A pink and white triangle shapes

Description automatically generated with medium confidence

UKTIN Future Capabilities Report

Building UK capability in telecoms network supply chains: insights, recommendations, and next steps

Telecoms R&D Future Capability Strategic Leadership Forum

Version 1.0

Co-Chair: Dritan Kaleshi, Simon Fletcher

Date: 12th February 2025

Contents

[1. Introduction 4](#_Toc190262848)

[2. Context and strategic goals 6](#_Toc190262849)

[Insights from Phase 1 6](#_Toc190262850)

[Trends in future telecom networks and services 7](#_Toc190262851)

[Strategic ambition 10](#_Toc190262852)

[A Single Voice 11](#_Toc190262853)

[3. Summary of recommendations 12](#_Toc190262854)

[3.1 Skills 14](#_Toc190262855)

[3.2 Commercialisation and Adoption 16](#_Toc190262856)

[3.3 Testbeds Platforms, Centres and Field Trials 17](#_Toc190262857)

[3.4 Research themes and areas of focus 19](#_Toc190262858)

[3.5 Collaboration, and strategic partnerships (including international) 21](#_Toc190262859)

[3.6 Government, Funding & Investment 22](#_Toc190262860)

[3.7 Legislation, Regulation and Policy 24](#_Toc190262861)

[3.8 Standards and intellectual property 25](#_Toc190262862)

[4. Next steps for the Expert Working Groups 27](#_Toc190262863)

[4.1 Phase 2 Direction 27](#_Toc190262864)

[5. Summary 29](#_Toc190262865)

[Annex A Contributors 33](#_Toc190262866)

[Annex B List of Acronyms 34](#_Toc190262867)

[Annex C References 36](#_Toc190262868)

[Annex D ToRs - Overview and Scope 37](#_Toc190262869)

[Annex E Collated EWG Recommendations 38](#_Toc190262870)

[E.1 Complete Recommendations Register 38](#_Toc190262871)

[E.2 Analysis of Recommendations 76](#_Toc190262872)

1. Introduction

The UKTIN Telecoms R&D Future Capability Strategic Leadership (FCSL) Forum was established to support the consolidation of the telecommunication sector community insights collected across various UKTIN Expert Working Groups (EWGs) and assist in the formulation of strategy leading to Mission and Vision oriented value propositions for UK telecommunications future capabilities between now and 2035, and beyond.

The FCSL consolidates domain knowledge and breaks down subsystem silos and enabling technology areas in the UK; aiming to create a common, sectoral, view of where the UK has capabilities, where it can focus more on growth, and where it should work towards with an impact horizon of 2035, starting from now.

### Scope of this report

This report marks the end of UKTIN Future Capabilities Phase 1 with the following scope:

**Section 2**: Sets out the context within which the UKTIN will work by summarising the main trends for telecoms networks and services, based on international organisation and industry visions and the views of the EWGs.

**Section 3:** A summary of the recommendations of the EWGs for achieving these strategic objectives grouped into common themes.

**Section 4**: Sets out the scope of the intended second phase of EWG work, which will focus on the future communications R&D&I roadmap and identify technology potential focus areas that will enable the UK to build capability in niches that play to the UK’s strengths and needs, with global market potential.

*The EWGs cover specific subsystem and enabling technologies across the whole telecommunication system end-to-end, and are chaired by recognised leaders in their field. The EWG membership is drawn from technology and business experts from both industry and academia. The EWGs are not only highly knowledgeable on the key features of the technologies under study, but also on the associated UK and International R&D supply chains and ecosystems. Their objective is to produce a consolidated and authoritative view from their technology segments that establish a trusted knowledge base upon which key stakeholders may strategise for future focus areas for the UK activities. There are 9 EWGs, focusing in key technology areas and corresponding sectors in telecommunications: Wireless, AI in Telecoms, Non-Terrestrial Networks, Network Management, Core Networking Technologies, Optical and Photonics Communications, Semiconductors for Telecoms, Telecoms Standards, and Security. Each has produced very substantial reports which have been published, and will continue to be published, on the UKTIN website[[1]](#footnote-2) .*

### Who should read this report and why

Key FCSL stakeholders, and thus targeted readers of this report, are **Industrial R&D Executive management**, **academic leaders** and **senior policy makers in government**.

Industry Executive management seek competitive advantage enabling from their R&D, and the FCSL aspires to make the UK a highly attractive market for R&D and business operations.

For academic leaders, the knowledge infrastructure of the UK, embedded in the University sector, and financed by both public and private sectors, is a critical success factor, leading to wealth generating capability of the UK through industrial outcomes.

Policy makers’ interest is understanding the needs and recommendations from industry and academia in order to deliver on government ambitions.

Other key FCSL stakeholders are organisations that uphold the values of **strategic co-ordination of research**, and that focus investment in research excellence in the university sector and industry interdependence.

### Inputs to this report

The nine individual EWG reports, published on the UKTIN website[[2]](#footnote-3) , present a comprehensive study of the corresponding subsector technologies and markets. The EWGs reports have a very comprehensive set of recommendations. They have sought to scope foundational aspects of the technologies and associated R&D ecosystems features – identifying UK strengths, challenges and opportunities across the sector in specific technology areas, fully referencing and leveraging the internationally-set direction of development in these technologies. Some segments such as wireless or fixed, are characterised by mature technologies, system architectures and markets. Other segments, however, such as AI are still nascent in the telecoms sector, with commensurately greater uncertainty in technology and markets aspects.

1. Context and strategic goals

## Insights from Phase 1

The need for the UK to continue to develop and grow capabilities for technology research and development in telecommunications, especially connectivity infrastructure, is driven by its ambition to be a technology superpower in the world. Through getting into that position, it will reap the benefits this brings to UK citizens in terms of economic growth and export, building knowledge and skills, protecting societal values through guiding sustainable and ethical use of technology, and underpinning national security and resilience on our streets and outside the perimeter of the UK. The Office for Science has recently published a brief risk assessment[[3]](#footnote-4) of not getting into this position.

### Direction of travel

Data, networks and Artificial Intelligence (AI)– **digital infrastructure** - are becoming the scaffolding of the digital social and economic life of the nation. This is underpinned by **secure, pervasive, high-performance, reliable and resilient connectivity** that delivers the Government’s 5 missions. For networks, Future Telecoms deserves strong and long term support based on the UK’s international standing, the foundational importance to services to citizens – e.g.energy and healthcare; equal opportunity; its market potential, and its key contribution to sustainability, the digital economy, security and resilience, national security and defence.

Delivering the right connectivity infrastructure in a technologically advanced nation with strong capabilities and aspirations to lead in science and technology requires a balance to be struck between near-term and longer-term objectives. The near-term is innovation in the demand side of the technology by demand generation through technology adoption support. The longer term is critical support for Research and Development (R&D) that delivers technology leadership and capabilities that are crucial for economic growth and for the national infrastructure in the AI-driven world we have just entered. This balancing act between the adoption and the research of the technology has led to a changed landscape over which government, industry and academic strategic conversations must be held.

In this balance a mission focussed on the supply side of Future Telecoms (embodied in the values of UKTIN), and the R&D that delivers this, becomes more prominent – as the process that delivers the most impactful change over a medium to long term.

To address this, UKTIN took on the mission to set up an open, inclusive and representative consultative structure to focus on the UK opportunities in future R&D in telecoms – the 8 EWGs and two Strategic Working Groups (SWGs). This report evidences the successful operation of this structure. During the Phase 1 work that the UKTIN Future Capabilities structure has carried out until now it has become crystal clear that the UK must leverage the excellent, and often world leading, research in future communication systems to strengthen and re-grow its industrial R&D, and focus even more on how to commercialise better, through better supported research translation, the often excellent research outputs from the UK telecommunication community, across academia and industry.

### **Expert Working Group recommendations**

The FCSL has looked across the 9 UKTIN EWGs, and it is clear that the inter-segment variance in technology and market defining aspects does lead to a corresponding variance in the recommendations. Many recommendations, however, had similar objectives. With the aim of bringing the different views together into a single telecommunication sector view, the FCSL has categorised the recommendations into thematic groups. These categories can be used by different stakeholders to understand, scope and contextualise strategies and interventions that maximise the impact across the sector and not only in one of the sub-sectors/domains of an individual EWG.

The categories that have been identified are consistently highlighted by specific analysis and/or recommendations across all EWG technology segments. They are expanded in Section 3 of this paper. The complete collection of recommendations and our analysis is provided in ‎Annex E.

Note: The insights and recommendation from the Security EWG were wide ranging. Many fitted into the categories we selected, as did related recommendations from other EWGs. Others raised issues of process and industry practice that are applicable to ICT systems top/bottom and transversely across all themes. These obviously deserve consideration but are not in the scope of the UKTIN Future Capability remit to consider horizons up to 2035 and beyond.

## Trends in future telecom networks and services

The direction of travel of technology development in the journey towards future communication systems and telecommunications is set internationally. Industry, academia, and institutions have published visions of the telecom ecosystem towards 2030 and beyond in their contribution to this journey’s route. Genuine problems that have to be solved are identified, alongside aspirations and thinly disguised marketing. Many suggest what telecom services will be used for, what could be novel or innovative, how networks will be deployed, how users will behave, and problems that must be solved.

This fits with the UK capability landscape, as presented in the various UKTIN activities and EWGs. It provides a context for the way the UK can contribute to an internationally-set technology development roadmap in ways that deliver towards its own national strategic interests and economic growth. This should be in taking leadership in understanding and establishing critical collaborations for specific frameworks within the internationally-set telecommunications roadmaps.

This has already happened both in adjacent technology areas and in the telecom domain as well. For example, the UK has projected leadership in the world around AI Safety[[4]](#footnote-5) – a critical area for managing the development and adoption of AI-centric technologies and services.

Another example is the decision to focus on open networks as an approach that underpins telecom supply chain diversification, as well as the way the convergence of connectivity and compute is most likely to happen[[5]](#footnote-6).

The UK should coordinate its capability development and contributions within this internationally-set direction of technology development, with strong prioritisation of specific areas the UK will want to invest strongly in and grow.

Over the longer term this will position the UK to leverage the capability from taking leadership in the fundamental changes in how national converged connectivity and compute infrastructure will be built and operated in the AI, Quantum and cyberphysical systems era in 2035+.

Reflecting on the internationally-set technology vision and roadmaps and on the UKTIN EWGs analysis, we summarise here the global trends in telecommunications networks and future communication systems:

* The expectation of being always best connected being reflected in the ambition to integrate terrestrial and non-terrestrial networks (satellite and other). This can be seen especially in Horizon Europe (HE) Smart Networks and Services (SNS) [[6]](#footnote-7) projects such as 6G-NTN[[7]](#footnote-8) and the vision of the 6G Infrastructure Association (6G-IA)[[8]](#footnote-9).
* The disaggregation of the network infrastructure manifests itself in many ways, for example:
  + In cellular networks this is reflected in the Open RAN approaches[[9]](#footnote-10).
  + The push towards Open APIs that allow easier harmonisation and integration of network services into compute cloud platforms.[[10]](#footnote-11)
* There will be no end to the effort devoted to improving mobile communications networks, their technologies (especially the air interface) and the features they offer. This can be seen in the ongoing development of 3GPP Technical Specifications for 5G Advanced and in the future for 6G. 5G introduced the disaggregation of the functions of a mobile network core. 6G will develop this further and improve it while extending the scope of the applications and services a mobile network will provide.
* Virtualisation of network services in many public and private commercially offered cloud platforms already supports a different business model for provisioning of network services and network management, built on top of a physical network. Vendors and hyperscalers promote this strongly through Network[[11]](#footnote-12) (or Infrastructure[[12]](#footnote-13)) as a Service or Network as Code[[13]](#footnote-14). Expectations are very high for such integrated connectivity that can be reconfigured continuously on demand and can be personalised. In future this will be done automatically by AI-based agents.
* The development of future communication systems will be significantly affected by the development of AI[[14]](#footnote-15) and Quantum (QKD[[15]](#footnote-16), post-quantum cryptography[[16]](#footnote-17), and quantum computing[[17]](#footnote-18)). These will be implemented initially as an overlay of existing systems and architectures. They will be addressed in the longer term by fundamental architectural and system changes across the telecommunication systems.
* ITU-T, and in particular IMT-2030[[18]](#footnote-19), aims at a secure global pervasive connectivity platform. This cannot be achieved without better integration of the management of networks across cellular, optical, non-cellular wireless, satellite, and free-space communications. The IMT-2030 objectives are broad in other respects and are still a work in progress for quantitative targets:
  + Increased and more reliable coverage of wireless communications, backed by resilient, reliable fibre connectivity, creates additional opportunities for using the future digital wireless connectivity fabric for new services.
  + Continuing advances in the physical network and device connectivity layers that underpin the overall connectivity fabric. For example in radio design: radio planning, spectrum efficiency, spectral efficiency, higher data rates, lower delay and loss, interference mitigation, higher frequency bands, better time and positioning accuracy, greener communications through optimising for sustainability.
  + Multidimensional sensing based on measuring and analysing wireless signals will open opportunities for high-precision positioning, ultra-high-resolution imaging, mapping and environment reconstruction, gesture and motion recognition, which will demand high sensing resolution, accuracy, and detection rate.
  + Preparing for the emergence of new applications and services, from distributed AI processing and interfacing to personalised connectivity services to completely new ways of interacting with one another. This is typically exemplified by using the term such as internet of the senses, or the integrated communication and sensing.
* Breakthroughs in optical communication such as hollowcore fibre, and what this means to meet the increasing demand for traffic intra- and inter-data centres in the era of AI.

Whilst the above are some clear technology trends, reflecting some elements of demand, we must also note the existing market challenges:

* Digital infrastructure must be deployed to ensure capacity is available at scale, like other national infrastructures. This will enable new digital innovation to emerge, adapting to market dynamics and business models.

Note: Availability means support for data throughput to and coverage of the entire UK territory with a realistic plan for sustainable growth. Fibre must be installed to serve industry and its assets, and consumers on the ground. Spectrum must be accessible to those users and assets when on the move for terrestrial and non terrestrial wireless networks.

* Develop the business models that enable continuing investment into this expensive digital infrastructure.

These challenges will continue to be addressed by the sector, its R&D, its innovation, and its technology roadmaps.

Every service, every application, every management function presumes that the Internet IPv4 or IPv6 address is the enabler of connectivity in the control plane and the management plane, fixed or mobile. This happened 30 years ago when it became obvious to network implementers and users that the broadband integrated services digital network (B-ISDN) was not what they wanted. There are challenging requirements for the Internet as we know it today. Its defects were known when it displaced B-ISDN as a network architecture. It is the foundation of 5G, eventually 6G, and their capabilities, but their architecture and functionality are quite different from the architecture and functionality of the Internet. Alongside AI and Quantum, this will be one of the key elements of research in future communication systems.

## Strategic ambition

The UK should take leadership in launching initiatives on specific international frameworks that help guide the development of the right solutions that meet the needs of the UK digital infrastructure moving forward, and contribute to economic growth through the development of technology.

As an initial example, the UK should look to launch frameworks that incorporate rules, methodologies and tools for AI-native networks, or similarly for open network management in integrated terrestrial-non-terrestrial networks,

Moreover the UK has strengths to:

* Lead a sustainable and programmatically coordinated Industrial and Academic led R&D&I in all aspects of telecommunications.
* Place the UK as a deep technical collaborator in the global map, and allowing to take leadership in specific focus areas aligned with national strategic objectives..
* Grow the commercial output from the excellent telecoms research undertaken in the UK, and enabling/attracting and establishing major centres of industrial R&D&I by major international companies in the UK. Making the UK the place to research and develop key technology components for the digital infrastructure of the future.

The UK must foster diverse community of design, manufacturing and service companies.

* Creating a fully diversified marketplace for delivering future telecom solutions and increased and growing revenues in global telecom network supplies; becoming a part of the global supply chain for future communication systems products and services.
* A rich source of skills and talent to deliver technical and societal benefits of telecoms to the UK and the world.
* Providing a foundation of human capital to sustain telecom R&D&I, delivery and enterprise.

## A Single Voice

The EWGs do not deliver a single voice in unison. They make recommendations that are in harmony and complementary consistent with the diverse technical considerations that affect the embedding of telecom systems and services within an integrated intelligent secure digital fabric.

To anchor this concept of a digital fabric, where the individual communication and compute technologies can be mixed and matched to derive the right infrastructure at the right place for the right purpose, we introduce the following tiered diagram. In Figure 1(a), the digital services are delivered through the devices at the bottom of the diagram, connected through and leveraging services across the tiers to deliver a digital application/product or solution in a specific sector/domain. The tiers in between comprise the full domain of future communication systems, reflecting the different technology roadmaps in individual technologies in the individual tiers in order to identify potential areas of focus for the UK.

|  |  |
| --- | --- |
| A diagram of network management  Description automatically generated  (a) | A close-up of a computer screen  Description automatically generated  (b) |

Figure 1 A digital fabric in five tiers

Figure 1(a) also places each EWG relative to the tiers and to the other EWGs. The themes central to communications technologies (Wireless, NTN, Core, Optical) cluster around the Connectivity tier and are entirely within Security. They are mainly within NM and AI but there will be some aspects that remain outside. They are all supported by Semiconductors.

Figure 1(b) provides a more detailed overview of the functional elements of each tier. The APIs between tiers, and protocols that link functions with each other are highlighted. Although APIs are shown vertically and protocols horizontally, either could operate horizontally, respectively vertically, as well depending on the type of functions that need to interact.

1. Summary of recommendations

The EWGs have each produced reports setting out their analysis of their respective technology areas and these can be found here[[19]](#footnote-20). Their consequent recommendations are provided in full in ‎Annex E. While these recommendations are somewhat specific to each technology area, there are many common themes, and these are listed below and explained individually.

It is the goal of the FCSL to work to harmonise the views from individual technology areas into a more cohesive, non-fragmented, telecom system view for the sector. It has undertaken a qualitative analysis and has categorised the recommendations into thematic groups that can then be used by different stakeholders to understand, scope and contextualise strategies and interventions that maximise the impact across the sector and not only in one of the sub-sectors/domains of an individual EWGs. These categories start to define the ontology of strategic thinking that may point to key features of a vision or mission both in intra- and inter-technology segments.

Across the EWGs examined, the categories are:

* **R&D key research themes**
* **Testbed, Platforms, Centres, and Field Trials**
* **Commercialisation and Adoption**
* **Skills**
* **Collaboration and strategic partnerships**
* **Government Funding, Policy & Investment**
* **Regulation**
* **Standards and intellectual property**

Together, these recommendations can be taken as input for a national telecoms strategy that will place the UK in a favourable position to take leadership in future telecoms, grow the UK economy, and meet the connectivity and digital infrastructure needs of the UK citizenry.

The themes from the EWG recommendations represent 8 pillars that comprehensively address the main challenges facing the UK telecoms sector and represent a 360° approach to rejuvenating the UK industry. Underpinned by the central drive to bolster R&D&I and maximise value from R&D&I, the themes of the recommendations feed into and are connected to each other, as illustrated in Figure 2 below.

This could be interpreted as a prioritisation but it is not. The recommendations are not just connected: an action to support one affects the others. Understanding these interactions is essential to the success of the technology superpower mission.

For example, all EWGs have recommended skills development. However lack of commercial activity at scale and low levels of adoption of new telecom capabilities means there is less need to invest in mass development of skills for innovation at levels below those of postgraduate specialisms for R&D, which are arguably well recognised and supported.

All EWGs recognise that UK R&D skills and experience are highly valued: the UK has the right R&D key themes that deliver a prized source of novelty and innovation that other countries commercialise and adopt to their profit. The UK loses the skills as well as the profit and IPR ownership. Should intervention on UK input into standards and protection of IPR take precedence over other categories?

Commercialisation and adoption could benefit from testbeds to establish proof of concept (usable, useful, scalable) and proof of value (understanding the potential return, the costs, etc.). But testbeds often have no commitment to proof of value. They are short term limited proofs of concept; the skills that we know we need are redirected, dispersed or otherwise lost when the testbed project ends.

The Government must have appropriate policies. Its ability to fund and invest is limited. It should be prioritized for R&D. Industry must do the bulk of funding, and it is essential to attract sustained long-term inward investment, which has shrunk overall even though there have been recent successes. The current industrial sector is fragmented. Some of this fragmentation is expected, at least in part due to regulation for competition (e.g. the largely successful fibre rollout in the UK). Continuing focus and innovation in regulatory approaches, reflecting on good examples and with a view to also help lower the fragmentation of the sector, is necessary.

Finally, the categories were selected based on the most common themes. No such approach is perfect, so some specific technical topics did not feature in the final selection. Spectrum, for example, was mentioned in eight recommendations. After considering the context we placed them in the following categories, alongside numerous other specific topics: R&D&I; Collaboration and Partnerships; and Regulation.

*A diagram of a company strategy

Description automatically generated*

Figure 2 Connectivity of Recommendation Themes

* 1. Skills

Many recommendations address the need for **greater telecoms technology skills all education levels and, including industry and employees in the UK**. Skills in STEM subject areas have been an issue for decades and something has to change.

It is strategically essential to rebuild a strong partnership between industry and academia in doing collaborative R&D as well as developing skills at apprentice, UG and PG levels.

The complexity and diversity of the national and international technology and systems landscape is such that future trained engineers could come from a variety of engineering, mathematical, and science backgrounds, to complement traditional electrical engineering backgrounds.

There need to be stronger, more capable skills in:

* Infrastructure,
* computer science (including software engineering and especially AI),
* semiconductors,
* wireless,
* optical technologies,
* quantum networking,

The crossover between these domains must be strengthened too, e.g. using AI in the Radio Access Network (RAN) and other parts of the telecom infrastructure. This is also necessary for system integration. The UK has some expertise in the integration of complex systems, and this is a strength to build upon, but it is still niche.

As telecoms is not seen as an attractive career for STEM graduates, finding people who understand how to build things is becoming harder and harder.  We need to sell the “mission”, incentivise graduates to take up careers in telecoms, with relevant and appealing rewards), and foster a self-development mindset.

Clear options for telecom career pathways should be defined so that school leadership and careers advisors benefit from an applied appreciation of the routes available, including differences between direct industry entry, apprenticeships and postgraduate research.

A wider evidence base on skills shortages in the telecommunications sectors, particularly NTN, should be commissioned to finalise the exact technology areas for these initiatives e.g. a bold ten-year national level programme that focuses on building the skills, talent and leadership in the UK for 21st century engineering education and expertise.

For future networks such as 6G, EWG experts recommend to the Government that further investment should be targeted at academia and universities - which can support the development of training and upskilling a new generation of experts in future networks and with cutting-edge research already in progress at research institutions. Future R&D on future telecom technologies could be supported and coordinated by the Department for Science, Innovation and Technology (DSIT) alongside UKRI with facilitation by a larger consortium of both industry and academic partners - ensuring both technical and policy views are heard.

The EWGs make many recommendations for initiatives to improve the supply of trained engineers by making telecoms network engineering more attractive as a long-term career path. Specific initiatives include:

* Apprenticeships, with dual support for study and work in industry,
* Industry training schemes (including subsidies),
* Further education colleges to support technicians for electronic and electrical engineering and telecoms, with an opportunity for work-place experience,
* Technicians for semiconductors skills,
* Re-ignited sponsorship schemes, and
* Lower cost post-graduate courses.

Specific initiatives should also be sought for the re-skilling of the existing workforce including to deal with the declining number of experienced network management staff as the working population ages and network operational management skills are outsourced overseas.

Additional key points are summarised below:

* Training for prospective standards delegates (or those dealing with standards including back-office staff) from SMEs or Universities:
  + Maximum use should be made of ETSI’s educational materials.
  + Should cover both hard and soft skills.
* Build a database of experienced standards delegates willing to provide some level of feedback or mentorship to new delegates from SMEs and/or Universities.
* Support workshop style meetings on specific topics e.g. how to write a WID (Work Item Description) and have it approved in 3GPP or ETSI.
* Increase take-up of undergraduate and doctoral training in photonics, communications, and systems engineering particularly for UK candidates by increasing the profile of hot topics in AI, 6G, infrastructure, photonics, free-space optics and quantum networks.
* Continue to recruit outstanding talent from abroad while we grow and invest in the home skills.
* Key skill areas in both fundamental (infrastructure, semiconductors, wireless and optical technologies) and developing technologies **(such as quantum and AI) as they apply to telecom technologies.**
* Incentivise the uptake of careers in telecoms by targeting schools, careers advisors and universities **with important information regarding career pathways**, as well as making telecoms careers more attractive.
* Improve the supply of trained engineers (e.g. through apprenticeships, industry training schemes **and graduate programmes**, reskilling of the existing workforce, sponsorship schemes, further education colleges and reducing the cost of post-graduate courses.)

Addressing the gap in standardisation skills will position the UK favourably in mid-to-long term for future networks, thereby affecting UK competitiveness as well as the communications needs of the UK population and the wider economy. Ensuring that there is better adoption of telecoms skills via courses or training, improving the supply of trained practitioners through partnerships between academia and industry from apprenticeships to postgraduate level, this will increase the appreciation of the global aspects of telecoms including the soft skills to develop standards and manage IPR.

* 1. Commercialisation and Adoption

Recommendations of the EWGs for Commercialisation broadly split into three areas:

* Measures to increase or **improve the supply** of innovative, monetisable telecoms technologies.
* Better understanding of the dynamics and interactions of demand and supply side, with actions to meet them.
* Recommendations to **increase the scale** of the UK addressable telecoms market to increase demand for telecoms technology or services e.g. improve the demand-side.

The UK needs to accelerate the transition from research to market development through structured funded programmes to provide academic researchers with the expertise, knowledge and training needed to convert their research into technologies, products and services.

Main themes to improve the supply include:

* Focus on a dynamic and integrated R&D ecosystem: Support and facilitate R&D producing organisations (such as universities, start-ups and SMEs) to push their research and innovations into large international organisations and operators.
* The UK Market needs to grow to drive enough scale to create the industrial research and development needed to create significant national leadership or sovereign capability.

Main themes to increase the scale or demand-side include:

* Incentivise UK network operators to play a bigger role in ensuring a pull-through of UK innovation into UK networks (could be achieved by 1) tax credits, or 2) direct funding for qualifying adoption of UK-born technology into their commercial networks)
* Support for universities specifically:
  + Government could invest to protect valuable IP then partner with the supply chain to take it to market. Another model would be to recover the investment by licencing the IP
  + “Spin-in” companies, which conduct engineering development and testing in the universities (with reciprocal support from university engineers to mentor, test and support those companies) are recommended as an example of best practice.
  + A national funding pool to top up university funds for research.

Additional key points are summarised below:

* Look for opportunities to establish UK as a telecoms service broker e.g.
  + Facilitating data exchange between telcos domestically and internationally.
  + Providing data insight services based on AI and experience operating networks.
  + For systems integration services based on open APIs and complexity management.
  + Leverage best practice from UK parallel industries 2T/1T London exchange, other Financial Services, Pharma, & Legal.
* The current regulatory policies are driving fragmentation of the market, which is reducing scale and, thus, the buying power of the UK.
* Funding routes to be more obviously available to allow UK universities, startups and SMEs to push their research and innovations into large international organisations and operators.
* Define initiatives that will attract investment from global optical network equipment vendors to establish systems R&D facilities in UK to drive vision and cohesion within the photonics ecosystem and to generate market pull for new technology innovations
* Given the challenges of addressing public mobile markets, we should fully explore and support the potential for adoption routes via private, local and short range wireless networks for special applications and IoT, which are already more diverse and may offer faster and less restricted opportunities for adoption.
  1. Testbeds Platforms, Centres and Field Trials

A testbed is a platform for testing and validating new ideas in the field of telecoms. Testbeds are a key tool for communication research and can be used for:

* Prototyping: Developing new ideas
* Testing: Demonstrating and testing wireless systems and equipment
* Training: Developing training, techniques, and procedures
* Validation: Validating telecom use cases.
* Demonstrating proof of potential value: scalable, optimised, useful, usable, affordable business case.
* Addressing other areas marked for development by the EWGs, including skills development.
* Testbeds can also potentially generate contributions to standards

The EWGs make many recommendations for testbeds to support focussed scalable R&D. It should be noted, however that much historic spending on testbeds seemed to be inefficient in translating to sustainable UK value or accelerating the practical rollout of 5G. Therefore, much focus in the recommendations is on improving the access to, coordination between and value created from, future testbed deployments.

A better approach for maximising the value of outputs from testbeds may be to partner with other countries, such as the EU, USA, Japan or South Korea, or organisations, such as Dante, Mitre, NTIA, or IOWN, or to develop until sufficient scale is possible.

Specific themes arising were:

* Testbed unification across all the EWG technologies, particularly in the context for preparation for 6G - a full end-to-end technology integration, encompassing the 5G/6G communication environment, incorporating both satellite and terrestrial components as well as allowing for innovations in radio spectrum use.
* Wider access to the unified testbeds – extend testbed access beyond the present small groups of universities and users.
* A Centre of Excellence in NTN for knowledge sharing between academia and industry and preparations for inputs to standards.
* Need for trusted access to specific network-based test data (real or synthetic) for AI R&D
* Testbeds are needed to support both R&D and, also, the development of better skills at undergraduate and postgraduate levels.
* Celebrate small industrial kernels/hubs such as those fostered by major vendors raising them to sustainable levels.
* Money is better spent on improving the exploitation of Core Technologies for specific objectives e.g. R&D to develop better customer-focussed systems integration or operationalisation tools and techniques and monetising this tooling.
* Testbeds should seek interconnectivity across various assets to both academia and industry, like the UKRI JOINER project is providing.
  1. Research themes and areas of focus

There are many R&D related Recommendations made by the EWGs and they can be broadly split into two types:

* Making the UK R&D initiatives work with better coordination between them, industry and government, and
* Specific technology areas for future R&D.

The NM EWG recommended that “umbrella activity is required to orchestrate, capture, and promote the achievements of UK research projects by facilitating activities in the inter-project working groups and maintaining membership links to the standardisation community” as a means improving focus and coordination.

Government should also identify future technology focus themes (e.g. 6G, net zero, power management and automation), and their intersection with digital services and applications. These are areas which Phase 2 of the UKTIN Future Capability structure will address.

The Government should consider a systematic approach to the creation of more international collaborations to maximise the market opportunity, such as establishing partnerships with countries similar to the UK’s telecoms investment (such as India, the USA, Japan and the Republic of Korea).

A coordinated, long-term strategic plan for R&D across UKRI and other government departments is needed.

Specific R&D priority areas in specific recommendations break-down in the following way:

* Digital Services and Applications:
  + 6G (technology and economics).
  + Net-zero, power management.
  + NTN economics (terrestrial and non-terrestrial; direct-to-device and backhaul).
* Service Enablement:
  + Automation (including of network complexity).
* Information:
  + AI.
  + CEM-based digital twins.
  + Network open-APIs including inter-operator APIs.
* Connectivity:
  + Core computer networking and future internet research.
  + Optics/photonics ecosystem (e.g. IOWN-like).

Connectivity issues were highlighted in particular by the Core Networking Technologies EWG:

* + The optimal distribution of infrastructure in hybrid, cloud-based network infrastructures
  + Function distribution between CPE, edge and core
  + Network instrumentation in increasingly complex, fragmented and encrypted networks, e.g. with QUIC, maybe also including "differential quality" approaches to performance management.
  + Functional decomposition and exposure in “fine-grain” microservice-based network-as-a service architectures
  + Approaches for sensor-fusion (+other 6G "wish list" stuff in network technology scope)
  + The challenge of the “Gs” in mobile networks – where does fixed/mobile/NTN convergent networks play a part – a “road-mapping” challenge.
  + New approaches to network quality/efficiency differentiation e.g. beyond L4S, TreeDN and MAUD
  + Quantum impact on networks e.g. Quantum-safe, key distribution, quantum networking
  + Approaches for Self-healing, Self-optimising and Self-monitoring networks (in conjunction with NM and AI)
  + Systems integration and Systemisation tooling and practices focused on application & control planes in the model
  + Architecture, application and optimisation of QKD in telecoms networks
  + Network reliability and availability; especially in the continued direction of generic compute and software functions and dis-aggregation.
  + Semantic networking and Web 3.0
  1. Collaboration, and strategic partnerships (including international)

The EWG recommendations relating to collaboration and Strategic Partnerships can be broken down into three main areas:

* The importance of **strategic international collaborations** and partnerships was stressed across EWGs. Examples include strategic partnerships where the UK is reliant on overseas semiconductor suppliers, such as silicon CMOS chips.
* **Collaborations across academia and industry** was also stressed. Examples include real system deployment to share knowledge, develop practical solutions, and address real-world security challenges.
  + For examplethe approach adopted by the 5G Open Innovation Lab in the USA, UK Government departments should partner with relevant and proactive innovation organisations on an occasional basis to create some cohorts targeted specifically at wireless networking.
* With regards to **6G specifically**, collaboration should be a condition of 6G research funding provided to universities. 6G technologies be focussed on open networking between NTN and TN and coordinated across DSIT and UKRI being facilitated by larger consortia of industry and academic partners. Key opportunities for collaboration should be on software platforms, cloud, API-based architectures, AI and sensing.

The integration of industrial and academic R&D in the UK, and internationally to collaborate, with a purpose of expanding on UK competencies, was noted in the discussion of Research Themes, above.

* 1. Government, Funding & Investment

Recommendations in this area were numerous and can be broken down into four main groups:

* Government Driven Strategy & Vision
* Establishment of New Government Bodies & Initiatives
* Government Funding & Incentives
* Commercial Investment

Key highlights of each group are presented below.

#### Government Driven Strategy & Vision

Key highlights of the recommendations are:

* UK long term Vision to develop and leverage AI/ Automation technologies to improve and facilitate the management of highly complex networks.
* Long term (20 year) strategy of how telecommunications enables the modern economy, not just the automation of itself, but also the facilitation and automation of all industries that will require telecommunications.
* Long-term (10 year+) strategy for improving the NM ecosystem in the UK covering development of homegrown NM specific skills, establishment of trusted methods for data exchange, open network management APIs and targeted investment in R&D and revenue growth facilitation measures.
* Initiatives to ensure telecom operators develop resilience strategies to maintain critical national infrastructure in the event of sustained supply chain disruption, for example by holding stock.

#### Establishment of New Government Bodies & Initiatives

Key highlights of the recommendations are:

* The delivery of capabilities to support telecoms in the UK must be coordinated across artificial intelligence, future telecoms, semiconductors and quantum technologies. A Future Telecoms Institute could be a focal point for this coordination, working together with other domain specific organisations.
* Facilitate the creation of a cross industry and research forum, to enable the sharing of knowledge, ideas, problems, and goals, to influence or create development and research areas (representatives from telecom networks, technology companies, universities, and other industries such as Energy, Health, Logistics, Transport, Finance etc.) Scope can include:
  + Co-creation of requirements from Health and Energy industries, maybe smart cities and network densification.
  + Understanding the absolute requirements from customers and translate into specifications for telcos.
  + Output from this is set of binding requirements e.g for robotic surgery or driverless cars.

#### Government Funding & Incentives

The key highlights from the recommendations for this category are:

* Initiatives to ensure telecom operators develop resilience strategies to maintain critical national infrastructure in the event of sustained supply chain disruption, for example by holding stock.
* Initiatives similar to the US Trusted Foundry Program, whereby designers can be assured that their chip has not been tampered during fabrication - synergies with the Innovate UK Digital Security by Design (DSbD) programme.
* EWGs recommend targeted funding aimed at the following themes:
  + Intelligent Transport Systems (ITS) Infrastructure to support Connected and Automated Mobility solutions.
  + Collaborative programmes for developing, launching, and validating in-orbit/flight, the end-to-end service management capabilities required by the evolving market to enable UK industry to develop world-leading insight and operational solutions.
  + Specific financial support to help UK companies develop the telecom and semiconductor technologies.
  + For universities specifically:
    - To deliver courses in strategically important degree courses, such as semiconductors and telecoms.
    - Specific CDTs (Centres for Doctoral Training) in semiconductors and telecoms.
    - Encourage and support diversity in the sector, addressing the extremely low number of female undergraduates within electronic engineering and the telecoms industry.
* Have open calls on a rolling basis without a specific application window, organised around a particular theme adopting the approach used by DASA (Defence and Security Accelerator) without a specific application window.

#### Commercial Investment

Recommendations are primarily **semiconductor focused** (including those from Wireless group) and focus on facilitating the growth of investments in the space, particularly at growth.

* A roadmap leveraging both industry and academia for the UK to meet sovereign needs and maximise opportunities for the supply chain.
* Concrete suggestions include:
  + Pooling investments across telecommunications, space and defence.
  + Initiatives to encourage more private sector investment in high-risk/VC-funded firms, including the ‘Mansion House’ reforms and CBI recommendations, to unlock larger scale investment from pension funds.
  + Review and potential reform of government incentive schemes, including the Enterprise Management Incentive (EMI) and R&D tax credits.
  + Review of the rules governing CAPEX and OPEX, to ensure that grants available to UK companies enable them to address the commercial opportunities identified in the technology roadmaps.
  + Review of the Subsidy Control Act and a review of UK companies’ access to Horizon funding.
  1. Legislation, Regulation and Policy

The Wireless and NTN EWGs address legislation and regulation recommendations to the UK government and Ofcom:

* UK government
  + Regulatory and legislative focus to enable economic network deployment, with a clear remit to help create the conditions for building UK capability.
  + Completing activity which has already commenced, notably the review of annual licence fees and swift and effective enablement of the Product Security and Telecommunications Infrastructure (PSTI) legislation.
* Ofcom:
  + Must coordinate with UK-based industry consortia and companies to keep influence channels open towards Brussels.
  + Must strengthen its existing leading engagement in any future international discussions (CEPT, ITU-R) for the identification of suitable frequency bands and the development of appropriate technical conditions for NTN, supporting their broader harmonisation.
  + Should be provisioned with a budget to create monitoring infrastructure suitable for ensuring compliance with future NTN systems.
  1. Standards and intellectual property

The Standards EWG produced a series of recommendations on their key subject and the general ones are covered here. The others are covered in the section more appropriate to the focus of the recommendation beyond standards. Wireless, NTN, NM and Core EWGs have produced recommendations related to standards and their subject areas. Key recommendations are summarised below:

* General – Standards Awareness & Promotion
  + Hold light touch coordination fora to bring together standards and technology experts in the UK, at least at some critical points, and allowing official (e.g. DSIT) views to be socialized (e.g. workshop on views on 3GPP releases, 6G, new ETSI projects etc).
  + Promote awareness of standards process and status / trends within universities, aimed particularly at early career telecom researchers or postgraduates (the first aspect through training, and the second via regular presentations and workshops). This could start with universities with existing commitments e.g. ETSI membership.
  + Create mechanisms to enable initial standards participation by universities and smaller players.
  + A managed and coordinated national approach is required to efficiently and effectively take the results of relevant UK 6G research projects into global standards bodies.
  + A network for individuals working for UK universities, SMEs and regional offices of international companies to collaborate in standards organisations should be created.
  + A selective approach should be taken to determining standards groups which are both impactful and cost-effective to support.
* NTN-focused
  + UK industry should work with 3GPP and other relevant standards entities to ensure that end-to-end management plane capabilities, including trans-TN-NTN boundary continuity, are included in future standards.
  + UK industry should work to identify any gaps and limitations in the current standards that would slow down the mass adoption of NTN technology. The UK industry should take lead to lobby with the relevant standard and regulatory bodies on the urgency to fix these issues in order to keep up with the pace of business trends.
* NM-focused
  + Review UK telecom representation to international bodies for NM, this includes – 3GPP, O-RAN Alliance, IETF, ETSI, TMForum & Opensource Projects
  + Increase UK’s presence in standards bodies and align ‘UK Inc’ input to prioritise development of UK areas of strength. The UK should have a strong “seat-at-the-table” in NM.
* A particular focus should be on standardising interoperability between operator platforms and systems, multi-network domains and APIs including aspects of trust. Potential areas for focus are APIs and the extension of the RIC into a wider real-time management platforms.

#### Intellectual property

The EWGs provided recommendations about building on IP outcomes from R&D projects and innovation activities as an opportunity to help maximise UK growth.

Companies participating in standards work must declare their IP upfront when it is crucial to the development of the standard being considered. In general IP, the conditions on its availability, and it use in standards have a well defined relationship now.

When Universities attempt to commercialise academic research, all too often the only option is a spin-out company which quickly gets bought by large international companies, who perceive the importance of associated IP at a time when it is potentially good value-for-money to acquire, e.g. Microsoft Azure’s recent purchase of Lumenisity (hollow-core fibre).

More specific recommendations included:

* Incentivise UK operators to make data on network deployments, network traffic, channel conditions, etc. available to researchers under mutually acceptable conditions.
* Could the Government invest to protect valuable IP then partner with the supply chain to take it to market? One model would be to recover the investment by licencing the IP.
* Establishing a public-private partnership framework for IP between the UK universities, research institutes, and smaller innovators, on one hand, and the global industry present in the UK and internationally on the other hand.
* A UK fund should be created to support UK universities and SMEs in particular to apply for patents and help monetize these patents for example through licensing directly or indirectly (e.g. via patent pools).

1. Next steps for the Expert Working Groups

The diversity of views of strengths, challenges and opportunities became clear during the analysis of the outcomes from Phase 1. It also highlighted the need for an architectural positioning of the technology domains in a systemic view of telecommunication systems.

We believe that the best way to address this is to look at the individual communication systems exactly as such – instantiations for specific customer groups, use cases and industry engagement of what is de-facto emerging in the next 5-10 years.

We think a view of a common digital fabric is emerging that integrates together communication/connectivity infrastructure and information/ compute infrastructure. There will be specific instantiations of it as needed in different deployment and use scenarios, from the commonly mobile broadband national service to existing private WiFi/cellular/ networks to, in the longer term future, fully personalised network instances that are shaped to the specific needs of the user at a particular geography and use case.

* 1. Phase 2 Direction

The insights from Phase 1 have provided UKTIN with a means of harmonising views into a technology end-to-end system view of the telecommunication sector.

Building on this, this section sets out what the EWGs will work on in Phase 2 of the UKTIN Future Capability studies.

* They will identify and prioritise areas of focus for R&D&I in the UK that drive technology development to build UK capabilities that contribute to UK economic growth, and ensure resilience and security of the nation’s critical digital infrastructure.
* The EWGs will establish consensus on UK technology R&D&I roadmaps, aligned with internationally set technology development directions.
* A key feature of the road map analysis will be timing. The EWGs will define feasible outcomes in three 5-year windows: 2025-2030, 2030-2035, and 2035+. The outcomes will be: to undertake R&D, innovate to develop capabilities; and ultimately translate these into commercial offerings. Every level of TRL or SRL is eligible.
* The EWGs will select the topics in which the UK should play a role, as a leader or a significant influential player in the leading pack; thus having a seat at the table in the shaping of the future of telecoms.
* Each EWG will determine the number and nature of the specific focus topics across the 3 windows. They can be oriented towards industry platforms, or systems concepts such as architectural entities, or specific technology capabilities.
* A short narrative will be developed for each focus topic, complementing the roadmap. It will draw on insights into dependencies on standards, or early-stage technologies, or adjacent/complementary markets or products.
* The EWGs are encouraged to work with other EWGs where there are common causes and dependencies. Such linkages point to structural synergies and identify opportunities for bridging and collaboration between EWGs’ domains.
* The EWGs are encouraged to also perform a gap analysis in their individual domains – reflecting more broadly where more fundamental changes are necessary or are emerging, and use this to build more specific UK.

This analysis is the key input into the UK telecommunication sector, and will be consulted widely as it is developed in the 2nd half of 2024.

The FCSL intent continues to be to establish ambitious horizons into which the UK can play a role, as a leader in specific focus areas and as an influential player in the international efforts to develop technologies and solutions for future communications. Starting the work on developing these capabilities now is the only way to enable this to happen, and make sure that the UK sector has a real chance to play a significant role to shape the future of communication systems and future digital fabric in a way that meets national strategic objectives and delivers economic growth for the UK, and contributes to the rest of the world.

1. Summary

It is critical for the UK to have a national ability to develop technology for future communications as the key part of the critical national infrastructure, and as a key enabler for digital innovation and the impact this will have in UK future economic growth as a leading science and technology nation. The UK should follow a strategic mid-to-long term programmatic coordination activity that develops and grows the R&D&I of the UK telecommunication sector, focusing on specific technology areas where there is strength of critical need for national sovereignty not just at the moment but projecting 10+ years in the future

The UK can take advantage of the significant strengths in its telecoms R&D capabilities, building on world leading academic and, in pockets, industrial research. It must carefully and strategically address identified challenges in skills, industrial R&D investment, research translation and industry R&D scale up in the UK.

The main ambition for the UK future capabilities is to successfully and sustainably translate the academic and industrial research into commercial offerings and grow them, so that it meets the national strategic objectives of the nation for a safe, secure and resilient infrastructure that enables and is a key promoter of digital innovation and economic growth for the UK. The best indicator of achieving this is to scale up the UK industrial R&D&I capabilities in future communication systems, and make the UK a key collaborator and place in the world for this research to be undertaken.

The journey to build this capability starts now, and it is to be delivered by building and supporting strong collaboration between industry and academic research, not only for the long term future of the UK telecommunication sector but to secure the ability of the UK to have the right infrastructure for the AI era into and beyond 2035

Sections of the network that we have analysed allow us to move to Phase 2, with specific focus to be on the roadmap. UKTIN Future Capabilities structure is also streamlining our processes to bring together, and prioritise better, the recommended directions of travel for the UK with the aim of moving into a sustainable national roadmap review and maintenance activity through the UKTIN Future Capability in Future Communications existing structure. We intend to consult with the community as we move into the next stage of UKTIN.

The FCSL fully endorses the recommendations of the EWGs. The recommendations are not just connected: an action to support one affects the others.

For example, commercialisation and adoption could be seen as the priority theme, for three reasons that clearly illustrate these interactions:

* Lack of commercial activity and low adoption of new telecom capabilities means there is less need to invest in mass development of skills for innovation at levels below those of postgraduate specialisms for R&D, which are arguably well recognised and supported.
* Commercialisation and adoption could benefit from testbeds to establish proof of concept (usable, useful, scalable) and proof of value (understanding the potential return, the costs, etc.). But testbeds often have no commitment to proof of value. They are short term limited proofs of concept; the skills that we know we need are redirected, dispersed or otherwise lost when the testbed project ends.
* The UK has the right R&D key themes that deliver a prized source of novelty and innovation that other countries commercialise and adopt to their profit. The UK loses the skills as well as the profit and IPR ownership. Should intervention on UK input into standards and protection of IPR take precedence over other categories?

Digital connectivity underpins success in all the government’s missions so these interactions must be understood. Robust links to the recommendation themes must be established through policy and regulation to create an end-to-end ecosystem to support digital connectivity. The example above is just one such link.

**Version Control**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Revision | Description | Author(s) | Reviewed by | Date |
| 0.1 | First draft – Vision and Recommendation Analysis | Alistair Munro, Julie Valk, Nick Coombes | Kostas Katsaros, Hamid Falaki | 2024-04-08 |
| 0.2 | First reviewed draft, comments resolved. Ongoing editing. | Alistair Munro, Julie Valk, Nick Coombes |  | 2024-05-06 |
| 0.2.1 | Temporary branch for SWG review | Alistair Munro |  | 2024-05-16 |
| 0.3 | New version for ongoing editorial updates, following meeting on 2024-05-23. | Alistair Munro Julie Valk, Nick Coombes | Julie Valk, Nick Coombes (including many revisions), presented to FC SWG members with feedback received on 2024-05-23. | 2024-05-28 |
| 0.4 | Text reorganised according to feedback from review. | Alistair Munro Julie Valk, Nick Coombes | Members of the FCSL. | 2024-06-11 |
| 0.5 | Structure and contents revision based on agreements at 18/6 meeting | Simon Saunders |  | 2024-06-19 |
| 0.6 | Final draft revision. Introduction, context, next steps and summary of the report.  Update of recommendations | Dritan Kaleshi,  Simon Fletcher, Alistair Munro | Members of the FCSL (Chairs) and the UKTIN Secretariat | 2024-07-06 |
| 0.6 | Final draft revision. Introduction, context, next steps and summary of the report. | Dritan Kaleshi,  Simon Fletcher |  | 2024-07-08 |
| 0.7 | Cleaned text to be circulated to DSIT for review | Alistair Munro | DSIT, Dritan Kaleshi | 2024-07-12 |
| 0.8 | New revision following discussion with DSIT on 2024-08-08, comments received from DSIT and Dritan Kaleshi | Alistair Munro |  | 2024-08-12 |
| 0.9 | Many significant editorial and technical revisions, cleaned up and prepared for internal review with some edits still to complete. | Juie Valk, Sophie Weston, Nick Coombes, Alistair Munro | Ian Smith, Dritan Kaleshi | 2024-09-03 |
| 0.10 | Integrated responses to comments from Ian Smith. Finalised response to DSIT comments. Added Security EWG recommendations to Annex E.1. Removed comments to prepare to be sent to Chairs. | Alistair Munro | Chairs | 2024-09-06 |
| 0.11 | Integrated text of Section 3 reviewed by Chairs, actionable comments resolved. Short summaries removed. To be sent to Chairs for final review.  Draft Executive Summary to be added. | Alistair Munro | Dritan Kaleshi, Ian Smith, Secretariat | 2024-10-03 |
| 1.0 | Proof-read version for publication | Alistair Munro, Kostas Katsaros | - | 2025-02-12 |

1. Contributors

Members of the Strategic Working Group are listed below. Members are voluntary, selected via an open selection process, and participate in an independent capacity, not on behalf of their organisations.

|  |  |
| --- | --- |
| Name | Role and Affiliation |
| Dritan Kaleshi | Co-Chair, Digital Catapult |
| Simon Fletcher | Co-Chair, Real Wireless |
| Barry Evans | Chair Non-Terrestrial Networks EWG, University of Surrey |
| David Happy | Chair Security EWG, Telint Ltd |
| Doug Pulley | Chair AI EWG, RANsemi |
| Luis Lopez | Chair Standards EWG, <affiliation> |
| Neil McRae | Chair Core Networking Technologies EWG, Juniper Networks |
| Nick Parsons | Chair Optical and Photonics EWG, Huber Suhner |
| Rupert Baines | Chair Semiconductors EWG, <affiliation> |
| Simon Saunders | Chair Wireless Networking Technologies EWG, Independent |
| Tom Bennet | Chair Network Management EWG, Freshwave |

Members of the UKTIN Secretariat assisted with drafting and review of the text: Julie Valk (Digital Catapult), Nick Coombes (Digital Catapult), Hamid Falaki (University of Bristol).

1. List of Acronyms

|  |  |
| --- | --- |
| Telecoms R&D Future Capability Strategic Leadership | FCSL |
| 3rd Generation Project Partnership | 3GPP |
| 5th generation of cellular mobile technologies, systems and services | 5G |
| 6th generation of cellular mobile technologies, systems and services | 6G |
| 6G Infrastructure Association | 6G-IA |
| Application Programming Interface | API |
| Broadband Integrated Services Digital Network | B-ISDN |
| Capital expenditure | CAPEX |
| Confederation of British Industry | CBI |
| Centre for Doctoral Training | CDT |
| Customer Experience Management | CEM |
| European Conference of Postal and Telecommunications Administrations | CEPT |
| Compound metal oxide silicon | CMOS |
| Customer Premises Equipment | CPE |
| Defence and Security Accelerator | DASA |
| Digital security by design | DSbD |
| UK Government Department of Science, Innovation and Technology | DSIT |
| Enterprise Management Incentive | EMI |
| Engineering and Physical Sciences Research Council | EPSRC |
| European Telecommunications Standards Insitute | ETSI |
| European Union | EU |
| Expert Working Group | EWG |
| Horizon Europe | HE |
| Information and Communications Technologies | ICT |
| Institute of Electrical and Electronics Engineers | IEEE |
| Internet Engineering Task Force | IETF |
| International Mobile Telecommunications | IMT |
| Innovative Optical and Wireless Network | IOWN |
| Internet Protocol | IP |
| Intellectual property | IP |
| Intellectual Property Rights | IPR |
| Intelligent Transport Services | ITS |
| International Telecommunications Union - Radio | ITU-R |
| International Telecommunications Union - Telecommunications | ITU-T |
| Layer 4 switching | L4S |
| Low latency, low loss, scalable throughput | L4S |
| Multicast-assisted unicast delivery | MAUD |
| New Economics Foundation | NEF |
| Network Management | NM |
| National Telecommunications and Information Administration | NTIA |
| Non-Terrestrial Networks | NTN |
| Operational expenditure | OPEX |
| Open-RAN | O-RAN |
| Product Security and Telecommunications Infrastructure | PSTI |
| Quantum key distribution | QKD |
| QUIC is not an acronym | QUIC |
| Research and Development | R&D |
| Research, Development and Innovation | R&D&I |
| Radio Access Network | RAN |
| Radio Intelligent Controller | RIC |
| Small and medium-sized enterprises | SMEs |
| Smart Networks and Services | SNS |
| Science Technology Engineering and Mathematics | STEM |
| Strategic Working Group | SWG |
| Terrestrial Networks | TN |
| UK Research and Innovation | UKRI |
| UK Telecoms Innovation Network | UKTIN |
| United States of America | USA |
| Work item description | WID |

1. References

These were the source of the trends analysis in Section 2, in addition to footnotes in that section.

[[1]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref1) IBM Institute for Business Value, GSMA, “Telecom 2030: Dial in for a decade of opportunity”, 2024, <https://www.ibm.com/thought-leadership/institute-business-value/en-us/report/telecom-2030>

[[2]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref2) Nokia, ” Networks in 2030: Why an open future is essential”, 2024, <https://www.nokia.com/thought-leadership/articles/networks-2030-open-telecoms-future/>

[[3]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref3) Nokia, “Network evolution towards the 6G era”, 2024, <https://www.nokia.com/blog/network-evolution-towards-the-6g-era/>

[[4]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref4) IETF Datatracker, “Low Latency, Low Loss, and Scalable Throughput (L4S) Internet Service: Architecture”, various dates, <https://datatracker.ietf.org/doc/rfc9330/> and related RFCs: 9331, 9332, etc.

[[5]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref5) Nokia, ” Crack innovation in telecoms with four dimensions of openness” <https://www.nokia.com/thought-leadership/articles/openness/openness-drives-innovation/>

[[6]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref6) <https://www.ericsson.com/en/about-us/new-world-of-possibilities/imagine-possible-perspectives>

[[7]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref7) <https://www.broadbandcommission.org/about-us/>

[[8]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref8) <https://www.itu.int/en/ITU-T/studygroups/2017-2020/13/Documents/Internet_2030%20.pdf>

[[9]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref9) <https://www-file.huawei.com/-/media/corp2020/pdf/giv/industry-reports/communications_network_2030_en.pdf>

[[10]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref10) <https://www-file.huawei.com/-/media/corp2020/pdf/giv/intelligent_world_2030_en.pdf>

[[11]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref11) <https://www.pewresearch.org/topic/internet-technology/emerging-technology/future-of-the-internet/>

[[12]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref12) <https://www.pewresearch.org/internet/2021/11/22/the-future-of-digital-spaces-and-their-role-in-democracy/>

[[13]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref13) <https://www.pewresearch.org/internet/2022/02/07/visions-of-the-internet-in-2035/>

[[14]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref14) <https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2030/Pages/default.aspx>

[[15]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref15) <https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2516-2022-MSW-E.docx>

[[16]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref16) Innovate UK. (2023). [Telecom Network 2030: Innovation Landscape and Opportunities](https://www.ukri.org/wp-content/uploads/2023/10/IUK-091023-TelecomNetwork2030InnovationLandscapeAndOpportunitiesV1.pdf)

[[17]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref17) <https://iowngf.org/about-us-overview/#sharedVision>

[[18]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref18) <https://www.rd.ntt/e/iown/0001.html>, <https://iowngf.org/wp-content/uploads/2023/03/IOWN_GF_WP_Vision_2030_2.0-2.pdf>

[[19]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref19) <https://www.keysight.com/us/en/assets/7124-1017/ebooks/The-Definitive-Guide-to-Non-Terrestrial-Networks.pdf>

[[20]](https://ukc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-US&rs=en-GB&wopisrc=https%3A%2F%2Fuob.sharepoint.com%2Fteams%2Fgrp-UoB-EWG-UKTIN%2F_vti_bin%2Fwopi.ashx%2Ffiles%2Fcec972fe77ac43149d3772cf3c13c021&wdenableroaming=1&mscc=1&hid=C9F61CA1-B0F2-8000-8F5E-6B8F5E0E7115.0&uih=sharepointcom&wdlcid=en-US&jsapi=1&jsapiver=v2&corrid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&usid=1840fa4d-38f7-9b6d-e73c-be14181f5b95&newsession=1&sftc=1&uihit=docaspx&muv=1&cac=1&sams=1&mtf=1&sfp=1&sdp=1&hch=1&hwfh=1&dchat=1&sc=%7B%22pmo%22%3A%22https%3A%2F%2Fuob.sharepoint.com%22%2C%22pmshare%22%3Atrue%7D&ctp=LeastProtected&rct=Normal&wdorigin=ItemsView&wdhostclicktime=1712572058535&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftnref20) <https://telecominfraproject.com/>

1. ToRs - Overview and Scope

The Forum will bring together industry leaders and representatives of the UK telecoms ecosystem to:

* Gather insights from across the telecommunications industry to shape future capability strategy.
* Align key findings and build new bridges between industry and academia (bringing in findings from the Academic Future Networks Strategic Group, led by the University of Bristol) in order to establish priority areas for future R&D&I.
* Collating information that will come from EWGs and wider groups to reach a community-wide consensus that can be shared with the x-Govt strategic group and inform new recommendations.
* Explore regional opportunities, strengths and challenges from across the UK in order to reflect national areas of prioritisation that will enable growth for all areas.
* Focus on analysing capabilities across different technology areas as well as areas of strength in the UK to inform understanding across the ecosystem.
* Explore, but not be limited to, R&D priorities identified in initial technology trend analysis.
* Identify opportunities for diversification in the telecommunications supply chain to support the analysis of the UKTIN Telecoms Diversification Industry Coordination Group.

1. Collated EWG Recommendations

The recommendations from all the Expert Working Groups are listed in the Table below. These are the recommendations as presented in the EWG reports. The “Category” column can be used as a cross-reference to Section 3 and more details of the analysis are given in Annex ‎E.2.

* 1. Complete Recommendations Register
     1. AI

| No. | EWG | Recommendation | Category |
| --- | --- | --- | --- |
| 1 | AI | Create a Future Network Platform and Innovation Program for co-innovation and experimentation of AI transformative capabilities in future Telco with stakeholders.     * Catalyse fast track innovations and disruption on AI capabilities in Telco technology, services, and business transformation. * Develop PoCs that attract third-party buy-in, fostering collaboration and partnership with diverse stakeholders including new entrants and SMEs. * As a training platform to share lessons learnt and best practices, upskill and reskill workforce to meet the demands for future AI-powered Telco and cloud providers. * Promote collaboration with international stakeholders to tap into global expertise and attract investments on future Telco in the UK" | Testbed, Platforms, Centres, Field trials, etc |
| 2 | AI | Open6G testbed  Establish a cohesive 'Open6G' testbed that facilitates the seamless integration and assessment of multivendor interoperability solutions for native AI network elements and testbeds. | Testbed, Platforms, Centres, Field trials, etc |
| 3 | AI | Unified Data Access  Create unified Data Accessibility Initiatives towards the goal of safely opening network data and facilitating data sharing for the UK telecom ecosystem. | Collaboration and Strategic Partnerships (including international) |
| 4 | AI | Telco-AI Initiatives  Form a mechanism to encourage and incubate radical, creative, fresh thinking research translation and adoption from SME and Universities on Telco AI business growth ideas. | Research themes and areas of focus |

* + 1. NTN

| No. | EWG | Recommendation | Category |
| --- | --- | --- | --- |
| 1 | NTN | UK industry should work with 3GPP and other relevant standards entities to ensure that end-to-end management plane capabilities, including trans-TN-NTN boundary continuity, are included in future standards. | Standards |
| 2 | NTN | UK industry should work to identify any gaps and limitations in the current standards that would slow down the mass adoption of NTN technology. The UK industry should take the lead to lobby with the relevant standard and regulatory bodies on the urgency to fix these issues in order to keep up with the pace of business trends. | Standards |
| 3 | NTN | It is recommended that the Government set up a Centre of Excellence in NTN for knowledge sharing between academia and industry and preparations for inputs to standards. In addition, that Government seeks ways to raise the profile of NTN within the National Space Strategy. | Testbed, Platforms, Centres, Field trials, etc |
| 4 | NTN | UK government should run collaborative programmes for developing, launching, and validating in-orbit/flight, the end-to-end service management capabilities required by the evolving market to enable UK industry to develop world-leading insight and operational solutions. | Funding |
| 5 | NTN | It is recommended that future R&D on 6G technologies be focussed on open networking between NTN and TN and coordinated across DSIT and UKRI being facilitated by larger consortia of industry and academic partners. Additional coverage should be extended to interference management/spectrum sharing, optical communications, AI/ML and on-board processing algorithms and semiconductors for on board processing. | Collaboration and Strategic Partnerships (including international) |
| 6 | NTN | A detailed comparison of the LCA for a variety of directly comparable scenarios (terrestrial and non-terrestrial; direct-to-device and backhaul) that sets good precedents for comparing differing telecommunications services is required. | Research themes and areas of focus |
| 7 | NTN | It is recommended that a wider evidence base on skills shortages in the telecommunications and NTN sector be commissioned in order to validate initial findings in this paper. | Skills |
| 8 | NTN | It is recommended that Test beds to assist in the training of skilled workforce be established. This would include bench testing capability for low level hardware as well as for NTN communications networking and would consist of simulation & modelling, laboratory ‘device in the loop’ tests with test equipment and extend to a ‘in-orbit’ test. | Testbed, Platforms, Centres, Field trials, etc |
| 9 | NTN | It is recommended to commission a rich research environment that brings together industry and academia in a cost-effective way with the dual aims of undertaking strategic pre-competitive research; and attracting and developing highly skilled PhD candidates with the means to facilitate entry into industry and become industry leaders in the area of NTN and satellite communications. | Collaboration and Strategic Partnerships (including international) |
| 10 | NTN | It is recommended to develop rich opportunities for apprentices at all levels, with the required dual support of study and industry work, where apprentices would work along-side experienced practitioners with a pathway to such roles in the future. | Skills |
| 11 | NTN | It is recommended that Ofcom engages in any future international discussions for the identification of suitable frequency bands and the development of appropriate technical conditions for NTN, supporting their broader harmonisation. That would avoid the risk of market fragmentation and allow NTN operators to deploy services more efficiently at a global scale. An early identification of frequency bands for NTN, would ensure speedy access to spectrum from the operators, encouraging an early uptake of systems using the new NTN standards. | Legislation, Regulation and policy |
| 12 | NTN | It is recommended that Ofcom should be provisioned with a budget to create monitoring infrastructure suitable for ensuring compliance with future NTN systems. | Legislation, Regulation and policy |

* + 1. Wireless Networking Technologies

| No. | EWG | Recommendation | Category |
| --- | --- | --- | --- |
| 1 | Wireless | Governments, both national and local, need to be the catalyst for high-quality network deployment: high-quality wide area wireless networks are an imperative for both economic growth and societal development. | Commercialisation |
| 2 | Wireless | The public sector should underwrite the deployment and availability of network capability which the private sector can then leverage to deliver significant economic benefit. | Commercialisation |
| 3 | Wireless | Relentless regulatory and legislative focus is required to enable economic network deployment, with a clear remit to help create the conditions for building UK capability. | Legislation, Regulation and policy |
| 4 | Wireless | The UK Government should ensure completion of activity which has already commenced, notably the review of annual licence fees and swift and effective enablement of the Product Security and Telecommunications Infrastructure (PSTI) legislation. | Legislation, Regulation and policy |
| 5 | Wireless | Priority opportunities for UK Government to incentivise for 6G research and innovation include: | Research themes and areas of focus |
|  |  | Widespread wireless service coverage to prevent the manifestation of a “digital divide” and to contribute to improved health and social care outcomes and future transport ambitions; | Legislation, Regulation and policy |
|  |  | Innovation in spectrum management (e.g., through the use of automation and AI), to improve spectrum efficiency and densify spectrum sharing, particularly in the low frequency, mid and mid-high frequency bands suitable for mobile connectivity; | Legislation, Regulation and policy |
|  |  | Economic viability of roll-out of next-generation mobile infrastructure (through enabling new service possibilities or significant cost savings); | Commercialisation |
|  |  | Alignment with the Government’s net zero targets. | Legislation, Regulation and policy |
| 6 | Wireless | Participation in an approved “collaboration model” should be a condition of 6G research funding provided to universities. | Collaboration and Strategic Partnerships (including international) |
| 7 | Wireless | A systematic approach to the creation of more international collaborations like those led by DCMS (e.g., with the Republic of Korea and India) should be adopted and should target key partners, such as the USA. | Collaboration and Strategic Partnerships (including international) |
| 8 | Wireless | A managed and coordinated national approach is required to efficiently and effectively take the results of relevant UK 6G research projects into global standards bodies. | Standards |
| 9 | Wireless | Similar to the approach adopted by the 5G Open Innovation Lab in the USA, UK Government departments should partner with relevant and proactive innovation organisations on an occasional basis to create some cohorts targeted specifically at wireless networking. | Collaboration and Strategic Partnerships (including international) |
| 10 | Wireless | Incentivise UK operators to make data on network deployments, network traffic, channel conditions, etc., available to researchers. | IP, Patents, Data, etc |
| 11 | Wireless | Funding routes to be more obviously available to allow UK universities, startups, and SMEs to push their research and innovations into large international organisations and operators. | Commercialisation |
| 12 | Wireless | Universities should be encouraged to develop a multi-disciplinary approach to innovation in wireless networking, which includes software engineering, chip design, AI, business, and commercialisation. | Interdisciplinarity |
| 13 | Wireless | International collaboration: While UK companies may thrive in niche, high-value elements of the supply chain, collaboration will be key to maximise the market opportunity and to embed UK content in future wireless systems. | Collaboration and Strategic Partnerships (including international) |
| 14 | Wireless | Low-cost access to test facilities: Access to test facilities can be a significant barrier to new entrants to the market. The best model seems to be to embed equipment within an industry setting with a core partner so the equipment is regularly used but remains open for access to others. | Testbed, Platforms, Centres, Field trials, etc |
| 15 | Wireless | Government procurement initiatives: Although not the largest buyer of telecoms infrastructure, the UK still has significant spending power, which could potentially be used to convince suppliers to include UK supply chain into their networks. If successful, this could lead to design into products that would then be sold in other territories. | Commercialisation |
| 16 | Wireless | UK Strategy to cover multiple markets: For wireless technology and related semiconductors, there is significant crossover from telecommunications requirements with those of defence and space, investments should be pooled, and the roadmap developed so the UK has its sovereign needs met while maximising the commercial opportunities for the supply chain. | Investment, VC, etc |
| 17 | Wireless | Focused UK roadmap leveraging UK academic base: Ensure the academic base buys into the same roadmap with a future-looking perspective. | Investment, VC, etc |
| 18 | Wireless | Commercialising academic research: Once we have alignment between the academic and UK strategic roadmap, the next issue to solve is the commercialisation of academic research. Could the Government invest to protect valuable IP then partner with the supply chain to take it to market? One model would be to recover the investment by licensing the IP. | IP, Patents, Data, etc |
| 19 | Wireless | Coherent drive on skills: Something needs to change as skills have been an issue for decades. A combination of education and promoting the industry combined with incentives (e.g., bursaries for students to study) may be a good combination. | Skills |
| 20 | Wireless | Advocate and support the upskilling of the existing base of those with deep baseband processing expertise in the field of AI. | Skills |
| 21 | Wireless | Support field trial access to trial innovative new techniques and demonstrate interoperability of AI techniques. | Testbed, Platforms, Centres, Field trials, etc |
| 22 | Wireless | Create an investment environment conducive to the funding business innovating in semiconductor compute devices for baseband processing in the RAN. | Investment, VC, etc |
| 23 | Wireless | A public-private partnership framework for intellectual property between the UK universities, research institutes, and smaller innovators, on one hand, and the global industry present in the UK and internationally on the other hand, is recommended. | IP, Patents, Data, etc |
| 24 | Wireless | A UK fund should be created to support UK universities and SMEs in particular to apply for patents and help monetize these patents for example through licensing directly or indirectly (e.g., via patent pools). | IP, Patents, Data, etc |
| 25 | Wireless | A network for individuals working for UK universities, SMEs and regional offices of international companies to collaborate in standards organisations should be created. | Standards |
| 26 | Wireless | A selective approach should be taken to determining standards groups which are both impactful and cost-effective to support. | Standards |
| 27 | Wireless | Ofcom, supported by UK Government, must continue the willingness to experiment, provide mechanisms for academia and companies to innovate in radio spectrum use. | Testbed, Platforms, Centres, Field trials, etc |
| 28 | Wireless | Ofcom, supported by UK Government, must coordinate with UK-based industry consortia and companies to keep influence channels open towards Brussels. | Legislation, Regulation and policy |
| 29 | Wireless | The UK should lead in providing access to shared MNCs and better coordinated private network MCCs for private networks and UK neutral host companies. | Research themes and areas of focus |
| 30 | Wireless | Extend the qualified expenses to R&D Tax Credits to patent filing and pursuit. | Establishment of government body, panel, Strategy, tax credits, etc |
| 31 | Wireless | Grants should be allocated on open calls which are rolling around a theme, adopting the approach used by DASA (Defence and Security Accelerator) without a specific application window. | Funding |
| 32 | Wireless | Government spending on setting up Intelligent Transport Systems (ITS) Infrastructure in the UK will help establish a lead in Connected and Automated Mobility solutions. | Funding |
| 33 | Wireless | To bridge the security and diverse interoperable system gaps, universities and research institutions need to collaborate with industry partners on real system deployment to share knowledge, develop practical solutions, and address real-world security challenges. | Collaboration and Strategic Partnerships (including international) |
| 34 | Wireless | While 5G test and trial projects offered valuable insights and in-depth exploration of 5G technology use cases and integration, a significant limitation is that many of these trials operated for a limited time, lacking the provision of sustained testing facilities. Therefore, there is a demand for permanent testbeds, akin to SONIC labs. | Testbed, Platforms, Centres, Field trials, etc |
| 35 | Wireless | The necessity for a security-focused Edge/Cloud interface underscores the importance of extensive academic research covering a spectrum from low to high Technology Readiness Levels (TRL) in the security perspective of 5G/6G networks. This involves bringing together interdisciplinary expertise for a comprehensive approach. | Interdisciplinarity |
| 36 | Wireless | A comprehensive testbed is required to facilitate full end-to-end technology integration, encompassing the 5G/6G communication environment, incorporating both satellite and terrestrial components. The diversity and distribution of funding to support expertise and facilities at different academic institutions are needed. | Testbed, Platforms, Centres, Field trials, etc |
| 37 | Wireless | Celebrate small industrial kernels/hubs such as those fostered by major vendors and should be assisted in raising them to sustainable levels. | Skills |
| 38 | Wireless | Encourage industry to re-ignite sponsorship and graduate programmes which have rarely seen by the current and coming generation. | Skills |
| 39 | Wireless | Focus upon areas where UK strengths exist and deliver high value such as systems integration and infrastructure provision. Recognise the importance of AI as an increasingly important skill in wireless networking especially in the disaggregated RAN. | Skills |
| 40 | Wireless | Develop shorter term wins, e.g., in commercial, capital, and real-estate services, which are in strong demand by Communication Service Providers and are very well represented in the UK and have a shorter path to success. | Commercialisation |
| 41 | Wireless | Bring high value IT techniques into the wireless networking curriculum. | Skills |
| 42 | Wireless | Develop strong, diverse role models to attract new talent and promote telecoms as an attractive career and as a sector bringing wider public value. | Skills |
| 43 | Wireless | Incentivise industry training schemes, e.g., by offering credits to smaller companies. | Skills |
| 44 | Wireless | Learn lessons from adjacent sectors to attract a more diverse talent pool, particularly before the older cohort is not available for skills transfer and mentoring. Engage the older generation, retaining them as consultants in order to use and transfer their talents beyond their expected retirements and loss of expertise. | Skills |
| 45 | Wireless | Reduce the additional costs of postgraduate study via targeted repayments of student loans, and visa costs for example. | Skills |
| 46 | Wireless | Set out clear options for telecom career pathways so that school leadership and careers advisors benefit from an applied appreciation of the routes available, including differences between direct industry entry, apprenticeships, and postgraduate research. | Skills |
| 47 | Wireless | The recommendations of the UK Government Wireless Infrastructure Strategy, and its Open RAN Principles, should be used to frame interventions that encourage adoption of new innovations, extending current programmes. | Commercialisation |
| 48 | Wireless | The constraints placed upon dual use of results funded by civil research programmes may benefit from review. The Group feels this would encourage innovation in other areas. | Commercialisation |
| 49 | Wireless | Open RAN should be fully embraced as an opportunity for good, applied (high TRL) R&D as there are a good range of companies in the UK with relevant skills and ORAN should increase the opportunity to concentrate on a single element vs an end-to-end system. Also, it is more AI and software dependent so it is easier to grow than hardware dominant companies. This could be built on for 6G. | Research themes and areas of focus |
| 50 | Wireless | Greater alignment between university research and facilities and industry could be assisted by “spin-in” companies, which conduct engineering development and testing in the universities and those universities should also have engineers dedicated to mentoring, testing, and support of those companies, independent from their own research. Some universities already apply such a model but this could be more consistently applied as an example of best practice. | Adoption |
| 51 | Wireless | The Government aspirations for UK involvement in 6G are welcome, but imply very near-term action on supporting companies to intersect with 6G standardisation and launch timescales. | Establishment of government body, panel, Strategy, tax credits, etc |
| 52 | Wireless | There should be incentives for universities based on implementation and impact dependent on financial output. A national funding pool to top up university funds for research would help. | Commercialisation |
| 53 | Wireless | There is a need and opportunity for UK network operators and deployers to play a bigger role in ensuring a pull-through of UK innovation into UK networks, bringing operator benefits of early innovation and innovators benefits of a credible lighthouse deployment. One approach would be to grant operators credits in the form of tax credits or direct funding for qualifying adoption of UK-born technology into their commercial networks. | Establishment of government body, panel, Strategy, tax credits, etc |
| 54 | Wireless | Given the challenges of addressing public mobile markets, we should fully explore and support the potential for adoption routes via private, local and short-range wireless networks for special applications and IoT, which are already more diverse and may offer faster and less restricted opportunities for adoption. | Adoption |

* + 1. Semiconductors

| No. | EWG | Recommendation | Category |
| --- | --- | --- | --- |
| 1 | Semiconductors: Strategy | The EWG recommends coordinated activity across all semiconductor activities with a well-defined single point between four of the five critical technologies identified by DSIT: artificial intelligence, future telecoms, semiconductors and quantum technologies, recognising the central role of semiconductors in delivering the other three technologies. This could be delivered via the National Semiconductor Institute described in the IfM Semiconductor Infrastructure Study, acting as a central interface between government, industry and academia. | Establishment of government body, panel, Strategy, tax credits, etc |
| 2 | Semiconductors: Supply Chain | The EWG recommends initiatives to ensure telecom operators develop resilience strategies to maintain critical national infrastructure in the event of sustained supply chain disruption, for example by holding stock. | Establishment of government body, panel, Strategy, tax credits, etc |
| 3 | Semiconductors: Supply Chain | The EWG strongly recommends strategic partnerships where the UK is reliant on overseas semiconductor suppliers, such as silicon CMOS chips, noting that strategic partnerships were considered as part of the IfM Semiconductor Infrastructure Study. These partnerships need to be strong and commercially binding, guaranteeing security of supply and not just technical cooperation. The partnerships may involve collaboration in research and innovation, financial commitments and/or co-investment to ensure committed capacity, but must ensure supply of components and systems to maintain telecom infrastructure. | Collaboration and Strategic Partnerships (including international) |
| 4 | Semiconductors: Supply Chain | The EWG recommends initiatives similar to the US Trusted Foundry Program, whereby designers can be assured that their chip has not been tampered during fabrication. This recommendation has synergies with the Innovate UK Digital Security by Design (DSbD) programme. | Establishment of government body, panel, Strategy, tax credits, etc |
| 5 | Semiconductors: Skills | The EWG found that skills shortages, at all levels, was one of the critical concerns facing the sector. There is a pressing need for funding to address the skills shortage by attracting new applicants and students at all levels, via a long-term, strategic programme. This programme needs to encourage school students to study subjects such as Computer Science, Electronic Engineering and Material Science. The programme could involve reforming the Apprenticeship Levy to provide employers with more spending flexibility, to overcome the current cap on the number of apprenticeships an employer can offer. There’s a need for greater emphasis and funding for further education colleges to support technicians for electronic and electrical engineering and telecoms, ensuring that undergraduates have an opportunity to gain practical work-place experience to complement their academic learning. | Skills |
| 6 | Semiconductors: Skills | The EWG recommends targeted funding for universities to deliver courses in strategically important degree courses, such as semiconductors and telecoms, as these courses are often more costly to run than other courses. The EWG recommends funding for specific CDTs (Centres for Doctoral Training) in semiconductors and telecoms, and other priority areas identified in the strategy. | Funding |
| 7 | Semiconductors: Skills | The EWG recommends specific funding to encourage and support diversity in the sector, addressing the extremely low number of female undergraduates within electronic engineering and the telecoms industry. | Funding |
| 8 | Semiconductors: Skills | The above measures are tactical but can be acted on quickly and produce results relatively fast. However, the EWG believes this is a long-term problem requiring a more strategic solution. We recommend a bold ten-year national level programme that focuses on building the skills, talent and leadership in the UK for 21st-century engineering education and expertise. The programme should produce a talent pipeline from schools and FE colleges to universities and industry, including upskilling and reskilling in the current workforce, in a coordinated way - working with employers, skills bodies, charities and professional institutions such as the Royal Academy of Engineering. This recommendation is based on the vision of Professor Bashir M. Al-Hashimi, FR, FREng UK Electronics Skills Foundation (UKESF) Trustee & Director: The Engineer - Comment: Engineering's skills gap demands a radical solution. | Skills |
| 9 | Semiconductors: Scale-up | The EWG recommends initiatives to encourage more private sector investment in high-risk/VC-funded firms, including the ‘Mansion House’ reforms and CBI recommendations, to unlock larger scale investment from pension funds. This investment is required to support a company’s growth stage. | Investment, VC, etc |
| 10 | Semiconductors: Scale-up | To address growth stage challenges, the EWG recommends a review and potential reform of government incentive schemes, including the Enterprise Management Incentive (EMI) and R&D tax credits. | Investment, VC, etc |
| 11 | Semiconductors: Scale-up | The EWG recommends technology roadmaps identifying the key semiconductor technologies required to deliver a resilient telecom network from 2025-2035, highlighting where the UK has expertise. This work could be undertaken by the National Semiconductor Institute, which was considered in the IfM Semiconductor Infrastructure Study, for example. | Research themes and areas of focus |
| 12 | Semiconductors: Scale-up | The EWG recommends specific financial support to help UK companies develop the telecom and semiconductor technologies identified in the technology roadmaps described in Recommendation 11. | Funding |
| 13 | Semiconductors: Scale-up | The EWG recommends a review of the rules governing CAPEX and OPEX, to ensure that grants available to UK companies enable them to address the commercial opportunities identified in the technology roadmaps. This might involve a review of the Subsidy Control Act and a review of UK companies’ access to Horizon funding, for example. | Investment, VC, etc |

* + 1. Network Management

| No. | EWG | Recommendation | Category |
| --- | --- | --- | --- |
| 1 | Network Management: Creation of Cross Industry and Research Forum | Creation of a cross industry and research forum, to enable the sharing of knowledge, ideas, problems, and goals, to influence or create development and research areas. For example, a forum where representatives from telecom networks, technology companies, universities, and other industries (Energy, Health, Logistics, Transport, Finance etc.) work together to develop ideas and concepts that will develop Network Management capabilities for the wider benefit. | Establishment of government body, panel, Strategy, tax credits, etc |
| 2 | Network Management: Data | Create a working party determine the measures necessary to overcome the barrier of the extreme difficulty in obtaining real network-based data for development and testing of new NM systems. This includes:   * How to incentivise operators to provide data, how to make disclosure trusted.? * Create the correctly skilled and resourced Data analyst team - to get or generate the data. * Find the appropriate Security body and resources within the data suppliers – to approve the release if the data. * Create the 3rd party lab - for testing on the data. ¶¶This recommendation will require the appropriate sponsorship from UK operators, both the academic and non-academic world should promote this. * The main objective of this data project would be to enable students to train on NM technology without the need for a “real-world” network and, to train AI systems to aid R&D on NM automation. | Establishment of government body, panel, Strategy, tax credits, etc |
| 3 | Network Management: UK Security, Resilience, Reliability & Scale | * Encourage insourcing back to the UK Network Management functions from overseas, this will improve CEM and contribute to above point. * Establish a strategy to introduce already well-established security best-practices in network management. | Testbed, Platforms, Centres, Field trials, etc |
| 4 | Network Management: Operational Efficiency | Leveraging AI and Automation goes hand in hand with training Network engineering and management resources so we can build those AI models in the future:   * Develop and leverage AI/ Automation technologies to improve and facilitate the management of highly complex networks. * Promote network management as a research area and focus for existing AI/ML developers. * Research and develop CEM based digital twin models with R&D leveraging experience of large customers e.g. NHS & Finance. | Skills |
| 5 | Network Management: Brokerage & Services | Look for opportunities to establish UK as a telecoms service broker e.g.   * For data exchange between telcos domestically and internationally * For data insight services based on AI and experience operating networks * For systems integration services based on open APIs and complexity management * Leverage Best practice from UK parallel industries 2T/1T London exchange, other Financial Services, Pharma, & Legal | Research themes and areas of focus |
| 6 | Network Management: Business Environment | * Review, identify and develop essential IPR in network management. * Expand Seed funding opportunities for NM start-ups. * Build on best-practice spin out/in university schemes. | Commercialisation |
| 7 | Network Management: Creation of Cross Industry And University Technology Collaboration Environment | Create a cross industry and university technology collaboration environment that enables the R&D and development of new ideas, services, and technologies. This would enable small to large technology organisations and universities to work together on “real data and systems” to understand, develop and prove new network management ideas, that without real data or platforms are prohibitive for small and medium organisations or universities research.  The goal would be that research would be focussed on scalable and robust Network Management (Software Defined Configuration, Automation, Fault Detection and Observability); Secure Networks; Data Brokerage (sharing data across industries to drive improved customer experiences and performance); AI within Networks. | Research themes and areas of focus |
| 8 | Network Management: Unifying Activities between Research Projects | (Based on [6GStart ‹ 5G-PPP](https://5g-ppp.eu/6gstart/))  An umbrella activity is required to orchestrate, capture, and promote the achievements of UK research projects by facilitating activities in the inter-project working groups and maintaining membership links to the standardisation community. This could be led by UK Catapults This is partially the role of UKTIN -- both promoting activities and bring the ecosystem together, now with activities around standards etc. In the past (5GTT programme) projects were 'forced' to collaborate/exchange info etc. This can be put in the GFA/CA for all DSIT and similar projects.  It is required to:   * Extracting strategic R&I orientations from the UK community of projects. * Coordination with 5G/6G R&I results/initiatives at UK level. * Establishing and maintaining dissemination structures and web presence for the UK research initiatives. * There are well established academic conferences for NM (CNSM, IM, NOMS). Build a NM community across the UK and internationally (e.g., by seed funding NM projects), organising workshops on strength areas for UK NM research and, when applicable, attach these workshops to the established international conferences.. * Orchestrating and tracking UK projects and programmes contribution to emerging standards. * Facilitating international cooperation across key regions based on promoting UK priorities. * Developing methodologies for collecting metrics data for technology solutions. | Testbed, Platforms, Centres, Field trials, etc |
| 9 | Network Management: R&D Infrastructure to Enable Leading-edge Ecosystems | * Research and consult on the facilities needed to create a representative development and verification network for NM research including those necessary for: * inter-operator network interconnection * orchestration across multiple network domains * NM in shared infrastructure and neutral host networks, * Make UK telecom 5G/6G labs more nationally available (beyond JOINER network) across more research institutions and universities in UK, who can exchange knowledge and learn from each other. Objective is to make AI applied to mobile communication network management more generally available across more research institutes and universities with the objective of training more students more widely. These can also be used as a source of service NM data specific for the types of leading-edge services carried over those platforms. * Establish funding for selected academic research to become successful SMEs. | Standards |
| 10 | Network Management: R&D Technical Focus | * The topics described in Section 7.1.2 should be used as a focus for future R&D. Projects involving the creation of R&D platforms and networks should consider the incorporation of these NM aspects. | Establishment of government body, panel, Strategy, tax credits, etc |
| 11 | Network Management: Standards | * Review UK telecom representation to international bodies for NM, this includes – 3GPP, O-RAN Alliance, IETF, ETSI, NEF, TMForum & Opensource Projects * Increase UK’s presence in standards bodies and align ‘UK Inc’ input to prioritise development of UK areas of strength. * A particular focus should be on standardising interoperability between operator platforms and systems, multi-network domains and APIs including aspects of trust. | Establishment of government body, panel, Strategy, tax credits, etc |
| 12 | Network Management: Focus On Developing Skills And Talent | A focus of developing skills and talent in Network and Network Management technologies within the UK, through tailored University courses, R&D and apprenticeships. Creation of the cross-industry forums and the technology collaboration area will be a key enabler for the new talent and skills to be developed. | Testbed, Platforms, Centres, Field trials, etc |
| 13 | Network Management: Skills & Talent Development | To counteract the shortage of skills described earlier, we recommend:   * A long-term investment in home grown skills pipelines to replace aging and outgoing network management resources. Renewing this workforce and skill set is akin to training more doctors and nurses since Network Management pervades every part of our telecoms economy. * To recruit outstanding talent from abroad as required while we grow and invest in the home skills described above. * Paying attention to EDI. * Network Management roles and skills to focus on are: * Field Technician Level – address the shortages by: * Building on existing successful apprentice and Knowledge Transfer Partnership schemes * Better definition of minimum requirements * Network Operations * These roles are fundamental to the development of AI driven automation. There is a 5-10 year lead time, need to recruit talent externally to fill short and medium term gaps * IP skills /virtualisation/AI. Without skills already in the UK we cannot develop our own skills * Skills development in this category should focus on a “4 eyes on” approach to change – resilience and reliability management leading to the ability to “co-pilot” AI driven automation system. This will be human led for the next 5-10 years focused on determining the appropriate level of human intervention needed in AI NM systems. * NM Developers. * This is focussed on software and AI driven skills development as described in the earlier section. | Skills |

* + 1. Optical and Photonics

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 1 | Optical and Photonics | Develop a long-term Grand Challenge technology programme similar to Japan's IOWN to foster collaboration and drive direction within the optics/photonics ecosystem, enabling development and demonstration of key innovations at both device and systems level for high-capacity end-to-end all-optical networks | Research themes and areas of focus |
| 2 | Optical and Photonics | Build on existing facilities (e.g. NDFF) to create a field-deployed fibre-rich network connecting major photonics institutions and including novel transmission media (HCF, MCF, FMF,…) to accelerate R&D in optical and quantum communications systems | Testbed, Platforms, Centres, Field trials, etc |
| 3 | Optical and Photonics | Define initiatives that will attract investment from global optical network equipment vendors to establish systems R&D facilities in UK to drive vision and cohesion within the photonics ecosystem and to generate market pull for new technology innovations | Investment, VC, etc |
| 4 | Optical and Photonics | Create pilot capabilities for integrated silicon photonics and compound semiconductor chips including open access to advanced fab, assembly and packaging facilities, in coordination with national and international semiconductor initiatives | Research themes and areas of focus |
| 5 | Optical and Photonics | Increase take-up of undergraduate and doctoral training in photonics/communications/systems engineering particularly for UK candidates by a) increasing profile of hot topics in AI/6G infrastructure, free-space optics and quantum networks and b) addressing apparently uncompetitive remuneration issues. Reinforce efforts to stimulate interest and engagement of young people in photonics and technology generally, from school age onwards. | Skills |
| 6 | Optical and Photonics | Reduce barriers to entry for SMEs in fixed wireless and broadband access networks by facilitating UK voice on standardisation activities, both formal and informal; b) promoting adoption of open initiatives, e.g. O-RAN, Open ROADM, Open Line Systems that disaggregate the physical layer and avoid vendor lock-in. Develop programmes to facilitate access for SMEs to leading edge technologies including integrated photonics. | Research themes and areas of focus |
| 7 | Optical and Photonics | Establish programme addressing power consumption in communications networks and data centres, emphasizing architectural developments and technology improvements through photonics and photonic-electronic codesign that can offer radical improvements in power efficiency and allow sustained traffic growth with minimal environmental impact. | Research themes and areas of focus |
| 8 | Optical and Photonics | The UK should establish recognised security certification processes for quantum communication technologies to lower the barriers to widespread adoption by Government and industry, building as appropriate on initiatives underway in the UK and other nations to establish third-party verification standards. | Security |

* + 1. Standards

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 1 | Standards - Policy and Regulation Aspects | Promote awareness of standards process and status / trends within universities, aimed particularly at early career telecom researchers or postgraduates (the first aspect through training, and the second via regular presentations and workshops). This could start with universities with existing commitments e.g. ETSI membership.   Encourage taught courses to include a standards awareness component.   Ensure that evaluation of new project proposals gives credit and weight to the evolutionary nature of the proposal (this applies to funding mechanisms within the UK).   Support UK universities willing to engage in standards (via similar or the same mechanisms as per SMEs).   Establish a sustainable framework for collaborative (University / industry including SMEs) pre-normative research projects with Universities taking a significant leading role.   This could include support for smaller nursery projects aimed at initial pairing with an industrial partner, with a view to future scaling of such initial collaborations (potential targeting Horizon or other projects). | Legislation, Regulation and policy |
| 2 | Standards - Intellectual Property Issues in Standards | An option that might be considered is to set up some form of investment bank (IB) sponsored by HMG/British industry, that would purchase such IPR (in whole or part). The IB could be in a better position to exploit (and defend) such IPR. This would effectively centralise the IPR exploitation of SME research for the most promising ideas. The IB could seek to make no profit or break even. This IB could then be used as a strategic vehicle to promote UK sovereign telecoms capability by building a pool of IPR that could allow UK industry to use and share any profits with the original SME IPR developer. Many configurations are possible, but the aim would be to offer an alternative option to the developers of UK IPR that could benefit the UK more widely. | IP, Patents, Data, etc |
| 3 | Standards - General approach of Standard Development Organisations to Patents and IPR | Develop mechanisms to encourage inter-operability projects (similar to SONIC), and encourage these projects to identify standards shortcomings | IP, Patents, Data, etc |
|  |  | Encourage integrators (e.g. network operators, 3rd party integrators etc) to share inter-operability issues found in UK deployments, particularly if including new or multiple vendors. | Collaboration and Strategic Partnerships (including international) |
|  |  | Develop mechanisms (potentially at international level) to provide a degree of feedback or rating of standards in terms of their proven interoperability. | Collaboration and Strategic Partnerships (including international) |
|  |  | Develop a formal framework to identify what is essential and what is optional within at least a subset of important standards. | Collaboration and Strategic Partnerships (including international) |
| 4 | Standards - Engagement of UK SMEs in Standards | Set up mechanisms to increase awareness of standards landscape and reduce knowledge barriers:  · Provision of training for SMEs and/or Universities on an ongoing basis, including online access to training materials and/or relevant experts.  · Training to include also case studies, possibly presented or written by experts involved, included SME participants.  · Training to include standards linked IPR aspects such as FRAND, IPR declaration etc | Skills |
|  |  | Set up mechanisms to enable development of appropriate standards strategies. | Collaboration and Strategic Partnerships (including international) |
|  |  | Support match making with standards experts / IPR experts / patent attorneys with possible seed funding (making use of the relatively large number of UK standards leaders in the latter career stages). | Collaboration and Strategic Partnerships (including international) |
|  |  | Set up fora for sharing and discussing knowledge and proposals with other players in the UK ecosystem, possibly on a per-SDO basis (note: the UKTIN’s Future Capability Paper on Wireless Networking proposes a “standards network” which has a similar context). | Collaboration and Strategic Partnerships (including international) |
|  |  | De-briefing on SDO status, proposals etc., could be achieved using different models such as:  · DSIT de-briefing targeted at UK SMEs – leverage DSIT representatives to share information with SMEs in de-briefing updates.  · As part of any SME grant (to attend meetings), the SME provides a briefing to the community on what they have learnt.  · A mix of the above, plus invited speakers such as WG chairs or other experts willing to present in a forum. | Collaboration and Strategic Partnerships (including international) |
|  |  | Set up mechanisms to reduce financial barriers to participation:  · Provide financial grants for initial standards engagement for SMEs and/or universities.  · Create a body to act as an umbrella member of standards organizations, whereby a participating SME could initiate its participation without the administrative and financial burden of full individual membership (at least for a certain number of meetings).  · These various mechanisms could be combined into a single organization or club covering activity in the different areas e.g. by having SMEs as member organizations which could then access one or more of a range of the specific “services” listed above. | Funding |
| 5 | Standards - Skills | Support either “classroom” or one to one training for presumptive standards delegates (or those dealing with standards including back-office staff) from SMEs or Universities. This may require having a basic organization and some instructors.   Maximum use should be made of ETSI’s educational materials. It should be noted that ETSI have agreed to further develop its training material, this should be completed by December 2024. As a key member of the ETSI board, DSIT can directly influence the areas covered.   Should cover both hard and soft skills.   Also cover new tools for contribution / IP intelligent searching (e.g. AI based)   Universities with existing experience could contribute to this program.   Build a database of experienced standards delegates willing to provide some level of feedback or mentorship to new delegates from SMEs and/or Universities on a voluntary basis (and pair with such mentors as needed, preferably on the same technical area or SDO)   Such a database can comprise both current and past delegates (the second case may reduce the possibility of conflicts of interest).   In the simplest model, only a pairing service is provided.   Support workshop style meetings on specific topics e.g. “how to write a WID (Work Item Description) and have it approved in 3GPP or ETSI”.   This could also make good use of standards delegates’ willingness to share their expertise and experiences.   In time, this could also be extended to topics of more interest to presumptive standards leaders such as “chairing a 3GPP standards meeting” etc. | Skills |

* + 1. Core Networking Technologies

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 1 | Core Networking Technologies - Scale | The UK Market needs to be more significant to drive enough scale to create the industrial research and development needed to create significant national leadership or sovereign capability. Core networking technologies are pieces of a larger ecosystem of standard solutions, and scale is vital. | Commercialisation |
|  |  | Many successful smaller companies, such as Lumenisity, are acquired by large international organisations (in this case, Microsoft Inc.). | IP, Patents, Data, etc |
|  |  | Smaller companies find it exceedingly difficult to export their products, making it more difficult to expand outside of the UK. | Collaboration and Strategic Partnerships (including international) |
|  |  | Measures should be devised and implemented to:  · Including identifying the profitable sector targets within the scope of the Core Technology model discussed earlier in the report and choosing the next growing technologies.  · And encourage the sector to grow to scale or to work better together, nationally or with friendly international partners, on targeted profitable technical niches. " | Collaboration and Strategic Partnerships (including international) |
| 2 | Core Networking Technologies - Better investment choices | The UK has run a series of competitions to create opportunities such as 5G Testbeds but evidence of delivering significant sustainable value or accelerating 5G deployment in the UK has been sparse. | Adoption |
|  |  | If the UK wishes to have sovereign telecommunications capability, how can the government set an audacious goal to create something that will bring value? An example would be IOWN in Japan, a network vision to create the Internet of the future and the core network technologies to underpin it. | Establishment of government body, panel, Strategy, tax credits, etc |
|  |  | Initiatives should be pursued to: |  |
|  |  | · Identify Future applications driving the future network growth | Research themes and areas of focus |
|  |  | · Manage Intellectual property to maximise UK growth | IP, Patents, Data, etc |
| 3 | Core Networking Technologies - Supporting Core Network and Services Research | Support core computer networking and future Internet research through appropriate state funding programmes for the development and demonstration of novel end-to-end services on top of connectivity. | Research themes and areas of focus |
|  |  | There is a growing need for greater coordination across the UK academic community. While there are many great and globally recognised universities within the ecosystem, too few of these have had sufficient investment to allow creating sustainable value for the UK through, for example: |  |
|  |  | · sustained commercialisation of their research, | Commercialisation |
|  |  | · sustained engagement with the IETF and other standards / industry bodies | Standards |
|  |  | This needs greater alignment with the industry and a greater focus on valuable outcomes. There are pockets of success (Lumenisity, for example), but not nearly enough. | Establishment of government body, panel, Strategy, tax credits, etc |
| 4 | Core Networking Technologies - Accelerate Transition from Research to Market | Develop structured funded programmes to provide academic researchers with the expertise, knowledge and training needed to convert their research into technologies, products and services in this key sector of the global economy, and create pipeline to move ideas out of the university lab and into the commercial market. | Skills |
|  |  | The UK market needs to be healthier. The current regulatory policies are driving fragmentation of the market, which is reducing scale and, thus, the buying power of the UK. | Legislation, Regulation and policy |
|  |  | · Over 140 alternative networks are building fibre infrastructure in a totally un-coordinated way, of varying quality, many of which are unlikely to survive in the medium term. | Collaboration and Strategic Partnerships (including international) |
|  |  | · This further dilutes the ability of the UK to create scale but crucially waste investment money. | Investment, VC, etc |
|  |  | · This will have a staggeringly negative impact on the UK market for decades and will not meet the government’s objective of being a digital communications leader. Crucially, the reason for Marconi’s failure was ultimately competitiveness; the UK operators needed lower-priced platforms, and Marconi could not deliver them. | Establishment of government body, panel, Strategy, tax credits, etc |
|  |  | There needs to be flexibility and appetite to restructure the UK market and willingness to explore transformative even if controversial options such as the UK seeking to take a position as the ‘testbed’ where commercial concepts are tried out and then copied (sold) to other parts of the world. | Establishment of government body, panel, Strategy, tax credits, etc |
| 5 | Core Networking Technologies - Skills | Greater technology skills are required across the UK. The UK has some significant successes, such as banking and video games, but there needs to be stronger, capable technology skills in telecommunications, specifically in infrastructure, computer science (including software engineering), semiconductors, and optical technologies. The UK has some expertise in the integration of complex systems, and this is a strength to build upon, but it is still niche.   The EWG considers that the UK has a severe problem with respect to developing the technology skills in the scope of this EWG. Finding people who can understand how to build things is becoming harder and harder.  We need to figure out how we sell the “mission”.  Initiatives should be sought to improve supply of trained engineers by making telecoms network engineering more attractive as a long-term career path, rather than opting for other STEM career areas. Note that the complexity and diversity of the national and international technology and systems landscape is such that future trained engineers could come from a variety of engineering, mathematical, and science backgrounds, and not just traditional electrical engineering backgrounds. | Skills |
| 6 | Core Networking Technologies - Standards | Many stakeholders across many standards bodies drive standards creation. However, at the heart of the standards process is the need to solve a problem either for network operators or to create a capability for network operators or vendors to monetise. Any state, organisation, or individual cannot control this collaborative environment, and any attempt to do so will likely drive standards in the opposite direction.  The UK needs to identify and support engagement in key network standards where there is a standardisation need that would aid R&D across UK industry and academia but at the same time be a strong and collaborative partner in any approach to working in standards. | Standards |

* + 1. Security

| No. | EWG | Recommendation | Category |
| --- | --- | --- | --- |
| 1 | Security | DSIT should explore ways to find better monitoring & evaluation frameworks to measure the real-world impact of R&D, and how it can focus on funding activities which yield more tangible and measurable security (and other) benefits. To date, despite significant funding of R&D by DSIT and DCMS, the Security EWG paper highlights that some of the main security issues affecting telecoms companies have been the same for over a decade. This indicates that we might not be measuring the right success factors when reviewing and planning future R&D, as our interventions are not having the desired impact on outcomes. | Research themes and areas of focus |
| 2 | Security | We recommend that, as a country and Government, we reflect on how to better target public investment in new and different ways to try to deliver specific outcomes (and more clearly and directly define and measure the outcomes we seek), to understand whether or not our R&D investment is feeding through to commercially deployed and available products at-scale. Arguably, to date, our current approach to R&D funding delivers promising early-stage outputs, which don’t end up materially impacting the security of our deployed networks, as discussed in our paper, and evidenced by findings that the same issues plague software as did a decade ago. | Research themes and areas of focus  Commercialisation and adoption |
| 3 | Security | DSIT should explore how future R&D projects can align and complement existing UKRI and RCUK funded research (early stage, low TRL) – rather than funding more fundamental research, so we can build up a cadre of industry expertise in taking our world-leading (and already-funded!) fundamental research and drive it towards real-world application – perhaps akin to DARPA, focused on specific mission outcomes. This then creates a feedback loop that be used to drive fundamental research to solve real problems the UK has.  In essence, our recommendation is to ensure we have better and more holistic pathways to take fundamental research to actual commercial impact, and to use real-world industry requirements to drive and motivate fundamental research that gets funded, so that more of it is applied and higher TRL and commercially viable.  We also believe that there is a challenge around growing the level of ambition in innovation in the UK, and looking better at how we can encourage companies to avoid competing in the same small and non-differentiated market sectors, and rather to widen their approach – there is a risk today that our startups and academics fight over the same scraps with very similar research and products, rather than broadening and tackling wider challenges. As David Lloyd-George said “you cannot cross a chasm in small steps...” | Research themes and areas of focus  Skills  Commercialisation |
| 4 | Security | We recommend that DSIT continue their approach around standards influence (as started several years ago by Ian Levy as Technical Director of NCSC), and take into consideration the timescales of this work when evaluating it. The Security EWG firmly and wholeheartedly supports this work, and the critical importance that standards formation, development and influence have on the security of the UK and our allies and partners.  We do however want to emphasise that the opportunities for the most fruitful standards input happen on external timeframes (driven by standards development organisations), and that these do not align with HMT spending review cycles. When DSIT funds R&D projects (such as the ONE programme through ONP), it is important to also consider the feasibility and deliverability of DSIT’s standards aspirations within the timescales of such programmes – standards input will generally follow after R&D work, and in projects with aggressive delivery timescales to meet end-of-year SR deadlines, there will be limited opportunity to participate and feed into standards as part of these projects. This leads to our final short-term recommendation.  We recommend that DSIT work with the Security EWG members and other standards experts as it wishes on an ongoing basis, specifically to explore opportunities to better structure a more enduring, UK-wide approach to standards engagement and influence, which can bring together a “one team” approach to standards, and take advantage of the willingness of both the EWG, and wider UK participants and potential participants, to deliver a louder and harmonised UK voice in international standards. We can only speak for our own EWG, but we doubt our colleagues would disagree with this.  We are aware of existing methods for standards coordination within HMG, but would emphasise that a key distinction in this recommendation be that we also look to both enable and leverage wider industry representation (and people with established industry track records in such fora), to create a stronger UK presence in standards groups, and build up enduring “soft power influence” and leadership among these groups. As Ian Levy pointed out in his departing blog post:  “This is also why standards bodies are becoming a tool of great power competition – control the standards and you can stack the deck to make your technology more likely to be implemented. Sometimes that’s just about money, but sometimes there could be other reasons. It’s interesting that Chinese people or Chinese companies hold leadership positions in more than 80% of key working groups in the main telecoms SDOs. Just saying.”  Groups like the UKTIN Security EWG could form a starting point to begin a UK and Western-aligned response to these challenges which will only grow in scale over the coming years. We believe that while this is a longer-term challenge, this warrants a shorter-term recommendation to begin planning for and discussing options to improve UK representation and prepare our next generation of leaders in telecoms security, as many of our primary points of influence retire or move on to other challenges.  We should also explore as a matter of urgency how to implement Levy’s recommendation on “market shaping”, so the global market demands what we can produce, and we have “sticky ecosystems” that resist copying and give us increased influence in the market. | Standards |
| 5 | Security | The UK should attempt to take a longer-term strategic view on security in telecoms, rather than chasing the current popular topics – by acting as “followers”, we often arrive too late to existing discussions to exert real influence, and we lack the scale to make up for this. For example, we would suggest that the biggest improvements to telecoms security will NOT come from R&D investment in popular (and widely saturated) areas like post-quantum cryptography, quantum key distribution, etc.  While important, there are already substantive activities by NIST and other allies and partners on them. Instead, we should take a longer-term more strategic view, and focus on some of the problems we face today, which won’t be addressed by these – which is in line with the approach CISA is taking in the US, in trying to get people to move away from writing software using memory-unsafe programming languages. We are recommending specifically that the UK consider how it can set out a longer-term agenda, without the uncertainty for industry presented by regular priority-shifts and changes in agenda.  For security, this would be about focusing more on longer term outcomes (using existing principles such as secure by design and default, for example), and how to deliver these into products deployed in the market, and in applied industry-focused R&D to reduce barriers to deploying the existing technical solutions to problems that are still a threat today. While exciting topics like post-quantum cryptography can be interesting research areas, they also are potential distractions (as enablers from other sectors), and we should adopt them as they become ready, without losing our focus on the underlying security issues that affect our networks – security architecture, deep technical understanding of the principles of security, and a range of specific types of recurring vulnerabilities which continue to pervade software on the long-term (decade+) timescales.  That the same types of security issues are still a concern on timescales of the order of a decade or longer gives good evidence of the need to take a longer-term view on security R&D, and one which is focused on outputs and outcomes, rather than on the research itself. | Government funding and investment  Legislation, regulation and policy  Research themes and areas of focus |
| 6 | Security | DSIT should consider adopting (alongside our shorter-term recommendation on standards and security) a long-term security first strategy towards all (including telecoms) standards, driven and funded by government, with particular (though not exclusive) focus on ETSI. Over recent years the UK has lost effectiveness and influence in security standards, - there are no longer the UK companies involved that there once were. However, we still retain a strong historic influence that has not been entirely lost yet, just severely eroded. This is bad for our national security and makes us increasingly dependent as a follower not a leader on methods and procedures favoured by other countries, that make it ever harder to keep our own networks secure. International standards drive the attack surfaces and interfaces we expose, as well as the security architectures that surround them. We have to be leaders, not followers. The need for a longer-term “informisation” strategy is set out in our first report as being of fundamental importance to the UK, in taking the 20+ year view.  In essence, our recommendation would be to look at how to drive the UK telecoms ecosystem to create the equivalent of special forces for telecoms and standards, to deliver outsized influence and results for the number of people deployed, and to do so on behalf of the UK’s national interests.  We know of significant support for this kind of initiative from a number of significant senior figures in UK industry, with track records including Apple, ARM, BT, Intel, Qualcomm, Samsung, and more. | Standards |
|  |  | ARM has demonstrated an interesting model for the commercialisation of UK-developed IPR through licensing of chip designs and other IP to the world market. Business models like this should be explored for the UK’s wider telecoms innovation, since it is already more expensive to do R&D in the UK than (for example) China or India, and anything we do develop would likely end up manufactured overseas in a low cost of labour economy. This model may also be a longer-term investable prospect for HMG, as applied, near-market, standards-ready innovation that is then driven into standards would increase UK influence and lead to an improved position in standards-essential IPR, without having to take on the costs of manufacturing and product development.  We believe there is a key role for HMG in this, (since the make-up of HMG funding and interventions can be used to encourage different business models), and there may be opportunities for direct HMG investment and financial return (via, for example, the British Business Bank) as an investable proposition, on the basis that the return on investment for core IP in telecoms standards is well-understood and modelled. |  |
| 7 | Security | DSIT should explore how to introduce a “Critical National Infrastructure” (CNI) culture and mindset to the telecoms industry, rather than that of heavily-financialised businesses seeking to deliver return on investment, even to the detriment of the national interest. One could argue that the core business function of many mobile operators today is no longer that of running a network (which is outsourced to a myriad of third parties), but rather in maintaining a polished retail high-street presence, and consumer financing of the latest mobile handsets, to generate return on capital deployed which can pay for leasing back their own (previously owned) physical network assets such as masts, and for outsourced managed service contracts to support their network infrastructure.  While it may be unpopular to note, the underlying incentive problems found in the DCMS Telecoms Supply Chain Review Report have not changed. Customers do not pay for more security when cheaper options are available. Telecoms is becoming a “market for lemons” given the difficulty in meaningfully comparing products’ security properties as a customer (including as a business or Government). This reduces (to near zero) the incentive to invest in meaningful improvements in security, as others can claim they are secure without taking those measures.  The TSCR found there was inadequate incentive for operators to manage risks, as ultimately Government carries the can on national level risk. DSIT may find it helpful to look at other regulated CNI sectors (since communications is already designated as a CNI sector), such as energy or gas, and note the differences in culture and practices compared with telecoms. We have experience in interacting with different utility sectors through our leadership in the UK Telecoms Data Taskforce, and would be happy to support DSIT in this area if required. | Legislation, regulation, and policy |
| 8 | Security | DSIT should look at how we can increase the incentives and rationale for vendors and operators to retain, grow, and broaden UK-based deep technical skills and talent in telecoms and security, so we retain the knowledge and expertise to meet our own security needs – the alternative is that we lose these skills, and end up as “customers”, buying what others choose to make available to us, with all the implications that has for the UK’s R&D activities and national security.  The UK is a high-wage economy, so it costs more to have a good person working here than in another market – the risk is that we lose (overseas via off-shoring) the deep technical knowledge and expertise through slow “brain drain” out of our telecoms industry, due to these companies taking an internationally-oriented approach (and seeking to reduce costs). Most telecoms companies (including those doing R&D in the UK, such as Qualcomm) have to internally compete to base R&D activities in a given location, and the UK struggles to compete with even France, Germany and Italy, since these businesses take such decisions on R&D investments centrally, and in a price-focused way. | Skills |
| 9 | Security | DSIT should explore how innovation and future R&D can reflect the UK’s opportunity to carry out high-value (and difficult-to-copy) work in systems integration and interoperability. The UK is not going to become a leader in at-scale manufacturing due to labour costs. We have significant potential in bringing together the parts of systems to make them work. This has potential to be a high-value, high-skill, people-intensive white-collar field of employment which can generate significant revenue for the UK, if we focus on tackling some of the harder and more technical areas of telecoms which traditionally off-shored companies are unable to credibly deliver on. Such employment would also be highly resistant to displacement via Generative AI, as well as market forces – deep technical systems integration is hard to displace, and also hard to compete with due to a high barrier-to-entry. Finally, it plays to the UK’s strengths in critical thinking and technical delivery which it seems many other countries have struggled to replicate.  Historically, this work has been outsourced or off-shored to generic IT global system integrators like Infosys, IBM, Tata, etc. Increasingly in telecoms however, this will become an opportunity for wider integration with end-user applications, and become a key potential area of sovereign UK capabilities. This is an area of potential high value-add strategic enablement, as it would put UK companies at the heart of making future networks and applications integrate and work together, and at a critical part of the connectivity value chain (since nobody wants a network that their equipment does not connect to).  In 5G Testbeds & Trials projects, one of the key learnings/outcomes of that process was that the system integration component added significant value to the end application (i.e. enabling a given application or use-case to physically integrate with and communicate with a network), requiring significant knowledge of the inner workings of both the telecoms network, as well as the underlying application. This capability to integrate systems together is one which could well become a UK speciality in delivering interoperability between networks and equipment. It is an area that we have a track record in military innovation around as well, as can be seen by partners like Ukraine being able to successfully field and deploy western and UK-developed munitions on other platforms and systems that the UK and allies do not themselves field. | Research themes and areas of focus |
| 10 | Security | In the longer term, we believe that there needs to be a better incentive for operators and vendors to adopt leading edge security measures, and invest proactively in security, rather than seeing it as a “cost” on the balance sheet. As Ian Levy pointed out in his parting message, better-managing expectations, and ensuring security is fully paid for, are likely to be key priorities going forward, and areas to be resolved for telecoms early (given their significance):  “…companies are doing exactly what they’re supposed to do – generate shareholder value. But we implicitly expect these companies to manage our national security risk by proxy, often without even telling them. Even in the best case, their commercial risk model is not the same as a national security risk model, and their commercial incentives are definitely not aligned with managing long-term national security. In the likely case, it’s worse. So, I think we need to stop just shouting “DO MORE SECURITY!” at companies and help incentivise them to do what we need long term […]  Sometimes we’re going to have to (shock, horror!) pay them to do what we need when it’s paranoid lunatic national security stuff. But making the market demand the right sort of security and rewarding those that do it well has got to be a decent place to start. Trying to manage cyber security completely devoid of the vendors’ commercial contexts doesn’t seem sensible to me.” | Legislation, regulation and policy |
| 11 | Security | Based on our findings and recommendations in the UKTIN paper, we concluded that further fundamental low-TRL R&D is not delivering value for money for the UK, and is failing to reach adoption and deployment, and therefore have the impact intended.  As a result, we therefore suggest some areas for applied R&D, which should be focused on delivering real-world industry adoption and uptake of enhanced security measures as part of products and networks.  1. Adoption of stronger AAA (Authentication, Authorisation & Accounting) across telecoms and enabling infrastructure.  2. Driving higher security practices in management of networks and associated IT infrastructure (raising the bar – hardening secure boot, software supply chains, hardware-backed security modules and root of trust, atomic and immutable operating systems).  3. Raising the bar on software container security and virtual machine hypervisors, and reducing the need for everyone to reinvent the wheel on end user device and infrastructure platform security with a single UK standard.  4. Securing delivery of software through automatic patching and updates, and developing better ways to reduce friction in rapidly deploying patches throughout complex networks.  5. Adopting secure-by-design principles in the early-stage architecture and making security a genuine starting consideration for deployment of infrastructure in any new network.  6. Developing, validating and adopting new industry-standard hardening techniques to reduce exploitability of exposed attack surfaces, and integrate these with modern software deployment practices to remove friction from carrying out a “wipe clean” in a network.  7. Developing and deploying techniques to detect and identify unauthorised access and exploration in a network, including attempts at lateral movement or access to management planes more quickly.  8. Working towards addressing and mitigating the underlying causes of pervasive security issues in software deployed in telecoms networks (memory safety, lack of systemic authorisation checks, authorisation bypass, and other similar common weaknesses that continue to be present despite being priorities for years).  9. Better integrating and embedding holistic skills development (to create broad depth of skills) across our future generation of telecoms professionals, as part of R&D, rather than as a separate secondary aside consideration – this should encompass all HMG-funded telecoms R&D, as well as industry activity, and should be discipline-agnostic, working with people from all backgrounds to improve security.  10. Exploring how to better prioritise technical factors in decision-making around security in organisations and HMG, and prevent downward pressure on costs from resulting in unacceptable trade-offs being made in the design, implementation, and operation of networks, as a result of arbitrary financial pressures.  We believe that to deliver on these applied research areas, it will be critical for HMG to work closely with the (already small) field of telecoms security practitioners, in order to find practical and pragmatic ways to deliver the real world impacts sought from the above points, and to ultimately drive adoption and uptake of outputs of applied R&D, and ensure the UK sees the benefits of them. | Research themes and areas of focus  Commercialisationand adoption  Legislation, regulation and policy |

* + 1. UKTIN Academic SWG

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 1 | Academic SWG | **Long-term funding models for research in future networks -** Long-term and sustained research funding is key for enabling an ambitious R&D agenda that leads to the development of cutting-edge technologies and the ability to both contribute to and influence global standards, ensuring the UK remains competitive on the global stage. Furthermore, long-term funding provides stability for researchers, encourages collaboration between academia and industry, and fosters the training of the next generation of telecommunications experts. | Legislation, regulation, and policy |
| 2 | Academic SWG | **Appropriate Funding Models to strengthen Industry-Academia Collaborations** - Establish funding models that incentivise industry to engage in long-term low TRL collaborations with universities. This approach will help create a stronger ecosystem where industry partners adopt solutions jointly developed with universities and promote these solutions in international standardisation bodies as well as influential open networking and open source initiatives. The European Commission's shift in more favourable funding models for industry, which started from Horizon 2020 onwards, has successfully fostered strong long-term partnerships between universities, industry, and SMEs, resulting in a significant increase in standard contributions from the EU R&I projects. Appropriate funding and continuing development of technology exchange with leading industrial partners will allow to consolidate and enhance UK capabilities. | Collaboration and strategic partnerships |
| 3 | Academic SWG | **Focus on filling skill gaps, including in non-traditional telecom engineering areas such as Software, AI, cybersecurity and optical networks in Telecom Education** - The future of telecom networks and infrastructure will increasingly rely on software, AI, open platforms, and diversification. At the same time this trend leads to new challenges in security, resilience, trustworthiness and explainability (in the case of AI). Traditional telecom engineering education currently lacks a strong focus on these crucial skills, which are already high in demand but short supply in the wider industry. Newly funded multidisciplinary Centres for Doctoral Training (CDTs), new MSc programmes at universities, supported by industry, can offer accelerated routes to address the industry’s needs in these areas. In the longer term, there is a need for the telecom engineering degrees and degree apprenticeships across the country to be updated to prepare the future engineers with skills in software engineering, AI, and security. Inclusive scholarships, mentorship programs, and marketing campaigns to raise awareness can attract diverse talent towards telecom research. It is also important to develop industrial sponsorships for home undergraduates to develop a cadre of qualified home students to prevent talent drain and skills gap. | Skills |
| 4 | Academic SWG | **Promote Collaboration in R&I between Telecoms and adjacent disciplines, and specially AI, Quantum and Optical Communications to reflect emerging trends in global Telcom and leverage UK’s unique strengths to secure UK’s future leadership.**  Specially designed collaborative initiatives should be created to foster cross-disciplinary research and innovation across Telecoms, AI, Quantum and optical communication technologies. Major vertical sectors should also be considered in cross-disciplinary approaches and initiatives. For example, telemedicine, intelligent healthcare, automation industry and transportation systems can be revolutionised with the synergy of telecom and related technological advancement. | Collaboration and strategic partnerships |
| 5 | Academic SWG | **Enhanced support for UK Universities for international collaborations to achieve scale, remain competitive and grow. -** Increase support for UK universities to achieve higher participation and success rates in Horizon Europe programs. Additionally, develop and promote bi-lateral collaboration opportunities with other key players, including the US, Japan, India, Korea, Canada, Australia, and Singapore as well as with emerging players in the Middle East, Africa and Latin America. | Collaboration and strategic partnerships |
| 6 | Academic SWG | **Establish a Future Network Observatory**  Create a future network R&I observatory to agree on the UK’s ambition, roadmap and set of KPIs for success. This group will regularly review the UK's R&I performance in future networks and benchmark against other advanced economies and provide recommendations and actions. | Legislation, regulation and policy |
| 7 | Academic SWG | **Federate the entire UK telecom research infrastructure into an end-to-end open platform system of systems to create both physical and digital experimental platform for future networks research.** Learn and further expand infrastructures such as JOINER, SONIC, NDFF to create a system of systems platform with the capability to reflect the real-life scale and complexity of production-level telecommunication network and systems, hence providing a unique UK-based facility for academia and industry for large-scale experimentation and innovation, including in energy efficiency, network AI, resiliency, cybersecurity, convergence and interoperability. The federation should also ensure strong alliance with leading countries having shared principles to secure a firm position in the competitive landscape. In terms of physical platforms, optical networks are part of an essential infrastructure which needs development for future networks. | Testbeds, platforms, etc. |
| 8 | Academic SWG | **Provide stronger and consolidated support to academics for translation of research into patents, standards, start-ups, and university spin-offs.** This should complement the “bottom-up” institutional support which is already available at universities, but significantly vary in scale and strength across UK’s Higher Education Sector. Entrepreneurial trainings and incubation programmes can also in help preventing talent drain and encourage researchers in the UK to contribute towards technological advancements as well as local economy. | Standards and intellectual property  Skills |

* 1. Analysis of Recommendations

We need to bring together the content of the first issue of the EWG reports, following the plan the Secretariat made last year. This will identify synergies (a combined potential outcome that is greater than its components), gaps, overlaps, (in)consistencies and alignments

DSIT has suggested some labels to attach to the recommendations. We added some of our own.

The Wireless EWG made 54 recommendations, many more than other EWGs who made between 4 and 13. It was suggested that this might bias our conclusions in favour of wireless communications. However, after closer evaluation we noted that

* The majority (39) of the Wireless EWG recommendations would apply across the telecom sector.
* Wireless EWG recommendations were very concise by comparison with other EWGs’ recommendations, which could often be broken down into multiple parts in different categories.
* There was rarely conflict between recommendations and thus very rare occasion for bias.

In consequence we have treated all recommendations as equal.

We attached 8 labels to the recommendations. The first, the general target subject, the “Category”, is examined in detail in section ‎3.1. There are 7 secondary labels. These may be useful in eventual further discrimination and prioritisation.

There is no reason at this stage to prioritise any category over another, nor any one label in a category over any other in that category or in other categories.

* + 1. Category Overview

The recommendations received by July 2024 were distributed across the categories as follows:

* Skills 19 [12 Wireless, 2 Non-Terrestrial Networks, 4 Semiconductors, 1 Network Management]
* Commercialisation 13 [12 Wireless, 1 Network Management]
* Testbed, Platforms, Centres , Field trials, etc 11 [5 Wireless, 2 AI, 2 Non-Terrestrial Networks, 2 Network Management]
* Research themes and areas of focus 10 [5 Wireless, 2 Network Management, 1 AI, 1 Semiconductors, 1 Non-Terrestrial Networks]
* Collaboration and strategic partnerships (including international) 8 [5 Wireless, 1 Semiconductors, 2 Non-terrestrial Networks]
* Funding 6 [2 Wireless, 1 Non-Terrestrial Networks, 3 Semiconductors]
* Investment, VC, etc 6 [3 Wireless, 3 Semiconductors]
* Establishment of government body, panel, Strategy, tax credits, etc 5 [3 Semiconductors, 2 Network Management]
* IP, Patents, Data, etc 5 [1 AI, 4 Wireless]
* Legislation, Regulation and policy 5 [3 Wireless, 2 Non-Terrestrial Networks]
* Standards 6 [3 Wireless, 2 Non-Terrestrial Networks, 1 Network Management]
* Interdisciplinarity 2 [2 Wireless]
* Adoption 1 [Wireless]

Based on the “Category” label the recommendations clusters are as follows in sections ‎E.2.2‎ to ‎E.2.14

* + 1. Skills

**19**: [12 Wireless, 2 Non-Terrestrial Networks, 4 Semiconductors, 1 Network Management, 2 Security, 2 Academic SWG, 1 Optical, 2 Standards, 2 Core]

#### Summary

* All EWGs highlight the importance of a coordinated, holistic approach to improving skills at all education levels and including industry and employers (Semiconductors 5 and 8, NM 4, see also AI 1 classified as ‘testbed’)
* A specific focus on AI skills in readiness for future requirements (Wireless 20, 39, NM 4, see also AI 1 classified as ‘testbed’)
* Focus on and develop existing areas of UK strength (Wireless 39)
* Focus on a variety of ways in which to improve skills beyond traditional education, including apprenticeships (NTN 10), industry training schemes (Wireless 43), further education (Semiconductors 5, specifically in the context of technicians for electronic and electrical engineering)
* Address not just future skills but reskilling of the current workforce (Wireless 44, Semiconductors 8)

##### Wireless

Wireless 19. Coherent drive on skills. Here something needs to change as skills have been an issue for decades. Some combination of education and selling the industry combined with incentives (e.g. bursaries for students to study) may be a good combination.

Wireless 20. Advocate and support the upskilling of the existing base of those with deep baseband processing expertise in the field of AI. [baseband/semiconductor]

Wireless 37. Celebrate small industrial kernels/hubs such as those fostered by major vendors and should be assisted in raising them to sustainable levels. "

Wireless 38. Encourage industry to re-ignite sponsorship and graduate programmes which have rarely seen by the current and coming generation.

Wireless 39. Focus upon areas where UK strengths exist and deliver high value such as systems integration and infrastructure provision. Recognise the importance of AI as an increasingly important skill in wireless networking especially in the disaggregated RAN.

Wireless 40. Develop shorter term wins, e.g. in commercial, capital and real-estate services, which are in strong demand by Communication Service Providers and are very well represented in the UK and have a shorter path to success.

Wireless 41. Bring high value IT techniques into the wireless networking curriculum.

Wireless 42. Develop strong, diverse role models to attract new talent and promote telecoms as an attractive career and as a sector bringing wider public value. "

Wireless 43. Incentivise industry training schemes, e.g. by offering credits to smaller companies.

Wireless 44. Learn lessons from adjacent sectors to attract a more diverse talent pool, particularly before the older cohort is not available for skills transfer and mentoring. Engage the older generation, retaining them as consultants in order to use and transfer their talents beyond their expected retirements and loss of expertise.

Wireless 45. Reduce the additional costs of postgraduate study via targetted repayments of student loans, and visa costs for example.

Wireless 46. Set out clear options for telecom career pathways so that school leadership and careers advisors benefit from an applied appreciation of the routes available, including differences between direct industry entry, apprenticeships and postgraduate research.

##### NTN

NTN R7. It is recommended that a wider evidence base on skills shortages in the telecommunications and NTN sector be commissioned in order to validate initial findings in this paper.

NTN R10. It is recommended to develop rich opportunities for apprentices at all levels, with the required dual support of study and industry work, where apprentices would work along-side experienced practitioners with a pathway to such roles in the future.

##### Semiconductors

Semiconductors 5. [Skills] The EWG found that skills shortages, at all levels, was one of the critical concerns facing the sector. There is a pressing need for funding to address the skills shortage by attracting new applicants and students at all levels, via a long-term, strategic programme. This programme needs to encourage school students to study subjects such as Computer Science, Electronic Engineering and Material Science. The programme could involve reforming the Apprenticeship Levy to provide employers with more spending flexibility, to overcome the current cap on the number of apprenticeships an employer can offer. There’s a need for greater emphasis and funding for further education colleges to support technicians for electronic and electrical engineering and telecoms, ensuring that undergraduates have an opportunity to gain practical work-place experience to complement their academic learning.

Rationale 5: Without interest from schools there will be no undergraduates and no engineers. There’s a need for more focus on STEM in the school curriculum, at primary and secondary levels, with better industrial engagement and improved careers advice. For example, the Scottish Government has set a target to increase undergraduates in engineering and physical sciences by 40%. The skills shortage applies to graduate engineers and technicians across all domains of engineering, but it is especially acute for Electronic Engineering where student numbers are low and falling, with only 3,245 UK students enrolled on degrees in Electronic and Electrical Engineering in the last year. "

Semiconductors 8. [Skills] The above measures are tactical but can be acted on quickly and produce results relatively fast. However, the EWG believes this is a long-term problem requiring a more strategic solution. We recommend a bold ten-year national level programme that focuses on building the skills, talent and leadership in the UK for 21stcenturyengineering education and expertise. The programme should produce a talent pipeline from schools and FE colleges to universitiesand industry, including upskilling and reskilling in the current workforce, in a coordinated way - working with employers, skills bodies, charities and professional institutions such as the Royal Academy of Engineering. This recommendation is based on the vision of Professor Bashir M. Al-Hashimi, FR, FREng UK Electronics Skills Foundation (UKESF) Trustee & Director: The Engineer - Comment: Engineering's skills gap demands a radical solution.

Rationale 8: The issues of Engineering education in UK have long been discussed, dating back to Finniston report of the 1980s. While other countries have shortages and concerns, the UK’s situation appears to be worse than comparative economies such as Germany, Taiwan and Singapore. A long-term approach, across the whole sector and at all levels is required. "

##### Network Management

NM Rec 4 - We are asking the government to invest in this. To counteract the shortage of skills described earlier, we recommend:

* A long-term investment in home grown skills pipelines to replace aging and outgoing network management resources. Renewing this workforce and skill set is akin to training more doctors and nurses since Network Management pervades every part of our telecoms economy.
* To recruit outstanding talent from abroad as required while we grow and invest in the home skills described above.
* Maximising the availability by utilising the people from diverse backgrounds.
* Provide tax incentives to incentivise investment in Level 1 NM staff development.
* This should ideally include strategy, development and tax incentives.
* Network Management roles and skills to focus on are:
* Field Technician Level – address the shortages by:
* Building on existing successful apprentice and Knowledge Transfer Partnership schemes Network Operations
* These roles are fundamental to the development of AI driven automation. There is a 5-10 year lead time, need to recruit talent externally to fill short and medium term gaps
* IP skills /virtualisation/AI. Without skills already in the UK we cannot develop our own skills
* Skills development in this category should focus on a “4 eyes on” approach to change – resilience and reliability management leading to the ability to “co-pilot” AI driven automation system. This will be human led for the next 5-10 years focused on determining the appropriate level of human intervention needed in AI NM systems.
* NM Developers.
* This is focussed on software and AI driven skills development as described in the earlier section.

##### Security

|  |  |
| --- | --- |
| Security.3 | DSIT should explore how future R&D projects can align and complement existing UKRI and RCUK funded research (early stage, low TRL), perhaps akin to DARPA, focused on specific mission outcomes. There is a challenge around growing the level of ambition in innovation in the UK, and looking better at how we can encourage companies to avoid competing in the same small and non-differentiated market sectors |
| Security.8 | DSIT should look at how we can increase the incentives and rationale for vendors and operators to retain, grow, and broaden UK-based deep technical skills and talent in telecoms and security. |

##### Academic SWG

|  |  |
| --- | --- |
| Academic SWG.3 | Focus on filling skill gaps, including in non-traditional telecom engineering areas such as Software, AI, cybersecurity and optical networks in Telecom Education |
| Academic SWG.8 | Provide stronger and consolidated support to academics for translation of research into patents, standards, start-ups, and university spin-offs. This |

##### Optical

|  |  |
| --- | --- |
| Optical and Photonics.5 | Increase take-up of undergraduate and doctoral training in photonics/communications/systems engineering particularly for UK candidates by a) increasing profile of hot topics in AI/6G infrastructure, free-space optics and quantum networks and b) addressing apparently uncompetitive remuneration issues. Reinforce efforts to stimulate interest and engagement of young people in photonics and technology generally, from school age onwards. |

##### Standards

|  |  |
| --- | --- |
| Standards.4 | **Engagement of UK SMEs in Standards** Set up mechanisms to increase awareness of standards landscape, and reduce knowledge barriers:  · Provision of training for SMEs and/or Universities on an ongoing basis, including online access to training materials and/or relevant experts.  · Training to include also case studies, possibly presented or written by experts involved, included SME participants.  · Training to include standards linked IPR aspects such as FRAND, IPR declaration etc |
| Standards.5 | Support either “classroom” or one to one training for presumptive standards delegates (or those dealing with standards including back-office staff) from SMEs or Universities. This may require having a basic organization and some instructors.   Maximum use should be made of ETSI’s educational materials. It should be noted that ETSI have agreed to further develop its training material, this should be completed by December 2024. As a key member of the ETSI board, DSIT can directly influence the areas covered.   Should cover both hard and soft skills.  Also cover new tools for contribution / IP intelligent searching (e.g. AI based)  Universities with existing experience could contribute to this program.   Build a database of experienced standards delegates willing to provide some level of feedback or mentorship to new delegates from SMEs and/or Universities on a voluntary basis (and pair with such mentors as needed, preferably on the same technical area or SDO)  Such a database can comprise both current and past delegates (the second case may reduce the possibility of conflicts of interest).  In the simplest model, only a pairing service is provided.   Support workshop style meetings on specific topics e.g. “how to write a WID (Work Item Description) and have it approved in 3GPP or ETSI”.  This could also make good use of standards delegates’ willingness to share their expertise and experiences.  In time, this could also be extended to topics of more interest to presumptive standards leaders such as “chairing a 3GPP standards meeting” etc. |

##### Core

|  |  |
| --- | --- |
| Core Networking Technologies.4 | **Accelerate Transition from Research to Market** Develop structured funded programmes to provide academic researchers with the expertise, knowledge and training needed to convert their research into technologies, products and services in this key sector of the global economy, and create pipeline to move ideas out of the university lab and into the commercial market. |
| Core Networking Technologies.5 | Greater technology skills are required across the UK. The UK has some significant successes, such as banking and video games, but there needs to be stronger, capable technology skills in telecommunications, specifically in infrastructure, computer science (including software engineering), semiconductors, and optical technologies. The UK has some expertise in the integration of complex systems, and this is a strength to build upon, but it is still niche.   The EWG considers that the UK has a severe problem with respect to developing the technology skills in the scope of this EWG. Finding people who can understand how to build things is becoming harder and harder.  We need to figure out how we sell the “mission”.  Initiatives should be sought to improve supply of trained engineers by making telecoms network engineering more attractive as a long-term career path, rather than opting for other STEM career areas. Note that the complexity and diversity of the national and international technology and systems landscape is such that future trained engineers could come from a variety of engineering, mathematical, and science backgrounds, and not just traditional electrical engineering backgrounds. |

* + 1. Commercialisation

**24:** [12 Wireless; 1 Network Management, 2 Security, 1 Academic SWG, 3 Core]

#### Summary

* **Focus on a dynamic and integrated R&D ecosystem**: Support and facilitate R&D producing organisations (such as universities, start-ups and SMEs) to push their research and innovations into large international organisations and operators (Wireless 1, 2, 11, 18, 50, 52)
* **Incentivise UK network operators** to play a bigger role in ensuring a pull-through of UK innovation into UK networks (could be achieved by 1) tax credits, or 2) direct funding for qualifying adoption of UK-born technology into their commercial networks) (Wireless 53)
* Support for universities specifically:
  + Government could invest to protect valuable IP then partner with the supply chain to take it to market. Another model would be to recover the investment by licencing the IP (Wireless 18)
  + “Spin-in” companies, which conduct engineering development and testing in the universities (with reciprocal support from university engineers to mentor, test and support those companies) are recommended as an example of best practice (Wireless 50)
  + A national funding pool to top up university funds for research (Wireless 52)
* **R&D Themes**: Wireless EWG recommends R&D efforts and programmes focused on Open RAN and 6G are recommended (Wireless 47, 49, 51), while Network Management recommends financial incentives to support investment in home grown Network Management capabilities and supply
* Supply chains and brokerage:
  + Supply chains: incentivise suppliers to include UK supply chain into their networks, which could potentially lead to design into products that would then be sold in other territories (Wireless 15)
  + Brokerage (NM 9):
    - For data exchange between telcos domestically and internationally
    - For data insight services based on AI and experience operating networks
    - For systems integration services based on open APIs and complexity management
    - Leverage Best practice from UK parallel industries 2T/1T London exchange, other Financial Services, Pharma, & Legal

##### Wireless

1. Government, both national and local, needs to be the catalyst for high quality network deployment: high quality wide area wireless networks are an imperative for both economic growth and societal development."

2. The public sector should underwrite the deployment and availability of network capability which the private sector can then leverage to deliver significant economic benefit.

11. Funding routes to be more obviously available to allow UK universities, startups and SMEs to push their research and innovations into large international organisations and operators.

15. Government procurement initiatives Although not the largest buyer of telecoms infrastructure the UK still has significant spending power, which could potentially be used to convince suppliers to include UK supply chain into their networks. If successful this could lead to design into products that would then be sold in other territories.

18. Commercialising academic research. Once we have alignment between the academic and UK strategic roadmap the next issue to solve is the commercialisation of academic research, all too often the only option is a spin-out company which either fails due to lack of money or commercial acumen or quickly gets bought by large international companies. Could the Government invest to protect valuable IP then partner with the supply chain to take it to market? One model would be to recover the investment by licencing the IP.

47. The recommendations of the UK Government Wireless Infrastructure Strategy, and its Open RAN Principles, should be used to frame interventions that encourage adoption of new innovations, extending current programmes.

48. The constraints placed upon dual use of results funded by civil research programmes may benefit from review. The Group feels this would encourage innovation in other areas.

49. Open RAN should be fully embraced as an opportunity for good, applied (high TRL) R&D as there are a good range of companies in the UK with relevant skills and ORAN should increase the opportunity to concentrate on a single element vs an end -to -end system. Also, it is more AI and software dependent so it is easier to grow than hardware dominant companies. This could be built on for 6G.

50. Greater alignment between university research and facilities and industry could be assisted by “spin-in” companies, which conduct engineering development and testing in the universities and those universities should also have engineers dedicated to mentoring, testing and support of those companies, independent from their own research. Some universities already apply such a model but this could be more consistently applied as an example of best practice.

51. The Government aspirations for UK involvement in 6G are welcome, but imply very near-term action on supporting companies to intersect with 6G standardisation and launch timescales.

52. There should be incentives for universities based on implementation and impact dependent on financial output. A national funding pool to top up university funds for research would help.

53. There is a need and opportunity for UK network operators and deployers to play a bigger role in ensuring a pull-through of UK innovation into UK networks, bringing operator benefits of early innovation and innovators benefits of a credible lighthouse deployment. One approach would be to grant operators credits in the form of tax credits or direct funding for qualifying adoption of UK-born technology into their commercial networks.

##### Network Management

Rec 9 - Provide financial incentives to support investment in home grown NM capabilities and supply.

For example, the provision of brokerage & Services. Bilateral agreements across all these agencies will not be feasible, is there an opportunity for the UK to create companies as trusted telecoms service brokers e.g. for data exchange between telcos & techcos domestically and internationally, for data insight services based on AI and experience operating networks or for systems integration services based on open APIs and complexity management. Leveraging best practice from UK parallel industries e.g. London exchange, other Financial Services, Pharma, & Legal

Look for opportunities to establish UK as a telecoms service broker e.g.

• For data exchange between telcos domestically and internationally

• For data insight services based on AI and experience operating networks

• For systems integration services based on open APIs and complexity management

• Leverage Best practice from UK parallel industries 2T/1T London exchange, other Financial Services, Pharma, & Legal "

##### Core

|  |  |
| --- | --- |
| Core Networking Technologies.1 | **Scale** The UK Market needs to be more significant to drive enough scale to create the industrial research and development needed to create significant national leadership or sovereign capability. Core networking technologies are pieces of a larger ecosystem of standard solutions, and scale is vital. |
| Core Networking Technologies.3 | **Supporting Core Network and Services Research** There is a growing need for greater coordination across the UK academic community. While there are many great and globally recognised universities within the ecosystem, too few of these have had sufficient investment to allow creating sustainable value for the UK through, for example: · sustained commercialisation of their research, |
| Core Networking Technologies.2 | **Better investment choices** The UK has run a series of competitions to create opportunities such as 5G Testbeds but evidence of delivering significant sustainable value or accelerating 5G deployment in the UK has been sparse. |

##### Security

|  |  |
| --- | --- |
| Security.2 | Better target public investment in new and different ways to try to deliver specific outcomes (and more clearly and directly define and measure the outcomes we seek), and to understand whether or not our R&D investment is feeding through to commercially deployed and available products at-scale. |
| Security.11 | We suggest some areas for applied R&D, which should be focused on delivering real-world industry adoption and uptake of enhanced security measures as part of products and networks. |

##### Academic SWG

|  |  |
| --- | --- |
| Academic SWG.8 | Provide stronger and consolidated support to academics for translation of research into patents, standards, start-ups, and university spin-offs. This |

* + 1. Testbed, Platforms, Etc.

**13** [2 AI ; 5 Wireless ; 2 NTN ; 2 NM; 1 Optical, 1 Academic SWG]

#### Summary

* Across AI, Wireless, NTN and NM EWGs, testbeds emerged as a strong area of focus in order to develop and maintain telecommunications capability in the UK. These are the key considerations for a coordinated testbed recommendation across EWGs (this could involve expanding an existing testbed or creating an entirely new one)
  + a permanent testbed, rather than a testbed operating for a limited amount of time (Wireless 34)
  + A two-pronged approach focusing on *both* skills and key sectors of R&D
    - R&D AREAS OF FOCUS: 1) a full end-to-end technology integration, encompassing the 5G/6G communication environment, incorporating both satellite and terrestrial components (Wireless 36) as well as allowing for innovations in radio spectrum use (Wireless 27). 2) a Centre of Excellence in NTN for knowledge sharing between academia and industry and preparations for inputs to standards (NTN R3) 3) AI techniques are major area of focus across EWGs (AI 1, 2, Wireless 21 and NM 3, 8). In particular as follows:
      * AI EWG recommends a Future Network Platform and Innovation Program for co-innovation and experimentation of AI transformative capabilities in future Telco with stakeholders which can also fast track innovations and disruption on AI capabilities in Telco technology, as well as develop PoCs that attract third-party buy-in, fostering and partnership with diverse stakeholders
      * AI EWG also recommends an 'Open6G' testbed that facilitates the seamless integration and assessment of multivendor interoperability solutions for native AI network elements (2). Similarly, Wireless recommends field trial access to trial innovative new techniques and demonstrate interoperability of AI techniques (21). NM also recommends an NM data repository, the main objective of which would be to enable students to train on NM technology without the need for a “real-world” network and to train AI systems to aid R&D on NM automation (3) as well as ensuring AI driven orchestration/automation across multiple network domains and to make AI applied to mobile communication network management more generally available across more research institutes and universities with the objective of training more students more widely (8)
    - SKILLS: a testbed in an opportunity to address skills as well as R&D. NTN EWG recommends that testbeds assist in the training of skilled workforce (bench testing capability for low level hard-ware, NTN communications networking, simulation & modelling, laboratory ‘device in the loop’ tests with test equipment and extend to a ‘in-orbit’ test) (R8). AI and NM similarly recommend embedding upskilling with regards to AI within testbeds (AI 1, NM 3, 8)
  + Additionally, lowering cost and increasing access to existing facilities (embed equipment within an industry setting with a core partner so the equipment is regularly used but remains open for access to others) Wireless 14

**--> potential solution: a single unified permanent testbed focusing on the key areas of R&D and associated skill sets**

##### AI

AI 1. Future Network Platforms: create a Future Network Platform and Innovation Program for co-innovation and experimentation of AI transformative capabilities in future Telco with stakeholders. (Catalyse fast track innovations and disruption on AI capabilities in Telco technology, services, and business transformation. Develop PoCs that attract third-party buy-in, fostering collaboration and partnership with diverse stakeholders including new entrants and SMEs. As a training platform to share lessons learnt and best practices, upskill and reskill workforce to meet the demands for future AI-powered Telco and cloud providers. [overlaps with NTN R8] Promote collaboration with international stakeholders to tap into global expertise and attract investments on future Telco in the UK"

AI 2. Open6G testbed: Establish a cohesive 'Open6G' testbed that facilitates the seamless integration and assessment of multivendor interoperability solutions for native AI network elements and testbeds. [overlaps with Wireless 21 and NM 3]

##### Wireless

Wireless 14. Low-cost access to test facilities. As previously mentioned, access to test facilities can be a significant barrier to new entrants to the market, although there are centres with relevant equipment these are often cost prohibitive to access. The best model seems to be to embed equipment within an industry setting with a core partner so the equipment is regularly used but remains open for access to others.

Wireless 21. Support field trial access to trial innovative new techniques and demonstrate interoperability of AI techniques. [baseband/semiconductor] [overlaps with NM 3 and AI 2]

Wireless 27. Ofcom, supported by UK Government, must continue the willingness to experiment, provide mechanisms for academia and companies to innovate in radio spectrum use.

Wireless 34. While 5G test and trial projects offered valuable insights and in-depth exploration of 5G technology use cases and integration, a significant limitation is that many of these trials operated for a limited time, lacking the provision of sustained testing facilities. Therefore, there is a demand for permanent testbeds, akin to SONIC labs.

Wireless 36. A comprehensive testbed is required to facilitate full end-to-end technology integration, encompassing the 5G/6G communication environment, incorporating both satellite and terrestrial components. The diversity and distribution of funding to support expertise and facilities at different academic institutions are needed. [this potentially covers NTN R3 below]

##### NTN

NTN R3. It is recommended that the Government set up a Centre of Excellence in NTN for knowledge sharing between academia and industry and preparations for inputs to standards. In addition, that Government seeks ways to raise the profile of NTN within the National Space Strategy.

NTN R8. It is recommended that Test beds to assist in the training of skilled workforce be established [overlaps with AI 1]. This would include bench testing capability for low level hardware as well as for NTN communications networking and would consist of simulation & modelling, laboratory ‘device in the loop’ tests with test equipment and extend to a ‘in-orbit’ test. [see also skills]

##### NM

NM Rec 3 – NM Data Repository <for testbed> We are asking the government to facilitate this. Determine the measures necessary to overcome the barrier of the extreme difficulty in obtaining real network-based data for development and testing of new NM systems. This includes: How to incentivise operators to provide data, how to make disclosure trusted.? ; Create the correctly skilled and resourced Data analyst team - to get or generate the data. ; Find the appropriate Security body and resources within the data suppliers – to approve the release if the data. ; Create the 3rd party lab - for testing on the data. This recommendation will require the appropriate sponsorship from UK operators, both the academic and non-academic world should promote this. The main objective of this data project would be to enable students to train on NM technology without the need for a “real-world” network and, to train AI systems to aid R&D on NM automation. [overlaps with Wireless 21 and AI 2]

NM Rec 8 -R&D Infrastructure to Enable Leading-edge Ecosystems ; Research and consult on the facilities needed to create a representative development and verification network for NM research e.g. for better manageability Including those necessary for: inter-operator network interconnection, AI driven orchestration/automation across multiple network domains; NM in shared infrastructure and neutral host networks, Make UK telecom 5G/6G labs more nationally available (beyond JOINER network) across more research institutions and universities in UK, who can exchange knowledge and learn from each other. Objective is to make AI applied to mobile communication network management more generally available across more research institutes and universities with the objective of training more students more widely. These can also be used as a source of service NM data specific for the types of leading-edge services carried over those platforms. Establish funding for selected academic research to become successful SMEs.

##### Optical

|  |  |
| --- | --- |
| Optical and Photonics.2 | Build on existing facilities (e.g. NDFF) to create a field-deployed fibre-rich network connecting major photonics institutions and including novel transmission media (HCF, MCF, FMF,…) to accelerate R&D in optical and quantum communications systems |

##### Academic SWG

|  |  |
| --- | --- |
| Academic SWG.7 | Federate the entire UK telecom research infrastructure into an end-to-end open platform system of systems to create both physical and digital experimental platform for future networks research. |

* + 1. Research themes and areas of focus

**21:** [5 Wireless, 2 Network Management, 1 AI, 1 Semiconductors, 1 Non-Terrestrial Networks, 5 Security, 4 Optical, 2 Core]

#### Summary

* EWGs recommend that attention be given to the following research themes and areas of focus:
  + Telco AI business growth ideas (AI 4)
  + Widespread wireless service coverage to prevent the manifestation of a “digital divide” and to contribute to improved health and social care outcomes and future transport ambitions (Wireless 5.1)
  + Improving spectrum efficiency and densify spectrum sharing, particularly in the low frequency, mid and mid high frequency bands suitable for mobile connectivity (Wireless 5.2)
  + Economic viability of roll-out of next generation mobile infrastructure (Wireless 5.3)
  + Alignment with government’s net zero targets (Wireless 5.4)
  + Providing access to shared MNCs and better coordinated private network MCCs for private networks and UK neutral host companies (Wireless 29)
  + Detailed comparison of the LCA for a variety of directly comparable scenarios (terrestrial and non-terrestrial; direct-to-device and backhaul) that sets good precedents for comparing differing telecommunications services (NTN R6)
  + Technology roadmaps identifying the key semiconductor technologies required to deliver a resilient telecom network from 2025-2035, highlighting where the UK has expertise, perhaps to be undertaken by National Semiconductor Institute (Semiconductors 11)

##### AI

"4. Telco-AI Initiatives

Form a mechanism to encourage and incubate radical, creative, fresh thinking research translation and adoption from SME and Universities on Telco AI business growth ideas. "

##### NTN

NTN.6: -A detailed comparison of the LCA for a variety of directly comparable scenarios (terrestrial and non-terrestrial; direct-to-device and backhaul) that sets good precedents for comparing differing telecommunications services is required.

##### Wireless

5.1 (priority opportunities for UK Government to incentivise for 6G research and innovation) Widespread wireless service coverage to prevent the manifestation of a “digital divide” and to contribute to improved health and social care outcomes and future transport ambitions.

5.2 (priority opportunities for UK Government to incentivise for 6G research and innovation) Innovation in spectrum management (e.g. through the use of automation and AI), to improve spectrum efficiency and densify spectrum sharing, particularly in the low frequency, mid and mid high frequency bands suitable for mobile connectivity.

5.3 (priority opportunities for UK Government to incentivise for 6G research and innovation). Economic viability of roll-out of next generation mobile infrastructure (through enabling new service possibilities or significant cost savings).

5.4 (priority opportunities for UK Government to incentivise for 6G research and innovation) Alignment with the Government’s net zero targets.

29. The UK should lead in providing access to shared MNCs and better coordinated private network MCCs for private networks and UK neutral host companies.

(for UKRI) R6. A detailed comparison of the LCA for a variety of directly comparable scenarios (terrestrial and non-terrestrial; direct-to-device and backhaul) that sets good precedents for comparing differing telecommunications services is required.

##### Semiconductors

"11. [Scale up] The EWG recommends technology roadmaps identifying the key semiconductor technologies required to deliver a resilient telecom network from 2025-2035, highlighting where the UK has expertise. This work could be undertaken by the National Semiconductor Institute, which was considered in the IfM Semiconductor Infrastructure Study, for example.

Rationale 11: There is a need to focus support where the UK has a competitive advantage, such as photonics, RF and mixed signal, building on UK research strengths and opportunities to commercialise. This would leverage the synergies in compound semiconductors with manufacturing clusters in South Wales and Scotland, and silicon RF/silicon photonics. "

##### Network Management

"Rec 5 - Growing the UK telco business efficiently – optimising investment.

As described earlier we need to grow the telco NM business in the face of ever-increasing network complexity. How to deal with growth without growing cost base in-line.

Leveraging AI and Automation goes hand in hand with training Network engineering and management resources so we can build those AI models in the future:

• Develop and AI/ Automation technologies to improve and facilitate the management of highly complex networks.

• Promote network management and network manageability as a specific research area and focus for existing AI/ML developers.

• Research and develop CEM based digital twin models for telecoms with R&D leveraging experience of large customers e.g. NHS & Finance.

• Provide financial incentives for NM IP commercialisation

• Expand Seed funding opportunities for NM start-ups.

• Build on best-practice spin out/in university schemes."

"Rec 4 - R&D Co-ordination

(Based on 6GStart ‹ 5G-PPP)

An umbrella activity is required to orchestrate, capture, and promote the achievements of UK research projects by facilitating activities in the inter-project working groups and maintaining membership links to the standardisation community. This could be led by UK Catapults This is partially the role of UKTIN -- both promoting activities and bring the ecosystem together, now with activities around standards etc. In the past (5GTT programme) projects were 'forced' to collaborate/exchange info etc. This can be put in the GFA/CA for all DSIT and similar projects.

It is required to:

• Extracting strategic R&I orientations from the UK community of projects.

• Coordination with 5G/6G R&I results/initiatives at UK level.

• Establishing and maintaining dissemination structures and web presence for the UK research initiatives.

• There are well established academic conferences for NM (CNSM, IM, NOMS). Build a NM community across the UK and internationally (e.g., by seed funding NM projects), organising workshops on strength areas for UK NM research and, when applicable, attach these workshops to the established international conferences..

• Orchestrating and tracking UK projects and programmes contribution to emerging standards.

• Facilitating international cooperation across key regions based on promoting UK priorities.

• Developing methodologies for collecting metrics data for technology solutions."

##### Security

|  |  |
| --- | --- |
| Security.1 | DSIT should explore ways to find better monitoring & evaluation frameworks to measure the real-world impact of R&D, and how it can focus on funding activities which yield more tangible and measurable security (and other) benefits. |
| Security.2 | Better target public investment in new and different ways to try to deliver specific outcomes (and more clearly and directly define and measure the outcomes we seek), and to understand whether or not our R&D investment is feeding through to commercially deployed and available products at-scale. |
| Security.3 | DSIT should explore how future R&D projects can align and complement existing UKRI and RCUK funded research (early stage, low TRL), perhaps akin to DARPA, focused on specific mission outcomes. There is a challenge around growing the level of ambition in innovation in the UK, and looking better at how we can encourage companies to avoid competing in the same small and non-differentiated market sectors |
| Security.5 | That the same types of security issues are still a concern on timescales of the order of a decade or longer gives good evidence of the need to take a longer-term view on security R&D, and one which is focused on outputs and outcomes, rather than on the research itself. |
| Security.9 | DSIT should explore how innovation and future R&D can reflect the UK’s opportunity to carry out high-value (and difficult-to-copy) work in systems integration and interoperability. |
| Security.11 | We suggest some areas for applied R&D, which should be focused on delivering real-world industry adoption and uptake of enhanced security measures as part of products and networks. |

##### Optical and Photonics

|  |  |
| --- | --- |
| Optical and Photonics.1 | Develop a long-term Grand Challenge technology programme similar to Japan's IOWN to foster collaboration and drive direction within the optics/photonics ecosystem, enabling development and demonstration of key innovations at both device and systems level for high-capacity end-to-end all-optical networks |
| Optical and Photonics.4 | Create pilot capabilities for integrated silicon photonics and compound semiconductor chips including open access to advanced fab, assembly and packaging facilities, in coordination with national and international semiconductor initiatives |
| Optical and Photonics.6 | Reduce barriers to entry for SMEs in fixed wireless and broadband access networks by facilitating UK voice on standardisation activities, both formal and informal; b) promoting adoption of open initiatives, e.g. O-RAN, Open ROADM, Open Line Systems that disaggregate the physical layer and avoid vendor lock-in. Develop programmes to facilitate access for SMEs to leading edge technologies including integrated photonics. |
| Optical and Photonics.7 | Establish programme addressing power consumption in communications networks and data centres, emphasizing architectural developments and technology improvements through photonics and photonic-electronic codesign that can offer radical improvements in power efficiency and allow sustained traffic growth with minimal environmental impact. |

##### Core

|  |  |
| --- | --- |
| Core Networking Technologies.2 | **Better investment choices** Initiatives should be pursued to: · Identify Future applications driving the future network growth |
| Core Networking Technologies.3 | **Supporting Core Network and Services Research** Support core computer networking and future Internet research through appropriate state funding programmes for the development and demonstration of novel end-to-end services on top of connectivity. |

* + 1. Collaboration, and strategic partnerships (including international)

**17** [5 Wireless, 1 Semiconductors, 2 Non-terrestrial Networks, 2 Core, 4 Standards, 3 Academic SWG]

#### Summary

* The importance of **strategic international collaborations** and partnerships was stressed across EWGs (Wireless 7, 13 and Semiconductors 3). Examples include strategic partnerships where the UK is reliant on overseas semiconductor suppliers, such as silicon CMOS chips (Semiconductors 3)
* **Collaborations across academia and industry** was also stressed (Wireless 6, 33, NTN R5, R9). Examples include real system deployment to share knowledge, develop practical solutions, and address real-world security challenges (Wireless 33)
* With regards to **6G specifically**, Wireless also suggested that collaboration should be a condition of 6G research funding provided to universities (Wireless 6) while NTN recommended that R&D on 6G technologies be focussed on open networking between NTN and TN and coordinated across DSIT and UKRI being facilitated by larger consortia of industry and academic partners

##### Wireless

6. Participation in an approved “collaboration model” should be a condition of 6G research funding provided to universities.

7. A systematic approach to the creation of more international collaborations like those led by DCMS (e.g. with the Republic of Korea and India) should be adopted and should target key partners, such as the USA.

9. Similar to the approach adopted by the 5G Open Innovation Lab in the USA UK Government departments should partner with relevant and proactive innovation organisations on an occasional basis to create some cohorts targeted specifically at wireless networking.

13. International collaboration. While UK companies may thrive in niche, high value elements of the supply chain, collaboration will be key to maximise the market opportunity and to embed UK content in future wireless systems.

33. To bridge the security and diverse interoperable system gaps, universities and research institutions need to collaborate with industry partners on real system deployment to share knowledge, develop practical solutions, and address real-world security challenges.

##### NTN

R5. It is recommended that future R&D on 6G technologies be focussed on open networking between NTN and TN and coordinated across DSIT and UKRI being facilitated by larger consortia of industry and academic partners. Additional coverage should be extended to interference management/spectrum sharing, optical communications, AI/ML and on-board processing algorithms and semiconductors for on board processing.

R9. It is recommended to commission a rich research environment that brings together industry and academia in a cost-effective way with the dual aims of undertaking strategic pre-competitive research; and attracting and developing highly skilled PhD candidates with the means to facilitate entry into industry and become industry leaders in the area of NTN and satellite communications.

##### Semiconductors

"3. [Supply chain] The EWG strongly recommends strategic partnerships where the UK is reliant on overseas semiconductor suppliers, such as silicon CMOS chips, noting that strategic partnerships were considered as part of the IfM Semiconductor Infrastructure Study. These partnerships need to be strong and commercially binding, guaranteeing security of supply and not just technical cooperation. The partnerships may involve collaboration in research and innovation, financial commitments and/or co-investment to ensure committed capacity, but must ensure supply of components and systems to maintain telecom infrastructure.

Rationale 3: As the UK cannot have a complete supply chain across all technologies, especially advanced node CMOS logic and memory, there must be an emphasis on trusted friends and nations. This might involve some financial commitment to ensure guaranteed capacity, whether as investment or commercially guaranteed access. The telecoms industry is reliant on these components, but we cannot afford a domestic supply. Friendly countries might include Taiwan (critically important, although with geopolitical risk), Korea, Japan, USA, India and Germany (TSMC investing there might mitigate the risks of Taiwan). It is worth noting that telecoms use various CMOS node sizes, each with different economics, which calls for a variety of partnerships. It is worth exploring partnerships with Intel’s leading-edge Intel 4 CMOS fab in Leixlip, Ireland, with cross-border university links and the ‘best of both worlds’ status of Northern Ireland. "

##### Academic SWG

|  |  |
| --- | --- |
| Academic SWG.2 | Appropriate Funding Models to strengthen Industry-Academia Collaborations |
| Academic SWG.4 | Promote Collaboration in R&I between Telecoms and adjacent disciplines, and specially AI, Quantum and Optical Communications to reflect emerging trends in global Telcom and leverage UK’s unique strengths to secure UK’s future leadership. |
| Academic SWG.5 | Enhanced support for UK Universities for international collaborations to achieve scale, remain competitive and grow. |

##### Standards

|  |  |
| --- | --- |
| Standards.3 | **General approach of Standard Development Organisations to Patents and IPR** |
|  | Encourage integrators (e.g. network operators, 3rd party integrators etc) to share inter-operability issues found in UK deployments, particularly if including new or multiple vendors. |
|  | Develop mechanisms (potentially at international level) to provide a degree of feedback or rating of standards in terms of their proven interoperability. |
|  | Develop a formal framework to identify what is essential and what is optional within at least a subset of important standards. |
| Standards.4 | **Engagement of UK SMEs in Standards** |
|  | Set up mechanisms to enable development of appropriate standards strategies. |
|  | Support match making with standards experts / IPR experts / patent attorneys with possible seed funding (making use of the relatively large number of UK standards leaders in the latter career stages). |
|  | Set up fora for sharing and discussing knowledge and proposals with other players in the UK ecosystem, possibly on a per-SDO basis (note: the UKTIN’s Future Capability Paper on Wireless Networking proposes a “standards network” which has a similar context). |
|  | De-briefing on SDO status, proposals etc., could be achieved using different models such as: |
|  | * DSIT de-briefing targeted at UK SMEs – leverage DSIT representatives to share information with SMEs in de-briefing updates. |
|  | * As part of any SME grant (to attend meetings), the SME provides a briefing to the community on what they have learnt. |
|  | * A mix of the above, plus invited speakers such as WG chairs or other experts willing to present in a forum. |

##### Core

|  |  |
| --- | --- |
| Core Networking Technologies.1 | **Scale** |
|  | Smaller companies find it exceedingly difficult to export their products, making it more difficult to expand outside of the UK. |
|  | Measures should be devised and implemented to: |
|  | * Including identifying the profitable sector targets within the scope of the Core Technology model discussed earlier in the report and choosing the next growing technologies. |
|  | * And encourage the sector to grow to scale or to work better together, nationally or with friendly international partners, on targeted profitable technical niches. " |
| Core Networking Technologies.4 | **Accelerate Transition from Research to Market** |
|  | The UK market needs to be healthier. The current regulatory policies are driving fragmentation of the market, which is reducing scale and, thus, the buying power of the UK. |
|  | Over 140 alternative networks are building fibre infrastructure in a totally un-coordinated way, of varying quality, many of which are unlikely to survive in the medium term. |

* + 1. Funding

**6** [2 Wireless, 1 Non-Terrestrial Networks, 3 Semiconductors]

#### Summary

* EWGs recommend targeted funding aimed at the following themes:
  + Intelligent Transport Systems (ITS) Infrastructure to support Connected and Automated Mobility solutions (Wireless 32)
  + Collaborative programmes for developing, launching, and validating in-orbit/flight, the end-to-end service management capabilities required by the evolving market to enable UK industry to develop world-leading insight and operational solutions (NTN R4)
  + Specific financial support to help UK companies develop the telecom and semiconductor technologies (Semiconductors 12, see also 11)
  + For universities specifically:
    - funding for universities to deliver courses in strategically important degree courses, such as semiconductors and telecoms (Semiconductors 6)
    - funding for specific CDTs (Centres for Doctoral Training) in semiconductors and telecoms (Semiconductors 6)
    - funding to encourage and support diversity in the sector, addressing the extremely low number of female undergraduates within electronic engineering and the telecoms industry (Semiconductors 7)
* Other suggestions include open calls on a rolling basis without a specific application window, organised around a particular theme (Wireless 31)

##### Wireless

31. Grants should be allocated on open calls which are rolling around a theme, adopting the approach used by DASA (Defence and Security Accelerator) without a specific application window.

32. Government spending on setting up Intelligent Transport Systems (ITS) Infrastructure in the UK will help establish a lead in Connected and Automated Mobility solutions

##### NTN

R4. UK government should run collaborative programmes for developing, launching, and validating in-orbit/flight, the end-to-end service management capabilities required by the evolving market to enable UK industry to develop world-leading insight and operational solutions.

##### Semiconductors

6. [Skills] The EWG recommends targeted funding for universities to deliver courses in strategically important degree courses, such as semiconductors and telecoms, as these courses are often more costly to run than other courses. The EWG recommends funding for specific CDTs (Centres for Doctoral Training) in semiconductors and telecoms, and other priority areas identified in the strategy.

Rationale 6: Given the fixed funding per student, universities often close expensive courses in telecoms and semiconductors due to the cost of specialised equipment, the need for expensive labs and staff and the perceived difficulty of the courses. Targeted funding is required to support both undergraduate and postgraduate students. CDTs provide a ‘win-win’ solution by aligning the needs of industry with the latest academic research. They are a cost-effective way of supporting translational research, delivering upstream benefits such as spinouts and enhanced undergraduate teaching. Because they are relatively long-term, they enable industry to be involved as partners, and for academic institutions to build institutional expertise. This recommendation calls for a ‘top-up’ to the recent round of CDT applications for areas identified by HMG as specific priorities. For example, a semiconductor CDT could focus on components for RF and photonics, using both compound semiconductors and silicon. "

7. [Skills] The EWG recommends specific funding to encourage and support diversity in the sector, addressing the extremely low number of female undergraduates within electronic engineering and the telecoms industry.

Rationale 7. Of the 3,245 UK students that enrolled in Electronic and Electrical Engineering degrees in the last year, only 335 were women. Women represent around 3% of employees within the telecoms sector generally. Increasing the number of women studying Electronics and Electrical Engineering would be an efficient way to increase the number of qualified engineers entering the sector. "

12. [Scale up] The EWG recommends specific financial support to help UK companies develop the telecom and semiconductor technologies identified in the technology roadmaps described in Recommendation 11.

Rationale 12: As telecoms and semiconductors have long development cycles, there is a need for long-term programmatic funding, similar to the Industrial Strategy Challenge Fund delivered by Innovate UK. These funds offer non-dilutive grants and tend to crowd in VC funds. Programmatic funds could be coupled with a dedicated investor fund, as this is done in some countries, or an expansion of the existing Investor Partnership Program, where investments by qualifying VCs are matched to address the segment. "

##### Core

|  |  |
| --- | --- |
| Core Networking Technologies.2 | **Better investment choices** If the UK wishes to have sovereign telecommunications capability, how can the government set an audacious goal to create something that will bring value? An example would be IOWN in Japan, a network vision to create the Internet of the future and the core network technologies to underpin it. |
| Core Networking Technologies.3 | **Supporting Core Network and Services Research** There is a growing need for greater coordination across the UK academic community. While there are many great and globally recognised universities within the ecosystem, too few of these have had sufficient investment to allow creating sustainable value for the UK through, for example: This needs greater alignment with the industry and a greater focus on valuable outcomes. There are pockets of success (Lumenisity, for example), but not nearly enough. |
| Core Networking Technologies.4 | **Accelerate Transition from Research to Market** The UK market needs to be healthier. The current regulatory policies are driving fragmentation of the market, which is reducing scale and, thus, the buying power of the UK. · This will have a staggeringly negative impact on the UK market for decades and will not meet the government’s objective of being a digital communications leader. Crucially, the reason for Marconi’s failure was ultimately competitiveness; the UK operators needed lower-priced platforms, and Marconi could not deliver them. There needs to be flexibility and appetite to restructure the UK market and willingness to explore transformative even if controversial options such as the UK seeking to take a position as the ‘testbed’ where commercial concepts are tried out and then copied (sold) to other parts of the world. |
| Standards.4 | **Engagement of UK SMEs in Standards** Set up mechanisms to reduce financial barriers to participation:  · Provide financial grants for initial standards engagement for SMEs and/or universities.  · Create a body to act as an umbrella member of standards organizations, whereby a participating SME could initiate its participation without the administrative and financial burden of full individual membership (at least for a certain number of meetings).  · These various mechanisms could be combined into a single organization or club covering activity in the different areas e.g. by having SMEs as member organizations which could then access one or more of a range of the specific “services” listed above. |
| Security.5 | **The UK should attempt to take a longer-term strategic view on security in telecoms.** The UK must consider how it can set out a longer-term agenda, without the uncertainty for industry presented by regular priority-shifts and changes in agenda. |
| Optical and Photonics.3 | **Define initiatives that will attract investment from global optical network equipment vendors to establish systems R&D facilities in UK to drive vision and cohesion within the photonics ecosystem and to generate market pull for new technology innovations** |
| Core Networking Technologies.4 | **Accelerate Transition from Research to Market The UK market needs to be healthier. The current regulatory policies are driving fragmentation of the market, which is reducing scale and, thus, the buying power of the UK. · This further dilutes the ability of the UK to create scale but crucially waste investment money.** |

* + 1. Investment, VC, etc

**6** [3 Wireless, 3 Semiconductors]

#### Summary

* Recommendations are primarily semiconductor focused (including those from Wireless group) and focus on facilitating the growth of investments in the space, particularly at growth stage (Wireless 16, 22, Semiconductors 9. 10, 13)
* A roadmap leveraging both industry and academia for the UK to meet sovereign needs and maximise opportunities for the supply chain (Wireless 16, 17)
* Concrete suggestions include:
  + Pooling investments across telecommunications, space and defence (Wireless 16)
  + Initiatives to encourage more private sector investment in high-risk/VC-funded firms, including the ‘Mansion House’ reforms and CBI recommendations, to unlock larger scale investment from pension funds (Semiconductors 9)
  + Review and potential reform of government incentive schemes, including the Enterprise Management Incentive (EMI) and R&D tax credits. (Semiconductors 10)
  + Review of the rules governing CAPEX and OPEX, to ensure that grants available to UK companies enable them to address the commercial opportunities identified in the technology roadmaps. (Semiconductors 13)
  + Review of the Subsidy Control Act and a review of UK companies’ access to Horizon funding (Semiconductors 13)

##### Wireless

16. UK Strategy to cover multiple markets. For wireless technology and related semiconductors there is significant crossover from telecommunications requirements with those of defence and space, investments should be pooled and the roadmap developed so the UK has its sovereign needs met while maximising the commercial opportunities for the supply chain.

17. Focussed UK roadmap leveraging UK academic base. Linked to above (16), ensure the academic base buys into the same roadmap with a future looking perspective.

22. Create an investment environment conducive to the funding business innovating in semiconductor compute devices for baseband processing in the RAN.

##### Semiconductors

"9. [Scale up] The EWG recommends initiatives to encourage more private sector investment in high-risk/VC-funded firms, including the ‘Mansion House’ reforms and CBI recommendations, to unlock larger scale investment from pension funds. This investment is required to support a company’s growth stage.

Rationale 9: Both semiconductors and telecoms are capital intensive, requiring late-stage investment. The UK successfully funds early stage and spinouts, but late-stage funding, including ‘mezzanine’ and ‘growth stage’ funding, is hard to find. While the UK does very well on early-stage funding, and VC funding is second only to US and China, when looking at the ratio of growth stage VC to early stage, the UK actually drops to bottom of the G7 (the UK has 30.8% late stage of total, compared to USA 50.8% or Germany at 48.8%). The ScaleUp Institute estimates there to be a ‘growth capital gap’ of around £15 billion a year in the UK – representing the level of funding scaleups require to properly realise their growth ambitions. "

"10. [Scale up] To address growth stage challenges, the EWG recommends a review and potential reform of government incentive schemes, including the Enterprise Management Incentive (EMI) and R&D tax credits.

Rationale 10: In their current form, government incentive schemes often constrain growth due to funding ceilings and other unintended consequences. This is analogous to the recent review of university spinouts, which identified best practices and common roadblocks or barriers. "

"13. [Scale up] The EWG recommends a review of the rules governing CAPEX and OPEX, to ensure that grants available to UK companies enable them to address the commercial opportunities identified in the technology roadmaps. This might involve a review of the Subsidy Control Act and a review of UK companies’ access to Horizon funding, for example

Rationale 13: Universities can apply to EPSRC for CAPEX funding without OPEX, whereas companies can apply to Innovate UK for OPEX funding without CAPEX. The UK state aid laws were based on EU rules, but the EU has liberalized them while UK has not. We have a paradox where Brexit was supposed to liberalize laws, but they are more restrictive in some instances. See also EU Chips Act & IPCEI. Both telecoms and semiconductors are capital intensive with relatively long investment timescales, so these rules have a disproportionate impact on the sector. "

* + 1. Establishment of government body, panel, Strategy, tax credits, etc

**5** [3 Semiconductors, 2 Network Management]

#### Summary

* Recommendations are focused on 1) semiconductors and 2) network management
* 1) Semiconductors:
  + coordinated activity across all semiconductor activities with a well-defined single point between four of the five critical technologies identified by DSIT: artificial intelligence, future telecoms, semiconductors and quantum technologies – could be delivered by the National Semiconductor Institute (Semiconductors 1)
  + Initiatives to ensure telecom operators develop resilience strategies to maintain critical national infrastructure in the event of sustained supply chain disruption, for example by holding stock (Semiconductors 2)
  + Initiatives similar to the US Trusted Foundry Program, whereby designers can be assured that their chip has not been tampered during fabrication - synergies with the Innovate UK Digital Security by Design (DSbD) programme (Semiconductors 4)
* 2) Network Management
  + UK long term Vision to develop and leverage AI/ Automation technologies to improve and facilitate the management of highly complex networks (NM 1)
  + Long term (20 year) strategy of how telecommunications enables the modern economy, not just the automation of itself, but also the facilitation and automation of all industries that will require telecommunications (NM 1).
  + Long-term (10 year+) strategy for improving the NM ecosystem in the UK covering development of homegrown NM specific skills, establishment of trusted methods for data exchange, open network management APIs and targeted investment in R&D and revenue growth facilitation measures (NM 1)
  + Facilitate the creation of a cross industry and research forum, to enable the sharing of knowledge, ideas, problems, and goals, to influence or create development and research areas (representatives from telecom networks, technology companies, universities, and other industries such as Energy, Health, Logistics, Transport, Finance etc.) Scope can include: a) co-creation of requirements from Health and Energy industries, maybe smart cities and network densification ; b) understanding the absolute requirements from customers and translate into specifications for telcos ; c) output form this is set of binding requirements e.g for robotic surgery or driverless cars.

##### Semiconductors

1. [Strategy] The EWG recommends coordinated activity across all semiconductor activities with a well-defined single point between four of the five critical technologies identified by DSIT: artificial intelligence, future telecoms, semiconductors and quantum technologies, recognising the central role of semiconductors in delivering the other three technologies. This could be delivered via the National Semiconductor Institute described in the IfM Semiconductor Infrastructure Study, acting as a central interface between government, industry and academia.

Rationale 1: The EWG applauds DSIT for publishing the National Semiconductor Strategy and establishing the Semiconductor Advisory Panel. However, there are concerns that support is spread across different organisations, including UKTIN, Quantum and AI, which is not fully coordinated. There is a need for a coordination function delivering a long-term strategy with funding, which does not need to match the scale of US or EU Chips Acts, but must be meaningful. This function would be responsible for innovation coordination, technology road-mapping and international partnerships, following the model proposed in the IfM Semiconductor Infrastructure Study. "

"2. [Supply chain] The EWG recommends initiatives to ensure telecom operators develop resilience strategies to maintain critical national infrastructure in the event of sustained supply chain disruption, for example by holding stock.

Rationale 2: Any supply chain disruption is likely to have serious implications for telecoms, similar to the 2021 disruption in automotive production due to a shortage of relatively basic semiconductors. It is improbable that UK companies could supply all telecom technologies and capabilities. However, as telecom networks form part of the UK’s critical national infrastructure, they are more important and warrant additional resilience and robustness. As future supply shocks might not pass quickly, there is a need for mitigation strategies, such as holding stock. "

"4. [Supply chain] The EWG recommends initiatives similar to the US Trusted Foundry Program, whereby designers can be assured that their chip has not been tampered during fabrication. This recommendation has synergies with the Innovate UK Digital Security by Design (DSbD) programme.

Rationale 4: Security of supply has an additional meaning: can the fab itself be trusted? The US is taking steps with its ‘Trusted Foundry Program’ and the UK should have a similar program. As this requirement primarily applies to CMOS digital logic, and less to UK compound semiconductor devices, it will need international cooperation."

##### Network Management

Rec 1 - UK long term Vision to develop and leverage AI/ Automation technologies to improve and facilitate the management of highly complex networks.

Back a truly long term (20 year) strategy of how telecommunications enables the modern economy, not just the automation of itself, but also the facilitation and automation of all industries that will require telecommunications. (reference HM Gov Wireless Infrastructure strategy here).

We believe we need a long-term (10 year+) strategy for improving the NM ecosystem in the UK covering development of homegrown NM specific skills, establishment of trusted methods for data exchange, open network management APIs and targeted investment in R&D and revenue growth facilitation measures.

To support this strategy for the future evolution of NM, we have detailed recommendations that could take advantage of opportunities available to the UK, strengthen areas of weakness, and counter emerging threats.

Rec 2 - Create a set of industry specific requirements

We are asking the government to facilitate the creation of a cross industry and research forum, to enable the sharing of knowledge, ideas, problems, and goals, to influence or create development and research areas. For example, a forum where representatives from telecom networks, technology companies, universities, and other industries (Energy, Health, Logistics, Transport, Finance etc.) work together to develop ideas and concepts that will develop Network Management capabilities for the wider benefit. Examples of the scope could include:

• co-creation of requirements from Health and Energy industries, maybe smart cities and network densification

• understanding the absolute requirements from customers and translate into specifications for telcos

• output form this is set of binding requirements e.g for robotic surgery or driverless cars.

##### Core

|  |  |
| --- | --- |
| Core Networking Technologies.2 | **Better investment choices** If the UK wishes to have sovereign telecommunications capability, how can the government set an audacious goal to create something that will bring value? An example would be IOWN in Japan, a network vision to create the Internet of the future and the core network technologies to underpin it. |
| Core Networking Technologies.3 | **Supporting Core Network and Services Research** There is a growing need for greater coordination across the UK academic community. While there are many great and globally recognised universities within the ecosystem, too few of these have had sufficient investment to allow creating sustainable value for the UK through, for example: This needs greater alignment with the industry and a greater focus on valuable outcomes. There are pockets of success (Lumenisity, for example), but not nearly enough. |
| Core Networking Technologies.4 | **Accelerate Transition from Research to Market** The UK market needs to be healthier. The current regulatory policies are driving fragmentation of the market, which is reducing scale and, thus, the buying power of the UK. · This will have a staggeringly negative impact on the UK market for decades and will not meet the government’s objective of being a digital communications leader. Crucially, the reason for Marconi’s failure was ultimately competitiveness; the UK operators needed lower-priced platforms, and Marconi could not deliver them. There needs to be flexibility and appetite to restructure the UK market and willingness to explore transformative even if controversial options such as the UK seeking to take a position as the ‘testbed’ where commercial concepts are tried out and then copied (sold) to other parts of the world. |

* + 1. IP, Patents, Data, etc

**5** [1 AI, 4 Wireless]

#### Summary

In the AI and Wireless EWGs, several recommendations pertain to data, IP, patents and tax credits

* Data
  + unified Data Accessibility Initiatives towards the goal of safely opening network data and facilitating data sharing for the UK telecom ecosystem (AI 3)
  + incentivise UK operators to make data on network deployments, network traffic, channel conditions, etc available to researchers (Wireless 10)
* Intellectual property
  + public-private partnership framework for intellectual property between the UK universities, research institutes, and smaller innovators and the global industry present in the UK and internationally (Wireless 23)
  + support UK universities and SMEs to apply for patents and help monetize these patents for example through licensing directly or indirectly (e.g. via patent pools). (Wireless 24)
* Tax Credits
  + Extend the qualified expenses to R&D Tax Credits to patent filing and pursuit (Wireless 30)

##### AI

3. Unified Data Access

Create unified Data Accessibility Initiatives towards the goal of safely opening network data and facilitating data sharing for the UK telecom ecosystem. "

##### Wireless

10. Incentivise UK operators to make data on network deployments, network traffic, channel conditions, etc available to researchers.

23. A public-private partnership framework for intellectual property between the UK universities, research institutes, and smaller innovators, on one hand, and the global industry present in the UK and internationally on the other hand, is recommended.

24. A UK fund should be created to support UK universities and SMEs in particular to apply for patents and help monetize these patents for example through licensing directly or indirectly (e.g. via patent pools).

30. Extend the qualified expenses to R&D Tax Credits to patent filing and pursuit.

##### Standards

|  |  |
| --- | --- |
| Standards.2 | **Intellectual Property Issues in Standards** An option that might be considered is to set up some form of investment bank (IB) sponsored by HMG/British industry, that would purchase such IPR (in whole or part). The IB could be in a better position to exploit (and defend) such IPR. This would effectively centralise the IPR exploitation of SME research for the most promising ideas. The IB could seek to make no profit or break even. This IB could then be used as a strategic vehicle to promote UK sovereign telecoms capability by building a pool of IPR that could allow UK industry to use and share any profits with the original SME IPR developer. Many configurations are possible, but the aim would be to offer an alternative option to the developers of UK IPR that could benefit the UK more widely. |
| Standards.3 | **General approach of Standard Development Organisations to Patents and IPR** Develop mechanisms to encourage inter-operability projects (similar to SONIC), and encourage these projects to identify standards shortcomings. Encourage integrators (e.g. network operators, 3rd party integrators etc) to share inter-operability issues found in UK deployments, particularly if including new or multiple vendors.  Develop mechanisms (potentially at international level) to provide a degree of feedback or rating of standards in terms of their proven interoperability.  Develop a formal framework to identify what is essential and what is optional within at least a subset of important standards. |

##### Core

|  |  |
| --- | --- |
| Core Networking Technologies.1 | **Scale** Many successful smaller companies, such as Lumenisity, are acquired by large international organisations (in this case, Microsoft Inc.). |
| Core Networking Technologies.2 | **Better investment choices** Initiatives should be pursued to: · Manage Intellectual property to maximise UK growth |

* + 1. Legislation, Regulation and policy

**5** [3 Wireless, 2 Non-Terrestrial Networks]

#### Summary

Wireless and NTN EWGs address legislation and regulation recommendations to the UK government and Ofcom:

* UK government
  + regulatory and legislative focus to enable economic network deployment, with a clear remit to help create the conditions for building UK capability (Wireless 3)
  + completing activity which has already commenced, notably the review of annual licence fees and swift and effective enablement of the Product Security and Telecommunications Infrastructure (PSTI) legislation (Wireless 4)
* Ofcom
  + Ofcom, supported by UK Government, must coordinate with UK-based industry consortia and companies to keep influence channels open towards Brussels (Wireless 28)
  + It is recommended that Ofcom engages in any future international discussions for the identification of suitable frequency bands and the development of appropriate technical conditions for NTN, supporting their broader harmonisation. That would avoid the risk of market fragmentation and allow NTN operators to deploy services more efficiently at a global scale. An early identification of frequency bands for NTN, would ensure speedy access to spectrum from the operators, encouraging an early uptake of systems using the new NTN standards (NTN R11)
  + It is recommended that Ofcom should be provisioned with a budget to create monitoring infrastructure suitable for ensuring compliance with future NTN systems (NTN R12)

##### Wireless

3. Relentless regulatory and legislative focus is required to enable economic network deployment, with a clear remit to help create the conditions for building UK capability.

4. The UK Government should ensure completion of activity which has already commenced, notably the review of annual licence fees and swift and effective enablement of the Product Security and Telecommunications Infrastructure (PSTI) legislation.

28. Ofcom, supported by UK Government, must coordinate with UK-based industry consortia and companies to keep influence channels open towards Brussels.

##### NTN

R11. It is recommended that Ofcom engages in any future international discussions for the identification of suitable frequency bands and the development of appropriate technical conditions for NTN, supporting their broader harmonisation. That would avoid the risk of market fragmentation and allow NTN operators to deploy services more efficiently at a global scale. An early identification of frequency bands for NTN, would ensure speedy access to spectrum from the operators, encouraging an early uptake of systems using the new NTN standards.

R12. It is recommended that Ofcom should be provisioned with a budget to create monitoring infrastructure suitable for ensuring compliance with future NTN systems.

##### Security

|  |  |
| --- | --- |
| Security.5 | The UK should attempt to take a longer-term strategic view on security in telecoms. The UK must consider how it can set out a longer-term agenda, without the uncertainty for industry presented by regular priority-shifts and changes in agenda. |
| Security.10 | In the longer term, there needs to be a better incentive for operators and vendors to adopt leading edge security measures, and invest proactively in security, |
| Security.11 | We suggest some areas for applied R&D, which should be focused on delivering real-world industry adoption and uptake of enhanced security measures as part of products and networks. |
| Security.7 | DSIT should explore how to introduce a “Critical National Infrastructure” (CNI) culture and mindset to the telecoms industry. |

##### Standards

|  |  |
| --- | --- |
| Standards.1 | **Policy and Regulation Aspects** Promote awareness of standards process and status / trends within universities, aimed particularly at early career telecom researchers or postgraduates (the first aspect through training, and the second via regular presentations and workshops). This could start with universities with existing commitments e.g. ETSI membership.  Encourage taught courses to include a standards awareness component.  Ensure that evaluation of new project proposals gives credit and weight to the evolutionary nature of the proposal (this applies to funding mechanisms within the UK).  Support UK universities willing to engage in standards (via similar or the same mechanisms as per SMEs).  Establish a sustainable framework for collaborative (University / industry including SMEs) pre-normative research projects with Universities taking a significant leading role.  This could include support for smaller nursery projects aimed at initial pairing with an industrial partner, with a view to future scaling of such initial collaborations (potential targeting Horizon or other projects). |

##### Core

|  |  |
| --- | --- |
| Core Networking Technologies.4 | **Accelerate Transition from Research to Market** The UK market needs to be healthier. The current regulatory policies are driving fragmentation of the market, which is reducing scale and, thus, the buying power of the UK. |

##### Academic SWG

|  |  |
| --- | --- |
| Academic SWG.1 | Long-term funding models for research in future networks |

##### Optical

|  |  |
| --- | --- |
| Optical and Photonics.8 | The UK should establish recognised security certification processes for quantum communication technologies to lower the barriers to widespread adoption by Government and industry, building as appropriate on initiatives underway in the UK and other nations to establish third-party verification standards. |

* + 1. Standards

**6** [3 Wireless, 2 Non-Terrestrial Networks, 1 Network Management]

#### Summary

Wireless, NTN and NM EWGs have produced several recommendations related to standards. These are:

* General
  + A managed and coordinated national approach is required to efficiently and effectively take the results of relevant UK 6G research projects into global standards bodies (Wireless 8)
  + A network for individuals working for UK universities, SMEs and regional offices of international companies to collaborate in standards organisations should be created (Wireless 25)
  + A selective approach should be taken to determining standards groups which are both impactful and cost-effective to support (Wireless 26)
* NTN-focused
  + UK industry should work with 3GPP and other relevant standards entities to ensure that end-to-end management plane capabilities, including trans-TN-NTN boundary continuity, are included in future standards (NTN R1)
  + UK industry should work to identify any gaps and limitations in the current standards that would slow down the mass adoption of NTN technology. The UK industry should take lead to lobby with the relevant standard and regulatory bodies on the urgency to fix these issues in order to keep up with the pace of business trends (NTN R2)
* NM-focused
  + Review UK telecom representation to international bodies for NM, this includes – 3GPP, O-RAN Alliance, IETF, ETSI, NEF, TMForum & Opensource Projects
  + Increase UK’s presence in standards bodies and align ‘UK Inc’ input to prioritise development of UK areas of strength. The UK should have a strong “set-at-the-table” in NM.
  + A particular focus should be on standardising interoperability between operator platforms and systems, multi-network domains and APIs including aspects of trust. Potential areas for focus are APIs and the extension of the RIC into a wider real-time management platforms. (all NM Rec 9)

##### Wireless

8. A managed and coordinated national approach is required to efficiently and effectively take the results of relevant UK 6G research projects into global standards bodies.

25. A network for individuals working for UK universities, SMEs and regional offices of international companies to collaborate in standards organisations should be created.

26. A selective approach should be taken to determining standards groups which are both impactful and cost-effective to support.

##### NTN

R1. UK industry should work with 3GPP and other relevant standards entities to ensure that end-to-end management plane capabilities, including trans-TN-NTN boundary continuity, are included in future standards.

R2. UK industry should work to identify any gaps and limitations in the current standards that would slow down the mass adoption of NTN technology. The UK industry should take lead to lobby with the relevant standard and regulatory bodies on the urgency to fix these issues in order to keep up with the pace of business trends.

##### Network Management

Rec 9 -Network Management Standards

• Review UK telecom representation to international bodies for NM, this includes – 3GPP, O-RAN Alliance, IETF, ETSI, NEF, TMForum & Opensource Projects

• Increase UK’s presence in standards bodies and align ‘UK Inc’ input to prioritise development of UK areas of strength. The UK should have a strong “set-at-the-table” in NM.

• A particular focus should be on standardising interoperability between operator platforms and systems, multi-network domains and APIs including aspects of trust. Potential areas for focus are APIs and the extension of the RIC into a wider real-time management platforms.

##### Security

|  |  |
| --- | --- |
| Security.4 | We recommend that DSIT continue their approach around standards influence |
| Security.6 | DSIT should consider adopting a long-term “security first” strategy towards all (including telecoms) standards, driven and funded by government, with particular focus on ETSI. ARM has demonstrated an interesting model through licensing of chip designs and other IP to the world market. Business models like this should be explored for the UK’s wider telecoms innovation. This model may also be a longer-term investable prospect for HMG. |

##### Core

|  |  |
| --- | --- |
| Core Networking Technologies.3 | **Supporting Core Network and Services Research** There is a growing need for greater coordination across the UK academic community. While there are many great and globally recognised universities within the ecosystem, too few of these have had sufficient investment to allow creating sustainable value for the UK through, for example: · sustained engagement with the IETF and other standards / industry bodies |
| Core Networking Technologies.6 | Many stakeholders across many standards bodies drive standards creation. However, at the heart of the standards process is the need to solve a problem either for network operators or to create a capability for network operators or vendors to monetise. Any state, organisation, or individual cannot control this collaborative environment, and any attempt to do so will likely drive standards in the opposite direction.  The UK needs to identify and support engagement in key network standards where there is a standardisation need that would aid R&D across UK industry and academia but at the same time be a strong and collaborative partner in any approach to working in standards. |

##### Academic SWG

|  |  |
| --- | --- |
| Academic SWG.8 | Provide stronger and consolidated support to academics for translation of research into patents, standards, start-ups, and university spin-offs. |

* + 1. Interdisciplinarity

**2** [2 Wireless]

##### Wireless

12. Universities should be encouraged to develop a multi-disciplinary approach to innovation in wireless networking, which includes software engineering, chip design, AI, business and commercialisation, for example.

35. The necessity for a security-focused Edge/Cloud interface underscores the importance of extensive academic research covering a spectrum from low to high Technology Readiness Levels (TRL) in the security perspective of 5G/6G networks. This involves bringing together interdisciplinary expertise for a comprehensive approach.

* + 1. Adoption

**1** [Wireless]

##### Wireless

54. Given the challenges of addressing public mobile markets, we should fully explore and support the potential for adoption routes via private, local and short range wireless networks for special applications and IoT, which are already more diverse and may offer faster and less restricted opportunities for adoption.

1. <https://uktin.net/whats-happening/resources?page=0> Individual reports can be located on this page by searching for “Future Capability”. [↑](#footnote-ref-2)
2. [<https://uktin.net/whats-happening/resources?page=0>](https://uktin.net/whats-happening/resources?page=0) Individual reports can be located on this page by searching for “Future Capability”. [↑](#footnote-ref-3)
3. https://www.gov.uk/government/publications/future-communications-technologies [↑](#footnote-ref-4)
4. [Introducing the AI Safety Institute - GOV.UK](https://www.gov.uk/government/publications/ai-safety-institute-overview/introducing-the-ai-safety-institute), https://www.gov.uk/government/publications/ai-safety-institute-overview/introducing-the-ai-safety-institute [↑](#footnote-ref-5)
5. https://www.gov.uk/government/publications/open-standards-principles/open-standards-principles [↑](#footnote-ref-6)
6. https://smart-networks.europa.eu/ [↑](#footnote-ref-7)
7. https://www.6g-ntn.eu/ [↑](#footnote-ref-8)
8. https://6g-ia.eu/6g-ia-working-groups/#vision [↑](#footnote-ref-9)
9. UK Gov’t, https://www.gov.uk/government/publications/uk-open-ran-principles/open-ran-principles [↑](#footnote-ref-10)
10. Nokia, ” Crack innovation in telecoms with four dimensions of openness” <https://www.nokia.com/thought-leadership/articles/openness/openness-drives-innovation/> [↑](#footnote-ref-11)
11. Cisco, “What is Network as a Service?”, https://www.cisco.com/c/en/us/solutions/enterprise-networks/network-as-service-naas.html [↑](#footnote-ref-12)
12. IBM “What is Infrastructure as a Service?”, https://www.ibm.com/topics/iaas [↑](#footnote-ref-13)
13. Nokia, “Network as Code”, https://www.nokia.com/networks/programmable-networks/network-as-code/ [↑](#footnote-ref-14)
14. Ericsson, “Transforming complexity into opportunity”, https://www.ericsson.com/en/ai/ai-in-networks [↑](#footnote-ref-15)
15. IEEE, “Trends, key actors and use cases in QKD technologies: an analysis of the research and innovation frontier using web-based methods” <https://ieeexplore.ieee.org/document/9882827> (a basic research view)

    Geant.org, QKD Concepts and Considerations”, <https://resources.geant.org/wp-content/uploads/2024/02/GN5-1_White-Paper_QKD-Concepts-and-Considerations.pdf>, (a networking view)

    Toshiba Corp, <https://www.global.toshiba/ww/company/digitalsolution/articles/tsoul/tech/t0203.html> (an industry view) ( [↑](#footnote-ref-16)
16. “A Survey of Post-Quantum Cryptography: Start of a New Race “, https://www.mdpi.com/2410-387X/7/3/40 [↑](#footnote-ref-17)
17. UK Quantum Computing Centre, “What is Quantum Computing?”, 2024, https://www.nqcc.ac.uk/what-is-quantum-computing/ [↑](#footnote-ref-18)
18. ITU-R, <https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2516-2022-MSW-E.docx> [↑](#footnote-ref-19)
19. The reports are stored at <https://uktin.net/whats-happening/resources>. Search in the page for “future capability report”. [↑](#footnote-ref-20)