**Allegato 3 – Topic e relativa dimensione del costo progettuale - RESTART SPOKE 3**

| N | Topic | Costo del progetto (k/€)<br>**N.B.: Il costo del singolo progetto dev'essere compreso tra €2.000.000 e € 4.000.000** In ogni caso, **l'agevolazione complessiva per singolo progetto non potrà essere superiore a € 3.000.000.**<br>Gli importi sotto sono indicativi |
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| 1 | **Cell-Free massive MIMO for 6G: design and implementation aspects**<br>The activities are fundamental research and they will consist of the following: Consideration of cell-free massive MIMO deployments at mmWave frequencies: design of cooperative beamforming schemes; adoption of the "learn to optimize" approach, based on machine learning tools, to develop real-time implementable power allocation schemes for dynamic user-centric cell-free networks; design and analysis of non-orthogonal multiplexing schemes for co-existence of eMBB, URLLC and mMTC traffic in cell-free massive MIMO systems; AI methods for power control in large-scale cell-free systems; consideration of key implementation constraints of scalable networks, including synchronization of distributed access points, hardware impairments (due to low-cost components) and quantization of fronthaul data. Matlab-based implementation of a system level simulator for cell-free massive MIMO network deployment operating at mmWave; the simulator will implement selected beamforming and power control schemes.<br>*Topic type: Research-oriented* | 280K€ |
| 2 | **Hardware realization of a 5G-NR compliant cell-free massive MIMO traffic emulator**<br>The idea is to use the concept of Hw in the loop to emulate a cell-free network deployment of distributed APs, connected to one or more CPUs, where, on the uplink, received data is decoded by the CPUs and then re-encoded in OFDM frames and put at the RF antenna input of a 5G-NR compliant base station. On the downlink, information symbols to be sent to the UEs served by the cell-free deployment are decoded from the RF signal transmitted by a commercial base station, and re-encoded and transmitted to the UEs by the APs of the cell-free deployment. Traffic generator generates a massive connectivity to make a load-stress test of a commercial basestation. Specifically, it is required to realize an uplink/downlink RF signal (to be sent/received by the antennas of a 5G-NR compliant base station) that would be used to feed a cell-free deployment of distributed APs. The purpose is to evaluate the impact and study the feasibility of a system where cell-free connectivity is realized in a transparent way by using standard 5G-NR compliant base stations with a proper HW and Software Defined Radio for Sw control system.<br>*Topic type: Demonstrator* | 190k |
| 3 | **Signal processing and resource allocation for range extending devices (IAB-nodes, smart repeaters, smartskins)**<br>Derivation of transceiver signal processing algorithms for integrating range-extending devices such as static-passive skins (SPS), smart repeaters (aka network-controlled device), and IAB nodes into B5G/6G wireless networks. Specifically, the activities will consider the design of channel estimation and beam alignment procedures; design of | 170k€ |


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| | power control and carrier allocation schemes, using model-based and data-driven approaches.<br>Static-passive skins (SPS) is favorable for some scenarios (e.g., walls), in detail, the activities ore on advanced design methodologies capable of solving the associated multi-scale metasurface optimization problem for some shapes, choice of materials, and EM design. Both topics are cross-seeded, and performance evaluation in a typical vehicular environment is requested. PoC involvement with practical validation jointly with 6GWINET.<br>*Topic type: Research-oriented* | |
| 4 | **Massive communication and URLLC: theoretical framework and small-scale PoC**<br>Investigation on networks of batteryless sensor nodes to enable zero-power ubiquitous sensing and computation: development of new schemes/designs for medium access and physical layer mechanisms, jointly accounting activity detection, channel estimation, interference cancellation, multi-packet reception, and channel coding in an advanced framework that relies on NOMA multiple access.<br>Definition of "deep" cross-layer paradigm including a detailed description of fundamental physical mechanisms, such as the ones related to energy harvesting and RIS. PoC Implementation of URLLC coding/decoding schemes in collaboration with researchers from Politecnico di Torino. A low complexity and high-performance physical layer targeting low power/low latency applications will be prototyped and tested on a FPGA breadboard.<br>*Topic type: Research-oriented call and Demonstrator* | 340k€<br>(di cui 200k€ RI) |
| 5 | **Novel mmW architectures and PoC prototypes for backhauling solution**<br>Millimeter wave (mmW) backhauling is a key technology for B5G/6G wireless. Activities are the investigation of Shared Access concept to the spectrum for backhauling and mmW waves to design Software Defined Network (SDN) architectures with a multi-hop mmW system. PoC is the validation of mesh structure with multiple MIMO and co-channel dual polarization.<br>*Topic type: Demonstrator* | 180k€ (solo RI) |
| 6 | **PoC realization of smart repeater: transceiver hardware and antenna array realization**<br>Smart repeaters (SR) (also known as Network Controlled Repeater) are envisioned as essential building blocks of B5G/6G mmWave/THz networks to augment coverage by reducing costs. Activities is the control system that is interfaced with two wide beamsteering arrays with more than 16 x 16 antennas and with proper interfacing and gain. The control box will manage TDD synchronization in order to properly switch between TX and RX mode. The control unit will be programmable with different algorithms and would allow also for gain and beam control through an external unit communicating with the control box through an ethernet port. Activities involve the design of the Hw system, TDD synchronization, isolation, control of the beamforming, and firmware development with interfacing. Antennas array will be designed to be controllable and steerable within a certain angle set, with a joint pairing with dimension of the repeater.<br>PoC is to be deployed at the mmWave test facility available at Politecnico di Milano.<br>*Topic type: Demonstrator* | 390k€<br>(di cui almeno 350k€ RI) |
| 7 | **Radio resource allocation in wireless networks powered by renewable energy**<br>Development of radio resource allocation algorithms aimed at maximizing the energy efficiency in networks with nodes powered by renewable energy sources, e.g., solar or wind energy. A model-aided deep learning approach will be taken, to optimize physical layers resources such as the transmit powers, transmit/receive filters, | 80k€ |


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| | spectrum usage. First, the development of offline algorithms which optimize the network energy efficiency for known realizations of the energy arrivals is required. Next, the project will consider the extension of the algorithms to the online scenario in which the amount of energy that can be harvested at any point in time is a random variable. This task is to be realized using AI-based solutions trained through the data obtained with the developed offline algorithms.<br>*Topic type: Research-oriented* | |
| 8 | **Large Antenna Array**<br>The propagation losses increase dramatically with frequency, limiting the range of mm-wave communications links. Therefore, electrically large antenna arrays, able to concentrate energy in narrow beams to compensate the strong attenuation, are required. An efficient approach to overcome this drawback is to employ array with a very large number of radiating elements. The main goal of this project is the design of large antenna arrays with extremely high gain and very low sidelobes at mm-waves, with optimized implementation to achieve cost-effective solutions. Further goal is the design of reconfigurable arrays based on modular design architecture, and adopting pattern synthesis approaches, very efficient to face realistic non ideal radiating elements, compensating for element position tolerances as well as thermal expansion effects.<br>*Topic type: Research-oriented* | 290k€ |
| 10 | **Antenna Array Measurement**<br>The mmW antennas require innovative strategies for an efficient characterization of their radiating properties. The goal here is the development of solutions for test and diagnosis of the DREAMS project antennas. In particular, innovative techniques based on field amplitude and phase measurement, with the aim to reduce the number of probe points, also accounting for the role of the source geometry for conformal arrays will be considered. Large probe positioning error corrections in near field techniques are required. The feasibility of techniques possibly based on: i) field amplitude, including the development of methods to recover the phase from data acquired on nonconventional sampling grid points and ii) state of the art array diagnosis techniques based on signal processing and advanced mathematical inversion techniques will be investigated.<br>*Topic type: Research-oriented* | 280k€ |
| 11 | **Millimeter wave opto-mechanical transducers**<br>Micro-thermo-mechanical devices offer great perspectives for sensitive THz and sub-THz detection at the array level. Several aspects, however, need crucial developments to be accomplished. These encompass: a) improving the efficiency of radiation absorption (either directly in the material of the mechanical element or through artificial field enhancing structures); b) optimizing the read-out / transduction approach to an electric signal, which could be performed in the optical domain through an interferometric displacement sensor, or directly at circuit level through the inductance modulation in the presence of a small permanent magnetic field; c) the integration of multiple detector elements in the same device with low cross-talk; d) the engineering of the spectral response of each individual pixel through appropriate resonant structures. In the first and last tasks, the use of 2D tailorable plasmonic materials like graphene is particularly appealing thanks to the low added mass.<br>*Topic type: Research-oriented* | 400k€ |


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| 12 | **Millimeter wave and THz modulators**<br>Optical modulators, widely used in modern telecommunication systems, are key photonic components that allow adjusting the amplitude, phase, frequency or polarization of a long-wavelength radiation beam. The recent demand of wireless communication networks providing high data-rates and the need of quantum communication platforms and quantum key distributions has dramatically enhanced the quest of modulator technologies allowing terabit-data communications by means of devices and array of devices, in the emerging frontier field of multi-GHz or THz-frequency range.<br>This task will develop amplitude and phase modulators in the 20 GHz – 500 GHz range, exploiting graphene/liquid electrolyte or graphene/solid ionic-gel interfaces. The Task will include three steps. At first, the device characteristics and figures-of-merit will be simulated and designed, considering different device architectures. Then, modulators arrays will be fabricated and tested both electrically and optically. The feedback from the characterization will be used to eventually optimized the device design. Finally, prototype arrays (2x2, 4x4) of optimized modulator pixels will be fabricated and tested.<br>*Topic type: Research-oriented* | 400k€ |

Si rimanda inoltre al seguente vincolo richiamato dall'art 3.2 del presente Avviso.
Contributo al conseguimento del vincolo climate: Le proposte di progetto dovranno dimostrare di sostenere non meno del 42% dell'allocazione del budget in attività che rispettano il vincolo climate (cd. Tagging climatico), in conformità con l'obiettivo di contribuire alla transizione verde, individuati dall'art.18 par. 4 lettera e) e Allegato VII del Regolamento (UE) 2021/241.[4]

[4] Per l'allegato VI "Metodologia di controllo del clima" si rimanda al seguente link EUR-Lex.


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