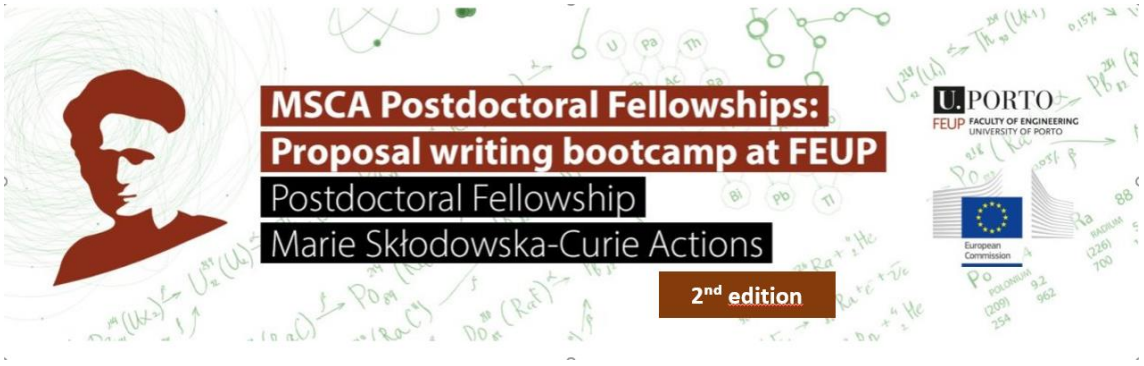

SUPERVISOR INFORMATION	
First and Last name	Henrique Salgado
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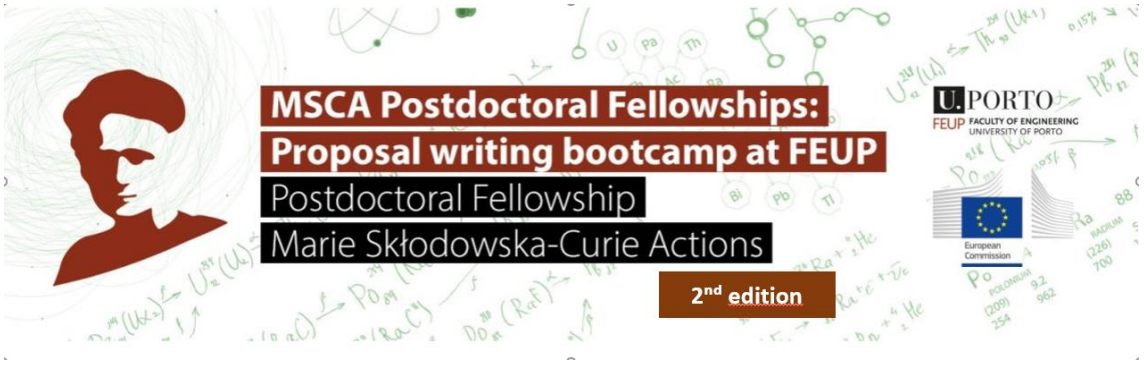
Department	Electrical and Computer Engineering
Field(s) of research	Optical and RF wireless communications
PROJECT PROPOSAL	
Title (optional)	Convergence of RF and Optical Wireless Communications for Beyond 6G Networks
Brief project description	This 2 year PhD research proposal investigates the **convergence of RF and optical wireless communications (OWC)** to address the challenges faced by current wireless networks as we move toward **beyond 6G technologies**. By integrating OWC with RF technologies, the project aims to develop a hybrid communication system that leverages the wide bandwidth and inherent security of OWC while maintaining the flexibility and reliability of RF.

With the rapid evolution of wireless communication systems, the demand for high-capacity, ultra-reliable, and low-latency communication (URLLC) has grown exponentially. Current 802.11 WiFi solutions and RF-based wireless technologies face limitations in addressing the requirements of emerging applications such as high-definition video streaming, cloud-based services, augmented/virtual reality (AR/VR), and autonomous systems. These limitations stem primarily from the limited spectral efficiency and congestion within traditional RF bands. Next-generation wireless networks, including 6G and beyond, will need to address these challenges while supporting new applications that require ultra-high data rates and reliability with minimal packet delays, even in mobile environments. A promising solution lies in the integration of optical wireless communication (OWC) technologies, operating in visible and infrared bands, with traditional RF wireless systems.

OWC offers significant advantages, such as:

- Higher bandwidth compared to RF.
- Inherent physical-layer security due to its line-of-sight nature.
- Immunity to RF-induced electromagnetic interference, making it suitable for dense network environments.

By shifting some or all network traffic to higher frequencies such as mmWave and optical bands, RF resources can be optimized for applications where optical solutions are infeasible or temporarily blocked. This research aims to advance the state-of-the-art by investigating the convergence of distributed MIMO OWC systems with existing RF wireless technologies. The ultimate goal is to develop a seamless, hybrid communication framework that leverages the



unique strengths of both domains and contributes to shaping future 6G standards, including THz communications.

The specific objectives of the project are:

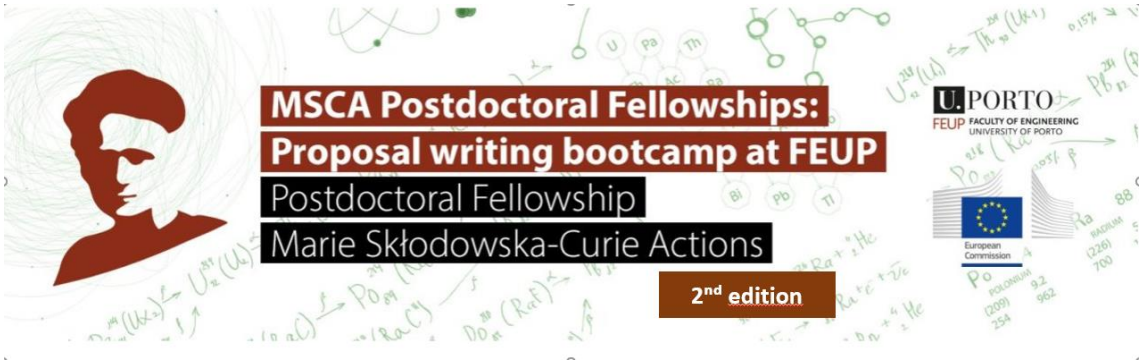
- To investigate a hybrid optical and RF wireless communication system, leveraging the strengths of both RF and optical communications. The focus will be on advancing the state-of-the-art through seamless integration to enhance data rates, reliability, and security in beyond 6G networks.
- To evaluate the performance of the hybrid system in terms of data rate, latency, packet loss, and reliability under diverse environmental conditions and mobility scenarios, while benchmarking it against traditional RF systems.
- To develop an energy-efficient hybrid communication node, combining RF and OWC technologies, with a focus on minimizing power consumption while maintaining high performance.
- To investigate constellation shaping techniques to improve spectral efficiency and reliability, ensuring the hybrid communication system can meet the stringent requirements of future beyond-6G networks.

Tasks

1. Literature Review and State-of-the-Art Analysis
   Conduct a comprehensive review of existing RF and optical wireless communication (OWC) technologies, focusing on their integration for next-generation wireless networks. Identify current research gaps, challenges, and opportunities in hybrid systems, including aspects of data rates, reliability, energy efficiency, and spectral optimization. This task will serve as the foundation for designing the proposed hybrid system.

2. Design and Development of a Hybrid RF-OWC Communication Node
   Design and develop a hybrid communication node that seamlessly integrates RF and optical wireless technologies, electronics and optics based on the COTS (commercial-off-the-shelf) components. The system will focus on enhancing data transmission rates, reliability, and security by dynamically leveraging the strengths of both communication domains. Emphasis should also be given to energy-efficient communication nodes that optimize power consumption while maintaining high-performance hybrid communication. This includes implementing low-power algorithms and leveraging the inherent energy efficiency of OWC to extend operational capabilities.

3. Performance Evaluation Under Realistic Conditions
   Assess the hybrid system's performance in terms of data rate, latency, packet loss, and reliability under various environmental and operational conditions, such as interference, mobility, and signal blockages. The results will be compared with traditional RF-only systems to demonstrate performance improvements.



4. Investigation of Constellation Shaping Techniques
   Explore and implement advanced constellation shaping techniques, such as probabilistic shaping and geometric shaping, to enhance spectral efficiency and communication reliability. These techniques will be tailored to meet the demands of hybrid RF-OWC systems in beyond 6G networks.

5. System Integration and Validation
   Integrate all components, including hybrid nodes and constellation shaping algorithms, into a functional system. The prototype will undergo testing in controlled and real-world scenarios to validate performance, energy efficiency, and reliability under dynamic conditions.

6. Documentation and Dissemination
   Document findings from all project phases, including system design, performance evaluation, and testing results. Publish research outcomes in peer-reviewed journals and conferences to contribute to the development of future 6G wireless standards.

By addressing these tasks, the project will deliver a prototype hybrid communication system, validated through real-world testing, and contribute to the development of future 6G wireless standards. The outcomes include enhanced performance, energy efficiency, and optimized spectral utilization, addressing the demands of next-generation wireless networks and laying the foundation for integrated RF, optical, and THz communications.