UKTIN

Future Capability Paper

Standards for Telecoms

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EXECUTIVE SUMMARY

Telecommunications standards have been instrumental in enabling fast progress in many areas of day-to-day life, from e-commerce to smart homes, from video streaming to collaborative working. Today it is a statement of the obvious that many ecosystems would have evolved considerably slower without the opening of interfaces at many different levels in the telecommunications world. Standards definition is driven by innovation, but also fosters further innovation and evolution, as new requirements grow out from original or adjacent markets, and new players join the effort to improve and expand the supported functionalities.

Standards activities in telecommunications have grown today to take up a considerable part of the economic activity of the sector. Large multi-national standards organizations have been set up and have operated over a period of several decades, producing ever more sophisticated interface standards applied to a myriad of sectors, and contributing to the general success and progress of not just the telecommunications sector itself, but also of many other sectors that have greatly benefitted from these advances.

Activity in standards bodies can be seen as an indicator of the health of an ecosystem, as well a driver. Participation in standards pre-supposes development and innovation activities, which are usually linked to economic investment and a healthy order book. But standards participation also confers some advantages of its own, including the ability to shape future technology and in some cases generate income from licensing. To that extent, it is desirable to increase the involvement of UK industry, including SMEs, and UK academia in international standards, although it is clear that standards do not operate in a vacuum, and cannot per se drive the growth of the sector. In general, the underlying challenge for the sector is to increase the level of economic activity and investment in the UK, and to this end a number of mechanisms and actions are needed, many of which are topics of debate for different working groups of UKTIN.

Nevertheless, it is important to analyse the role and impact of standards and find mechanisms to foster further activity in this area, bearing in mind the virtuous circle alluded to above. To this end, the Standards Expert Working Group of UKTIN was initially formed in November 2023 and has worked in this analysis in the first half of 2024. This report contains the output of its work so far, specifically:

- Discussion of the general importance and value of standards,
- Detailed analysis of aspects related to the UK's influence in standards, with SWOTs for general aspects of UK participation, effectiveness of multi-vendor support and SME involvement.
- Further discussion of critical topics such as UK participation in standards, Policy and Regulation, relationship between UK R&D and Standards, Intellectual property issues,
- Discussion of future and emerging trends in standards including both technology and policy/governmental issues.

On the basis of these analyses, the EWG puts forward a number of recommendations, however it should be noted that these will require further development to derive a program of action. These fall into a few major categories:

- Increasing UK influence and participation
- Increasing standards education and skills in particular for SMEs and Academia
- Encouraging UK Government to help set future standards direction
- Addressing the future of Standards Essential Patents
- Encouraging greater inter-operability to help supplier diversification

Finally, the report also includes several informative annexes including high level information on the major telecoms standards bodies, links to useful resources, as well as details of some critical telecommunications areas where standards have had a major impact.

1/ INTRODUCTION

The Standards Expert Working Group (EWG) terms of reference require it to inform the UK telecoms innovation community about the value of standards and engagement with Standards Development Organisations (SDOs). The EWG also seeks to increase the engagement of the UK telecoms innovation community in the development and appreciation of standards related to the Telecommunications eco-system.

The members of the EWG were selected to be representative of a wide cross section of the telecommunications ecosystem with a focus and experience of standards. Members contribute their time freely, and participate in an independent capacity, not on behalf of their organisations. Contributing members are listed in Annex A.

The overall role of all the UKTIN EWGs is to:

- Inform a better-shared understanding of key technical issues through knowledge sharing, leading to increased use of testbeds and other facilities across the ecosystem;
- Drive increased confidence in the security and resilience of the UK telecoms infrastructure and supply chain development by connecting with a broad supplier base, aiming to remove dependency on high-risk vendors;
- Consider measures that will accelerate the development and deployment of interoperable and open interface solutions, as well as catalysing the telecoms diversification strategy.

The Standards EWG was formed in November 2023, and the current report was the main focus of the EWG's work in the first half of 2024.

The report aims to provide background information on standards activities in the UK and worldwide, as well as consider aspects where actions could be taken to improve the general influence of the UK and its industrial and academic sector, with particular emphasis on SMEs. Thus, an initial section presents a discussion of the general importance and value of standards, taking various perspectives into account. This section also signposts the interested reader to informative annexes, including high level information on the major telecoms standards bodies, as well as details of some critical telecommunications areas where standards have had a major impact. The annexes also include a discussion of standards education and a list of related resources.

Introduction

The report's main body focusses on aspects related to the UK's influence in standards. Multiple SWOTs were conducted at different levels of analysis including general aspects of UK participation, effectiveness of multi-vendor support and SME involvement.

These led to identification of the following areas for further analysis:

- UK Participation in standards
- Policy and Regulation Aspects
- Relationship between UK R&D and Standards
- Intellectual property issues
- Standards and Supply Diversification
- Engagement of UK SMEs in Standards
- Skills

Each of the above areas is treated separately, and where applicable recommendations are provided. These are later collected in a single section for ease of reading; it should be obvious to the reader that at this stage they are not meant to be orthogonal or to present a unified plan of action – which the EWG plans to address in a latter phase of work, taking further feedback into account.

While most of the report is focussed on existing SDOs and related issues, standards are never static – and often unpredictable. Thus, a final section discusses various critical future and emerging trends which should be taken into account when considering actions in this area.

2/ IMPORTANCE OF STANDARDS

2.1/ The value of standards to society

Standards are effectively tools for compatibility and interoperability. This ensures a common language for defining product, service and process requirements. The importance of standards to the telecommunications industry is evident in the success it has brought in the scale and interoperability of competing implementations. When separate functions, modules and implementation approaches become interoperable the ensuing network effects are evident in the economic value generated. The British Standards Institution (BSI) estimates that in total 23% of all UK GDP growth in the current century are attributable to the impact of standards and 38% of all productivity growth[1].

Standards act as a diffusion process for innovations, which spans from initial concepts and technologies through standardization to tangible business and eventually the adoption by intended end users. Radically new innovations have shorter time to market when suitable standards and regulation are already in place. Common test and measurement procedures, and reference performance indicators allow a fair comparison of products and solutions from different vendors. All of these are delivered through standards such as the Harmonised Norms in Europe.

Standards also benefit safety and sustainability in providing a basis on which regulation can impose constraints on products and services. Compliance with such regulation enlarges the potential market for a vendor's products and ensures fairer competition.

Standards are mostly about interfaces – the interaction between systems or components from different manufacturers. For example, BS 1363 specifies the plug on a piece of electrical equipment and the socket into which it fits. ISO 668 is one of a group of standards that allows manufacturers of shipping containers to be sure their product can be carried on trains, ships, and lorries worldwide.

Those standards have been widely implemented for decades, but there are many more that have sunk without trace. Successful standards tend to be those that fulfil a need that is recognised by most of the players in a market, and where those players get together to agree on the detail of the solution, such as (in both the examples above) the mechanical dimensions.

[1] The contribution of standards to the UK economy, A Cebr Report of BSI

2.2/ Benefits of contributing to standards: a vendor perspective

For a vendor, some of the benefits of actively participating in the standardisation process include

- Building a large sustainable ecosystem leading to growth and enhanced business opportunities.
- Potential to influence a specification, perhaps to align with own design or to meet the needs of your particular niche.
- Early sight of the specification, enabling tracking by development and early implementation (or even first to market availability).
- Understanding the background beyond the written specification – which is often as important as the text itself.
- Meeting with others in your market (networking with potential customers or partners, and better understanding your competitors).

In addition, active participants in standards typically propose their technology for adoption, which may also enhance the value of their IP portfolio. Policies regarding use of proprietary technology (including the adoption and disclosure of patent covered technology) differ between standards bodies and industry sectors. Further discussion of this aspect is addressed in section 4.4.

2.3/ A Service Provider Perspective

Technical standards are important for service providers, and getting involved in their development brings multiple benefits, for example:

- Participating in the development of standards allows organisations to influence the development of the technical specifications so that they include features to enable service providers to deploy their services with the required end-to-end quality & reliability as well as to provide new & innovative services to users.
- Technical standards allow interoperability between different manufactures/technology providers leading to the potential for more players to enter the market and therefore fostering competition. It also enables a given service to be deployed more widely across devices, and the increased competition leads to a potential reduction in cost for the service providers' operations. It also enables more choice of devices/services for users.
- Active participation in technical standardisation provides important expertise on how the technology works and very importantly its limitations. That knowledge and expertise is a valuable asset as it can inform the strategic decisions of a company, for example on technology roadmaps and investments.
- By gaining deeper knowledge of the technical standards, there are also important opportunities for the development and subsequent licensing of IPR.

2.4/ SME Perspective

Technical standards can be valuable for SMEs in additional ways from other organizations. For example:

- An SME may often be focusing on innovation in a particular subsystem and even if it does not participate in standards setting, it relies on interoperable interfaces to be able to interwork with other sub-systems or allow painless integration.
- Adoption of the SME's technology in standards (usually requiring active participation) has the potential to increase the intrinsic value of the business by a significant factor as well as provide some market advantage (since the SME has developed the underlying technology).
- Standards participation can be a cost-effective tool to increase the visibility and credibility of an SME. It may also provide the SME with early visibility of technology trends.
- SMEs may choose to participate to raise the profile of their business within the sector to the businesses there – for example by demonstrating subject matter expertise or particular skill in a technology domain by contributing to the standards.

Further discussion of SMEs in standards may be found in later sections of this document.

2.5/ Standards and Standards Developing Organisations (SDOs)

While the term 'standard' is used in different ways in different industries, in this report the term is used broadly and consistent with the way the term is defined by the World Trade Organisation (WTO) in the agreement on Technical Barriers to Trade (TBT[2]). In the context of this report 'standards'[3]:

- are voluntary as adherence to the standard is not mandated by law;
- cover a broad scope including specifications, rules, guidelines, best practices, etc.

There are many organisations which exist to develop standards, often called standards developing organisations (SDOs) which are of relevance to telecommunications. A list and short description of some of more important organisations is set out in Annex A of this report.

The scope and working methods of these SDOs varies considerably as does the way that the telecommunications industry uses the standards. For example, in many cases and especially where hardware development is needed, the industry will get together at a SDO to agree a specification and then create implementations of the specification which are then deployed into the network. However, it is also the case that a successful implementation can come first, and then the industry takes this already popular specification to an SDO to be published as a more formal standard. This is more often the case for systems whose implementation is software-based, which is a growing trend in the industry.

[2] Agreement on Technical Barriers to Trade
[3] Regulation (EU) No 1025/2012 of the European Parliament and of the Council of 25 October 2012 on European standardisation

In addition, different SDOs have different systems of membership and participation, and this also includes the way the SDO covers its costs. Annex A also includes a table detailing the membership and participation rules of the more important SDOs including the likely costs of participation.

Further, Annex B sets a number of 'standards success stories' including how specific SDOs have been central to the success of a telecommunications technology and how SDOs have organised to overcome the practical challenges faced by the industry. The first part of Annex B describes how the respective standardisation efforts were central to the development of both the mobile phone and the Internet. The second part describes the formation and operation of 3GPP setting standards for mobile where achieving global compatibility and roaming was a major challenge and formation and operation of the JPEG/MPEG SDO for the efficient encoding of images, audio, and video where managing access to intellectual property was a primary challenge.

3/ SWOT ANALYSES

3.1/ Introduction

This section presents multiple SWOT analyses related to different aspects of the telecommunications standards ecosystem in the UK. These were performed by the Standards EWG in order to identify aspects for further discussion to be addressed (and documented in the remainder of the document).

- Generic UK standards SWOT
- Supplier diversification and standards SWOT
- SME Standards Engagement SWOT

Although there is some obvious overlap between the three SWOTs, the goal is to allow separate focus on the two latter topics (supplier diversification and SMEs) in respect of standards.

The generic SWOT is also discussed in this section, while further discussion of the two additional areas is addressed in dedicated sections later in this document.

3.2/ UK Standards SWOT

A generic SWOT analysis for the position of the UK in international standards is provided below. There are two slightly different perspectives in which the above analysis can be framed, and this should be borne in mind in the follow-up. The first is the objective ability of the UK to shape standards along what may be seen as explicit UK-defined objectives (e.g. as stated by regulators or government, even if shared with other like-minded partners). The other perspective is the ability of the UK telecoms ecosystem to contribute, influence and shape standards in a general sense. The two perspectives may often be connected; insofar as the ecosystem is sensitive to explicit UK objectives, their advancement should broadly benefit from the UK ecosystem's relative strength in international standards organizations. However, such strength is a worthwhile goal in itself, since it can be seen as a proxy for the vitality of the ecosystem and more generally for the economic contribution of the sector.

Hence the analysis is biased towards the second perspective.

Strengths	Weaknesses
• Existing depth of technical expertise • Existing strength and numbers of UK-based standards experts • Research in the University sector. • Dynamic telecommunications ecosystem • Natural go-between between regions (Europe and US or Asia) • Language • Geography and time zone • Increasing participation of UK government departments or agencies in SDOs	• Lack of large-scale companies with ability to sustain multi-year commitments. • Reduced design and system engineering base. • Relative size of UK's home market • Limited historic involvement of UK academia in standards • Distinction between UK delegates and companies • Excessive focus on Standards Essential Patent (SEP)
Opportunities	**Threats**
• Setting up pre-standards collaborative organizations • Driving pre-and post-standards testbeds and standards-track implementations • Support growth of related activities in UK academia • Support meta-specification activities. • Early visibility of pre- or initial standards work by regulators and government agencies. • Continued focus on improved telecoms services for the UK population. • SEP generation via next gen activities and participation • Recruitment of world class experts	• Standards agenda dominance by regions with largest operators and largest vendors (US, Asia) • Standards fragmentation • UK-specific implementations or de-facto standards • Reduction of language advantage • Diminishing number of UK standards experts

3.2.1/ Strengths

Existing depth of technical expertise: organizations based or operating in the UK have often been crucial in the pioneering and adoption of new technologies, including both operators and vendors. This has tended to create and sustain new generations of experts in innovative or complex areas in telecommunications (for example, the early development and deployments of cellular radio, more recently areas such as cybersecurity).

Existing strength and numbers of UK-based standards experts: historically, in many standards groups the number of UK-based experts has been arguably higher than you would expect based on e.g. per capita, or telecoms GDP criteria. For example, the largest number of ETSI members are UK based and UK ETSI delegation is considered to be the largest and most influential. A similar observation may be made for the number of such experts in leadership positions (e.g. group chairing, work item leaders, etc). This could be considered a natural consequence of other primary strengths listed here.

Research in the University sector: the UK has a long tradition of innovation emanating out of its University sector, including both blue sky and shorter term industrially linked activities. Over time, this has tended to generate many experts that eventually become engaged in the standards area, comprising both contributors and standards leaders. UK universities also have a significant pull factor on talent at many different levels from other countries or regions.

Dynamic telecommunications ecosystem: with its early adoption of market liberalisation in the 80's, the UK has developed a rich ecosystem that also calls for emphasis on inter-operability at early stages of new technology deployment, for example the standards published by Network Interoperability Consultative Committee (NICC) (and its impact on global standards), JOTS[4], etc. This also leads to the need for live testbeds or early deployments of new technology where the UK has a rich history, with significant examples today with O-RAN related trials and deployments by operators as well as live testbeds (SONIC[5], UKTL[6]). Parts of the ecosystem have also shown the capability to act as a group e.g. establishing pre-standards fora.

Natural go-between between regions (Europe and US or Asia): the telecommunications industry in the UK has been outward looking for longer than most, and this has enabled the UK to learn and apply learnings from experiences in different regions, build consensus where needed etc. The presence of international companies in the UK is a further contributor to this aspect.

[4] Mobile UK Joint Operators Technical Specifications
[5] SmartRAN Open Network Interoperability Centre (SONIC) Labs Case Study
[6] UK Telecoms Lab

Language: English is in most cases the language of choice in SDOs, and in the past this has often resulted in strong formal or informal influencing roles for those using English as their day-to-day work language, including UK based experts. Although each SDO has specific vocabulary and/or language conventions, in general both the writing and interpretation of technical specifications tend to be easier for English speaking experts. This advantage could also be argued to extend to procedural aspects. Further, this also makes it easier for UK organizations to recruit overseas experts since there is no significant language barrier.

Geography and time zone: in the case of physical meetings, the UK's geographical position allows for relatively limited travel times, and possibly costs (compared for example to travel between US and many locations in Asia, and vice-versa). In addition, UK airports provide excellent and varied connections which can be very delegate and budget friendly. Even for virtual meetings, it is often difficult to avoid the mid-day Europe timeslot if US, Asia and Europe delegates are involved. These factors tend to encourage location of groups in Europe – and also specifically in the UK – provided of course that they are not countered by other issues.

Increasing participation of UK government departments or agencies of in SDOs: direct participation of UK government departments or agencies (e.g. DSIT, Ofcom) can have a significant impact in socialising higher-level policy goals and influencing directions in a "soft" manner. Often the stated interest of a non-vendor actor (particularly at national level) can be a critical influencing factor in standards discussions between vendors in SDOs.

3.2.2/ Weaknesses

Lack of large-scale companies with ability to sustain multi-year commitments: this applies particularly (but not exclusively) to the vendor sector. UK operators do have a strong and continuous presence in many SDOs, but typically they have limited standards resources and their coverage tends to be sparser across the board than some of the larger operators in the US, China, Japan, or Korea. On the other hand, SMEs do not necessarily have the funding, motivation, or expertise to engage in a complex multi-year process[7].

Reduced design and systems engineering base: engineering development of integrated telecommunication products as supplied to network operators is now mostly performed outside of the UK, meaning the stronger UK SME sector must supply to non-UK based companies and UK network operators purchase from these non-UK based companies. Over time, the industrial engineering base in integrated product has reduced (including cases of initial inward investment). As standards are closely associated with the integration step, involvement in standards has tended to diminish as a result. While the rise of network functions virtualisation (NFV) (largely a UK initiative) should, in principle, simplify the integration of software components supplied by SMEs, this has not as yet emerged as a significant feature in the supply marketplace and the issues of integration largely remain.

[7]See section 4.6 for SME focussed discussion.

Relative size of UK's home market: when compared to the USA, China or even Japan, the UK's telecoms market is somewhat smaller. Importantly, the UK has not been big enough to attract a significant R&D presence in the UK by a major systems supplier. There are of course many mitigations within the existing strengths, but by definition its influence on standards as a single player is limited by this factor. This impacts for example the ability to define UK-specific standards requirements (e.g. based on regulation, or spectrum aspects) without international coordination. It also impacts the ability of new players to be nurtured and grow significantly starting from protected or niche / emerging areas, which means that such new players tend to be too small to influence standards.

Limited historic involvement of UK academia in standards: there are relatively few cases of direct or even indirect engagement of the UK university sector in standards. The sector's awareness of standards is typically good today, but its research has often not translated in applicable technologies in standards. It is also difficult for academia to make the long standards journey from selecting and developing ideas to patenting technologies and finally going through the arduous standards process.

Distinction between UK delegates and companies: one might walk into some standards meetings and come out with a distorted impression of the UK's influence, as many delegates are UK-educated or UK based – however they may be based abroad, or otherwise have weak linkage to UK ecosystem activities even if UK based. This suggests that the UK ecosystem has been producing high quality experts but does not necessarily contribute to the overall influence of the UK telecommunications ecosystem in standards bodies. This view may also be biased towards those bodies that the authors of the paper are involved in. In other bodies and in the open-source space, there are British organisations and SMEs outside of the telecommunications sector that participate in key work items (for example in the internet domain). There is a disconnect between these individuals and organisations that operate at a primarily global level and the UK community which may take a more parochial view towards standards and their level of influence within the global community. More efforts should be put into reducing barriers and increasing communications between these communities of interest.

Excessive focus on SEPs: not all standards patents are SEPs, and equally not all innovation results in patentable output, for a variety of reasons. An exclusive focus on SEPs as a metric may be counter-productive as this becomes a very high barrier to justify sustained investment in standards; it can also result in negative perceptions by other players in SDOs.

3.2.3/ Opportunities

Setting up pre-standards collaborative organizations: the UK should continue to strengthen these activities, which typically are formed around a market theme that creates requirements and will filter downstream into standards.

Driving pre-and post-standards testbeds and standards-track implementations: activities that pre-date the completion of a standard can generate learnings and/or innovations which may be directly applied to the standard. Equally, initiatives related to inter-operability testbeds should be encouraged as these are often triggers not only for standards correction, but also for new developments in SDOs (today for example there is an opportunity to apply any learnings of SONIC and UKTL in this direction).

Support growth of related activities in UK academia: this existing strength can be further built on, through targeted funding mechanisms, and support for improved linkage to standards development efforts.

Support meta-specification activities: standards do not define everything, and in the UK telecoms marketplace, it is important to encourage initiatives that improve inter-operability and market capability by drawing up “voluntary” meta-specifications in cases of interest. A good example is neutral host / JOTS. Such activities augment UK expertise that is often applicable to further standards development.

Early visibility of pre- or initial standards work by regulators and government agencies: new technologies give rise to new standards or developments of existing standards, often changing the regulatory and policy landscape. This creates a continuing need for the regulator and/or policy agents to pro-actively monitor upcoming inflection points (which may be visible in pre-, or early standards discussions), and interact with the technical and commercial community at an early stage to ensure that legal, policy or regulatory framework changes are considered in a timely manner.

Continued focus on improved telecoms services for the UK population: driving improved availability of high-quality services, or innovative capabilities and features, will create opportunities for innovation that will tend to translate into standards leadership.

SEP generation via next generation activities and participation: new iterations of telecoms standards (or new standards) enable new SEPs which could add to the value of companies in the UK ecosystem, and the influence of the UK ecosystem as a whole. This implies the need to incentivise the ecosystem to take part in the early design of new generations of the standards, or even to create new standards.

Recruitment of world class experts: the UK environment, international outlook and use of English provide an opportunity for successful competition for the best experts in fields related to standards (in academia or elsewhere). Note also the advantages afforded by geography and time zone as discussed above.

3.2.4/ Threats

Standards agenda dominated by regions with largest operators and largest vendors (US, Asia): larger players are able to dedicate greater resources to pre-standards research as well as standardisation itself and sustain this over the long term. This can lead to focus on other regions' requirements, and typically this also results in the related accumulation of SEPs (either because the work items do not justify investment in the UK, or because such players have anyway pre-standards IP). It should also be noted that SDOs have limited bandwidth, and any specific item removes or takes time away from other items.

Standards fragmentation: there is currently a risk that due to geopolitical and other factors, some standards may start fully fragmenting or creating regional versions with reduced inter-operability. This would reduce market opportunity, increase barriers to entry and growth for UK companies, increase costs for UK operators and reduce the value of any IP portfolio.

UK-specific implementations or de-facto standards: UK specific market requirements should wherever possible be handled in the context of a standards compliant framework, and UK specific aspects could be candidates for further standardisation (formally in SDOs or informally via pre-standards organizations). However, there is always a danger that UK-only de-facto specification without associated international cooperation leads to significant market size reduction and inefficiency – even if it increases entry barriers to outsiders.

Reduction of language advantage: internationally, as more people globally learn English and speak it very effectively, the natural advantage of being a native (or quasi-native) English speaker is diminishing. Moreover, an international audience tends to create its own version of technical English which slowly absorbs the procedural and technical vocabulary and eventually becomes the "lingua franca" in the working group or SDO. At least in large companies, this is further diffused via the research and back-up teams.

Diminishing number of UK standards experts: many respected UK standards experts are at the late-career stage. this is partly a consequence of the size of the cohorts that started out around the time that GSM was designed and later ETSI was formed and following years of standards expansion – including 3GPP. Thus, it may not apply to all relevant SDOs. Nevertheless, it does appear that there is a danger of losing net experience in standards even if new generations are coming through gradually. Within specific organizations, the main impact is the loss of informal support and mentorship networks.

3.3/ Supplier Diversification SWOT

The following SWOT analysis considers supplier diversification in the UK, with focus on the development of full multi-vendor support in standards.

The analysis concentrates on mobile networks since this is the area where supplier diversification is currently of most interest.

Discussion of supplier diversification aspects of standards is addressed in section 4.5.

Strengths • Network operator focus / interest • Actual deployments of distributed RAN in UK • Growing standards focus (O-RAN filling 3GPP gaps) • Sonic labs work on integration testing • Support of smaller vendors facilitates diversification (standards and/or integration work)	**Weaknesses** • Standardization of interfaces critical to multi-vendor is still driven by major / legacy players • Shortage of UK-based telecom vendors • Network management is often a key obstacle (Network management may be linked to vendor specific hardware or features) • Additional integration difficulties with AI • Not all operators are set up to do in-house integration • 3GPP standards do not cover intra-network interop testing in general • New vendors need to demonstrate performance for every MNO (costly and time consuming) • Multi-vendor solution does not necessarily perform better (KPIs, features, cost) • Operators may still tend to procure from large vendors / integrators (due to lower costs / higher level of confidence etc.)
Opportunities • Early implementations including inter-op collaboration can be used to drive standards. • Contributing to standards by smaller players in emerging areas (6G, AI in RAN) allows companies to develop products earlier, and increase focus on inter-operability in SDOs at an early stage. • Opportunities for collaboration with other country's research labs • Opportunity to take feedback from SONIC labs into standards • Shift in mindset towards more plugfests and interoperability • Use of open source where applicable.	**Threats** • Proliferation of options: SDOs promote multiple or different Split Options and/or different interfaces in other domains that will divide the market • Lots of organisations attempting to clarify/profile 3GPP (O-RAN Alliance, GSMA, TIP etc.) risk adding to the fragmentation instead of mitigating it. • Proliferation of options results in difficult interoperability, and large vendors dictate the dominant subset of options. • Radio Resource Management (RRM)-related standardization as part of RAN(Radio Access Network) Intelligent Controller (RIC) is difficult (tied to specific vendor features) • Third party integrator introduces another link in the supply chain; 3rd party may take safe option and elect to work with established players. • Successful open-source projects often have strong lead from one company.

3.4/ SWOT for SME Engagement in Standards

The following SWOT analysis considers aspects related to engagement of UK SMEs in standards.

It is acknowledged that many SME business models in telecoms have no requirement for standards involvement and/or no requirement for patent activity. On the other hand, there will always be a cohort for which standards and IPR have potential significance. The following SWOT is aimed at this group.

Discussion of SME standards engagement aspects is addressed in section 4.6.

Strengths • Growing database of SMEs involved in telecoms supply • Good match between SME innovation and telecoms architectural changes/disruption • Split architecture enables SMEs to focus on smaller elements • UK universities successfully spawning new startups • Many SDOs have lower fees for SMEs.	**Weaknesses** • SME boards and investors do not always understand the potential value of standards (or see it as too high risk/low priority) • Tight SME budgets (e.g. this month's payroll) mitigating against long term standards participation. • Initial cost and learning curve. • Standards involvement may happen only after the fact and thereby too late to make a difference. • Temptation to concentrate on product development in a silo • Many SME product focus is at 'sub-component' level • SME IPR is not typically standards essential (protecting implementations etc.)
Opportunities • Demonstrate that standards have led to products getting to market faster and with fewer faults at launch, overall reducing costs for SMEs. • Change perception that standards stifle innovation. • Ownership of SEP(s) by an SME gives strong valuation uptick • Standards participation gives competitor intelligence and can help with access to large base of potential customers (soft marketing). • Opportunities for networking and finding contacts at standards meetings. • Work collaboratively to have an influence / impact: collaboration between SMEs active in different parts of a space to standardize a framework. • Opportunity to create a UK SME 'standards body' from scratch to specifically meet their needs. • Support for sustained championing of a submission through 3-stages of the standard. • Additional activity and growth of UK-based standards expertise.	**Threats** • Larger vendors have no incentive to make it easier for SMEs to participate. • Complex or fragmented standards make it harder for small players to participate (increased cost/risk). • Negative perceptions about speed and ROI dominate, so relevant SMEs do not participate. • Increasing domination of companies head-quartered elsewhere (including former UK SMEs). • Enhancing external profile (via standards participation) triggers licensing demands from large patent holders. • New support mechanisms fail to target future start-ups.

4/ ISSUES ARISING FROM SWOT ANALYSIS

4.1/ UK Participation in Standards

Whilst it is not realistic to survey the participation of UK delegates in every standards body, it is useful to gather some data from a few sample organizations. Here we consider four such organizations with widely different scopes, i.e., 3GPP, ETSI, O-RAN, and the SCF.

4.1.1/ 3GPP

3GPP is currently organized into three main areas or Technical Specifications Groups (TSGs), i.e., core network and terminals (CT), radio access networks (RAN) and service and system aspects (SA), each of which has a number of technical working groups. Details of 3GPP and its structure can be consulted at www.3gpp.org.

UK participation level

As discussed in the SWOT section, there is a view that the 1990's probably saw a high point in the UK's influence in mobile standards due to factors such as:

- Innovative and first-to-market activities by operators, many of whom achieved various world firsts in terms of trial and deployment of 2G and 3G.
- A good number of companies setting up product development in the UK (including for example Lucent, Motorola, Nokia, Ericsson, Nortel, etc.), often with significant research segments and associated standards staff.
- Additional activity by SMEs and start-ups covering areas such as chipsets for mobiles, network management and optimization, deployment and logistics etc.

As a result, in the early days of mobile before 3GPP was established, UK based industry had a very significant influence on the mobile standards committees in ETSI, including a number of leadership roles as well as high contribution levels. This level of influence continued to some extent into 3GPP, although the wider scope of participation from other regions tended to change the balance. As discussed in the SWOT, over a period of time the above factors may have weakened, not least due to some reductions in UK-based product development for mobile networks.

It is then useful to check the current levels of participation in the three largest working groups, namely RAN1, RAN2 and SA2. Note that this analysis has many 'noise factors', but it is expected that many of these would cancel each other out given the size of attendance.

Considering first regional worldwide distribution, the figure below provides the relative participation of experts in RAN1 (physical layer), RAN2 (Layers 2/3) and SA2 (system architecture) in their February 2024 meetings, using the list of physically attending participants. These three groups are probably the groups of most interest in terms of SEP technology in 3GPP (with possible exception of codec technology in SA4). Note that the data is based on the actual home location of the participants which is an interesting snapshot indicator of related R&D sector activity (as opposed to the headquarters of the companies that hire them).

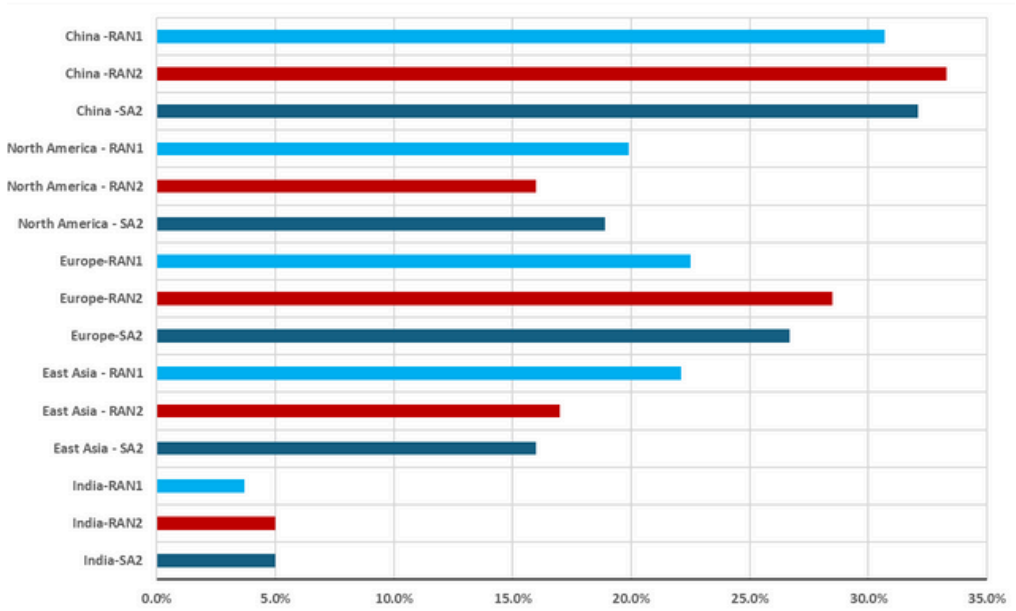

Fig.4.1-1 Relative participation per region, 3GPP working groups RAN1, RAN2 and SA2, February 2024 meeting.

It is known that meeting location does have an impact on attendance, as typically the delegation of the home regions sees an upwards spike. In this case the location of the meeting (Athens) is slightly more advantageous for Europe than Asia, and certainly less convenient for North America – and particularly West Coast based attendees. Nevertheless, an interesting aspect from this data is the slightly greater proportion of Europe based delegates in the higher layer groups compared to physical layer.

Within Europe, the distribution of the major participant countries is shown in the graph below (numbers should be taken as indicative due to uncertainty levels becoming more significant):

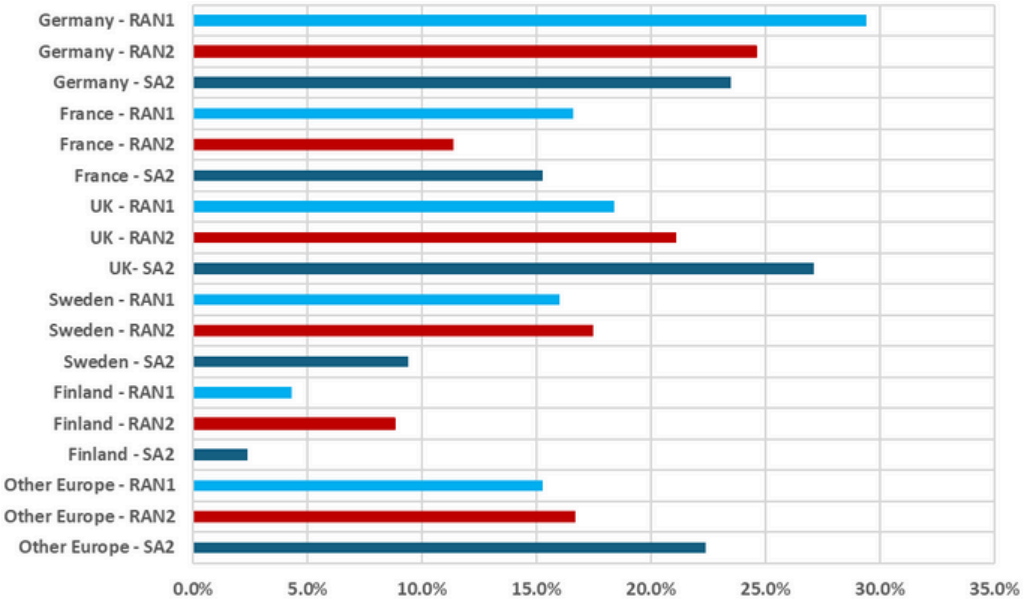

Fig.4.1-2 Relative participation per country as a proportion of total European delegation, 3GPP working groups RAN1, RAN2 and SA2, February 2024 meeting.

Interestingly, some of the European higher layer participation increase is indeed contributed by the UK (the remainder appears to result from a more geographically distributed set of delegates within Europe for higher layers). Further analysis of the UK participation shows that a very high proportion represent companies headquartered outside the UK including MediaTek, Sony, Nokia, Ericsson, Samsung, Intel, Qualcomm, Huawei, Apple and others. Notable exceptions include network operators including satellite.

Apart from the bias towards higher layer and systems, one interesting difference between the UK's distribution and some of the others is that (with a few exceptions) the numbers are relatively small (usually 1 or 2 at most) per company and working group, suggesting that perhaps the locally based R&D is not as deep as in other cases. Finally, there is very little UK SME or University participation. Typically, such participation, if any, tends to be at a very high level in workshops for feature releases or very detailed such as testing.

UK Membership profile

There are in total 2,343 individual members of 3GPP, out of which the UK membership stands at 56 (i.e. around 2.4%). Less than half of these (around 23) are headquartered in the UK, i.e. most of the members are as expected international companies with UK presence. Out of the UK-based group, one university can be identified, and no more than 7-8 SMEs. Large UK-based members are mainly telecoms operators.

Some international companies with UK memberships include (for example) Apple, Ericsson, Huawei, Intel, Interdigital, Keysight Technologies, LG, MediaTek, Motorola Mobility, Motorola Solutions, NEC, Nokia, Qualcomm, Samsung, Sony, Toshiba, Verizon and Viavi. This list tends to tie up with the data on individual participants in WGs.

Snapshot of leadership roles

At the time of writing, and to the extent that it is possible to determine this with any certainty, there are 2 elected officials that are UK-based, both in the Service and Systems Aspects (SA) area, and including one chair (SA2) of one of the most important groups. There are currently 55 elected officials (including both Technical Specification Group and Working Group level). Leadership positions give direct access to discussions on the organisational structure, work schedule and work prioritisation.

Coordination aspects

To our knowledge, there are no UK specific coordination mechanisms (i.e. similar to ETSI). It is also arguable whether such mechanisms would be useful or viable given that most UK participants attend on behalf of multinational companies with variable UK presence. Of course, there may be common interest in some cases partly dictated by the market, operator requirements, regulation, etc.

4.1.2/ ETSI

ETSI was formed in 1988 as part of the effort to establish pan-European telecoms supply and level playing field under the EU single market. ETSI is today a large organisation which is a partner in 3GPP and OneM2M, as well as hosting a large number of technical committees covering virtually all aspects of telecoms. ETSI also supports "Industry Specification Groups" (ISGs) with bespoke constitutions, and which may include non-ETSI members.

ETSI provides 3GPP's administrative and logistic support, and many of 3GPP procedures were based on, and evolved from ETSI's[8].

UK participation level

Given the size and diversity of ETSI, it is rather difficult to generalize, however our understanding is that the UK's participation has been and remains significant. A reflection of this can be seen in the fact that the UK delegation at the General Assembly is typically the largest one.

UK Membership profile

There are over 850 ETSI members worldwide. The distribution of memberships (for the countries with highest number of members) is as follows[9]:

Germany	143
UK	111
France	98
USA	57
Spain	41
Sweden	38
Italy	36

[8]For further detail on ETSI's activities and procedures, refer to http://www.etsi.org.
[9] ETSI Membership

Going one step deeper, the 111 UK members are classed as follows by ETSI (noting that the classifications are not orthogonal, i.e., some members fall under multiple tags):

Micro enterprises	15
SMEs	11
Trade associations	2
Not for profit user associations	3
Consultancy company / partnership	1
Manufacturers	38
National Standards Organizations	1
Network operators	9
Other	6
Other governmental body	8
Research body (private)	6
Research body (public)	2
Service provider	12
University	8
User	6

Although there are significant overlaps with 3GPP membership (for example, many of the manufacturers and network operators are also 3GPP individual members), it is clear that a number of member types participate in ETSI which are not seen in similar numbers in 3GPP. This includes micro, small and medium enterprises, universities, and also service providers. This reflects the lower barriers to entry and continued participation in ETSI, as well as the wider remit of its standards.

Snapshot of leadership roles

The graph below provides an estimation of the distribution of leadership roles per country of residence, to the extent that this can be gleaned from the ETSI data. A leadership role has been defined as either a chair or vice-chair in a Technical Committee or Industry Specification Group, or to subcommittees / working groups.

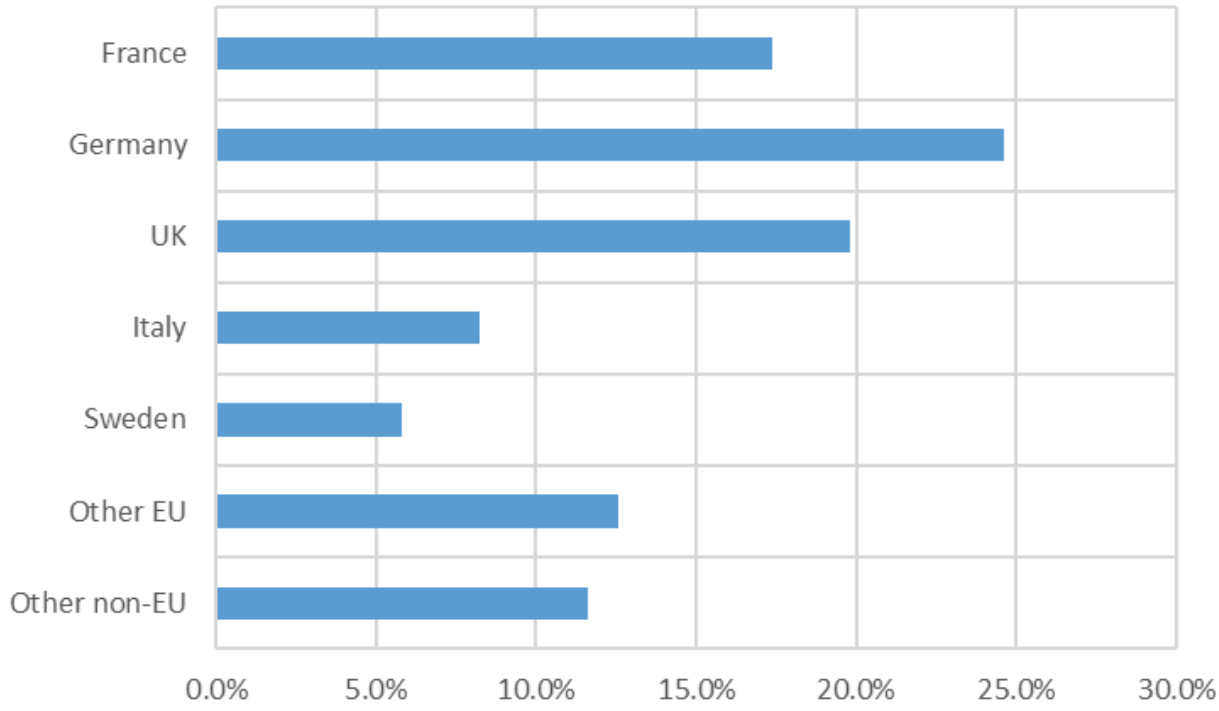

Fig.4.1-3 Estimation of the distribution of leadership roles per country for Technical Committee or Industry Specification Group

Interestingly, the relationship between the top three European countries in terms of leadership roles bears some similarity to the distribution of memberships.

4.1.3/ O-RAN Alliance

The O-RAN ALLIANCE was founded in February 2018, and its stated mission[10] is "to re-shape the RAN industry towards more intelligent, open, virtualized and fully interoperable mobile networks". O-RAN publishes specifications covering a wide range of interfaces in the RAN, which may be considered as complementary to those of SDOs, particularly 3GPP. Some of O-RAN's specifications have become ETSI standards.

UK participation level and membership profile: the available data is not as comprehensive as in the above cases. However, it is noticeable that UK operators are part of the "operator members" (BT and Vodafone). Contributors include some UK SMEs (Picocom, AccelerComm), plus e.g. ARM, Digital Catapult, NCSC and OFCOM. In addition, there are several UK University Contributors (Bristol, Glasgow, York and Surrey, as well as King's College). Attendance of some UK-based contributors working for international companies is also noticeable (e.g. VIAVI, Cisco, Keysight).

[10] ORAN.org About Page

4.1.4/ Small Cell Forum

Originally formed in 2007, the Small Cell Forum[11] is an industry body which looks to ensure interoperability for small cell systems. Benefiting from the nascent set of UK SMEs that were bringing small cell solutions to market, such as IP.Access (acquired by Mavenir in 2020), Ubiquisys (acquired by Cisco in 2013), 3Way Networks (acquired by Airvana in 2007), as well as Picocom, SCF paved the way in defining the original 3GPP Iuh standard[12] for the interface between the small cell and the small cell gateway, as well as more recently the Open6 initiative for defining an open multi-vendor split between the small cell RU implementing the physical layer and the virtualized small cell MAC layer.

As indicated above, while not being strictly an SDO, the SCF publishes specifications (e.g. FAPI[13]) as well as being involved in other activities such as production of white papers, organization of the Small Cell World Symposium, etc. From a UK participation viewpoint, the SCF is an interesting model of an industry body where players of varying sizes (many of which have been UK based) have come together to draft inter-operability specifications in areas of common interest. This type of environment enables like-minded companies including SMEs to make progress while not precluding eventual translation into 3GPP or other standards at a later stage. It also facilitates marketing activities which raise the profile of the outputs of the forum, its contributing companies, and the associated industry trends.

4.1.5/ Discussion & Recommendations

The overall landscape varies considerably but there are some common themes. In general, influence by UK based participants in standards bodies is high in areas where there has been significant past focus and where sustained presence has allowed experts to develop both technically and in terms of international credibility, and standards process skills.

However, in sheer numbers, there is no evidence that the UK is punching above its weight across the board.

Standards participation can be seen as one indicator of the health of the telecommunications industry, and in that sense the relatively low presence of SMEs and the relatively small numbers of strong UK based industrial R&D groups is a matter of concern. The same could be said for universities, although direct intervention by universities in the standards process is not necessarily critical[14].

[11] Small Cell Forum
[12] 3GPP TS 25.467; UTRAN architecture for 3G Home Node B (HNB); Stage 2
[13] 5G FAPI specifications
[14] The relationship between standards and University research is considered in a later section.

On the other hand, there is very considerable activity in innovative post-standards deployment, or in ancillary products and services, and such activity does not necessarily require standards participation. In other words, there are large markets for telecommunication products and services that are somewhat dependent on the standards setting process in the sense that its building blocks and capabilities evolve based on standards, but their core business does not call for standards participation. Such sectors can be quite vibrant and profitable without necessarily any reflection on standards activities

Thus, in many cases tracking of relevant standards will be sufficient; while in others there may a justification for a specific targeted involvement, but without long-term commitment.

Nevertheless, standards will continue to play a major part in the value chain, at least in two ways:

- Significant players set the tone, timetable and details of the standards, and effectively modulate the overall market (including the system architecture and the timing of its major step functions) to their customer requirements and internal development. They will be best placed to be first to market and also to create barriers to entry.
- Significant players generate the bedrock of innovation and IPR that the rest of the ecosystem relies upon, and logically expect some level of return; and minor players can use the same strategy in niche areas.

So, standards participation can be seen as both an indicator and a booster of economic activity in telecommunications. From that perspective, maintaining and possibly increasing standards participation and focus by UK-based companies is a desirable goal.

Possible ways to achieve this are set out below. They address different aspects and are not presented in a specific order.

- Incentivise international companies to locate R&D groups in the UK (whether or not linked to product development), and particularly including standards (how to do this is outside the scope of this document but could include targeted tax credits or non-financial support in terms of training, immigration etc.).
- Facilitate relocation of international standards experts to UK (similar to above but including individual incentives as appropriate).
- Hold light touch coordination fora to bring together standards and technology experts based in the UK working for UK-linked companies/operations, 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.)

- Create mechanisms to enable initial standards participation by universities and smaller players. This is further discussed in a later section, but two possible models are:
  - By providing incentives to UK based SMEs e.g. grants for standards memberships, loans linked to standards attendance etc.[15]
    - For example, a scheme of competitive grants to cover at least partially the costs of standards participation projects with well-defined objectives and timeframes.
  - By setting up a single over-arching organization with participation in selected SDOs (insofar as a particular SDO membership/participation rules allow[16]) and use this to support direct participation (if needed) by member companies, or indirect participation (in the latter case, this would include a skeleton standards staff to provide "glue" in the most important groups and coordinate participation and strategy)
    - NB: it is assumed that growing organizations would eventually "graduate out" of this scheme.

4.2/ Policy and Regulation Aspects of Standards

The role of government and government related bodies in standards and more recent significant interest taken was noted in the SWOT as both a current strength and future opportunity of the UK.

In this section we consider only the particular role of government in formal 'de jure' standards which have some form of statutory requirement. We note that these represent a small proportion of all standards in telecoms (taking the broad meaning of 'standards' described in section 2).

4.2.1/ European Context – State of Play

ETSI, CEN and CENELEC are officially recognized as European bodies for standardization. A part of their work is based on mandates from the European Commission. In order for a standard from one of these SDOs to become a harmonized Standard it has to be approved by the Commission to be included in the Official Journal of European Union. Here policy making has a large influence on standards development, particularly in the concept of 'legal certainty' that the European Commission insists on.

The radio spectrum regulatory framework in Europe consists of the European Commission (issues mandates to recognized SDOs and European Communications Commission(ECC)), ECC (issues CEPT reports to the Commission and coordinates with ETSI) and ETSI (develops standards and harmonized standards).

[15] Some of these mechanisms could be equally open to universities.
[16] Most SDOs are cautious about allowing such groups full membership but do often have mechanisms for partnership, for example, SCF is a Market Representation Partner (MRP) of 3GPP.

CE marking is an indicator of a product's compliance with EU legislation and enables the free movement of products within the European market. By showing the CE marking on a product, a manufacturer is declaring conformity with all the applicable Directives and therefore ensuring free circulation for that product throughout the European Economic Area (EEA, the Member States of the EU and EFTA countries). The accuracy of this declaration is the manufacturer's responsibility and market surveillance authorities do observe the products brought to the European marketplace.

The UK government is transitioning to use both CE marking and UKCA[17] (UK Conformity Assessed) marking. Radio equipment manufacturers will have the choice to use either the CE marking or the UKCA marking (apart from Northern Ireland which does not accept UKCA). The applicability of the EU CE mark in the UK market is extended indefinitely beyond 31 December 2024.

The requirements of the CE Marking process are as follows:

1. Identify applicable directive(s)
2. Identify the harmonized standards concerned
3. Verify the product's specific requirements
4. Identify whether a conformity assessment by a notified body is necessary
5. Test the product's conformity with the relevant requirements and, if necessary, have tests performed by a notified body
6. Establish the required technical documentation
7. Affix the CE marking and complete the Declaration of Conformity

In cybersecurity standards we see a similar role for policy makers. It is the European Commission and key governments (such as UK outside the EU) who set requirements on cybersecurity and SDOs (ETSI, CEN, CENELEC) develop standards based on those requirements.

In Intelligent Traffic Systems (ITS) the two alternatives of 802.11p and LTE-V2X are both authorized to operate at ITS band, but the coordination has been made very difficult due to policy maker requirements (CEPT WG FM <-> ETSI).

Lawful Intercept and Emergency Calling are both strongly influenced by policy makers. The eCall function is mandatory in vehicles sold in Europe (based on very old technology). Lawful Intercept standards are developed with public authority participation (ETSI LI).

Policy decisions can have a huge impact on the Standards Essential Patents (SEP) landscape depending on the balance between patent hold-up and hold-out[18]. Note: the European Commission SEP regulation proposal.

[17] Using the UKCA marking - GOV.UK (www.gov.uk)
[18] The Patent Lawyer Magazine, Article Feb 2024, UK IPO publishes update and forward look on SEPs work

4.2.2/ Outside Europe

There are several standards organizations that operate on a regional or national level, similarly to Europe. For example, ANSI (USA), CCSA (China), TTA (South Korea), ARIB (Japan). In some cases, national priorities from policy makers have a decisive role on which standards are being endorsed or developed in these countries.

Technical barriers to trade: minimum quality standards[19] may be used to increase barriers of market entry; local standards may be set to benefit local manufacturers.

4.2.3/ Global aspects

ITU has member state representation but particularly at ITU-R the work reflects regional priorities rather than single member state (such as UK) policy goals. Mechanisms to collaborate with key countries across regions may bear fruit. Regional fragmentation in standards is likelier when there are geopolitical strains present. Europe may no longer have sufficient weight to have its standards adopted in other countries vis-à-vis China/USA should such fragmentation occur.

4.2.4/ Discussion and recommendations

IMT-2030 requirements work is starting at ITU-R WP5D. It is assumed that Ofcom and DSIT will continue their leading role representing the UK in ITU-R and ensuring that the UK interests are looked after, particularly in the satellite aspects of IMT-2030. Outside of the legal frameworks that Governments can use, the UK can also help set the technical requirements for standards. For example, 3GPP are starting work on the releases that will be branded as 6G. It is recommended that DSIT actively consult all the UK stakeholders to develop policy positions that can be taken into the SDOs to influence the direction of technology developments.

4.3/ Relationship Between UK R&D and Standards

The SWOT analysis noted that academic research in telecoms in a significant strength for the UK with many UK university telecoms research teams widely recognised around the world. On the other hand, it was also noted that a significant weakness is the ability to turn world leading research into industrial developments and commercial success within the UK.

4.3.1/ Academic research

By and large, the basic currency of academic research is normally the successful publication of papers in peer-reviewed journals and work is normally targeted at this. This is reinforced by ranking and rating of journals and calculation of publication indices for individual academics. While funding bodies can have a wider set of objectives, successful publication of papers in peer reviewed journals is normally a key metric when assessing the project outcomes.

[19] Minimum quality standards refer to the minimum acceptable level of requirements, which can be related to reliability, durability or safety.

However, the objectives and criteria that make for a successful academic paper are different to that of standards. First, journal editors and peer reviewers are normally looking for novelty in papers; while there are 'review papers', normally a successful paper will 'advance the world's body of knowledge'. There is therefore a strong pressure on academics to emphasise the distinction between the subject of the paper and the current state of the art; there is an incentive to present the ideas and concepts of the paper as being radical.

Conversely, standards by their very nature, like to emphasise and maximise backwards compatibility. In general, the stronger the backwards compatibility, the more likely a new feature is to be both agreed in a standards body and adopted by the industry as the costs of introduction are minimised. Even when developing a new standard, or a new release of an existing standard, interworking with existing technology is often a major concern. Standards will therefore highlight evolutionary developments and new contributions to standards bodies, in contrast with academic papers, will emphasise the path from the current state of the art.

Another important and related difference between academic papers and contributions to standards is the scope of the problem addressed. Academic papers will tend to focus on a narrow scope to define a clearly distinct and current unsolved problem that is then solved in the paper. On the other hand, a contribution to standards will normally want to emphasise the broad scope of applicability of the proposal. Very broadly, academic papers will tend to show significant improvement on a narrow problem while a standards contribution will tend to propose a modest improvement on a broad problem.

In addition to the differing objectives and pressures, another significant barrier to academic engagement with standards is that many standards bodies do not have a history of academic memberships and including academic contributions into discussion. A notable exception to this, and potentially useful model, is the IETF which has its very origins in academia. IETF has a sister body, the Internet Research Task Force (IRTF), which has a specific remit to provide a forum for academic and industrial research to bridge into the IETF standards process. Other standards bodies are now beginning to show a greater awareness of the contribution of academia and introducing ways of bringing them into the standards development process (for example, the 3GPP 6G workshop in May 2024).

ETSI recognised the issues around academic access a number of years ago and now actively encourage participation in "pre-3GPP" work. These are mainly in ISGs (Industry Specification Groups), for example ISG THz are working on pre-6G THz channel models and have a strong UK university participation. ETSI are also active in Horizon EU funded research programs to help drive research output into standards.

From the perspective of UK academia, there is merit in increasing the awareness of standards within UK university research groups and building the necessary skills for successful participation in standards.

This would be further strengthened if funding bodies actively promote and provide budget for standards participation within research projects and define the scope and success criteria accordingly. Therefore, rather than research projects emphasising how they are distinct from the current state of the art, emphasis on how the proposals are evolutionary from the current systems and how backwards compatibility works should be given weight and priority. These need not be in conflict but, unfortunately, currently they frequently are. If funded research projects are to directly lead into standards, the evaluation of the original project proposals should give credit and weight to the evolutionary nature of the proposal. Of course, in the context of a broad portfolio of projects, it is beneficial to fund significant blue-sky research, but proposals should at least demonstrate an understanding of how their advances might be applied to provide feasible evolutionary paths.

4.3.2/ Case Study of a research project

With the UK now rejoining Horizon Europe projects, it is interesting to look back to one telecommunications related group of projects with involvement of UK academia. The predecessors of Horizon projects were known as Framework Programmes (FP).

The Wireless world initiative new radio spanned across three projects:

- **WINNER, WINNER II and WINNER+.**
- **WINNER project and its continuation**
- **1 January 2004 – 31 December 2005 (WINNER) – FP6**
- **Coordinated by Siemens**
- **13 countries & 14 universities (Surrey from the UK)**

WINNER worked on developing a new concept in radio access (this was WCDMA days, LTE was just emerging as a study topic). It was a significant research effort with contributors from 13 EU member states. The project developed an overall systems concept from layer 1 to layer 3 including cooperation mechanisms with legacy systems. The project contributed towards CEPT and ITU-R prior to World Radio Conference 2007. Many of the research outcomes around MIMO and heterogenous networks were integrated into 3GPP specifications through contributions from WINNER members who were also 3GPP Individual Members.

- **1 January 2006 – 31 December 2007 (WINNER II) – FP6**
- **Coordinated by Nokia Siemens Networks**
- **12 countries & 14 universities (Surrey from the UK)**
- **Continuation of WINNER I project, developing a detailed system definition.**

The technologies developed in WINNER II contributed to channel models (submitted to ITU-R and 3GPP) and some of the core technologies that eventually became LTE in 3GPP. For example, it investigated energy-efficient solutions, interference management strategies and novel network architectures.

- **1 April 2008 – 30 June 2010 (WINNER+) – CELTIC-NEXT**
- **Coordinated by Nokia Siemens Networks**
- **9 countries & 8 universities (none from the UK)**
- **Involved in the development of IMT-Advanced candidate proposal to ITU-R (i.e. LTE-Advanced).**

The main areas of work were RRM concepts, flexible spectrum use, innovative transmission techniques such as network coding, advanced antenna schemes, coordinated multipoint systems and trial & demonstration platforms. WINNER+ acted as the European Evaluation Group for the 3GPP LTE-Advanced proposal.

The three phases of WINNER, spanning five and a half years, are a very good example of how pre-standards research projects provide a means for academia to develop concepts together with larger entities who then can contribute these concepts to standards making. However, all the three WINNER stages lacked any meaningful SME presence.

In later projects under Horizon, such as HEXA-X there are also SMEs present, so the situation appears to have improved in recent years[20].

[20] Horizon projects in particular require at least 30% SME participation.

4.3.3/ Discussion & Recommendations

From the above case study and the previous discussion, we can take some pointers towards improving the connection between University R&D and standards. In general, it seems beneficial to encourage greater awareness of the global technology context that any particular research project addresses, and to reinforce a mindset that seeks to understand and track the discussions in standards and global fora, even if the projects follow alternative paths, or do not seek to intercept standards within a limited timeframe.

Some recommendations to achieve this goal are listed below:

- 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 (potentially targeting Horizon or other projects).

4.4/ Intellectual Property Issues in Standards

Intellectual Property Rights (IPR) including patents are a way of ensuring that those that spend time and/or money developing new ideas can be properly rewarded for that effort. This ability to be rewarded for research is essential to encourage an economically efficient market that ultimately benefits consumers and growth. In telecoms the investment in R&D is very large, with Nokia alone spending €4.3Bn in 2023[21], while Ericsson reported earning nearly €1Bn in licensing revenue from its IPR portfolio in 2023[22]. It is this sort of investment and revenue that has helped push new telecom technologies (such as 3/4/5G) that offer the potential to grow economies and provide new and innovative services to consumers.

IPR promotes incentives to innovate by giving exclusive rights to the patent holder, but this may create tension with the objectives of standards. As a result, most SDOs have an explicit IPR policy which aims at a balancing the incentives to innovate and the openness of standards.

[21] Statista, Nokia expenditure on research and development worldwide from 1999 to 2023
[22] Nasdaq News, How to Use Options to Profit During Earnings Season

4.4.1/ Standards in Telecoms

The benefit of standards (especially for telecoms and interoperability) is that they allow global markets for products to develop, which means that economies of scale can drive down costs. This has been especially pronounced in mobile, where in the 1980's a a number of national and regional standards existed. The development of GSM meant that the costs of development were shared by many countries/markets, and hence prices fell. This encouraged more users and a virtuous circle of spreading development costs.

It is recognised by competition authorities that standards usually produce significant positive economic effect. However, standards setting might also harm competition (especially if access to the standard is restricted). To help overcome such concerns with competition four principles are usually required in standards setting, namely:

1. Unrestricted participation;
2. Transparent procedures;
3. Not a mandatory standard;
4. IPR access is "fair" – FRAND[23].

Fair, reasonable, and non-discriminatory IPR access (FRAND) is an important concept in standardisation. Unfortunately, what is "fair" to one person may not seem "fair" to another. Even "non-discriminatory" does not mean that all companies wanting to use the IPR need to be treated (or charged) the same.

When a company participates in a standards development organisation (SDO), it can add its IPR into the standard. To ensure compliance with competition law principles, two issues tend to come to the fore. Firstly, transparency, in the sense that those who submit contributions to an SDO declare if they or others have IPR. The other issue is how important that IPR might be (is it essential)? Even if a patent is not deemed essential it may be very difficult to make products using the standard without adding significant extra cost compared to a solution which uses the patented idea. The EU has proposed a new framework for improving the transparency of standard essential IP within telecommunications covering both what is patented and the terms under which licences may be obtained[24].

[23] FieldFisher.com, What is FRAND, John Cassels, August 2013
[24] European Commission, Standard Essential Patents

Even if contributors to SDO's declare what patents they hold, and whether they are essential (as well as if they will licence on FRAND terms), it is not always easy to judge or understand the impact of IPR in a standard. The associated pilot study of 2020 to the EU proposed framework notes that:

> **"European Telecommunications Standards Institute (ETSI) alone published 297,557 disclosed patents, belonging to approximately 25,000 patent families. It is important, however, that these are patents that were believed to 'may be or may become' essential for a standard, and do not tell us about whether they are actually essential".**

Such a large number of patents (that might be listed by a couple of lines on a spreadsheet) can make an assessment of the importance of IPR difficult.

It is possible for SME research to lead to new and innovative technologies in telecoms. Such innovations can lead to valuable IPR, as well as improving the performance and value of communication systems. Indeed, one might argue that such "blue sky thinking" and "thinking outside the box" which is often characteristic of SMEs is important to prevent the large manufacturers who dominate much of standards from falling victim to "group think".

However, it is very difficult for an SME that develops IPR in the field of telecoms to fully exploit it, because of the costs and time involved. If a small company does develop IPR it may be that the easiest way for the SME to get value is to sell it to a larger company.

IPR as an Incentive for SME Participation

As noted above SMEs can find it very difficult to follow the complex and sometimes not entirely transparent issue of IPR in telecom standards. Some thought should be given to offering SMEs who have developed valuable IPR another option to commercially exploit it (other than selling it to a large vendor). The difficulty would seem to be that without some help to an SME to understand and use the IPR landscape to their advantage, their only option is to sell. What might be more attractive is some form of incentive or partnership that ensures that IPR developed in the UK is available to UK companies to use in a way that encourages the aims of diversification.

Recommendation

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.

Free & Open Source Software & Royalty Free

In contrast to the development of traditional telecoms equipment development, such as for switches or mobile phones, consideration should be given to other licensing models – such as used for software. Free and Open Source Software (FOSS) is a well known way of allowing anyone to use copy, distribute, and modify software, and generally means the source code is available. With the advent of the internet and world wide web, how telecoms interacts with this world of software in general and the Web in particular is important to understand. The ethos of the two appears quite different.

An example model for licensing IPR is how the World Wide Web Consortium (W3C) goes about its vision to “make the web work, for everyone” and its core values to define an open web platform[25]. The W3C patent policy aims to make specifications available on a “Royalty-Free” (RF) basis. However, this does not necessarily mean that all IPR in their specifications is RF (i.e. free). For example, this policy only applies to essential patents and there may be patents which are useful but not deemed essential. In addition, the policy only applies to IPR declared to W3C by the working group participants and does not guarantee that essential patents do not exist which are not registered with W3C[26].

It is a point of considerable debate how the FOSS and/or Royalty-Free licensing models should apply to the world of telecoms. If taken directly, they would appear to remove the current business models used to pay for R&D for things like 5G and 6G. There are other business models by which FOSS can and does work but is not clear how these can be developed in the telecoms environment. Some standards organisations such as ETSI and IEEE-SA have active FOSS projects and are working to see if good solutions to this business model issue exist. There may also be implications for SMEs in their ability to exploit any IPR they made available to organisations such as W3C (if it was an essential part of a standard).

[25] W3.org Mission
[26] W3.org, Patent Policy, Definition of Essential Claims

Further work would need to be done to understand if such IPR licensing models could be applicable/acceptable to telecoms and to what extent this change in the current landscape would continue to encourage more/new telecom equipment vendors to enter the market. For example, O-RAN Alliance is working closely with the Linux Foundation on open-source solutions within the 5G and 6G RAN architecture, however, it is still very early days to assess the commercial significance of this.

4.4.2/ General approach of Standard Development Organisations to Patents & IPR

As already stated, SDOs will normally have an explicit IPR policy which is publicly declared and may place some obligations on member organisations and/or participants. To summarise, the generally accepted approach is that organisations who participate in standards development should declare if they are contributing material that includes IPR, and whether it is considered essential or not. The SDO does not normally check or validate the statement but relies on self-declaration by the contributor. Third parties may alert the SDO that they believe a standard being developed relies on IPR that has not been declared. The IPR holder will normally agree that the IPR will be licenced on FRAND terms if it is to be included in the standard. However, as noted above the term FRAND may mean different things to different players, and ultimately if parties cannot agree some form of court will need to decide.

The SDOs make it clear that contractual terms between parties on what FRAND means is not for the SDO, and they will not get involved in licensing negotiations on patents. Those making submissions on patents can also make provisos that it is done on a reciprocal basis.

ISO standards are intended to be patent-free but in the area of IT embedded IP is common and ISO lists some 3,000 plus patents in a downloadable spreadsheet.

4.4.3/ IPR Positions of various SDOs

ITU, ISO, and IEC have a common patent policy[27] and have published guidelines for its implementation[28]. The guidelines document (December 2022) states that the aim is to encourage early disclosure of patents that may relate to recommendations deliverables under development. It notes that early disclosure of patent rights in standards development leads to greater efficiency and helps avoid future problems.

The policy makes clear that they (ITU/ISO/IEC) do not check or evaluate the patent position on any standard and leave it to those participating to inform them. These SDOs limit themselves to requesting that information is provided and publishing what is received. Part 1 of the guidelines states:

[27] ITU Common Patent Policy for ITU-T/ITU-R/ISO/IEC
[28] Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC

"The Organizations should not be involved in evaluating patent relevance or essentiality with regards to Recommendations | Deliverables, interfere with licensing negotiations, or engage in settling disputes on Patents; this should be left – as in the past – to the parties concerned. "

The SDOs use patent statement and licensing declaration forms which are intended to be submitted by patent holders to provide information that can be used to populate their patent information databases. The declaration forms allow the patent holder to state:

1. The IPR is available Free of Charge,
2. The IPR is available world-wide, on a non-discriminatory basis on reasonable terms to all that ask – but they can charge and that is a commercial issue between the parties performed outside the SDO.

The declaration can also include a "reciprocity" requirement, i.e. the IPR will be licenced on these terms but only if others with IPR do the same.

ETSI's position is similar to ITU except that they focus on 'Essential IPR' relating to standards and technical specifications. ETSI asks its members to use 'reasonable endeavours' during standards developments to inform ETSI of essential IPRs. When ETSI becomes aware of an essential IPR (https://ipr.etsi.org/) in a standard the Director General (DG) of ETSI will request that the IPR owner will agree to licence it on fair, reasonable, and non-discriminatory way (FRAND). ETSI maintains a database of IPR used in its standards. If an essential IPR is not granted on FRAND terms to ETSI then ETSI may consider removing it from relevant standards.

UK patent courts' importance in FRAND setting

The UK has established a reputation as a hub for global FRAND-rate setting. Two very important cases that were decided in the High Court were InterDigital vs Lenovo[29] and Unwired Planet vs Huawei[30] (this last one went eventually to Supreme Court). The fact that none of the claimants and defendants are UK based shows the esteem that the UK holds in FRAND disputes.

The establishment of the Unified Patent Court (UPC) in the European Union is changing the situation, and it is early to say how the balance between UK cases and UPC cases will play out.

[29] England and Wales High Court (Patent Court) Decision [2023] EWHC 539
[30] England and Wales High Court (Patents Court) Decision [2017] EWHC 711

4.5/ Standards & Supply Diversification

Much of the specific SWOT analysis of supply diversification in the UK in section 3.3 above related to the role of systems integration and the dominant role played by the major vendors in both supply to network operators and in driving standards. Under strengths and opportunities, it was noted that there is a growing interest and concern to address this. Amongst network operators this includes the establishment of the O-RAN Alliance. In the UK industry, this includes the establishment of the SONIC Labs to carry out neutral testing of critical integration interfaces. In this section we consider some of the options for diversification in critical stage in the industry's production chain.

When considering diversification of supply, this is largely focussed on the network system integration level of the supply chain for mobile network systems, where today there are three major suppliers, one of whom has been excluded from future supply in the UK. Following the initial study on diversification, DSIT commissioned a report from Frontier Economics on "Open Networks Research And Development Fund Baseline Study" which assessed the current capability to support "open systems" specifically in the context of mobile RAN, and interviewed current actors. This section builds from that report and using the same basic model of the industry. Compared to that report, the terminology is generalised to include more than just the mobile RAN part of the network and also differentiates between "major components" which map to the "Open RAN components" of the Frontier report, and "components" which are a step further back and include, for example, semiconductor devices.

There are several ways in which diversification could take place with some options illustrated in Fig.4.5-1 and the impact of standards enabling this diversification depends on the assumed model.

In the model currently predominant, a network operator buys from one or more of the major vendors who combine the role of building or customising the major components and integrating them into a complete network system. This greatly reduces the number of interfaces which the network operator takes responsibility for integrating. The interfaces that remain for the network operator to integrate are normally network management interfaces between the major vendor's management elements and the network operator's common OSS/BSS. Any interface between the major vendor's system and customer equipment, for example the mobile air interface, is often well standardised as there is a need for full and reliable 'plug and play' interoperability for the basic working of the industry.

Conversely, many interfaces between major component systems are internalised by the major vendor and while these interfaces are often the subject of significant standardisation efforts, for example by 3GPP and O-RAN Alliance, in the currently dominant model, there is little practical requirement for interoperability between different commercial actors. This situation is reinforced as some of the major components, for example virtualisation infrastructure, fixed transmission infrastructure, and synchronisation infrastructure can require a level of customisation compared to 'off the shelf solutions'.

An obvious diversification model is to seek new major vendor suppliers as an alternative to the current major incumbents. However, these vendors are large and complex organisations, and take time to grow and emerge and/or adapt to new markets.

Therefore, in this paper, we focus on other models of diversification and consider the extra burden these models place on standards. In considering three particular options, it is important to note that they all require that interfaces currently internalised by the major vendors become fully exposed as interoperable inter-vendor interfaces.

Currently, standard interface specifications of this type often include several options. These options can be alternative ways of achieving the same interface capability, but more frequently, they are additional capabilities, what might be called 'optional extras'. Either way, what one major vendor chooses from the standard may well be different from the choice of another. Indeed, the very existence of the options is quite likely to have arisen because the major vendors were protecting their particular set of capabilities in the development of the standard. Therefore, currently implementations may claim conformance to the same standard, and yet they may be largely incompatible or at least sub-optimal when connected together (e.g. due to different features, or at a micro level different algorithms or use of different information elements or even interpretation of the same elements in internal logic).

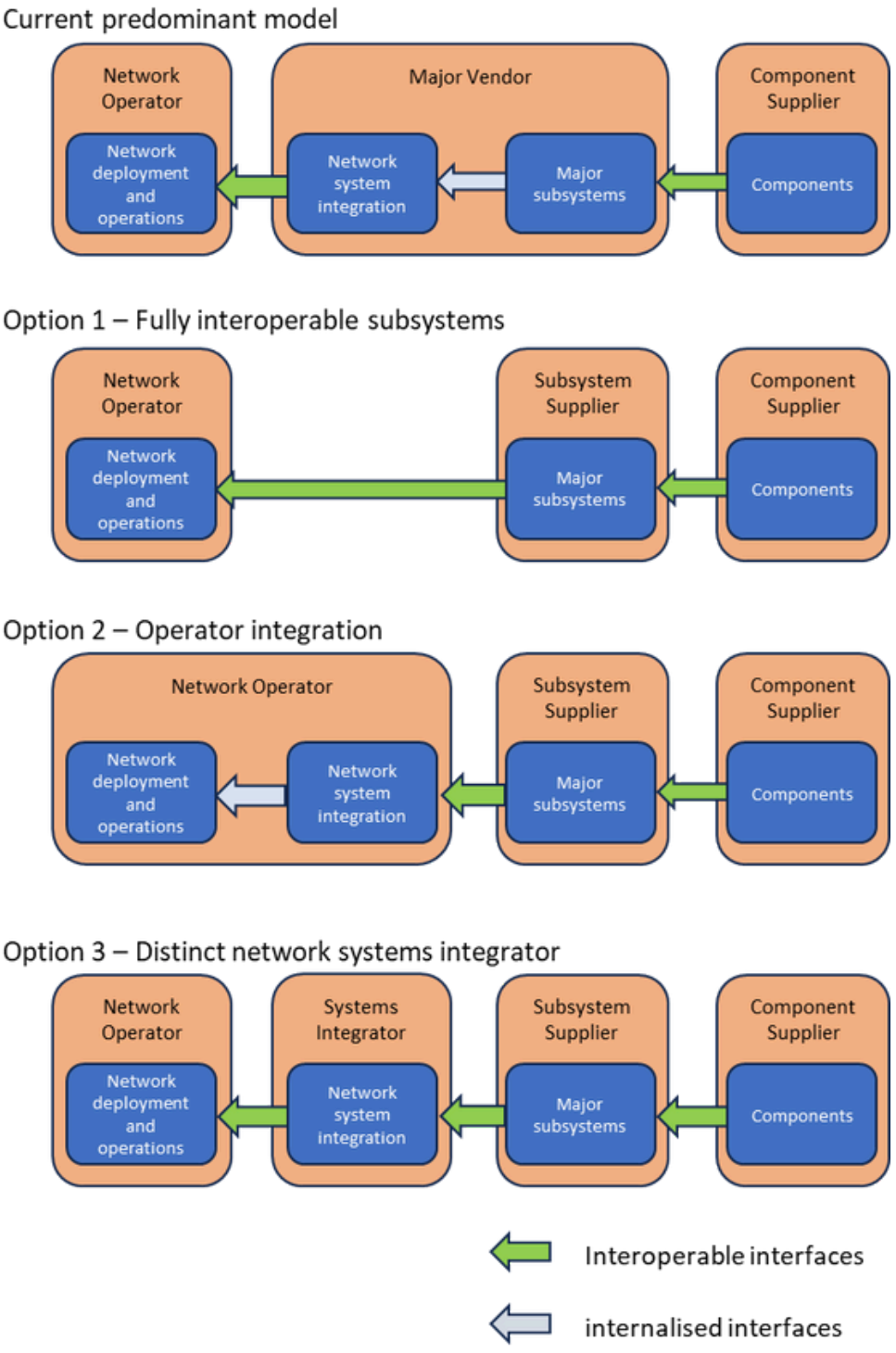

Fig.4.5-1 Options for System Integration.

4.5.1/ Option 1: Fully Interoperable Major Subsystems

This option is the objective of bodies such as O-RAN Alliance and Telecoms Infrastructure Project (TIP) which have been set up by the world's largest network operators and operators retain leadership control in these bodies. In response to the complexity and practical ineffectiveness of standards to 'break open' the interfaces internalised by the major vendors, these bodies have set themselves the target of creating interface specifications sufficient to allow interoperability between the major network components.

These organisations are profiling and completing existing standards with the objective that significant systems integration is not necessary. They have also established test and validation facilities which can establish compliance and bi-lateral interoperability independent of any individual commercial actor.

On the other hand, there is a certain amount of doubt about how successful these activities can be. Inevitably, these profiled and completed standards are likely to be a 'lowest common denominator' and offer less functionality than could be offered by a major vendor. It is also the case that much of the technical expertise and contribution into these organisations still comes from the major vendors whose commercial interests may not directly align with the stated objectives of these standards bodies.

In summary, this option is a primary direction in standards driven by the world's largest operators, however, the ultimate objectives are very ambitious, and it remains to be seen if this can be successful.

4.5.2/ Option 2: Operator Integration

An alternative to relying on standards to achieve the elimination of incompatibilities in the interfaces between major components is for the network operator to undertake the integration working with suppliers of the major components.

However, this is a significant undertaking and while many network operators have appropriate knowledge and skills, most are not currently sufficiently resourced. Moreover, from an industry perspective, this may not be especially efficient as every operator will be effectively repeating the same costly exercise.

This option can go together with option 1 in that the more standardisation does achieve, the less integration the network operator needs to undertake.
In summary, this option would be challenging taken by itself but could work well as a mitigation and de-risking to imperfections in the standardisation efforts in option 1.

4.5.3/ Option 3: Distinct 3rd Party Network Systems Integrator

Another alternative to relying on standards to eliminate the need for network systems integration, the network operator could turn to a third-party integrator. The integrator would work with suppliers of major components to customise each major component as necessary and ensure the successful interoperability between the major components.

As the scope of the task of the third-party integrator is substantially less than that of a major vendor, it is, at least in principle, quicker and easier for actors to establish themselves in the market compared to becoming a major vendor. Frontier Economics identified and interviewed a number of actors in this area anticipating the potential significance of this option.

However, the downside of this option is that an extra actor is introduced into the production chain adding significantly to its commercial complexity. The implication of this model is that there would be transparency in the commercial relationship between the network operator and the suppliers of the major components, indeed, they be contracted directly and not via the integrator. However, this complexity of contracting and responsibility is considerably complicated compared to a network operator contracting with a major vendor.

4.5.4/ Recommendations

Based on the above considerations and the previous SWOT, some generic actions seem appropriate in this area e.g.:

- 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.
    - A possible mechanism might consist of setting up an inter-operability forum for this purpose, with the aim of exchanging information and requesting support from other stakeholders in solving the detected issues.
- 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.

4.6/ Engagement of UK SMEs in Standards

4.6.1/ Discussion

As captured in the SWOT for SME Engagement in Standards (see section 3.4), there has generally been a healthy number of UK SMEs involved in telecoms, and typically they have attempted to develop and exploit new technology ahead of the existing large players, with some notable successes. Today, there are also several potential disruption points in technology that match and incentivize the entry of new players (though of course by definition such disruption cannot be accurately predicted). For example, the drive towards virtualization, the opportunities for application of AI, and the move to 6G in the mobile area. Thus, the current environment in general is supportive of innovation and agile new players. Furthermore, it is obvious that such developments will be tracked largely in standards projects, creating opportunities for such players in SDO's.

Standards participation is obviously a pre-requisite to ensure that an SME's technology is considered as a candidate, and potentially standardized (either as a SEP, or an optional feature). This can have considerable upside (not least in the SME's valuation) but requires investment over a period of time that may span several years.

In addition, standards participation itself can be of high value for SMEs regardless of immediate results in terms of technology adoption, since it provides real-time visibility of potential competitive activities, early warning of technology inflection points, and most importantly, increases the visibility of the SMEs themselves within the ecosystem.

On the other hand, standards engagement may not always be appropriate or cost-effective for an SME, depending on its business model. But in addition, not all SMEs or start-ups will consider the possibility of involvement in standards due to other factors such as cost (participation / membership), lack of understanding of processes, lack of capability to sustain a long-term effort, and so on.

Nevertheless, there are multiple examples of SMEs that have developed successful strategies in this space. For example:

- Some SMEs were able to develop technology and IPR and were able to insert their technology in standards (by themselves / as part of an ecosystem). In some cases, such companies followed this up in the marketplace, while in others they were acquired by a third party, but either way this effort resulted in a significant value increase.
- Other SMEs developed standards-related technology and IPR but for one of a range of reasons, were not in a position to develop standards. However, their potential was recognized by a third party which acquired them – and the third party had the capability to subsequently take the technology to the appropriate standards bodies (with/without further development).

Regardless of the path taken, it can be assumed that a level of support could help to increase the number of these examples. Support mechanisms should aim to mitigate the weaknesses and threats listed above (section 3.4), including particularly:

- Understanding standards opportunities including potential ROI and resulting value uptick.
- Knowledge of the standards landscape and ability to develop actionable standards strategies at an early stage.
- Ability to develop in-house skills or make use of external support to navigate a highly complex and competitive standards environment dominated by larger players.
- Reduction of financial barriers including membership costs

In addition to the above, there is the tightly related issue of IPR which is handled elsewhere in this document but is very relevant as a basis and support for the participation of SMEs in standards. We also note that the UKTIN's Future Capability Paper on Wireless Networking[31] has specific recommendations on this area including:

- 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.
- 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).

In this document we acknowledge these IPR recommendations as a valuable support mechanism. The focus of the following is specifically on standards.

4.6.2/ Recommendations

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, including SME participants.
- Training to include standards linked IPR aspects such as FRAND, IPR declaration etc.

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).

[31] UKTIN Future Capability Paper, Wireless Networking

- 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:
    i. DSIT de-briefing targeted at UK SMEs – leverage DSIT representatives to share information with SMEs in de-briefing updates.
    ii. As part of any SME grant (to attend meetings), the SME provides a briefing to the community on what they have learnt.
    iii. A mix of the above, plus invited speakers such as WG chairs or other experts willing to present in a forum.

  - 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.

4.7/ Skills

4.7.1/ State of standards skills in UK

The SWOT noted that the UK currently has significant skills in the area of standards, however, it was also noted that academia has not generally been involved (with the specific exception of IETF and Internet standards). As a result of both this and other factors detailed below, the age profile of expertise in standards in the UK is currently not well balanced and so there is growing need to build a new generation of expertise.

It is a statement of the obvious that excellence in standards presupposes a high degree of technical excellence and strong background activity in related R&D. Although there are exceptions, it is typically the case that successful standards teams are connected and often emanate from significant industrial players with large development teams and a consistently strong product portfolio.

Such players have the internal capability to train and develop staff as they move from purely technical roles to standards roles or vice versa; in fact, even to IP related roles. This enables a continuous supply of skilled standards engineers, which can additionally be supplemented through external recruiting as needed.

There are variants to this model, which relate to the relative time allocation to standards vs R&D for delegates – in some companies the delegates perform R&D work and are directly responsible for the foundational inventive work as well as its delivery downstream in standards, while in others the delegates are somewhat involved but not prime movers in the R&D work – so their roles are clearly different from those in R&D. Obviously, further variations are possible and co-exist in a single organization. And as mentioned above, different career paths are possible within each framework.

In any case, the models often rely on the capability of a large organization, of which there were multiple examples in the UK in the 80's and 90's. Over time this has become rarer for several factors of which the most obvious one is the closure or reduction of large R&D sites (including e.g. Motorola, Alcatel-Lucent, Nortel, Nokia, Ericsson). Although there remain many hundreds of highly skilled standards engineers in the UK, a good portion are ex-employees of these companies and may often constitute small remote groups that may or may not be sustainable in the long run.

On the other hand, SMEs may or may not have recruited some of these experts, but even if they have, they are not necessarily deployed on standards. If they are, their skills do not necessarily get passed on because the standards team may often consist of that one person (or even a fraction of a person).

Finally in the University sector, there is also a significant lack of deep standards understanding or experience, further compounded by the fact that it is relatively rare for an expert with previous standards exposure to move into this sector at any level. Overall, this results in a landscape which includes a relatively large proportion of late-career stage standards experts mostly working either by themselves or in small teams dependent on R&D organizations in other regions or countries.

4.7.2/ What are standards skills?

It is useful to understand the range of skills that apply or are required in standards, and that somewhat go beyond the purely technical expertise which may be considered an essential pre-requisite. The following are relevant to many standards delegates, while intended to be illustrative and not exhaustive or required in each and every case:

- Understanding of the standards landscape, different SDOs and their scope, and particularly understanding of the appropriate SDOs to contribute to in order to achieve the goals of the contributing organization.

- Being able to translate technological advances into feasible specifications for inter-operable systems, and understanding how these may fit into one or more SDO's existing (or potentially new) standardization projects.
- Understanding of how the SDO's goals are set (e.g. how does the SDO decide what to work on at a procedural level).
- In parallel, understanding the soft issues i.e. the SDO's "culture" (e.g. how in practice the SDO agrees goals and makes decisions, noting that a skilled delegate will additionally be known to a number of other players and be able to influence their views).
- Understanding of the lifecycle of a specification and the processes at all levels that contribute to the production and maintenance of a specification.
- Understanding the limits of what may or may not be standardized; this is also often a function of the SDO's generic culture, but also of the dominant culture and interests of the main players within the industry that are active in each working group in a SDO – which has often been modulated by years if not decades of successes and failures.
- Understanding of the patenting and licensing process that is applicable to the SDO, which informs decisions on the related investment – both at organization and personal level.
- Understanding how to write good specifications, at different levels.
- Understanding processes by which the detailed specification work moves forward, which is often working group specific.
- Ability to deploy excellent communication skills, allied with the ability to understand other players' motivations, and be able to form alliances as needed, while all the time maintaining trust of different peers.
- Negotiating skills: understanding how to build towards an outcome that can form a consensus and is a win-win for a large set of involved parties.
- Sensitivity to cultural differences (both attitudes and communication peculiarities).
- Ability to tackle difficult and sensitive issues, for example, by having one to one exchanges, and being able to distinguish between commercially sensitive issues and personal hobby horses.
- Recognising when giving up is the best strategy, but also knowing how to give up!

These constitute a mixture of soft and hard skills, some of which can be described but not necessarily learnt without practice. Obviously, each delegate develops his/her personal style to address the soft skill aspects. There is also an inevitable specialization, not just in terms of technical area, but also of level of focus (e.g. strategic vs highly specialized). Nevertheless, at the very least, a good prior understanding of the hard skills combined with some explanation of the soft skills enables a "newbie" to go up the learning curve faster, within their specific role. It is also useful to have the possibility of receiving feedback while developing a personal style and confidence.

It is also interesting to note that the widespread web availability of standards contributions and patents databases is enabling the emergence of new tools that may be used to accelerate the process of creating new technology and/or successfully contributing to an SDO. Examples are e.g. Iprova[32] and Apex Standards[33]. It is likely that this trend will accelerate in future with ever more powerful tools aiding engineers working in these areas, and these should form an important part of the appropriate training or skills.

4.7.3/ Standards Leaders

In addition to the above, it is important to develop standards leaders. To some extent, such leaders tend to grow naturally from the cohort of delegates by a process of natural selection, and it is much harder to train specifically for such roles in advance. However, at the very minimum, the following skills are useful:

- Ability to chair a meeting, keep to time, call priorities etc.
- Ability to comprehend topics quickly enough in order to be able to understand proposals and differences between them.
- Ability to design potential compromises or ways to reach a compromise.
- Ability to reach outcomes that are broadly seen as fair by most if not all participants.
- Ability to ensure that the group as a whole attains its agreed objectives.

4.7.4/ Recommendations

- 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[34]. 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”.

[32] iprova.com
[33] ApexStandards.com
[34] ETSI.org eLearning Portal

- 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.

5/ Trends & Issues Looking Ahead

5.1/ Geopolitical challenges in Standards

At a superficial level one can argue that the Global Standards setting ecosystem is in good health. Many Standards bodies have been in operation and developing new generations of their technologies, many of which will be utilised in Telecoms Systems worldwide.

However, government and political level issues combined with aging structures in some institutions are creating challenges for strategists.

5.1.1/ Sustainability

The Sustainability agenda has long been established as a desirable objective, and the creation of the Sustainable Development Goals from the United Nations crystallised this ambition. These Goals have created a framework for governments and industries to work towards that increases societal value, and they succeeded in shaping the Telecoms industry agenda. However, the translation of these goals into meaningful system metrics for standards bodies is proving to be a challenge with R&D&I investment activities such as those in Europe, through Horizon Europe, investing significant funds in refining the Key Value and Key Value Indicator and translation into KPIs. Ultimately KPIs are the focus of technical standards bodies, however the approaches to verification and validation through which the standard achieves such goals are always the subject of much debate.

5.1.2/ Segmentation of Systems

The ITU continues to develop visions for future systems that are siloed in Satellite, Fixed and Wireless. For wireless technologies the approach to assigning the required quantities and range of electromagnetic spectrum continues with the World Radio Conference of 2023 (WRC23) in Dubai completing in December[35]. Geopolitical and Economic implications are always part of the spectrum allocation process as geopolitical strategies and market interests considered by countries and corporations. Some notable decisions were:

Mobile Communications

1. Spectrum Allocation for 5G and Future Technologies:
   a. New frequency bands were identified for International Mobile Telecommunications (IMT), crucial for expanding 4G, 5G, and future 6G services. These include the 3,300-3,400 MHz, 3,600-3,800 MHz, 4,800-4,990 MHz, and 6,425-7,125 MHz bands in various regions.
   b. The upper 6 GHz band was identified for IMT in Europe, the Middle East, Africa, Brazil, Mexico, and three Asian countries, with technical conditions to protect satellite receivers.

[35] ITU, Final Acts WRC-23, Publication 2023

2. High-Altitude Platform Stations
   a. Regulations were established for using high-altitude platform stations as IMT base stations in the 2 GHz and 2.6 GHz bands. The main justification is to help provide coverage in remote areas.

Broadcasting

1. UHF Band Allocation:
   - The 470-694 MHz band retained its primary allocation to broadcasting services in ITU Region 1 (Europe, Africa, the Middle East, and parts of Asia), ensuring continued access for terrestrial television and Programme Making and Special Events (PMSE) applications.
   - A secondary allocation for mobile services was introduced in Europe, allowing for potential future use by mobile networks, subject to coordination.

Satellite Services

1. New Frequency Allocations:
   - New spectrum was allocated for satellite communications, including 117.975-137 MHz for aeronautical communications and several bands for satellite stations in motion on ships and planes (17.7-18.6 GHz, 18.8-19.3 GHz, 19.7-20.2 GHz, 27.5-29.1 GHz, and 29.5-30 GHz).
   - The conference also addressed the need for coordination of non-geostationary satellite orbits (NGSO) like Low Earth Orbit (LEO) satellites, which are increasingly used for global internet coverage.

Revisions to Radio Regulations and future conferences

WRC-23 approved 43 new resolutions, revised 56 existing ones, and suppressed 33 resolutions, updating the global treaty governing the use of the radio frequency spectrum. The conference set the agenda for the next WRC in 2027, which will focus heavily on satellite services and the continued development of IMT.

5.1.3/ Governments Influencing Supply Chains & Markets

In the last few years India has raised its profile significantly regarding its ambitions in the standardisation of ICT. Two standards bodies are present in India with various levels of engagement in the global standards community. The Indian Prime Minister's statement on the 6G ambitions of India in 2023[36,37] is potentially significant in terms of how the market develops.

[36] TelecomTV Article, India eyes global leadership role in 6G, Ray Le Maistre, March 2023
[37] 3gpp.org, Stage 1, IMT 2030

A number of democratic Countries have chosen in the last few years to address what they regard as a strategic threat with respect to China and have taken various safeguarding actions including designating high-risk vendors and investing in the diversification of network supply chains with Open RAN and Open Networks being common themes. The O-RAN Alliance has developed a set of standards that define the architecture and interface protocols of the RAN, creating another ecosystem of suppliers. They have partnered with 3GPP Market Representation Partners such as the Small Cell Forum (SCF) and Next Generation Mobile Networks (NGMN) to establish yet another layer of standards for R&D groups to take into account when doing System and Product Design.

5.1.4/ Dealing with the Risk of Fragmentation

It becomes increasing likely that fragmentation could occur as the scope and scale of the standardisation ecosystem grapples with the above factors at a world, regional and national market scale. Different standards bodies have different strengths and weaknesses and forecasting which will be sustained over the coming ten years is not a simple task for a large global vendor or operator – let alone an SME. The mapping out of the trajectory of Standards bodies and providing a trusted knowledge resource for smaller Countries is arguably more important than ever before in the history of Telecoms.

5.2/ The Future of Telecoms Standards

Having provided a view on the political and structural risks a view can be formed on the major trends in the future of telecoms standards and what is likely to shape that future. Trends and technological advancements can help to shape the view. Significant trends to take into account are the evolution of 5G, the transition to 6G, the expansion of full-fibre connectivity, and the convergence of fixed and mobile networks. The decision of WRC23 to have a significant focus on satellite in WRC27 points to space-based systems such as NTN as an important segment. Satellites have traditionally been a closed system – the way in which the systems open, and how they are utilised in the Telecoms ecosystem is far from a foregone conclusion. However, NTN are now a significant feature within mobile networks in order to provide full geographic coverage and emergency coverage. NTN support has been included in 5G Advanced (5GA) features and is expected to be an integral part of 6G.

5.2.1/ 5G Evolution & Beyond

5G New Radio (NR) technology is still under development, and new 3GPP releases extend it further, while in some cases (RedCap) simplify or focus its capability. Releases 16 and beyond are directed at enhancing 5G's performance and enabling new use cases in various industry sectors, such as manufacturing, health, and transport. The expectation is that the evolution of 5G will also involve the integration of AI to manage networks more efficiently and support advanced applications.

5.2.2/ Transition to 6G

Discussions and research on 6G have already begun, focusing on fundamental drivers and potential technologies that could define the next generation of wireless communication. Even at this early stage the expectation is that 6G should focus on delivering even faster speeds, lower latency, and more reliable connections. The context is again the enabling of transformative applications that are not feasible with 5G. However, the commercial case for 6G is far from being made. The cost of deployment of 5G has not resulted in additional revenue for operators. This has resulted in challenges to the timescales for 6G and even to the point where some are challenging the very need for 6G. 5G Standalone deployments are not yet complete and this will likely push out 6G timescales.

5.2.3/ Full-Fibre Connectivity

A number of governments have recognised that fixed/fibre/IP networks are critical national infrastructure – the resilience of telecoms services during the COVID period driving that recognition home. The UK government can be used as an exemplar of a typical approach. There are ambitious targets for full-fibre connectivity, aiming for nationwide coverage by 2033. Full-fibre networks are recognised for the speed, reliability, lower operational cost and improved energy efficiency compared to copper. These Optical and IP network backbones also form an important underpinning for the wireless networks of the future.

5.2.4/ Convergence of Fixed & Mobile Networks

The desirability of the convergence of technology stacks in the fixed and mobile domains has been the subject of speculation for some time. Most national operators in European markets have control of fixed and mobile assets. The proponents of convergence of fixed and mobile networks will claim that this trend could unlock the benefits of both technologies, leading to improved speed, resilience, and reliability for consumers and businesses. They argue that this convergence should be supported by policies and market conditions that encourage investment in both full-fibre and 5G networks, and perhaps standards bodies should be addressing these issues. However, there is a counter view. Fixed networks using full fibre can in most cases provide all that is needed in buildings. Convergence in the core networks is perhaps only an optimisation activity that may reduce costs but does not require standards development. Convergence at the service layer costs extra and the willingness of the consumer to pay more for this is questionable.

5.2.5/ Government & Regulatory Initiatives

The UK government, through initiatives like the Future Telecoms Infrastructure Review (FTIR) and the Digital Economy Act 2017, is actively working to create a favourable policy and regulatory framework to support the development of future telecoms infrastructure. This includes setting strategic priorities for telecoms and spectrum, which Ofcom must consider in its regulatory functions.

5.2.6/ Open Standards & Interoperability

The UK and other governments have called out Standards as an essential part of the future. Their policy statements place an emphasis on Open standards to assure a path to interoperability and flexibility within telecommunication networks. The desire of the policy makers is that Future telecoms standards will place an emphasis on openness, and the promotion of open standards to enhance interoperability. However, one must recognise that standards bodies are not generally in control of compliance, the subtleties of normative and optional clauses in standards are a minefield for the unwary, and investment in interoperability assurance through labs and conformance processes is going to be necessary to track progress on the reality of delivery. In a recent O-RAN Alliance conference session at MWC24 a representative of the US government made this very point.

5.2.7/ Open Source and Virtualisation – computing convergence on Communications

The Information Technology (IT) industry has long grasped the potential of open-source software developer communities, with examples such as Linux and its evolution towards Android establishing clear value in the mobile value chain. APIs are growing in popularity with languages such as JSON and YAML being common ways in which to describe the interfaces. Whilst a great deal of the proprietary functionality of telecoms systems has always been encoded in the System Design and the software that glues the hardware platform together, the trend now is to encourage open-source implementations in the telecoms network equipment. As processors become more capable the adoption of hypervisor based micro-architectures has led to an explosion in the virtualisation/containerisation of functionality. Virtualisation/containerisation is the core competence of the cloud computing ecosystem and is bringing software and IT skills and approaches to standards in the telecoms sector at a growing scale and impact. Many standards bodies will have relationships with or include open-source players in their governance.

6/ Summary of Recommendations

6.1/ UK Participation in Standards

The following address different aspects (albeit related) and are not presented in a specific order.

Incentivize international companies to locate R&D groups in the UK (whether or not linked to product development), and particularly including standards (how to do this is outside the scope of this document but could include targeted tax credits or non-financial support in terms of training, immigration etc.).

Facilitate relocation of international standards experts to UK (similar to above but including individual incentives as appropriate).

Hold light touch coordination fora to bring together standards and technology experts based in the UK working for UK-linked companies/operations, 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)

Create mechanisms to enable initial standards participation by universities and smaller players[38]. Two possible models are:

- By providing incentives to UK based SMEs e.g. grants for standards memberships, loans linked to standards attendance, training, workshops, etc[39].
  - For example, a scheme of competitive grants to cover at least partially the costs of standards participation projects with well-defined objectives and timeframes.
- By setting up a single over-arching organization with membership in selected SDOs and use this to support direct participation (if needed and insofar as a particular SDO membership rules allow) by member companies, or indirect participation (in the latter case, this would include a skeleton standards staff to provide “glue” in the most important groups and coordinate participation and strategy)

NB: it is assumed that growing organizations would eventually “graduate out” of this scheme.

[38] Section 6.6. provides further detail of possible mechanisms with focus on SMEs
[39] Some of these mechanisms could be equally open to universities.

Recommendations

6.2/ Policy & Regulation Aspects of Standards

IMT-2030 requirements work is starting at ITU-R WP5D. It is assumed that Ofcom and DSIT will continue their leading role representing the UK in ITU-R, and ensuring that the UK interests are looked after, particularly in the satellite aspects of IMT-2030. Outside of the legal frameworks that Governments can use the UK can also help set the technical requirements for standards. For example, 3GPP are starting work on the releases that will be branded as 6G. It is recommended that DSIT actively consult all the UK stakeholders to develop policy positions that can be taken into the SDOs to influence the direction of technology developments.

6.3/ Relationship between UK R&D & Standards

- 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 (potentially targeting Horizon or other projects).

6.4/ 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 by being larger than many individual SMEs). 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.

Recommendations

6.5/ Standards & Supply Diversification

- 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.
  - A possible mechanism might consist of setting up an inter-operability forum for this purpose, with the aim of exchanging information and requesting support from other stakeholders in solving the detected issues.
- 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.

6.6/ 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, including SME participants.
- Training to include standards linked IPR aspects such as FRAND, IPR declaration etc

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:
    i. DSIT de-briefing targeted at UK SMEs – leverage DSIT representatives to share information with SMEs in de-briefing updates.
    ii. As part of any SME grant (to attend meetings), the SME provides a briefing to the community on what they have learnt.
    iii. A mix of the above, plus invited speakers such as WG chairs or other experts willing to present in a forum.

Recommendations

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.

6.7/ 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[40]. 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 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 any existing 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.

6.8/ Trends & Issues Looking Ahead

Create pathways to standards for software skilled individuals through focus on the softwareisation and virtualisation trends in standards.

[40] ETSI.ord, e-learning

Annex A

A/ Standards Landscape

Before describing the standards landscape for telecommunications, it is helpful to set our understanding of what we include within the definition of 'standards'. In many industries standards refer to specifications and measurements which carry some legal significance, for example for safety or for accuracy of measurements or quality and are often called 'de jure' (meaning by law) standards.

In telecommunications the majority of what are commonly referred to as 'standards' are created by the industry for the mutual benefit of the industry and their use is entirely voluntary. In telecommunications a 'standard' is more helpfully defined as what the industry uses in practice. Moreover, their creation is funded directly by industry players as they each see creating and working to standards as being in their commercial interests. It is therefore important not to assume that 'standards' in telecommunications carry the legal significance of 'de jure' standards; in particular, players are not obliged to follow a standard.

For example, in order to clarify this point, the World Trade Organisation (WTO) agreement on Technical Barriers to Trade (TBT) sets out their definition in a way that anything that is subject to legal requirements is defined as a 'technical regulation' and their definition of 'standard' is reserved to exclusively refer to specifications that are voluntary[41].

In this report, we are primarily concerned with voluntary standards and use the term in the spirit of this WTO TBT definition. This means that for the purposes of this report, 'standards' include the output of bodies who do not necessarily use the term 'standard' for their documents. For example:

- The International Telecommunications Union (ITU)[42]; being a UN body without jurisdiction over any member state, publishes 'recommendations' to member states;
- 3GPP[43] which is partnership between a number of regional standards bodies produces 'specifications' and these are only named as standards when adopted by the partner organisations;
- The Internet Engineering Task Force (IETF) only declare a specification to be a standard after many years of widespread adoption and until that time they refer to a specification as a 'draft standard'.

[41] wto.org legal document
[42] www.itu.int
[43] 3gpp.org

In addition, while it is often the case that the industry will get together at standards bodies to agree a specification as a proposed standard for the industry and then create implementations of the specification which are then deployed into the network, it is also sometimes the case that a successful implementation comes first, and then the industry agrees to adopt this already popular specification as a more formally defined standard. This is more often the case for systems whose implementation is entirely software-based, which is a growing trend in the industry.

Some organisations in the standards space, define what are termed 'guidelines', or 'best common practice' or 'recommendations' in addition to or instead of formal technical specifications which can still be 'standards' under the WTO TBT definition and a large amount of material produced by the organisations in the standards space fall into this category. The way that such documents are written can be less rigorous than a formal specification in that they do not require an accompanying test specification and are less formal about the use of key standards reserved words such as 'MUST' or 'SHALL' which would otherwise mandate particular technical aspects of the requirements. The formulation and purpose of these documents may be to set out a collated industry view on a particular topic which may have benefits in terms of recommending action inside the industry on a topic – which may mean collective action on an issue that may be potentially subject to regulation if no action were taken (i.e. self-regulation). These can also form what is colloquially known as 'pre-standards', gaining consensus in a topic area before moving forward to formally standardise a technology. Such documents may be included in a service provider RFP (Request for Proposal) documents or even in vendor marketing material to demonstrate that their technology adheres to what the body has requested.

The remainder of this Annex gives a brief description of many of the important standards and recommendations bodies within telecommunications. It is not an exclusive list and others exist beyond this list, noting again, that the whole process is essentially voluntary within the industry and new bodies form as groups of organisations see a need.

The bodies in this document are divided into two groups. The first group sets standards and recommendations for the telecommunications network itself, while the second group defines information formats for applications that use the telecommunications network.

A.1/ Standards & Recommendations Bodies for Telecommunications Networking

These bodies develop standards and recommendations for essential functions, interfaces and protocols within telecommunications networks including the security aspects. This list is not exhaustive, there are many domain or topic-specific bodies that also exist.

ITU (International Telecommunications Union – itu.int) is UN specialised agency headquartered in Geneva but has other classes of members as well as countries. The UK delegation is led by Ofcom, who coordinate delegations of government departments and private companies attending the various meetings and Study Groups. Private companies do not have voting rights at ITU, but governments do. ITU's focus groups (which usually exist for about a year) are open to all who can contribute. Its radio division (ITU-R) administers worldwide allocation of radio spectrum; the other main division is ITU-T (Telecommunications), with ITU-D (Development) working on some relevant topics (but not creating standards). Its standards are free to download on the Web.

ETSI (European Telecommunications Standards Institute – etsi.org) is a membership organisation headquartered in the south of France; its Technical Committees are restricted to members (which include British Standards Institution (BSI) and several UK universities as well as telecoms industry companies), but its Industry Specification Groups are open. Standards are free to download.

3GPP (3rd Generation Partnership Project – 3gpp.org) develops standards for mobile phone services. Its various groups hold frequent meetings attended by several hundred people; the locations rotate between different regions. The specifications become standards in the UK when published by ETSI. Membership for UK companies is through ETSI membership.

IETF (Internet Engineering Task Force – ietf.org) writes standards for the technology on which the Internet is based. Anyone can join the groups that write the standards, which for historical reasons are called RFCs (Requests for Comment), though in practice comments are resolved at the earlier Internet Draft stage. In addition, the IRTF (Internet Research Task Force) meet alongside IETF and considers concepts and proposals at a pre-standardisation stage.

IEEE-SA (Institute of Electrical and Electronics Engineers Standard Association – standards.ieee.org) A professional society headquartered in New York which produces a wide range of standards including the IEEE 802 family which covers technologies such as Ethernet and Wi-Fi, and IEEE 1588 which covers network timing and synchronisation. Each standard is the responsibility of a working-group which is open to all.

TMForum (Telecoms Management Forum – tmforum.org) An industry forum that develops architecture and standards for network management interfaces within telecommunications networks.

GSMA (GSM Association – gsma.com) represents the interests of mobile network operators and industry participants worldwide. It plays a key role in influencing standardization organizations such as 3GPP by identifying new technological trends and creating requirements and recommendations documents across the technology space via its Working Groups, which range from Networks through to Fraud and Security. It plays a key role in the industry as the issuing body for mobile equipment identities, the custodian of the mobile security algorithms and the owners of the specifications for the eSIM. It operates key industry services such as tools and services for managing roaming interconnect, essential for operationally functional global mobile networks. It also creates its own standards, in many cases these profile the 3GPP/ETSI specifications reducing the options and recommending a subset of solutions for mobile network operator adoption. Its commercial arm organises the Mobile World Congress events.

O-RAN Alliance (Open Radio Access Network Alliance – o-ran.org) is a recently formed industry body, led by network operators aimed at refining 3GPP and other standards in order to increase the degree of interoperability between the main building blocks of the mobile RAN. Its scope includes specifications, testing and integration as well as software components, software hosting infrastructure, and AI control of the configuration of RAN components.

GSOA (Global Satellite Operators Alliance - gsoasatellite.com) is an industry association representing the satellite industry and includes standards working groups and technology working groups. GSOA liaise closely with both ITU-R and 3GPP.

LFN (Linux Foundation Networking – lfnetworking.org) is a collection of co-ordinated and co-funded open-source software projects producing open-source implementations of virtualisation infrastructure to host, orchestrate, and manage virtualised network functions. These are also effectively reference implementations of the associated interface standards, but it is possible that the reference implementation may be implicitly the definition of the interface standard, and a separate document explicitly defining the interface as a standard might not be created.

SCF (Small Cell Forum – smallcellforum.org) focuses on enabling an open, multivendor technology platform based on 3GPP specifications. SCF has driven the standardization of cellular technology elements such as FAPI, nFAPI, SON, service APIs and split-6 management solutions.

NICC (Network Interoperability Consultative Committee – niccstandards.org.uk) NICC Standards Limited develops telecommunications technical interconnect and interoperability standards, but only when international standards cannot be used or adopted for use in the UK. NICC feeds standards information into international standards bodies to minimise and identify the problems associated with differing requirements in different administrative domains. NICC members, both vendors and operators, have implemented these standards in the UK for more than three decades.

A.2/ Standards & Recommendations Bodies for Telecommunications Applications

These are Telecommunications Related Standards bodies which develop standards and recommendations that impact telecommunications or are impacted by telecommunications, including bodies which specify the formats of information carried by telecommunications networks. This list is not exhaustive, there are many domain or topic-specific bodies that also exist.

ISO (International Standards Organisation – iso.org) and IEC (International Electrotechnical Commission – iec.ch) are treaty organisations headquartered in Geneva, and their members are national standards committees (BSI in the case of the UK). Companies and individuals attend as part of a national delegation. BSI has "mirror committees" which decide how the UK will vote. Access to standards is normally charged, but committee members have some free access. There is some funding (administered by BSI) to help UK SMEs attend meetings in other countries.

ISO/IEC JTC 1's (ISO/IEC Joint Technical Committee 1 – jtc1info.org) scope is standardization in the field of information technology and covers a wide range of standards including information formats which are of relevance to telecommunications. For example, its Sub-Committee 29 includes JPEG and MPEG which are still very active in creating new standards for coding of audio, video, and other media. MPEG meets three or four times a year; each meeting lasts five or six days and is attended by several hundred people. SC 6 developed Open Systems Interconnection in the 1980s and still has a meeting every nine months, attended by a few dozen people.

CEN (Comité Européen de Normalisation – cenelec.eu) and CENELEC (Comité Européen de Normalisation Électrotechnique – cenelec.eu) develop European standards which mirror ISO and IEC respectively. Some CEN/CENELEC standards are cited in EU legislation. Participation for UK delegates is through BSI. They develop a vast array of standards in many fields, very few are directly related to telecoms.

BSI (British Standards Institution - bsigroup.com) is the UK's national standards body, responsible for British Standards and for UK input into ISO, IEC, CEN, CENELEC. In-person meetings are held in Chiswick (west London), but most meetings are now held remotely. BSI is the UK national standards organisation in ETSI and chairs ETSI's NSO Group meetings.

W3C (World Wide Web Consortium – w3.org) develops open, royalty free standards and guidelines to help everyone build a web based on the principles of accessibility, internationalization, privacy and security.

OASIS-OPEN (Organization for the Advancement of Structured Information Standards – oasis-open.org) is a non-profit standards body that offers open-source projects (also other projects) a path to standardization and de jure approval for reference. OASIS projects exist in the areas of cybersecurity, blockchain, IoT, emergency management, cloud computing, legal data exchange etc.

EBU (European Broadcasting Union – ebu.ch) creates standards for radio and television broadcasters; its reports are free to download. Standards-writing groups are in general restricted to its member organisations but can also co-opt experts from outside; sometimes there is a separate group which equipment manufacturers are invited to join. It is headquartered in Geneva.

AESSC (Audio Engineering Society Standards Committee – aes.org/standards) writes standards for the audio industry, including AES3 (digital audio over copper, created with EBU in 1985) and the more recent AES67 (audio over IP). Standards groups are open to anyone, and all the formal standards work is done on-line. Standards are typically $50 but AES members can download them for free. AES itself is headquartered in New York.

5GAA (5G Automotive Association – 5gaa.org) is a global, cross-industry organisation of companies from the automotive, technology, and telecommunications industries (ICT), working together to develop end-to-end solutions for future mobility and transportation services. Created in September 2016, the 5GAA works for the standardization needed for the implementation of V2X communication in cooperation with standards organizations such as 3GPP and ETSI, focusing on cellular based communication known as Cellular V2X. V2X communications are primarily used for advanced driver-assistance systems which increase road safety and traffic efficiency, but are hoped to be integrated into autonomous driving systems.

5G-ACIA (5G Alliance for Connected Industries and Automation – 5gacia-org): The overriding objective of 5G-ACIA is to maximize the applicability of 5G technology in connected industries, in particular the manufacturing and process sectors. 5G-ACIA works to ensure that 5G standardization and regulation efforts adequately consider the interests and unique characteristics of the industrial domain.

A.3/ Differences in Standards Bodies

The mode of operation can be significantly different between standards bodies. For example the mechanism for funding for each organisation differs considerably and the way in which documentation is made available to the general public.
The following table summarises, for the bodies listed in this part of the paper, the key differences between organisations in the standards space.

Indicative table of Standard Defining Organization Types, Working Processes and Membership Costs

Organisation Name	Organisation Type	Type of Standard / Recommendation		Access to Agreed Documentation	Access to Draft Documentation	Visibility of Workgroup Activity (e.g., email lists / forums)	Participation in Workgroups	Participation in Steering Groups	IP Licensing Model	Example Participation Cost* for SME**
		Legally enforced	Voluntary							
ITU (ITU-T / ITU-R)	UN Agency	✓	✓	Open access	Open access	Open access	With membership	Election	FRAND-like	~£27355pa (each for ITU-T and ITU-R)
ETSI	SDO	✓	✓	Open access	With membership	With membership	With membership	Election	FRAND	~£5368pa
3GPP	SDO	✓	✓	Open access	Open access	Open access	With membership	Election	Covered by ETSI IPR policy	With ETSI*** membership plus ~£3025pa
IETF	SDO	✗	✓	Open access	Open access	Open access	Open access subject to registration fee	Election	participants required to disclose IPR	~£400 to £800 per meeting
IEEE-SA	Industry Association	✗	✓	Payment ($50 to $1000 per document) but many important documents free under sponsorship deal	With membership or via 60-day public review (requires per document payment)	With membership	With membership	Election	FRAND-like	~£6300pa
TMForum	Industry Association	✗	✓	With membership	With membership	With membership	With membership	Via Board membership	FRAND-like / Apache 2.0 open-source for software	~£18766pa

Organisation Name	Organisation Type	Type of Standard / Recommendation		Access to Agreed Documentation	Access to Draft Documentation	Visibility of Workgroup Activity (e.g., email lists / forums)	Participation in Workgroups	Participation in Steering Groups	IP Licensing Model	Example Participation Cost* for SME**
		Legally enforced	Voluntary							
GSMA	Industry Association	✗	✓	Mixed. Most open access. Some with membership	With membership	With membership or with special agreement	With membership or with special agreement	Via Election. Split 50/50 between MNOs and other members.	FRAND-like / Apache 2.0 open-source for software	~£11801pa
O-RAN Alliance	Industry Association	✗	✓	Open access	With membership	With membership	With membership	Election	FRAND	~£7868pa
LFN	Industry Association	✗	✓	Open access	Open access	Open access	Open access	Mostly Board selected members, plus some Elected members.	Apache 2.0 open source for software (Typically)	~£7868pa (Silver)
SCF	Industry Association	✗	✓	Open access	With membership	With membership	With membership	Via Board membership	FRAND	£9,500pa (Regular) £17,750pa (Board)
NICC	Industry Association	✗	✓	Open access	With membership	With membership	With membership	Via Full membership	FRAND	£1500pa (Associate) £3500pa (Full)
ISO/IEC (i.e. for access to ISO/IEC JTC 1)	SDO	✓	✓	Pay to download – Typically £50 to £200 per document	Via National Standard Bodies (i.e. BSI)	Via National Standard Bodies (i.e. BSI)	Via National Standard Bodies (i.e. BSI)	By National Standard Body members only	FRAND-like	N/A
CEN/CENELEC	SDO	✓	✓	Pay to download via National Standard Bodies	Via National Standard Bodies (i.e. BSI)	Via National Standard Bodies or invited Industry Associations	Via National Standard Bodies or invited Industry Associations	By National Standard Body members only	FRAND	N/A
BSI	SDO	✓	✓	Pay to download – Typically £100 to £300 per document	Open access during public review period	By application to BSI	By application to BSI	Via Board appointment	Unknown	£1515pa
W3C	Industry Association	✗	✓	Open access	Open access during public review period	With membership or special invitation	With membership or special invitation	Election	Royalty-free	£6648pa

Organisation Name	Organisation Type	Type of Standard / Recommendation		Access to Agreed Documentation	Access to Draft Documentation	Visibility of Workgroup Activity (e.g., email lists / forums)	Participation in Workgroups	Participation in Steering Groups	IP Licensing Model	Example Participation Cost* for SME**
		Legally enforced	Voluntary							
OASIS -OPEN	Industry Association	✗	✓	Open access	With membership	With membership	With membership	Election	FRAND-like	£17694pa
European Broadcasting Union (EBU)	Industry Association	✗	✓	Open access	With membership	With membership	With membership	Election	Unknown	Unknown
Audio Engineering Society (AES)	Industry Association	✗	✓	Pay to download – Typically £40 to £80 per document. Or free with membership.	Via working group membership or free via 6-week public review	Working group membership is open to all (participants are vetted)	Working group membership is open to all (participants are vetted)	Election by members	FRAND-like	(Personal membership only)
5G-ACIA	Industry Association	✗	✓	Open access	With membership	With membership	With membership	Via Board membership	Unknown	Unknown
NGMN	Industry Association	✗	✓	Open access	With membership	With membership	With membership	Via Board membership (MNOs only)	Unknown	£5972pa
TIP	Industry Association	✗	✓	Open access	With membership	With membership	With membership	Via Board membership	FRAND / BSD open-source for Software	£19651pa
OMASpecWorks	Industry Association	✗	✓	Open access	With membership	With membership	With membership	Election or via 'Sponsor' membership	FRAND	£4714pa (Full) £15714 (Sponsor)

Notes

* Cost converted to GBP on 24th May 2024 using xe.com mid-market exchange rate. All excluding VAT.

** SME: An autonomous entity with less than 250 staff and less than €50 Million turnover per year.

*** 3GPP membership is included with membership of one of seven regional standards bodies (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC) plus an additional fee.

A.4/ NICC Standards Limited's role in UK telecommunications standards for interoperability

NICC was originally created by Oftel in 1984 to help control the transition from a British Telecoms monopoly to an open competition telecommunications market in the UK. This created an environment that broke the traditional national monopoly and resulted in the proliferation of telecommunication companies we know today.
In this saturated market, standards are vital to ensure that new entrants, SMEs, etc. are able to bring new products and services to customers, and to enable them to migrate seamlessly between providers.

NICC Standards Limited develops UK telecommunications for technical interconnect, interoperability and end to end network standards. Specific UK standards are only developed when international standards cannot be used or adopted for use in the UK. NICC members, both vendors and operators, have implemented these standards in the UK for more than three decades.

The adoption of international standards and any required UK standards opens the UK telecommunications market to any new entrant.

Standards ensure that different networks and services can connect with other services operating on different networks.

Standards enable the new entrant to the telecommunications market, including SMEs, to buy equipment from vendors that has already been built to existing UK or international standards, allowing rapid implementation into the network.

Standards for interconnection tend to drive innovation to the features and technology level. Before interoperability standards, a telephone was, typically, a black GPO 746 rotary dial phone. Now, with standards driving features and technology, the market is full of new services and features. New technology is leading to the development of more intelligent communication services.

NICC Standards Limited produces UK (or adopts international) technical standards to ensure that telephony and telecommunication products and services work from end to end over the UK network. The UK network landscape is now more stable and, more recently, NICC has worked with Ofcom and the UK government on more specific projects and requirements.

These include –

- Stopping scam calls.
- Developing a fast, automated call tracing process.
- Ensuring accurate location information for emergency callers.
- Guidance on blocking of scam calls from international origins.
- Rules to implement the Ofcom General Conditions of Entitlement.
- Guidance to providers on interpretation of the Telecommunications (Security) Act 2021.
- End-to-End network performance.
- All IP Telephony industry guidance and lessons learnt.
- Guidelines for the security of All-IP telephony (All-IPT) service.
- Guidance for the transport of data in an All-IP Telephony world.
- Guidance on customer premises equipment compatibility for All-IP Telephony networks.

The benefits of standards include –

- Allowing number portability.
- Allowing ease of customers' movement between telecommunications providers.
- Quality and minimum requirements and provide recognised solutions for the protection of consumers, customer equipment, network connectivity, connection to the emergency services, etc.
- Encouraging/permitting competitiveness and innovation.
- Protection of consumer interests.
- Regulatory compliance.
- Contributing to productivity by lowering the cost of regulatory compliance and shorten the time to market of new products.

B/ Standards Success Stories & Case Studies

In this annex, we look back briefly at two areas which have arguably been the greatest exponents of the impact of telecommunications on society. Both have contributed significantly to economic development and the quality of life of citizens. In both cases, inter-operability was a major factor in their success, even if the paths taken were different.

In addition, two highly impacting standardization projects are considered, providing an illustration of varying working procedures in the respective expert groups.

B.1/ Two Major Success Stories: Mobile Communications & the Internet

B1.1/ Mobile Telecoms Domain

Initially mobile communication (1G) was an extension to the fixed telephony services with proprietary specifications. One example is the Advanced Mobile Phone System (AMPS) in the USA.

Operators in the Nordic countries realised that building independent networks and technologies in such small markets would be wasteful. The first mobile communication system with international roaming was launched in 1981 (Nordic Mobile Telephone – NMT). This developed into a long-lasting collaboration model in telecoms.

Some years after service launch it was clear that first generation analogue systems experienced severe congestion (limited radio spectrum). In Europe, national telecommunications authorities in CEPT decided to develop one single European system with open standardized solutions. In 1982, CEPT established the Special Mobile Group (GSM) to explore pan-European mobile communications system based on open standards.

In CEPT countries, strong requirements on interoperability differentiated this region from North America and Japan, with competition between national networks, liberalised device ownership and international roaming. GSM gained leadership in ITU Region 1, USA was the leader in ITU Region 2, and only Japan developed a national 2G system in ITU Region 3.

All the content-oriented services in 2G were fully integrated into the mobile network and operated by the MNO. There were hardly any separate content cluster players at this stage, and the value system consisted of three actors: end users, MNOs with their integrated content services, and companies providing devices to end users.

The success of GSM together with the emerging data networking and internet technologies (in fixed networks) motivated the inception of the third generation (3G) of mobile communications. This need was recognised at international level at ITU.

IMT-2000 paved the way for 3G which originally had five Radio Interface Technologies, with a sixth one (WiMAX) added several years later. Circuit-switched voice remained the main service and growth in data services took up slowly. There was no obligation to follow the internet value system which was taking a leading position outside the mobile communication value system.

The open standards approach of GSM gained the upper hand in 3G, where 3GPP was based on core network protocols and SIM cards from GSM. On the other hand, in the USA and Japan the regulators set fewer requirements for MNOs to interoperate; several non-interoperable systems for messaging and other value-added services developed in those two markets. For example, in Japan the mobile market only fully converged in 4G where LTE allowed the cdma2000 MNO (KDDI) to adopt SIM cards and roaming with the other national MNOs.

The success of 3GPP is evident in that out of the six IMT-2000 Radio Interface Technologies only WCDMA (and TD-SCDMA in China) survived in the marketplace. The North American approach, cdma2000, tapered away in late 2000's.

The global consolidation emerging from 3GPP technologies finally allowed a mature ecosystem in 4G (IMT-Advanced), which enabled separate business systems to emerge on top of the mobile platform. This was referred to as flat architecture using IP transport connectivity within 4G network infrastructure. Internet services wholly independent of MNOs appear Over The Top (OTT) over the Long Term Evolution (LTE) radio and flat network architecture.

Key takeaway: open standards and focus on interoperability (GSM) paved the way to a global platform that extends beyond the mobile communications network itself.

B.1.2/ Internet Domain

The conceptual ideas for the system that later became known as the Internet developed in the context of Advanced Research Project Agency (ARPA) in the United States. The project involved the United States Department of Defence and several universities. The original, closed protocol was replaced by an open, multivendor environment which brought forward the first version of TCP/IP.

TCP/IP implemented all the key aspects of the Internet today: computer platform independence, best-effort communication, retransmission in case of packet loss. The connections operate without any centralised control and the formal architecture is simple.

During the early days of computer networking, the commercial solutions were vertically integrated into each vendor's platforms (IBM, DEC, etc). The National Science Foundation adopted TCP/IP and promoted its use in interworking with other countries. The voluntary nature of this growth, sponsored by governments, essentially donated the fundamental operative characteristics to the Internet, which became a value system independent from major commercial companies.

Internet services are defined by protocols developed at the Internet Engineering Task Force (IETF). There is no mandatory requirement for a specific protocol set which operates between end points of a network. The transport network is rather intended to be transparent and provide fallback options, relying on best-effort approach to support connectivity of the Internet services.

The most important actors in the Internet value system are companies, institutes and service providers which control their own domain names and operate respective subsystems independently. Different subsystems are interconnected through peering points by a set of peering agreements, or by transit arrangements that allow traffic to be transported over third party networks. This value system initially focused on basic applications such as email and file transfer, and thus content clustering was voluntary.

The emergence of Internet browsers brought forth the fast development of web content. These web applications often use protocols developed at the World Wide Web Consortium (W3C).

Internet services are decentralized, and they initially did not consider mobility at all. Wireless LAN evolved from the already established Ethernet technology in IEEE. The very different models of vertical structure in mobile communications and internet value systems kept these domains a long time separate from one another.

Key takeaway: standards in the Internet domain retain the original decentralized approach of supporting protocols which develop without holistic coordination. There is no equivalent of the "generations" that are distinguishable in the telecoms domain.

B.2/ Two Standards Projects: 3GPP & JPEG/MPEG

B.2.1/ 3GPP

3GPP was formed in 1998 as a result of an effort to avoid the dispersion of the 2nd generation of mobile, and move towards a global standard in 3G. Although there was still an evolution of the CDMA standards under 3GPP2, most of the market followed 3GPP, and eventually in 4G the parallel projects merged into a true single global standard – which has continued in 5G.

Annex B

The scope of 3GPP covers the critical interfaces in mobile networks, including the multiple layers of the radio interface, higher layers (mobile/CN), RAN network interfaces, RAN/CN interfaces, CN interfaces or latterly interworking between CN functions, in addition to management functions.

Making contributions to a large international standards body such as 3GPP can be challenging since it encompasses fast moving processes and has many large and well-established members with long experience in the project. As a beginner, it can be challenging to understand its procedures and culture, and to manage the volume of proposals and pace of work, especially for small delegations. However, the 3GPP Group Chairs, Secretariat and most delegates are helpful in getting you started; newbies need not be afraid to ask questions or ask for guidance.

All the work in 3GPP, as in most Standards Developing Organisations (SDOs), is driven by technical contributions. In 3GPP's case, these must map into previously agreed work or study items, and where typically each of these items has been agreed in a plenary meeting of each Technical Specification Group (TSG). Each TSG determines the work programme of its technical working groups. Often but not always, such items are agreed as part of a release package (a collection of items that are targeted for completion at broadly the same time, typically every 18-24 months). So, if you want your ideas to be considered, you need to actively contribute – potentially not just at working group level, but also at plenary level.

Technical agreements in 3GPP are based on consensus amongst different stakeholders - indeed consensus is a cornerstone of the 3GPP processes. For a small delegation or company, simply making a technical input and expecting that your proposals will be automatically accepted is unrealistic. It is therefore vital to collaborate with those different stakeholders and share and discuss your ideas in the first instance.

Most explicit business of 3GPP takes place in physical working group meetings, with most having a schedule of 4-6 per year, spread around different regions. However, collaboration and discussion outside of the meetings is critical to making progress.

Building supporters with companies that have similar objectives/requirements can amplify your influence and increase the chances that your proposals are accepted. This can be achieved, for example, through collaborative research projects, industry associations, and/or 3GPP Market Representative Partners (MRPs) targeting particular 'verticals' or industry sectors. All of these can allow discussion, alignment and the building of industry consensus of technical proposals ahead of the standardisation meetings themselves. Technical inputs that are well supported by various actors across the industry, and/or address multiple use cases have a far better chance of success; collaboration is key.

There are examples where issues identified by MRPs at Project Coordination Group level have eventually become Work Items. In addition, and in spite of the complexity of the organization, many SMEs have also been able in the past to become influential in specific areas, often by developing and leveraging broad interest and support (e.g. of potential customers, other players in the same sector, etc). There are many examples of SMEs successfully driving areas of the 3GPP specifications, including cases where such efforts significantly increased their market value[44].

B.2.2/ JPEG & MPEG (ISO/IEC JTC1/SC29)

The main business of these two groups is efficient coding of still images (JPEG), moving pictures (MPEG), and audio (also MPEG). The standards specify the format of a bit stream by describing how it is decoded to produce an image, sequence of images, or digital audio signal.

Bit stream compression is achieved by taking advantage of redundancy in the data, for example in a video sequence each frame contains material that also appears in adjacent frames, perhaps displaced by a few pixels as the camera pans or the object moves. The quality of the final result (for any given bit rate) depends on how well the encoder chooses which parts of adjacent images (or other parts of the same image) to use; this is entirely up to the implementer and is not specified by the standards. Thus an implementer is free to use any technique for the encoding, and to keep novel aspects secret rather than go to the expense of filing and defending patents.

Ideally the bit stream format would be entirely free to use, and there have been several projects to standardise formats using only technology for which any patents have expired, but in practice the compression efficiency can be significantly improved by using proprietary techniques in the encoding. This is enabled by the formation of “patent pools” to which companies donate patents and then get access to all the other patents in the pool. Sometimes introduction of a new compression technology to the market is delayed by negotiations to form a patent pool.

MPEG has a 5-day (Monday to Friday) physical meeting about four times a year. A project such as a new coding format begins with discussions at these meetings. Use cases and requirements are then developed, during meetings and also by “ad hoc” groups which exist from the end of one meeting until the start of the next. Often the output from an ad hoc group will be finalised at a physical meeting held during the weekend preceding the MPEG meeting. A public call for technology is then issued and “core experiments” (reference implementations to test the effectiveness of proposed technology) carried out. Then the standard is written. For more detail see https://blog.chiariglione.org/how-does-mpeg-actually-work. The process for JPEG is similar.

[44] An example among many is that of IP Wireless. Founded in the UK in 1999, it made significant contributions to the LTE TDD standards and was acquired by General Dynamics in 2012, see LINK

C/ Standards Education

Standardization plays a pivotal role in fostering economic growth, ensuring public safety, and facilitating global trade. It is of critical importance to incorporate comprehensive education on standardization into national curricula. As we navigate an increasingly interconnected and competitive world, an informed population equipped with a solid understanding of standardization is essential for each nation's prosperity and global standing. The use of standards brings many benefits to Small and Medium- sized Enterprises (SMEs - https://sbs-sme.eu/standards-and-smes/) who make up the vast majority of companies, access and participation generates economic growth leading to increased GDP.

C.1/ Background

Standardization is the process of developing, establishing, and implementing technical standards to ensure uniformity and consistency across products, services, and systems. These standards cover a wide array of sectors, including technology, manufacturing, healthcare, and environmental practices. Standards contribute to interoperability, innovation, competitive and sustainable development.

C.2/ Key Reasons to Prioritize Education on Standardization

- Economic Competitiveness: Standardization is a key driver of economic competitiveness. By adhering to recognized standards, industries enhance product quality, reduce costs, and streamline processes. Educating the workforce about these standards ensures that businesses remain globally competitive and can participate actively in international trade.
- Innovation and Research: Standardization fosters innovation by providing a common framework for the development and implementation of new technologies. A well-educated population is better equipped to engage in research and development activities that adhere to established standards, contributing to technological advancements and breakthroughs
- Consumer Protection: Standardization is crucial for ensuring the safety and quality of products and services, this includes the ever increasing threats due to Cyber security. Educating consumers about the significance of standards empowers them to make informed choices, protecting their interests and fostering trust in the marketplace
- Global Trade Facilitation: International trade relies on standardized practices to ensure smooth cross-border transactions. By educating the workforce about global standards, businesses are able to seamlessly integrate into the international market, fostering economic growth and diplomatic relations.
- Environmental Sustainability: Standards play a vital role in promoting sustainable practices and mitigating environmental impact. Integrating education on environmental standards prepares our citizens to contribute to sustainable development and address global challenges, such as climate change.

C.3/ Recommendations

- Work with the Ministry of Education to integrate modules on standardization across various educational levels, emphasizing its importance in different sectors.
- Invest in professional development programs for educators to enhance their knowledge of standardization, enabling them to teach these concepts to students effectively.
- Foster collaboration between the education sector and industry leaders to ensure that educational programs align with the evolving needs of the workforce and business landscape.
- Launch public awareness campaigns to inform citizens about the role of standardization in their daily lives and the broader impact on the nation's economic and social development.

In conclusion, educating about standardization is an investment in the future resilience, competitiveness, and sustainability of each nation. By fostering a culture of awareness and understanding, the workforce is empowered to actively contribute to a globally competitive and harmonized society.

C.4/ Some Available Resources

Asia-Pacific Economic Cooperation (APEC)
ASME
ASTM International
CNIS
ETSI
Global Advanced Technology Innovation Consortium (GATIC)
IEEE
IEC Young Professionals Program
ISO
ISO Academy
International Cooperation for Education about Standardization (ICES)
Korean Standards Association
NIST
Society for Standards Professionals (SES)
World Standards Cooperation (WSC)
British Standards Institute
CEN/CENELEC/ETSI Joint Working Group on Education about Standardization

Annex D

D/ Abbreviations

5G-ACIA	5G Alliance for Connected Industries and Automation
5GAA	5G Automotive Association
3GPP	3rd Generation Partnership Project
AESSC	Audio Engineering Society Standards Committee
AMPS	Advanced Mobile Phone System
APIs	Application Platform Interface
ARPA	Advanced Research Project Agency
BSI	British Standards Institute
CEN	Comité Européen de Normalisation
CENELEC	European Committee for Electrotechnical Standardization
CEPT	European Conference of Postal and Telecommunications Administrations
GSM	Global System for Mobile communication
GSMA	GSM Association
EBU	European Broadcasting Union
ETSI	European Telecommunications Standards Institute
EWG	Expert Working Group
FAPI	Functional application platform interface
FRAND	Fair, reasonable and non-discriminatory
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ISGs	Industry Specification Groups
ISO	International Standards Organisation
ISO/IEC JTC 1's	ISO/IEC Joint Technical Committee
IRTF	Internet Research Task Force
ITU	International Telecommunications Union
ITU-D	International Telecommunications Union - Development
ITU-R	International Telecommunications Union Radio
ITU-T	International Telecommunications Union - Telecommunications
JOTS	Joint Operators Technical Specifications
LFN	Linux Foundation Networking
LTE	Long Term Evolution

MAC	Multiple Access Control
MNO	Mobile Network Operator
MRP	Market Representation Partner
nFAPI	network FAPI
NICC	Network Interoperability Consultative Committee
NMT	Nordic Mobile Telephone
O-RAN Alliance	Open Radio Access Network Alliance
OASIS-OPEN	Organization for the Advancement of Structured Information Standards
OTT	Over The Top
RAN	Radio Access Network
RRI	RAN Intelligent Controller
RRM	Radio Resource Management
RU	Radio Unit
SCF	Small Cell Forum
SDO	Standards Defining Organization
SEP	Standards Essential Patent
SME	Small and Medium-sized Enterprises
SMG	Special Mobile Group
SON	Self Organising Network (defined for RAN networks)
SONIC	SmartRAN Open Network Interoperability Centre
TCP/IP	Transmission Control Protocol / Internet Protocol
TMForum	Telecoms Management Forum
TSGs	Technical Specifications Groups
UKTL	UK Telecoms Lab
UPC	Unified Patent Cour
W3C	World Wide Web Consortium
WID	Work Item Description

E/ Contributors

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