Federated Telecoms Hub 6G Research Partnership Funds (THRPF)

Introduction and Background

Figure 1: UK 6G research pillars proposed by Wireless Infrastructure Strategy.

The UK science and technology (S&T) framework identifies future telecommunications as one of the five critical technologies for defining, pursuing and achieving strategic advantage for the UK. Figure 1 shows the 6 research pillars from the UK wireless infrastructure strategy.

EPSRC and DSIT have funded three future Telecoms Hubs and provided additional resources to bring them together in a federated structure, which will help deliver the six core areas identified in the Strategy. This structure brings together three existent EPSRC funded future telecoms platforms together with new connecting infrastructure (JOINER). The three Hubs are;

- Platform Driving The Ultimate Connectivity (TITAN)
- Hub in All Spectrum Connectivity (HASC)
- Communications Hub for Empowering Distributed clouD computing Applications and Research (CHEDDAR)

The Hubs are geared to address research challenges in three broad areas, namely, network-of-networks, wireless and wired spectrum, and cloud & distributed computing for telecommunication. Additionally, as part of the federated telecoms hubs a Joint Open Infrastructure for Networks Research (JOINER) is also being developed to support collaborative experimentation and experimentation at scale across the Hubs' research ecosystem and beyond. A brief summary for each of these platforms and JOINER can be found at the end of this document.

Call Overview

TITAN, HASC, and CHEDDAR have been allocated a £4m in total (£1.33m each) to expand the scope of the research programme, showcase 6G trials and experiments, and build joint work between members of the Hubs and new partners across the UK landscape. This document sets out a call for proposals to use these funds.

Scope

We particularly encourage projects that:

- Involve industrial partners, preferably as an active partner
- Bring in new expertise and institutions, not currently part of the Hubs
- Showcase early 6G experiments and trials using local Hub institutional facilities
- Make use of the JOINER infrastructure to enable collaborative research and drive national 6G pilots

Part of the mission of the Hubs is to offer a springboard for early career researchers (ECRs) and to promote equality, diversity, and inclusion (EDI), so applications that help to advance these aspects of the Hubs are encouraged.

In addition, each of the Hubs encourage projects as follows (these lists are non-exhaustive):

In **TITAN**, we first seek to consolidate our six lighthouse project (LP) areas: i) network intelligence and end-to-end integration, ii) RF wireless communication networks, iii) optical wireless networks, iv) fibre networks, v) non-terrestrial networks, and vi) emerging quantum networks. We also aim to advance research across the LPs and, therefore, favour cross-disciplinary projects. Research proposals with experimental content towards first 6G trials using the JOINER infrastructure are preferred. Please see Appendix 1 for more detail on TITAN and its objectives.

Hub in All-Spectrum Connectivity (HASC) - We seek projects within the scope of HASC, as detailed in Appendix 1. We are particularly interested in projects that strengthen research in the area of terrestrial RF wireless communications, showcase end-to-end connectivity using different wired and wireless resources; Projects that focus on the efficient use of spectrum and its evolution.

In **CHEDDAR**, we seek to align new projects with our three general pillars of research: 1. Emergent Telecoms Systems, 2. Sustainable Systems and 3. Human Centric systems. We encourage the co-creation of new ideas in the fields such as: Multi-access Edge Computing (MEC), Intelligent Cloud-Native RAN, Cloud Native Networked Control Systems, Digital Twins, Foundational Models, 6G Carbon-Neutrality, ISAC, Green AutoML, Trustworthy AI in Network Optimisation, Formal Verification, Network Intelligence Privacy, Security and Post-Quantum.

JOINER will enable experimental validation of telecoms R&D under representative conditions and scale in order to drive impactful outcomes. JOINER will deliver a National distributed infrastructure to support enhanced experimentation, collaboration and exploitation of Telecoms R&D. Initially, we aim to federate 10 university research labs and the SONIC Lab (Digital Catapult) to facilitate collaborations across academia while engaging industry and SMEs with experimental research. Such testbed is critical to support telco R&D, in order to address end-to-end challenges, complexity and co-dependencies across technologies (software and hardware) which are central challenges for future networks and a key focus for 6G development.

CHEDDAR, TITAN and HASC will consider projects that request funding to connect to the JOINER infrastructure, if this connection is to enable the wider research goals of the project, and these goals align with the aims listed above.

Eligibility

Funding is subject to EPSRC rules and eligibility. A key goal of the call is to expand the scope and membership of the Hubs, and to ensure that the work in these projects is connected to the core research programmes. For these reasons

- Projects must include at least **one** Co-I from any of the Hubs, so that projects are linked to the core Hub research programme(s). Each Hub Co-I can only be involved in one proposal and projects cannot be led by a Hub Co-I. Investigators who are not an existing Hub Co-I can only be involved in **one** proposal.

- We expect the majority of the resources within project proposals will be allocated to investigators who are not a Co-I within the Hubs. Our strong preference is that these investigators are from new institutions, and we will consider this in our evaluation of proposals and funding allocation.

Scale of project and timing

We would expect projects to be of the scale of £250k-£500k (80%FEC). We intend to start projects as soon as possible, and **expenditure must be completed by the end of March 2025**.

Assessment and Evaluation

A review team including the Hubs Directors and JOINER Director and external representation will review and decide on the applications received. Proposals may require a further iteration and re-review before an accept or decline decision is made.

All proposals will be evaluated according to the evaluation criteria below;

- The added value /impact of each proposal against the objectives of the call and the Hubs, as summarised above and in the Appendix 1
- The quality/excellence of the proposed research and the ability of the team to execute the project
- The plan, proposed resources, and management of the project with a particular focus on the ability to deliver the project and complete spending by 31 March 2025

Funding will be allocated considering the evaluation against these criteria, the need to balance the portfolio of projects across the three Hubs, and the overarching goal of building a broad and inclusive network of expertise and research across the UK.

Please note that given the nature of the call, your application may be shared with the other hubs (HASC, CHEDDAR, TITAN, and JOINER) and their reviewers to ensure the projects to be funded through this joint call for proposals are coordinated between the Hubs.

Application Process

Applications should be made to the relevant Hub. We will be using submit.com to manage the application process and links to this will be made available shortly.

The Applicant(s) should include the information requested on the THPF application form, using not more than four sides of A4-with one additional side allowed for references if required (11pt Arial, 2 cm margins), including.

- Technical description and plan for the project with measurable goals. This should include a brief description of the state of the art in the area, and how the proposal relates to this
- A clear explanation about how it contributes to and complements the Hub objectives
- The name and position and track record of the lead applicant, focusing on research relevant to the proposal

- Parties involved and their roles and include researcher names if they are known. If recruitment is required, please briefly explain steps that will be taken to ensure a diverse set of applicants and the delivery against the ambitious timeline. For industrial partners outline their involvement in the project and their contribution.
- Any actions to promote EDI in the execution of the project
- A brief project plan, including the start and end dates and milestone dates if applicable-please include measurable goals (and intermediate milestones if applicable).
- Applicants will also be asked to fill in an online form, including a brief project abstract
- Detailed JeS-type costing (equipment cost is not permitted) to execute the project
- The award requested from the Hubs
- The contributions from each of the parties and co-funders (if applicable). We do not require formal letters of support. However, if possible, please email or similar communication from the industrial partners who will be involved, detailing their interest, in order to strengthen the case for the application.

Arrangements for the administration of successful awards will be made in collaboration with the awarding Hub and require a formal Project agreement.

This Agreement will include the project scope and schedule, ownership and use of inputs and results including IP, contributions, liabilities etc.

Non-Academic Collaborators

For external collaborators, the terms of a research collaboration will be based on the established principles of Industry-University collaborations in the UK as set out in the Lambert Toolkit.

Contact details:

HASC: Please email Dominic Shaw: dominic.shaw@eng.ox.ac.uk

TITAN: Please email Iman Tavakkolnia: it360@cam.ac.uk

CHEDDAR: Please email Halil Uzuner: h.uzuner@imperial.ac.uk

JOINER: Please email Ildi Fogel: ildiko.fogel@bristol.ac.uk

Appendix 1: Hub Summaries

Future Communications Hub on All Spectrum Connectivity

Understanding how to best use established and emerging frequency bands across the wireless and wired spectrum is a key challenge for future communications systems. This hub brings together a network of researchers and institutions with world-leading capabilities and facilities to answer this question and deliver innovation in the use and exploitation of future wired and wireless spectrum. The core consortium consists of the University of Oxford, Queens University Belfast, the University of Bristol, the University of Cambridge, University College London, Imperial College London, and the University of Southampton.

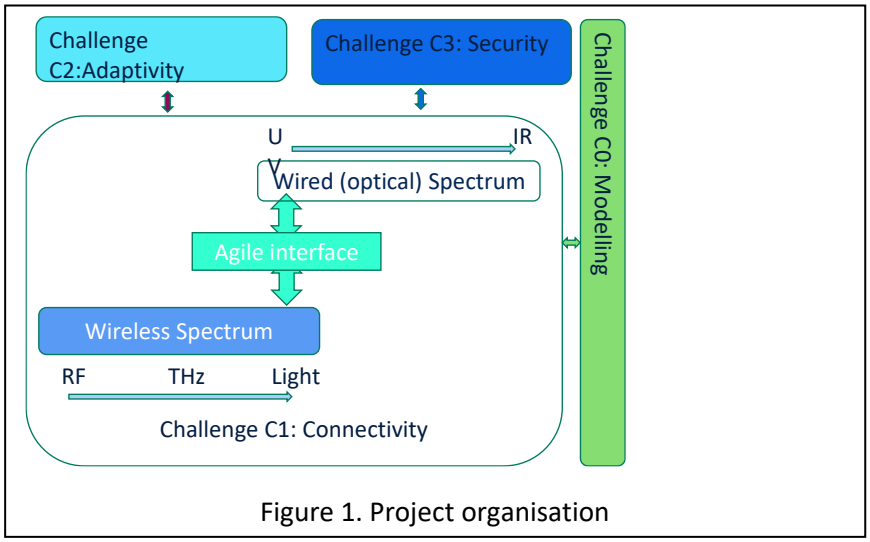


Figure 1. Project organisation

Programme

Figure 1 shows the organisation of the programme. Research will address four challenges.

C0: Modelling (led by Oxford)

This will bring together existing models of different parts of the wired and wired network to create an holistic model that allows comparison of different approaches to end-to-end connectivity using wireless.

Key Milestones/Goals

- Initial model completed using existing data/base models
- Measurements of test environments across ranges of frequencies for validation and model development
- Models incorporating advanced Physical Layer (including MIMO, RIS and other elements)
- Models incorporating adaptivity.

C1 :Connectivity (led by UCL)

Partners in this challenge will demonstrate wired/wireless connectivity if different regimes (THz/optical/mm wave etc.) in order to validate aspects of the modelling. They will also develop designs and strategies for implementing the interfaces between different channels.

Key Milestones/Goals

- Spectrum map showing capabilities of different wired and wireless channels
- Spectrum optimisation and interference management strategies

- Demonstration of end-to-end connectivity using combination of wired/wireless channels including
    - Tbps optical wireless distribution
    - Demonstration of THz over Fibre
    - Demonstration of PON/optical wireless interface
- Demonstration of capabilities using new fibre types

C2: Adaptivity and efficient and reliable networks (led by Bristol)

This will examine techniques to interface and switch between the different methods of connectivity, including AI/ML. Both theoretical and practical aspects will be investigated.

Key Milestones/Goals

- Development and initial demonstration of ML techniques for coordinated spectrum management across all spectrum regions
- Management tools addressing co-optimisation of spectrum resource, security, accessibility, sustainability.
- Demonstration and implementation of prototype controllers

C3: Security (led by Cambridge)

This will examine the combination of QKD and classical wired and wireless communications, as well as physical layer security and other techniques that use properties of the PHY layer.

Key Milestones/Goals

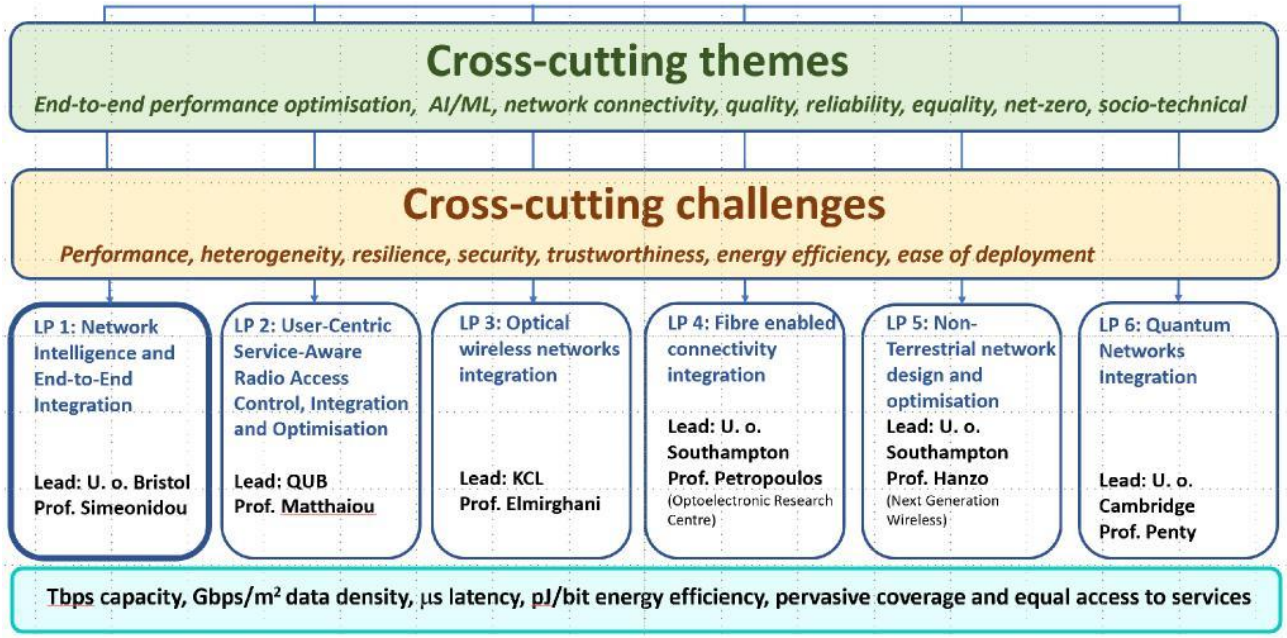
- Combined operation of quantum ATM and fibre network
- Study of optical/RF PLS techniques
- Demonstration of quantum secure Open RAN network
- Development/demonstration of entanglement-based approaches

allspectrumhub.org

PlaTform DrIving The UltimAte CoNnectivity (TITAN)

TITAN aims to **deliver ground-breaking research** in communication networks and underpinning technologies with a focus on the **intersections of traditional and future communication network elements.** Our ultimate objective is to architect **a seamless, open,** and **holistically integrated** Network of Networks (NoN). This will serve as a **foundational blueprint** for the evolution of **6G networks and beyond.** To this end, the ambition is to create the ultimate **secure, self-configurable, self-optimising, self-healing, net-zero, resilient** NoN that achieves **pervasive coverage** and can drive new applications around the emerging metaverse and the diverse range of new autonomous systems. While bringing all the necessary network elements together, it is envisaged that TITAN will **uncover many unsolved research challenges across traditional network elements** and will **solve these challenges.** The TITAN vision can only be realised by **co-creation** enabled by an environment that allows **active and meaningful cross-disciplinary collaboration harnessing the new Joint Open Infrastructure for Networks Research (JOINER).** TITAN will provide **strong consolidated inputs** to **global activities in telecommunications** in **partnership** with the **companion Hubs and JOINER.** The TITAN Hub will provide a governance function across all Hubs and Joiner with four main functions: i) Standardisation, ii) Roadmapping and Technologies, iii) Skills and Training and iv) Marketing.

TITAN is structured in six Lighthouse Projects (LPs) led by a domain expert.



Partners

1	Bangor University	11	Loughborough University
2	Queen's University Belfast	12	University of Oxford
3	University of Bristol	13	Queen Mary University of London
4	University of Cambridge	14	University of Southampton
5	University of Durham	15	University of Strathclyde
6	University of Edinburgh	16	University of Warwick
7	University of Essex	17	Digital Catapult
8	Heriot Watt University	18	Compound Semiconductor Center
9	Imperial College London	19	Bristol Digital Futures Institute
10	King's College London	20	Fraunhofer CAP UK

High-level LP Objectives

LP1

O1.1) Reference architectures for future E2E autonomous open networks;
O1.2) Multi-access network solutions, considering future radio access network RAN and beyond (e.g. optical-wireless, fibre and satellite), including new intelligent multi-technology access control;
O1.3) Frameworks for embedded, trustworthy, and verified AI for the whole system coordinating AI solutions across the different segments of the network;
O1.4) AI/ML methods for network intelligence to enable E2E autonomous and predictive service delivery;
O1.5) Security by design framework for open architectures.

LP2

O2.1) Orchestrate different radio access technologies for different emerging application scenarios;
O2.2) Optimise radio access from a user-centric perspective considering diverse service and security requirements as well as taking into account network resilience;
O2.3) Introduce new performance evaluation metrics, specifically tailored to user-centric service-aware radio access control, that can be used to assess the suitability of the proposed technologies within future 6G networks taking also into account energy efficiency and security requirements.

LP3

O3.1) Build resilient, net-zero optical wireless networks that achieve link data rate of hundreds of Gbps while enhancing physical layer security;
O3.2) Exploit the properties of optical wireless networks to integrate sensing capabilities into networks;
O3.3) Explore new architectures and transmission systems based on new device technologies.

LP4

O4.1) Develop flexible fibre network architectures that exploit the physical characteristics of the fibre channel across different parts of the spectrum to support heterogeneous traffic and to explore sensing capabilities;
O4.2) Develop models based on ML to inform and optimise dynamic spectrum allocation and switching;
O4.3) Exploit the potential of new fibre, transmission and amplifier technologies for the implementation of low-latency, high-capacity access networks.

LP5

O5.1) Develop techniques that will allow maintaining a uniform quality of service in a network with increasing non-terrestrial network elements, and thus effectively mitigating the digital divide;
O5.2) Develop techniques for prompt, low-delay on-line optimisation allowing each network element to make its decisions independently - ideally based on local constraints and on limited cooperation strictly with immediate neighbours only, while approaching the Pareto-front of centrally controlled solutions;
O5.3) Conceive Pareto-optimal RA solutions without relying on high-overhead central control.

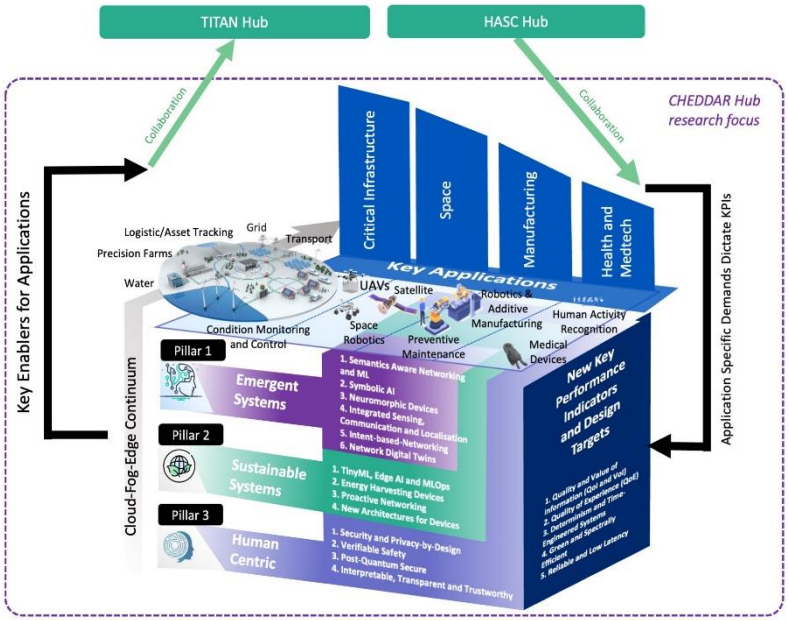
LP6

O6.1) Create an effective research forum comprising research groups with activities in application of quantum networking in future telecom networks;
O6.2) Create a collaborative research program to address application and challenges of Quantum Networking in future telecom networks with focus on security, distributed computing and sensing;
O6.3) Create a collaborative research program to address technological and architectural challenges for co-existence of quantum and classical information channels in terrestrial and satellite telecom networks

Communications Hub for Empowering Distributed clouD Computing Applications and Research (CHEDDAR)

Partners: Imperial College London (Lead), Cranfield University, Durham University, University of Glasgow, University of Leeds, University of York

Aims and vision - The evolution of future communications ecosystems represents a continuum spanning from the smallest devices to extensive cloud farms. Anticipated around 2030, international standards for 6G are poised to usher in a transformation from interconnected people and devices to interconnected intelligence. It is crucial for these technologies to underpin and be reinforced by communications infrastructures that are safe, secure, trustworthy, and sustainable. CHEDDAR, in collaboration with the other two hubs, will contribute to building a unified research ecosystem that nurtures talent and explores ground-breaking ideas, specifically concentrating on 6G technologies facilitation the shift towards interconnected intelligence.



Pillar 1 - Emergent Systems

- 1.1 Multi-access Edge Computing (MEC) Integration in 6G
- 1.2 Autonomous Distribution of Intelligence Across Cloud-Native RAN Implementation
- 1.3 Autonomous Generation of Cloud Native Radio Intelligence Controller (RIC) Apps
- 1.4 Cloud Native Networked Control Systems and Integration within Digital Twins
- 1.5 Foundational Models for Telecommunication

Pillar 2 - Sustainable Systems

- 2.1 Towards Carbon-Neutrality for 6G
- 2.2 Integrated Sensing, Communication and Localisation for 6G
- 2.3 Green AutoML for Future Edge-Fog-Cloud Continuum

Pillar 3 - Human Centric Systems

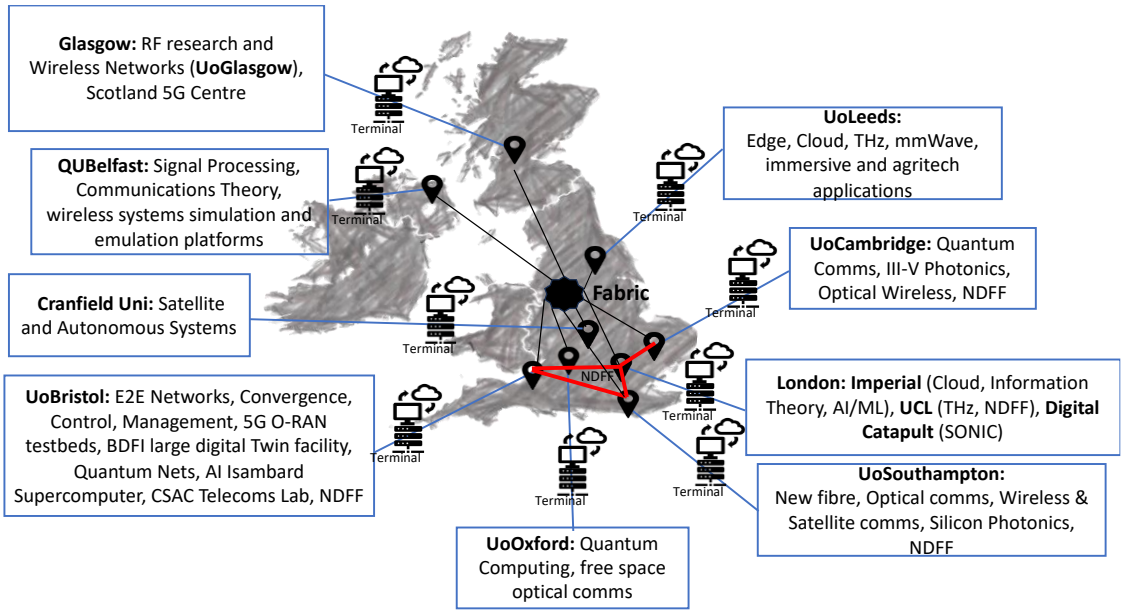
- 3.1 Trustworthy AI for Automating Ultra-Large Network Optimisation
- 3.2 Formal Verification of 5G advanced protocols to inform a verifiable 6G
- 3.3 Making Network Intelligence Private
- 3.4 New Adversarial Threats and Post-Quantum Security

Research themes - CHEDDAR strives to research, design, and derive proofs-of-concept of the 6G technologies that will support edge-fog-cloud continuum of computation through three thematic pillars: (i) Emergent systems: emergence, encompassing network embedded sensing & intelligence, and the support of emerging methods of computation from autonomy to quantum; (ii) Sustainable systems: sustainability of device, algorithms, data pipelines and service integration, green-by-design; and (iii) Human-centric systems: human-centric design with trust, security, privacy, resilience, interpretability, transparency, and equitability. The pillars are augmented by innovative blue-sky and pilot research projects, which are structured to encourage multi-partner collaboration, generating a substantial presence and impact in each research area. CHEDDAR welcomes proposals that squarely sit within the themes or indeed bring components together. We also welcome projects that compliment this work or fill in gaps, however this needs to well-motivated.

Contact us:
cheddarcommshub@imperial.ac.uk
cheddarhub.org

JOINER

JOINER is a national scale experimentation platform aiming to initially support the needs of the EPSRC Future Communications Federated Hubs and other Future Networks R&D initiatives such as DSIT and Innovate UK programs. In the longer term, it could develop capability to support the wider telco ecosystem in the UK, including academia (inside and outside the existing Hubs) and industry including SMEs. JOINER will achieve this by providing an open and federated state-of-the-art experimental platform able to support collaborative research and experimentation and test outcomes in representative network conditions and at appropriate scales.



<u>In summary the JOINER aims to be:</u>

1. **A large-scale host** for experimental research, development and testing with **common interfaces and services** to build on existing and further leverage on future R&D research capital investments in the UK. We have initially identified **12 locations** to interconnect, providing access to advanced and complementary research labs and testbeds with a roadmap to upgrade connected facilities and scale to further locations if future funding allows.
2. A federated testbed enabling research on the full breadth and depth of solutions involved in an end-to-end telecom ecosystem enabling **sharing of experimental resources, and introducing new technologies, services and applications** resulting from R&D programmes. This will provide a growing and enhanced experimental capability that does not currently exist in any single location.
3. A facility for **research and pre-commercial collaboration** across the Hubs' academics, the wider academic ecosystem, industry and Government.
4. A platform that helps to accelerate the **translation and TRL advancement of early-stage research** and provide credible experimental evidence towards the introduction of new IP and products into the UK supply chain.
5. A place to showcase the outcomes of collaborative R&D and host **impactful demonstrations** of future networks capabilities. To this effect, JOINER will deliver the UK's first full-scale 6G demonstration by March '25 in line with the timelines announced by other international initiatives.
6. A place for hands-on training on telecoms systems and therefore a key contributor to a national (multidisciplinary) **skills development** pipeline.
7. A national champion that demonstrates UK capabilities on future network concepts **supporting UK's ambitions into standards and international collaborations** with similar experimental initiatives/platforms. For more information, see: https://www.bristol.ac.uk/engineering/research/smart/projects/Joiner/

Appendix 2: Current Hub Investigators

Hub in All-Spectrum Connectivity (HASC)

Name	Organisation
Professor Bruno Clerckx	Imperial College London
Dr Ayush Bhandari	Imperial College London
Professor Kin Leung	Imperial College London
Professor Simon Cotton	Queen's University of Belfast
Professor Michalis Matthaiou	Queen's University of Belfast
Dr Hien Ngo	Queen's University of Belfast
Dr Okan Yurduseven	Queen's University of Belfast
Professor Alwyn Seeds	University College London
Dr Martyn Fice	University College London
Professor Dimitra Simeonidou	University of Bristol
Professor Reza Nejabati	University of Bristol
Dr Shuangyi Yan	University of Bristol
Professor Richard Penty	University of Cambridge
Dr Michael Crisp	University of Cambridge
Professor Harald Haas	University of Cambridge
Dr Iman Tavakkolnia	University of Cambridge
Professor Dominic O'Brien (PI)	University of Oxford
Dr Justin Coon	University of Oxford
Professor Periklis Petropoulos	University of Southampton

PlaTform DrIving The UltimAte CoNnectivity (TITAN)

Name	**Organisation**
Professor Harald Haas (PI)	University of Cambridge
Professor Richard Penty	University of Cambridge
Dr Iman Tavakkolnia	University of Cambridge
Professor Seb Savory	University of Cambridge
Professor Jianming Tang	Bangor University
Professor Dimitra Simeonidou	University of Bristol
Professor Reza Nejabati	University of Bristol
Dr Rasheed Hussain	University of Bristol
Dr Shuangyi Yan	University of Bristol
Dr Xenofon Vasilakos	University of Bristol
Professor Yunfei Chen	Durham University
Professor Wasiu Popoola	University of Edinburgh
Professor Majid Safari	University of Edinburgh
Professor John Thompson	University of Edinburgh
Professor Kin Leung	Imperial College London
Professor Bruno Clerckx	Imperial College London
Dr Cong Ling	Imperial College London
Dr Stefan Vlaski	Imperial College London
Professor Sangarapillai Lambotharan	Loughborough University
Dr Masha Derakshani	Loughborough University
Professor Arumugam Nallanathan	Queen Mary University of London
Dr Yuanwei Liu	Queen Mary University of London
Professor Mathini Sellathurai	Heriot Watt University

Professor Michalis Matthaiou	Queen's University Belfast
Professor Simon Cotton	Queen's University Belfast
Dr Hien Ngo	Queen's University Belfast
Professor Periklis Petropoulos	University of Southampton
Professor Lajos Hanzo	University of Southampton
Dr Mohammed El-Hajjar	University of Southampton
Dr Kyle Bottrill	University of Southampton
Dr Johannes Herrnsdorf	University of Strathclyde
Professor Martin David Dawson	University of Strathclyde
Professor Gan Zheng	University of Warwick
Dr Taisir Elgorashi	King's College London
Dr Mohammad Nakhai	King's College London
Professor Jaafar Elmirghani	King's College London
Professor Toktam Mahmoodi	King's College London
Dr Yansha Deng	King's College London
Professor Leila Musavian	University of Essex
Professor Nikolaos Thomos	University of Essex
Dr Yuli Yang	University of Essex
Professor Dominic O'Brien	University of Oxford

Communications Hub for Empowering Distributed clouD computing Applications and Research (CHEDDAR)

Name	**Organisation**
Professor Julie A McCann (PI)	Imperial College London
Professor Alessandra Russo	Imperial College London
Dr Dalal Alrajeh	Imperial College London
Dr David Boyle	Imperial College London
Professor Geoffrey Li	Imperial College London
Dr Yves-Alexandre de Montjoye	Imperial College London
Professor Muffy Calder	University of Glasgow
Professor Muhammad lmran	University of Glasgow
Professor Qammer Hussain Abbasi	University of Glasgow
Dr Poonam Yadav	University of York
Professor Marco Lucamarini	University of York
Professor Radu Calinescu	University of York
Professor Hongjian Sun	Durham University
Dr Aissa lkhlef	Durham University
Dr Anish Jindal	Durham University
Dr Gagangeet Singh Aujla	Durham University
Dr Wanqing Tu	Durham University
Professor Weisi Guo	Cranfield University
Professor Antonios Tsourdos	Cranfield University
Dr Ivan Petrunin	Cranfield University
Dr Syed Ali Raza Zaidi	University of Leeds
Dr Desmond McLernon	University of Leeds

Professor Mohsen Razavi	University of Leeds
Professor Ian Robertson	University of Leeds
Professor Jie Xu	University of Leeds
Dr Li Zhang	University of Leeds

JOINER

Name	Institution
Professor Dimitra Simeonidou (PI)	University of Bristol
Professor Reza Nejabati	University of Bristol
Professor Harald Haas	University of Cambridge
Professor Dominic O'Brien	University of Oxford
Professor Julie A McCann	Imperial College London