MARIE SKŁODOWSKA-CURIE ACTIONS

Postdoctoral Fellowships (PF) – Horizon Europe

Proposal Part B1 – Section 1–3

Project Acronym:	SYNAPSE-NET
Project Title:	Next-Generation Neuromorphic Edge Computing Networks
Scientific Panel:	Information Science and Engineering (ENG)
Fellow:	Dr. Evelyn Vance
Host Institution:	Meridian Institute of Technology (Nexa Campus)
Supervisor:	Prof. Marcus Sterling
Project Duration:	24 Months

1 Excellence

1.1 Quality and pertinence of the project's research and innovation objectives

The SYNAPSE-NET project aims to design and implement a next-generation neuromorphic edge computing network tailored for real-time, low-power biomedical signal processing. Modern edge devices are severely limited by energy consumption and latency when executing deep learning models. This project bridges this critical gap by developing an event-driven Spiking Neural Network (SNN) framework integrated with a custom physical substrate.

Key Research Objectives

- **Objective 1 (Algorithm):** Develop a novel hardware-aware spike-timing-dependent plasticity (STDP) learning algorithm that reduces computational complexity by 85% compared to standard backpropagation methods.
- **Objective 2 (Hardware):** Design and emulate the custom neuromorphic processing architecture, SynapseCore, demonstrating sub-milliwatt power consumption at the millisecond scale.
- **Objective 3 (Integration):** Integrate and validate the system using clinical-grade electrocardiogram (ECG) data from Meridian Health databases, achieving $\geq$ 98% classification accuracy.

1.2 Soundness of the proposed methodology

The methodology follows a co-design approach where algorithms are optimized for physical constraints, and hardware architectures are tailored to network dynamics. We utilize a combination of digital and analog design principles to model physical neuron behaviors.

1.2.1 Hardware-Algorithm Co-Design

Rather than training SNNs in software and mapping them directly to hardware (which often leads to severe degradation in accuracy), we propose an in-situ training framework. The learning rules are computed locally

on-chip, minimizing high-energy memory access cycles. This configuration addresses the classical memory-bottleneck problem in traditional architectures by placing processing units and memory elements in physical proximity.

1.3 Quality of the supervision, training and of the two-way transfer of knowledge

Supervision quality: Prof. Marcus Sterling is the Director of the Neuromorphic Systems Lab at the Meridian Institute of Technology, with over 150 high-impact papers and multiple patents in mixed-signal silicon architectures. The lab provides a state-of-the-art environment for experimental silicon testing and system engineering.

Two-Way Knowledge Transfer:

- **Researcher to Host:** Dr. Evelyn Vance transfers her deep expertise in tensor-based compression methods and machine learning compiler frameworks, expanding the host lab's capabilities in automated model deployment.
- **Host to Researcher:** Dr. Vance receives advanced training in hardware description languages (Verilog/SystemVerilog), mixed-signal emulation, and cleanroom fabrication flows, filling a crucial gap in her physical design skills.

1.4 Quality and appropriateness of the researcher's professional experience

Dr. Evelyn Vance received her PhD from Synapse University in 2024, focusing on sparse neural networks. She has published 5 first-author papers in top-tier venues (NeurIPS, ICML, ISCA) and received the prestigious Vertex Research Grant in 2025. Her unique combination of mathematical rigor in network theory and software engineering makes her exceptionally qualified to execute the SYNAPSE-NET project.

2 Impact

2.1 Credibility of the measures to design the career perspectives and next career steps

The fellowship will act as a launchpad for Dr. Vance to establish an independent research group in Europe. By bridging computer science (software) and electrical engineering (hardware), she enters a highly sought-after interdisciplinary niche. During the 24 months, a Career Development Plan (CDP) will be established, focusing on:

- **Grant Writing:** Preparing an ERC Starting Grant application based on the results of SYNAPSE-NET.
- **Leadership:** Supervising two MSc students and mentoring one PhD candidate in the Neuromorphic Systems Lab.
- **Networking:** Participating in the annual Horizon Europe MSCA Network meetings and building collaborations with leading industrial partners like Nexa and Vertex.

2.2 Suitability and quality of the measures to maximize expected outcomes and impacts

The proposal incorporates a structured Dissemination, Exploitation, and Communication plan to maximize the societal, scientific, and commercial impacts of the research.

Table 1: Dissemination, Exploitation and Communication Strategy

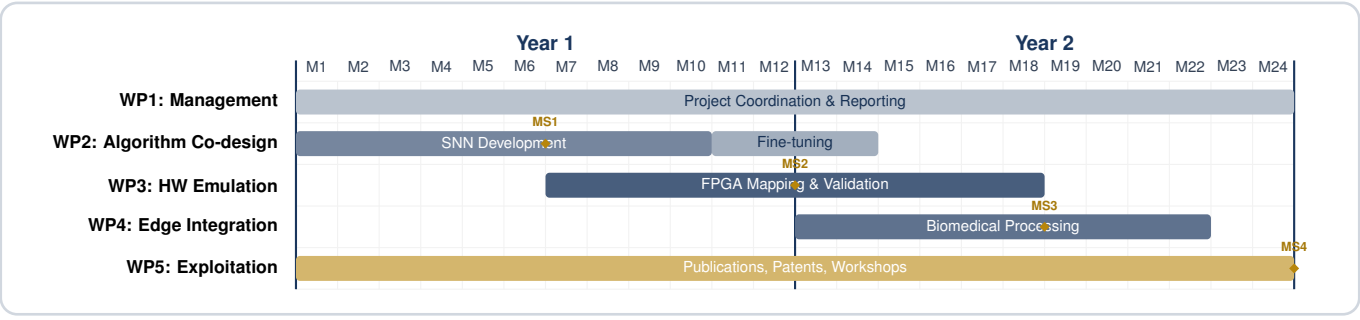
Target Audience	Dissemination/Communication Channel	Key Performance Indicator (KPI)
Scientific Community	Publications in IEEE JSSC, Nature Electronics; presentations at ISSCC.	$\geq$ 3 Peer-reviewed papers, open-source model repository with $\geq$ 200 GitHub stars.
Industrial Partners	Workshops at Meridian Institute, technology transfer reports to Nexa.	1 Patent application on self-healing synapse circuits filed.
General Public	Science festivals, public lectures at Meridian, blog posts on MSCA Portal.	Reach $\geq$ 5,000 individuals through public engagement and digital media.

3 Quality and Efficiency of the Implementation

3.1 Coherence and effectiveness of the work plan

The project is organized into 5 Work Packages (WPs) structured over 24 months. The allocation of tasks is balanced, leveraging both the researcher's background and the host's infrastructure.

Figure 1: SYNAPSE-NET Project Gantt Chart (Months 1–24)



3.2 Appropriateness of the management structure and procedures, including risk management

The project will be monitored through bi-weekly meetings between Dr. Vance and Prof. Sterling. Financial and administrative management will be handled by the Meridian Research Office (MRO), which has managed over 50 Horizon Europe projects. Table 2 outlines the potential risks and the corresponding mitigation strategies.

Table 2: Critical Risks and Mitigation Measures

Risk Description	Impact/Probability	Proposed Mitigation Measure
High Latency in Spike Generation	Medium / Low	Fallback to sparse rate-based encoding with event-driven updates.
FPGA Hardware Bottlenecks	Low / Medium	Utilize Meridian's secondary high-capacity emulator boards.
Delayed Clinical Data Access	Medium / Low	Utilize open-source synthetic datasets (e.g. Vertex Medical open-data).

3.3 Quality and capacity of the host institutions/participating organisations

Meridian Institute of Technology (Nexa Campus) is a premier European research institution. The Neuromorphic Systems Lab occupies over 250m^2 of state-of-the-art laboratory space, featuring cleanrooms, high-frequency testing equipment, and a dedicated cluster of 128 high-performance GPUs. Meridian provides comprehensive administrative support, language courses, and relocation assistance through its Euraxess Services Centre.