**ALLEGATO 10**

**BANDO PUBBLICO PER LA SELEZIONE DI PROPOSTE PROGETTUALI, FINALIZZATE ALLA CONCESSIONE DI FINANZIAMENTI PER ATTIVITA' COERENTI CON QUELLE DELLO SPOKE 1 "PERVASIVE AND PHOTONIC NETWORK TECHNOLOGIES AND INFRASTRUCTURES" DELL'INIZIATIVA "RESEARCH AND INNOVATION ON FUTURE TELECOMMUNICATIONS SYSTEMS AND NETWORKS, TO MAKE ITALY MORE SMART (RESTART)" A VALERE SULLE RISORSE DEL PIANO NAZIONALE DI RIPRESA E RESILIENZA (DI SEGUITO PNRR), IN ATTUAZIONE DELL'INVESTIMENTO 1.3 – CREAZIONE DI "PARTENARIATI ESTESI ALLE UNIVERSITÀ, AI CENTRI DI RICERCA, ALLE AZIENDE PER IL FINANZIAMENTO DI PROGETTI DI RICERCA DI BASE" NELL' AMBITO DELLA MISSIONE 4 "ISTRUZIONE E RICERCA" – COMPONENTE 2 "DALLA RICERCA ALL' IMPRESA", (PE 0000001), DI CUI ALL'ART. 5, DELL'AVVISO PUBBLICO NR. 341.2022**

**CODICE BANDO: IEIIT-RESTART-SP1-02**

**CUP B53C22003970001**

**Requisiti scientifici**

**Pervasive IoT: novel IoT paradigms, localization and tracking technologies, and UAV-based communication and sensing**

The activities must be synergic with and complement the existing activities planned in the Structural project S8 Pervasive Communications (PESCO), and in particular they will be included in the planned activities for Tasks 3.1, 3.2 and 3.3 of PESCO. The complete description of PESCO is provided as Allegato 9 of this call.

Specifically, the activities must comply with the following requirements.

**Activity 1.1 (covering Task 3.1 of PESCO)**

**Description of the activities**

PESCO aims at addressing in an integrated manner all aspects related to pervasive technologies for beyond 5G and 6G networks, in order to support critical applications such as, e.g., connected vehicles, autonomous factories, and smart cities. It sets, among its ambitious goals, to develop foundational models and concrete technological enablers, as well as a reference architecture and consistent performance evaluation, for a pervasive Internet also exploiting joint communication and sensing in a sustainable manner. Consistently, pervasive Internet of Things (IoT) is a key area of research for PESCO, as it covers the most promising approaches for pervasive communication, sensing and computing with heterogeneous IoT devices, ranging from personal devices to high-end ones (such as, e.g., UAVs). In particular, novel IoT communication and computing paradigms need to be developed to accommodate the project goals as mentioned above, with related research activities arranged into a dedicated Task (3.1) of the project.

The main objectives of these activities, which are intended to be entirely carried out by partners identified through this call, can be further detailed as follows:

- enabling the use of IoT resources at the network edge in a more flexible and efficient way, possibly through resource sharing and/or virtualization (coherently with, e.g., PESCO Obj 1.4), going towards a deviceless approach. This approach resembles the idea of serverless computing, which is widely adopted in cloud environments, and allows service providers to offer services in a scalable manner,

in the form of functions that are not tightly associated with a physical server. Extending the serverless paradigm in the IoT domain, however, is not a straightforward process and requires addressing several challenges associated with the specific characteristics of IoT devices. First, proper communication protocols should be designed or adapted to allow interacting with constrained devices in an as-a-Service manner. Second, device-discovery protocols should be selected to allow the execution of functions on devices that could have discontinuous availability. Finally, novel orchestration approaches should be devised, to allow dynamic allocation and deallocation of functions following both device availability and user demand.

- devising novel IoT architectures and management solutions to support the seamless integration of heterogeneous devices connected with varying wireless technologies. Coherently with , e.g., PESCO Obj 1.5, this approach aims at enabling future holistic IoT systems by devising: (i) novel network architectures that integrate into a single network heterogeneous communication technologies from low-power (e.g. IEEE 802.15.4e, BLE, etc) to long-range (e.g., 5G/6G, LoRaWAN); (ii) management solutions to support different IoT devices characterized by different requirements from resource-constrained devices with limited computing and power capabilities (e.g., low-end embedded systems battery powered or even battery less) to resource-rich devices with high capacity (e.g., high-end embedded devices). The proposed solutions should take into account ongoing standardization efforts (e.g., the 6TiSCH WG at IETF or 6G at ETSI).
- enabling support for critical communication requirements such as low latency and reliability to also include mobility support by design to enable industrial applications, in line with, e.g., PESCO Obj 3.1 of PESCO. To this aim, innovative resource allocation algorithms to ensure millisecond-order latency between devices and sensing functions while handling mobile IoT devices need to be devised and integrated into proper network resource management and service orchestration paradigms.
- devising novel paradigms and approaches to fully exploit the abundance and heterogeneity of IoT devices towards a multimodal and distributed sensing. Data can indeed be captured from heterogeneous types of devices, such as cameras, LIDARs, ambient sensors, etc., which are specifically deployed for sensing purposes in a more and more pervasive manner. Moreover, in line with WP4 activities, other devices, not specifically dedicated to sensing, could be exploited to attain communication-enabled sensing, and further extend the volume of available data. Coherently with, e.g., PESCO Obj 3.2, the proposed approaches should consider proper mathematical modelling tools to manage the complexity associated with such an abundance of heterogeneous data, e.g., following data-fusion approaches.
- ensuring the long-term sustainability of IoT solutions to reduce costs and electronic waste, coherently with PESCO Obj 4.1. This objective can be reached, e.g., by devising: (i) novel energy saving paradigms to extend the life of battery powered IoT devices to minimize the frequency for battery replacement; (ii) improve existing approaches for IoT device programmability and virtualization to ensure the adaptability of future IoT deployments to changing conditions/requirements, without requiring device replacement.

**Activity 1.2 (complementing Task 3.2 of PESCO)**

The emerging paradigm of integrated sensing and communications entails the use of existing communication infrastructure for sensing purposes (and vice versa). In this respect, novel sensing techniques integrated in communication technologies are of interest for a number of applications, ranging from target detection, classification and identification, tracking. This is a key factor in PESCO project, expressed in Goal#2 and more specifically in Objects 2.1, 2.2 and 2.5.

Within this context the main objective of the activities to be carried out in Task T3.2 are:

- Development of suitable electromagnetic propagation models, which properly describe the interaction between sensors (possibly heterogeneous and working in different frequency bands) and complex environment, as well as among sensors themselves;
- Development of novel imaging or detection techniques, which exploit electromagnetic data gathered from communication technologies, aimed at the localization of targets in outdoor environments for different applications;
- Development of innovative strategies for tracking targets using data collected by electromagnetic sensors;

**Activity 1.3 (complementing Task 3.3 of PESCO)**

The use of UAVs as a means to reach not easily accessible places and provide new observation platforms for monitoring complex scenarios is gaining huge attention. Within PESCO project UAV-based communication and sensing strategies will be applied to improve aspects like coverage, power consumption and link efficiency. This goal will be pursued also considering scenarios composed of multiple UAVs, deployed as aerial base stations, to provide service to mobile ground users, and investigate the new sensing capabilities that will result.

Within this context the main objective of the activities to be carried out in Task T3.3 are:

- Development of accurate models to describe the propagation and scattering when sensors are mounted on moving platform, e.g. drones. This activity shall also consider the use of sensors on different platforms as a single multi-static system.
- Development of novel scattering, radar, and synthetic aperture radar (SAR) imaging, to provide new powerful observation platforms for timely and high-resolution monitoring of complex scenarios.

**Relation with the PESCO project workpackages**

**WP3 (Pervasive IoT):**

This is the main WP where the proposed solutions will be anchored. The proposed activities will develop fully T3.1, and support and complement the existing activities in T3.2 and T3.3.

**WP1 (User-centric Pervasive Internet):**

The developed solutions must integrate with the serverless computing environment in T1.3. Solutions will have to be compatible with the device-centric solutions developed in T1.1 and T1.2, and possibly exploit the Digital Twin paradigm to support distributed sensing, data fusion, and learning.

**WP2 (Edge Intelligence and Data Management):**

The proposed activities must consider and exploit the in-network intelligence and smart data management solutions developed in WP2, leveraging on novel federated-learning solutions as well as decentralized ML algorithms designed for resource-constrained (IoT) devices.

**WP4 (Novel sensing paradigms integrated with communication):**

Algorithms and models will exploit specific technologies for joint sensing and communication developed in T4.1 and T4.2, as well as cognitive approaches defined in T4.3, exploiting the full range of heterogeneous IoT devices and signals considered in WP3.

**WP5 (common performance evaluation tools, methods, and results in integrated scenarios)**

The proposed activities are expected to contribute to a PoC at the end of the project, in the framework of the overall activities of WP3.

**WP6 (requirements, scenarios, and architecture):**

The activities will contribute to the refinement of the use cases identified in the first six months, elicitation of requirements and definition of the final architecture of the project.

**WP7 (dissemination and impact creation):**

The funded partners are expected to contribute to the joint dissemination and impact creation activities, both at the level of PESCO and at the level of RESTART overall

**Deliverables (all deadlines are related to the workplan of the PESCO project)**

The output of the activities will be included in the WP-level deliverables, specified as follows:

- D3.2 (M18): Consolidated algorithms and models, with intermediate performance assessment for Pervasive IoT systems – interim report.
- D3.3 (M24): Consolidated algorithms and models, with intermediate performance assessment for Pervasive IoT systems.
- D3.4 (M30): Refined algorithms and models, with finalized performance assessment for pervasive IoT systems – interim report.
- D3.5 (M36): Refined algorithms and models, with finalized performance assessment for pervasive IoT systems.
- Moreover, it is expected to contribute, in the framework of WP5, to the following deliverable:
- D5.3 (M36): Infrastructure operation, field tests and PoC.

**Additional Constraints**

Proposals should clearly indicate how they will achieve the following constraints in terms of budget allocation. Compliance with the following requirements will be mandatory for proposals to be considered eligible. In addition to the general constraints already specified in the call, the following constraints must be met:

- Between 15% and 20% of the requested funding should be devoted to a mix of the following:
  - activities devoted to the development of new hardware components;
  - involvement of industrial partners whose key focus is on business verticals relevant for the topic of the call, e.g., healthcare, energy, automotive, transportation, smart cities, Industry 4.0.
- The breakdown of funding requested to the activities of Topic 1 must fall within the following ranges:
  - between 40% and 60% allocated to Activity 1.1
  - between 25% and 35% allocated to Activity 1.2
  - between 15% and 25% allocated to Activity 1.3