical products. Designing electronics with EMC considerations requires highly experienced engineers, whose expertise is built over many years of implementing, validating, and debugging design techniques. Despite this, pinpointing the origin of an EMC problem and finding the best solution can still be challenging. Additionally, integrating SSbD KPIs into solutions to control EMI has become an added challenge.
Secondments (2-4months in total): Barco (BE) and Philips (NL)

DC12: Development of AI tools to assess accurately the influence of EMI on biosignals
Host: FCT UNL (PT)
Main supervisor: Prof. Hugo Gamboa
Co-supervisors/mentors: Dr. Ir. Anne Roc'h, Prof. Hugo Silva,
Duration: 36 months
Required profile: Electrical Engineering or Biomedical Engineering
Desirable skills/interests: Signal Processing, Machine Learning, Biosignals acquisition.
Objectives: The research will support the implementation of AI tools to overcome the problems of EMI in the medical context of biosignals Aquisition that some time occur in critical clinical scenarios. Aims: 1. Develop accurate and reliable prediction of a risk of EMI influencing biosignals requiring a careful reconstruction of the signals. 2. Validate the developed AI tools in the case of a bio-sensing platform. 3. Contribute to the development of safer, more reliable health monitoring technologies, ultimately benefiting public health and wellbeing. The DC12 will develop novel Deep Learning architectures and Explainable AI models ****will improve the detection of interference and identify the sources, and actions to improve the biosignals quality or recreate the signal. The synthesis capabilities will improve the development by reducing the testing time via simulation.
Secondments (2-4 months in total): TU/e (N)

DC13: Real-Time Anomaly Detection in the Electromagnetic Environment Using AI and EMNF
Host: KUL (BE)
Main supervisor: Prof. Mathias Verbeke (KUL, BE)
Co-supervisors/mentors: Prof. Philippe Besnier (CNRS, FR), Ronny Deseine (Barco, BE), Prof. Tim Claeys (KUL, BE)
Duration: 36 months
Required profile: Electrical Engineering or Computer Science
Desirable skills/interests: Machine Learning, Artificial Intelligence, Electromagnetism
Objectives: DC13 aims to leverage AI for real-time anomaly detection in the electromagnetic environment, where anomalies are rare deviations from normal behavior. Due to the challenge of gathering a comprehensive dataset of anomalies, a semi-supervised approach will be devised, using normal data to construct a model representing regular electromagnetic behavior. The project will combine "EMI footprints", which capture normal variations through characteristic curves and statistical distributions, with traditional machine learning techniques (e.g., one-class support vector machines) and deep learning techniques (e.g., autoencoders/ transformers) to detect anomalies. By integrating these AI techniques with EMI footprints, DC13 seeks to develop an efficient methodology for real-time anomaly detection in the electromagnetic environment.
Secondments (2-4 months in total): Thales (NL) and CNRS (FR)

DC14: Development of diagnostic AI tools to change from (post-design) analysis to (pre-design) synthesis
Host: University of Twente (UT) (NL)
Main supervisor: Dr. Ir. Tom Hartman
Co-supervisors/mentors: Prof. Philippe Besnier, Ir. Hans Schipper, Prof. Raymond Veldhuis
Duration: 36 months
Required profile: Electrical Engineering
Desirable skills/interests: Electromagnetic Compatibility, Data Processing
Objectives: The unwanted emission or unwanted susceptibility of complex systems are always caused by aspects which are "forgotten" in the design. This is also the reason why even fantastic extreme difficult simulations fail to model accurately the EMI propagation in products. This DC will first ensure the data validity used for modeling EMI propagation at system level. S/he will consider "forgotten" parameters from Expert Systems made exceptionally available by industry, containing field diagnostic and accumulated precious (unpublished) knowledge from senior (EMC) experts.
Secondments (2-4 months in total): Thales (NL), KU Leuven (BE)

DC15: Development AI tools for adaptive sampling of the in-situ near field of an electronic device
Host: KUL (BE)
Main supervisor: Prof. Tim Claeys
Co-supervisors/mentors: Prof. Frank Leferink (UT, NL), Ronny Deseine (Barco, BE), Prof. Mathias Verbeke (KUL, BE)
Duration: 36 months
Required profile: Electrical Engineering
Desirable skills/interests: Electromagnetism, antenna theory, signal processing, measurement techniques,…
Objectives: DC15 will explore how AI can enhance the efficiency and accuracy of near-field - adaptive sampling on (aged) deployed products. Special emphasis is placed on optimizing near-field sampling, as it captures all radiant energy affecting the EM integrity of the entire system. This aims to reduce the duration of lengthy EMC tests and enable in-situ testing. Factors such as human errors during installation, product aging, corrosion, shock, vibration, and interactions between subsystems will also be considered. To address this challenge, DC15 will work on an AI/ML approach combining advanced sampling, modeling techniques, and electronically switched probe arrays.
Secondments (2-4months in total): Barco (BE) and TU/e (NL)

DC16: Human analogue training for neural networks
Host: De Montfort University, UK
Main supervisor: Alistair Duffy
Co-supervisors/mentors: Hugo Gamboa, Hugo da Silva
Duration: 36 months
Required profile: Electrical Engineering
Desirable skills/interests: Electromagnetics, Electromagnetic Compatibility, AI, data comparison
Objectives: The feature selective validation (FSV) method compares data sets (particularly those for EMC applications) in a way that broadly matches the range of views of a group of experts. The hypothesis being tested in this project is whether it is possible to build this fundamental 'algorithmic knowledge' into 'artificial intelligence' to develop a more 'algorithmic intelligence' that might be better capable of interpreting data in a more natural and nuanced way, as well as requiring smaller training sets.
Secondments (2-4 months in total): PLUX, TUHH

PATTERN is a Doctoral Network at the intersection of electromagnetic compatibility, medical engineering, system-safety engineering, and sustainability management. In its push to go beyond the state of the art the project will embed artificial intelligence (AI) into every challenge. The project will research how best to use AI to discover innovative and sustainable solutions to manage electromagnetic interference (EMI) and develop new sets of design guidelines for electromagnetic reliability and the safety of European medical products of the future.

PATTERN's science case is based on the integration and optimization of every key performance indicator (KPI) linked to the two revolutions faced by medical electronics: risk and sustainability. This requires us to think in terms of a trade-off across a new mix of disciplines, to develop innovative solutions, and to consider all the far-reaching societal and technical consequences of a design choice. Until now, even the most high-tech of industries have been forced to manufacture several prototypes and perform tests, because the actual performance of an EMI solution in a product is unknown. A characterization strategy embedded in these new realities is urgently needed.

PATTERN is the first training network dedicated to the inclusion of AI as the choice of technology to support these paradigm shifts with a new design philosophy. It answers the recently highlighted, pressing need for trained specialists in the field.

PATTERN involves 9 academic Beneficiaries and 9 industrial Associated Partners, across the complete lifecycle of design solutions, from 8 countries. A pan-European approach in a multi-sectoral context is guaranteed (universities, an established start-up, SMEs, and major industries).

PATTERN will train a new generation of scientific professionals who can transition between disciplines and take up leading positions in the field of electronics, safety, sustainability and AI, while thinking about design differently.

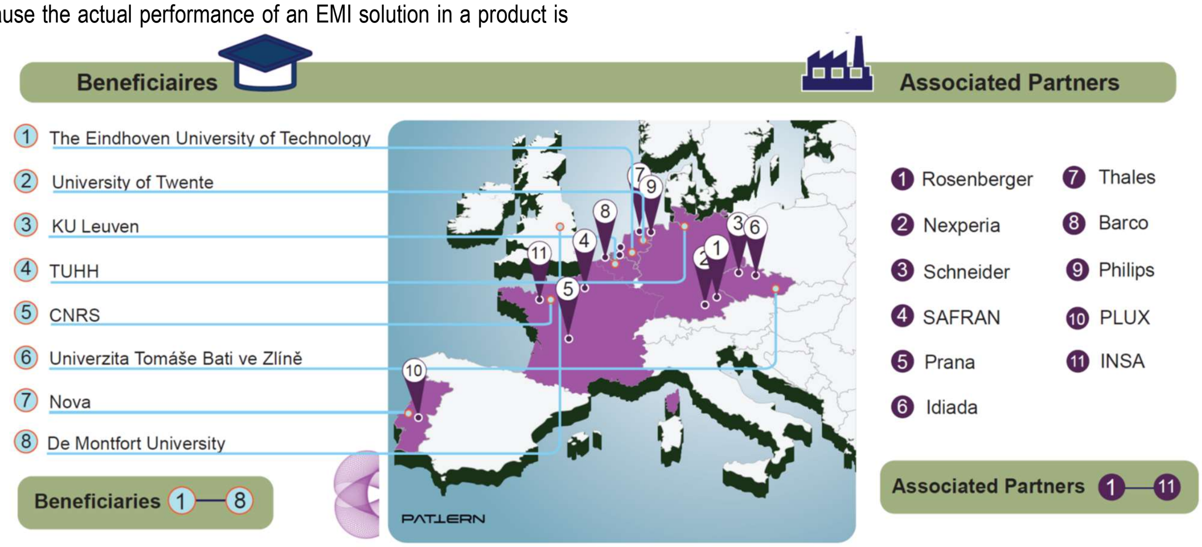

Figure 1: PATTERN Consortium

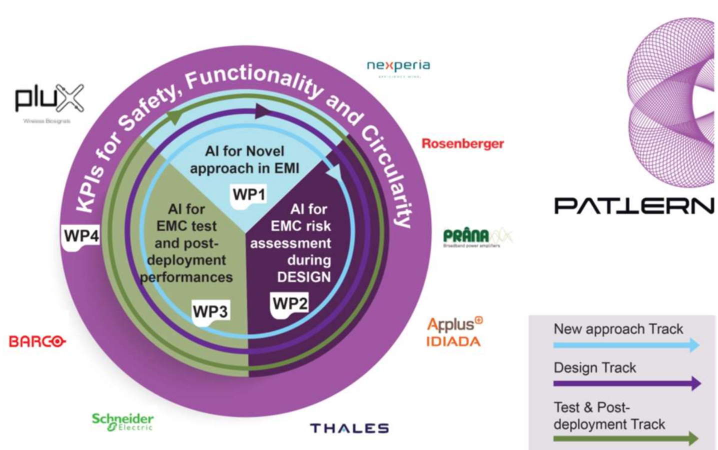

Figure 2: PATTERN WPs and DRs

The PATTERN project is based on 7 Work Packages (WPs), four of which are S&T WPs (WP1–4), one for Training (WP5), one for Exploitation, Dissemination and Communication (WP6) and one for Management (WP7). Innovative aspects for each of the DCs are detailed in Table 1.2.b.

The consortium is made up of 9 universities TUe (NL), UT(NL), KUL(Be), GU(Be), TUHH(DE), DMU(UK), TBU(CZ), NOVA(PT) and CNRS (FR). Together, these universities have a proven track record in the management of EMI, AI, material engineering, system-safety engineering, and risk management, and are the leaders in their field in Europe. Existing knowledge in sustainability management will be reinforced by connecting the industrial network of PATTERN's 9 stakeholders across the complete lifecycle of medical products.

A total of 16 individuals DC projects have been defined. Based on their projects and (common) secondments, each DC will have a mix of requirements, design, and system-level verifications. While each DC project has been defined as a stand-alone research line with its own unique contribution, several collaboration points have been planned to bring complementary results together and give extra value-added to the project. The inter-relation between each DC project and their corresponding core WPs are described below.

WP1: AI driven EMC design

The goal of this work package is to unravel unknown PATTERNS in how the EM noise interacts with medical products by exploring AI approaches never used so far in EMC to create deeply structured knowledge ("class 3" AI systems): these causality models are a prime example on how AI can support EMC expertise to progress into gaining structural knowledge and an understanding of the complex mechanism and pattern of EM propagation.

To ensure adequacy with the reality of design requirements, **DC1** to **DC5** and **DC16** will, as a group, work closely with all other 10 DCs, through secondments in both academia and industry. **DC1** will focus on utilizing Physics-guided Neural Networks (PGNNs) and optimal control methods to enhance electromagnetic compatibility in complex electronic systems. It consists of accurately learning an interpretable representation of dynamic variations within electronic systems that can potentially lead to EMI. **DC1** will work with the so-called "forgotten parameters" thanks to unique access to the proprietary EMC expert database of Philips. **DC1** will support **DC11** in the development of self-learning diagnostic tools also using the expert database of Barco. **DC2** and **DC4** will address, respectively, the cabling and PCB layout management through the recent concept of EM Noise Footprint (EMNF), which will be combined for the first time leading to study novel patterns for the system analyses of **DC6** and **DC8** at Safran, CNRS and TUHH. For these same PCBs and cables, **DC3** will support an accelerated sensitivity analysis, which is particularly relevant as these interconnects are extremely sensible to any design changes and are the main propagation means for EMI through systems. Feature selection of the data combined with suitable machine-learning methods involving hybridization with support vector machines (i.e., kriging) will be used. The human analogue training will be a first in EMC with **DC16**: it is an FSV (Feature Selective Validation) technique that been shown to provide a heuristic approach that closely matches the overall opinion of a group of experts. **DC16** will combine FSV with Artificial Neural Networks (ANN) and Convolutional Neural Networks (CNN) to investigate whether such a heuristic in the training phase can produce neural networks that achieve higher accuracy, faster convergence and with smaller training sets. **DC16** will apply his/her findings with **DC12** and **DC9** on a biosensing platform and wearables at PLUX. This medical application is particularly sensitive to multiple parameters such as its shape, its users, or its EM environment. **DC5** will explore Bayesian optimization based adaptive sampling for Accelerating EMC Measurements. By leveraging state-of-the-art, data-efficient, Machine Learning approaches and developing novel Bayesian active learning (BAL) techniques, the goal is to reduce the time of well-known, lengthy EMC tests, especially for radiated field sampling. **DC5** will work closely with DCs of WP3, Barco, PLUX and Philips.

WP2: AI for EMC Risk assessment during Design

DC6 to **DC10** will focus on the phase of integrated EMC design in medical products. It starts at the heart of the EMI generation with its smallest element: the integrated circuit (IC) with its Printed Circuit Board (PCB) towards the whole hierarchical scale of components propagating these EMIs (EMI filter – **DC7** and cables and interconnects – **DC8**, **9** and **10**). All five DCs combine the SSbD approach in AI-based tools to accurately predict the EM propagation and performance of these diverse electronic parts. The developed methodologies will build on the fusion of existing first-principal knowledge and the modelling capabilities of deep-learning methods to provide physically driven, interpretable prediction tools with reliable performance guarantees. **DC6** to **DC10** will leverage on the methods developed in WP1 by **DC1** to **DC5** and **DC16**.

DC6 will work on the generation of an adaptive database in combination with methods of Machine Learning (ML) towards the prediction of EMI. Optimization of High-Speed Packages for Discrete Devices. Such developments are hampered by the astronomically wide spectrum of design options and resulting in very slow progress. Hence, appropriate AI tools based on ML would greatly enhance R&D in this challenging direction and provide a prediction of performance together with the confidence of these predictions, by working with **DC3** in CNRS on a specific accelerated sensitivity analysis. **DC3** and **DC6** will apply the developed tools on discrete components. These components are central in the safety of wireless communication used in safety-critical medical products. **DC7** and **DC10** will investigate the incorporation of advanced Evolutionally Algorithms (EAs) (e.g., tree-adjoining grammar-based memetic algorithms with multi-objective optimization) into the design of EMI filter and the shielding design process of high-speed PCB (respectively), which takes into the user requirements (weight, thickness, mechanical strength, and other SSbD criteria). EMI filter and shielding solutions are their primary protection against a constantly changing EM environment. **DC10** will explore further the challenge of 3D simulation with the specialized company IDIADA. DC7 and **DC10** will work together with Schneider on a RF PCB towards a common solution where the shielding and filtering performance have been optimized for weight, volume, and cost with Bayesian family algorithms. **DC8** and **DC9** will focus on optimizing the routing of connectors and cables with tools such as: artificial neural networks, Gaussian process regression and Bayesian optimization and comparing Physics-Based vs. Data-Based Approaches. Cables are the key propagator of EMI through systems, and appropriate routing supports the containment of EM noise**. DCs 8** and **9** will test their own tool and the new approaches of WP1 (with **DCs1** and **2**) with the company Safran.

WP3: AI for EMC Risk assessment during Test and Post-Deployment

DC11 to **DC15** will focus on the development of diagnostic tools for EMC to test the post-deployment phase of safety-critical medical products from immediate release to aged devices. Diverse metadata (e.g., mechanical, thermal or tolerances) of the product will be combined and analysed by AI tools to comprehend the propagation of EMI in a diverse deployed installation, used in different EM environments (various geographical locations and settings). Aging and mechanical fatigue are among other known factors degrading the initially predicted performance of EMC design solutions. Algorithms from the Bayesian family and Evolutionary Algorithms will typically first be considered in this Work Package. In addition, the **DC11** to **DC15** will leverage on the methods developed in WP1 by **DC1** to **DC5** and **DC16**.

The developed methods will exploit already-existing physical knowledge in existing "EMC expert systems" (**DC11&12**) and exploit them to rapidly learn diagnostic capabilities for specific products with unprecedented interpretability in EM engineering (leading to pre-design synthesis – **DC14**). **DC11&12** will research how AI can help the design engineer to identify the origin and the best solution for an EMC problem with self-learning diagnostic tools. The algorithm would build up its experience based on sets of EMC measurements for a given set of implemented design techniques in the EMC expert system of medical products in Barco and Philips (developed over the last 30 years) – for **DC11**, and collected in-situ field data from Plux, over multiple product versions, – for **DC12**. They will both work conjointly with **DC16** on FSV with Artificial Neural Networks (ANN). **DC13** will work on the data collection of EM-field surrounding devices. In many cases of EMC measurements, the sampling of the EM fields is performed on uniform grids to ensure that the maximum emission is found. **DC13** will leverage on the work of **DC1&2** on EMNF, and **DC5** on accelerated sampling in Thales. A specific focus is given to the optimization of the near-field sampling of a deployed product as it contains all the radiant energy threatening the EM integrity of the complete deployed system (**DC15**). The goal is to reduce the time of well-known, lengthy EMC tests and open a new window of opportunity for in-situ testing: the unwanted emission or unwanted susceptibility of complex systems are also caused by human factors (during installations), deterioration in lifetime, corrosion, shock and vibration or high-level system interactions between various sub-systems. The environment in which the product is used also brings unpredicted aspects. **DC14** will use the in-situ measurement results (Thales and Barco) to update guidelines and good practices towards a pre-design synthesis, based on collected knowledge that was never available before the PATTERN DN.

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Appendix 1: Recruitment Procedure and Principles

Advertisement Process. The search for appropriate candidates is initially based on normal recruitment strategies (e.g., publication on ec.europa.eu/Euraxess, etc.; personal contacts of the network partners). 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 PATTERN 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 (RC) has members of each gender and considers the promotion of equal opportunities and gender balance as part of the recruitment strategy. A special focus will be made to attract female DCs from EU's new Member States.

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 32-48 most suitable candidate DCs are invited to an Online Recruitment Workshop. 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.

Gender aspects in the selection process

The Participants would also like to pursue the PATTERN programme with representative gender balance among the DCs to be recruited. The advertisements for the DC positions will explicitly encourage the application of female DCs. The advertising will target women through female-specific science groups (e.g., IEEE Women in Engineering globally). The female coordinator is personally aware of the importance of reaching a representative gender balance in the new generation of scientist in the fields of PATTERN.

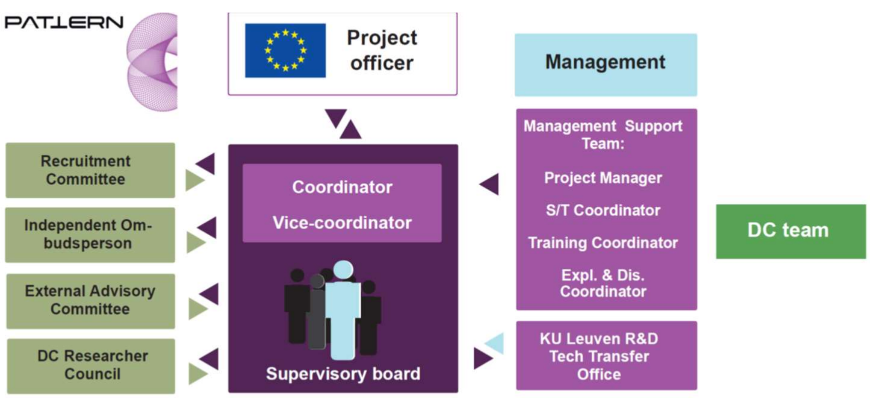

Figure 3: PATTERN Project Management Structure

Recruitment Committee = This committee involves the General Coordinator, the Vice-Coordinator and at least one representative per hiring University. Its goal is to oversee the recruitment of the 16 DCs during the collective recruitment event.