Research program

For the activation within the PhD course in Industrial and Information Engineering of the following Research Program, using the resources referred to in Ministerial Decree no. 351/2022, relating to the following Measure

[x] **M4C1- Inv. 4.1** *"Extension of the number of research doctorates and innovative doctorates for public administration and cultural heritage"*. In particular:

[x] **Doctorates for the Public Administration**

[x] Area 09 –Industrial and information engineering

- **Title of the research program**: Smart monitoring system for the intelligent management of port environments.

- **Description:**

The use of ICT solutions has now become more and more pervasive with repercussions in different areas of the life of each individual thanks to the proliferation of so-called smart environments. Smart City, Smart Industry, Smart Agriculture are just some examples of cyber-physical systems (composed of sensors and actuators and equipped with artificial intelligence techniques) used for the improvement and redesign of environments and systems with the ultimate goal of greater efficiency, a reduction in environmental impact and an increase in safety levels. Internet of Things, big data and artificial intelligence are the main technologies underlying this new paradigm.

The purpose of this research program is the study, analysis and design of innovative cyber-physical solutions for intelligent monitoring, traffic management and the improvement of port security.

Port areas represent a nerve centre and complex infrastructure, essential for the transport of goods and people and which conveys different sub-infrastructures (maritime, rail, road) that must coexist with a high degree of multi-modality. The intelligent management of the various activities that fall into these areas plays a crucial role in light of the logistical importance that the infrastructure covers, making it therefore a duty to investigate the phenomena that exist within it by analysing the operating conditions and assessing their criticalities. For example, the monitoring and detection of movement and the parking of vehicles at intersections or in areas with parking served will allow to estimate queue lengths, traffic volumes, classification of different vehicle mixes, also taking into account the density conditions (vehicle/km) and time gap between the vehicles and therefore also obtain information on the nature of the vehicles in transit and the number of equivalent axles to be loaded on the ship.
The research program will therefore be characterized as an accelerator of the digital transition necessary for the modernization of PA management systems and will also have an impact on safety and environmental sustainability through the optimization of processes.

In order to study advanced techniques for the intelligent management of port areas, interdisciplinary skills from the fields of Computer Engineering and Transport Engineering are required.
It is possible to identify different study areas that will be affected by the research program.

- Monitoring and reporting infrastructures. Sensors for the detection of data relating to air quality and noise, intelligent cameras capable of detecting the license plate of vehicles, actuators such as signalling panels, traffic clearing barriers, intelligent traffic lights, embedded acquisition and interfacing cards.

- Communication protocols for Smart Cities. Low Power Wide Area Network protocols such as LoRaWAN or Sigfox and their use in Smart Cities, 5G / 6G data transfer technologies.

- Software architectures. Software systems for data collection, storage and processing. Modern Edge-Cloud architectures and the main protocols for efficient and secure data management will be investigated.

- Artificial intelligence. Deep learning techniques for analysing sensor data and designing intelligent and predictive algorithms. Intelligent techniques will be investigated for the prediction of traffic flows and for the optimization of resources.

- Blockchain technologies. They can be used to implement a secure database that guarantees the immutability of the collected data and a trustless computing infrastructure for the algorithms that implement the control policies also for the purpose of investigating the advantages for the public administration (for example for what concerns the transparency and legal responsibility).

The research program will be characterized by high scientific innovation and originality which will be demonstrated through scientific publications in international congresses and journals with particular attention to open-access policies.

❖ **Period in companies, research centres and Public Administrations**

The research program will be carried out in collaboration with the following subject:

Company name: Port System Authority of the Strait
Registered office: Via Vittorio Emanuele II, 27 - 98122 Messina
Legal representative: Ing. Mario Mega

The aforementioned institution will host the PhD student beneficiary of the scholarship financed on the resources of Ministerial Decree 351/2022 for no. **6** months during the doctorate.

❖ **Period abroad:**
The research program provides for a period abroad of no. **6** months at the following institution:
Missouri University of Science and Technology, Rolla, MO, United States

We also declare that this program complies with the principle "not to cause significant damage" (DHSH) pursuant to art. 17 of regulation (EU) 2020/852 in coherence with the technical guidelines prepared by the European Commission (Communication of the European Commission 2021 / C58 / 01) and guarantees compliance with the horizontal principles of the PNRR (contribution to the climate and digital target so-called tagging, the principle of gender equality and the obligation to protect and enhance young people).