OpenForum Europe

# Open Source Software in Europe's Telecoms Industry:

## Capabilities, Ecosystems, and Policies for a More Sovereign and Competitive Future

*A Vision Paper*

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# List of Acronyms

| | |
|---|---|
| **3GPP** | 3rd Generation Partnership Project |
| **AI** | Artificial intelligence |
| **APIs** | Application programming interfaces |
| **ARPU** | Average revenue per user |
| **BEREC** | Body of European Regulators for Electronic Communications |
| **CaaS** | Communications as a Service |
| **CADA** | Cloud and AI Development Act |
| **CAMARA** | Common API Marketplace And Repository Architecture |
| **CEN** | European Committee for Standardization |
| **CENELEC** | European Committee for Electrotechnical Standardization |
| **CNCF** | Cloud Native Computing Foundation |
| **CPE** | Customer premises equipment |
| **DNA** | Digital Networks Act |
| **DT** | Deutsche Telekom |
| **EC** | European Commission |
| **ETSI** | European Telecommunications Standards Institute |
| **HE** | Horizon Europe |
| **IEEE** | Institute of Electrical and Electronics Engineers |
| **IP** | Intellectual property |
| **IPCEI** | Important Projects of Common European Interest |
| **IPCEI-CIS** | Important Project of Common European Interest on Next Generation Cloud Infrastructure and Services |
| **IPR** | Intellectual property rights |
| **IT** | Information technology |
| **LF** | Linux Foundation |
| **NFV** | Network functions virtualisation |
| **O-RAN** | O-RAN Alliance |
| **ONAP** | Open Network Automation Platform |

| | |
|---|---|
| **OSH** | Open source hardware |
| **OSM** | Open Source Management and Orchestration (MANO) |
| **OSPO** | Open Source Programme Office |
| **OSS/BSS** | Operations Support System and Business Support System |
| **R&D** | Research and development |
| **RAN** | Radio access network(s) |
| **RFP** | Request for proposal |
| **SDN** | Software defined networking |
| **SDOs** | Standards Developing Organisations |
| **SME(s)** | Small and medium-sized enterprise(s) |
| **SRS/OCUDU** | Software Radio Systems/Open Centralized Unit/Distributed Unit |
| **TIM** | Telecom Italia Group |
| **U.S.** | United States |
| **VMs** | Virtual machines |

# Executive Summary

Europe's telecoms industry is at an inflection point. Over the past decade, successive waves of virtualisation, softwarisation, network disaggregation, and cloudification have transformed the vertically integrated, hardware-centric model that defined the industry for decades, reorganising networks into horizontal, software-defined layers. Open source software has been both an engine and a beneficiary of this shift, with open source foundations acting as de facto standards bodies and projects such as OpenStack, Kubernetes, Sylva, and CAMARA becoming deployable industry defaults.

From the operators themselves, engagement varies sharply by operator size. Tier 1 carriers have built internal engineering teams and sit on the governance boards of major projects. Orange's procurement-driven "Open Source Factory" has been particularly innovative and a leader in the use of open source in Europe's telecoms industry, with the organisation embracing open source software and linking every request for proposal to open source software requirements, inverting traditional vendor relationships. Deutsche Telekom has also been influential for its leadership in critical open source software projects like Sylva and CAMARA. By comparison, mid-sized operators tend to engage mainly through vendors and a more limited use of the procurement function, while broadly lacking the engineering scale to contribute upstream.

The report argues that, with the right policy choices and resources, open source software can help unlock greater digital sovereignty and competitiveness for European telecoms operators without compromising network security or stability. Its analysis is organised around three dimensions: capabilities, ecosystems, and policies. Its observations are based on a combination of qualitative desk research and 17 semi-structured interviews with representatives from across the EU public sector, European telecoms industry, and open source ecosystem, including operators, vendors, foundations, standards bodies, EU institutions, regulators, OSS projects/communities, and experts.

**Capabilities:** The first key finding is that the binding constraint on Europe's telecoms industry is capability, not code. Europe accounts for a large share of global open source software contributions, yet struggles to convert that technical presence into high-scale commercial products or strategic control. Most operators remain consumers rather than contributors, locked in a self-reinforcing cycle: outsourcing software to suppliers, particularly large equipment vendors (especially in radio networks), along with a combination of systems integrators and technology providers. This reliance on external suppliers has largely eroded the in-house capability that many operators would need to exercise leverage, subsuming them into relationships of dependence with tightly integrated networks of vendors serving different components of the telecoms software stack.

**Ecosystems:** The second key finding concerns the wider web of competition, collaboration, and vendor relationships that no single operator controls. Neutral, foundation-hosted collaboration offers a way through, with projects like Sylva and CAMARA letting competing operators pool investment in non-differentiating layers. There are also challenges with the ecosystem of suppliers operators depend on but cannot fully control, creating coordination challenges which will need to be addressed. Three structural barriers recur. First, market fragmentation: roughly 170 operators in Europe compete on

cost and coverage rather than services, leaving little margin for the long-term R&D that OSS participation requires. Second, vendor and integrator incentives: equipment vendors and systems integrators derive recurring revenue from the proprietary complexity that open, commoditised infrastructure would compress, so they have limited reason to accelerate the transition. Third, an internal skills gap and an ageing workforce oriented toward legacy hardware rather than software contribution.

**Policies:** The third key finding is that four policy concerns converge around open source software in the telecoms industry, concerns which sometimes pull against one another. They are competitiveness, sustainability, regulatory burden, and sovereignty. Funding is considered the most critical lever, but European Union instruments are criticised as fragmented and short-term, with Horizon Europe's 3-5 year windows ill-suited to maintaining critical strategic infrastructure that the telecoms industry needs. The Important Projects of Common European Interest model was cited as better matched to sustaining strategic open source software projects, especially where funding is tied to upstream code contribution. Compounding regulation creates overlapping mandates and confusion that fall hardest on smaller operators. On sovereignty, the report finds that the open source software and sovereignty link is therefore only as strong as the industrial policy behind it.

The report also sets out a vision for what Europe's telecoms industry could look like by 2040 and the interventions needed to get there. It argues that the main constraints on open source adoption are structural rather than technical or financial, and that the European Union has a narrow window to act because the decisive instruments (the Digital Networks Act, the Tech Sovereignty Package, and the European Competitiveness Fund) are being negotiated now. The 2040 goal is not self-sufficiency, but tactical control over the governance and region-specific layers on which sovereignty and competitiveness actually turn. To achieve this, the report makes nine recommendations across its three dimensions of capabilities, ecosystems, and policies.

**On capabilities:** reskill an ageing workforce, reform public and private procurement so OSS-based control points and multi-vendor interoperability become standard requirements, and incentivise upstream contribution in proportion to each operator tier's resources. On ecosystems: extend multi-vendor discipline from hardware into the software and management layers, and build an OSS-native systems integrator layer including SMEs. On policies: reduce compounding regulatory burden through the Digital Omnibus and Digital Networks Act, consolidate and lengthen funding instruments including a dedicated funding vehicle for telecoms that ties public money to upstream contribution, and address supply chain concentration, starting with a dependency analysis that extends beyond RAN.

# Chapter I: Introduction – Europe's Telecoms Industry at an Inflection Point

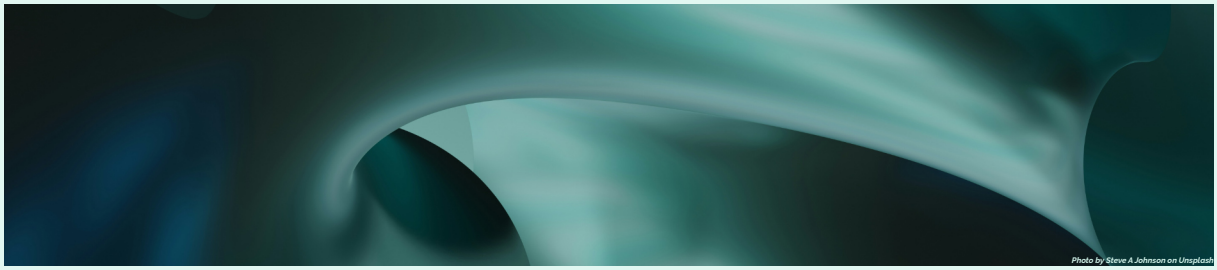


Photo by Steve A Johnson on Unsplash

This report explores the capabilities, ecosystems, and policies that are shaping the telecommunications (hereinafter 'telecoms') industry in Europe, as it relates to software development and engagement with open source software (OSS) specifically. It evaluates the state of play for OSS and software-defined networking (SDN) in European telecoms, and then considers a forward-looking vision for what the European Union (EU) should do to come together with telecoms operators and the open source ecosystem to accelerate a more sovereign and competitive future for the industry.

Advancement in the use of OSS and other open technologies in telecoms software stacks has happened for many years, but has increased precipitously over the last decade. During that period, collaboration between the telecoms industry and open source ecosystem has steadily increased, with OSS becoming entrenched as a foundational element of network architectures and software stacks. In light of the telecoms industry's dual mandate as providing both a universal connectivity service and strategic digital infrastructure, the question of the sustainability and competitiveness of operators in countries and regions across Europe is more crucial now than ever, particularly given the importance of operational resilience and sovereign control in an era of heightened geopolitical tensions.

In Europe, telecoms operators have faced unprecedented challenges related to their market operations, ecosystem relationships, revenue stagnation, and large-scale geopolitical disruptions. Mergers of large operators in select European markets have provided them with much-needed operational scale, while also making it harder for new entrants to join and for smaller operators to stay afloat. Although the trend of moving to cloud-based infrastructure has jolted operators into modernising their networks, the entry of foreign cloud hyperscalers into the European market has been met with calls for greater regulation.

The structural issues present in telecoms networks in Europe are even more dire when considering the research and development (R&D) capacity that operators lost through underinvestment or outsourcing. In this context, it becomes clear that embracing OSS has and will continue to play a crucial part in solving operators' problems. Europe must pivot toward a services-led market strategy that leverages procurement to scale domestic innovation and ensures resilience through multi-vendor, disaggregated architectures.

This report argues that, with the right policy choices and resources, OSS could be well placed to unlock greater digital sovereignty within Europe's telecoms industry, all without compromising the networks' security or stability and in a way that creates more sustainable, healthy, and competitive foundations for the industry. In Chapter II, we lay out this detailed landscape in more depth, evaluating the state of OSS in European telecoms,

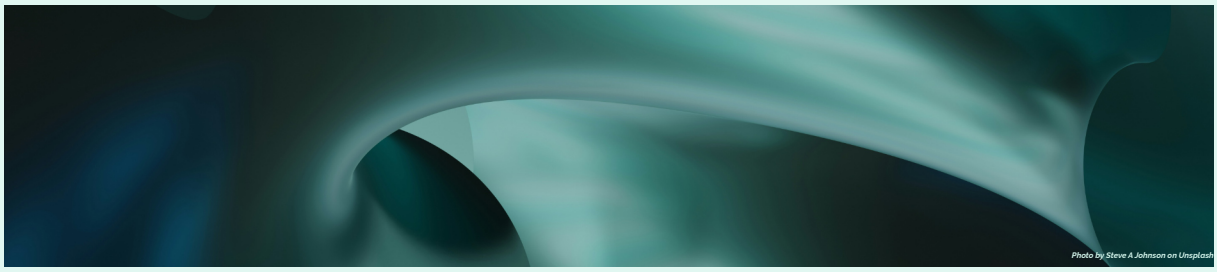
with added historical context. In Chapter III, we illustrate some of these dynamics more clearly by offering three case studies of European operators who have navigated the transition to OSS in telecoms software stacks in different ways over the last ten years. In Chapters IV to VI, we look at some of the key dimensions of these challenges – capabilities, ecosystems, and policies – highlighting key lessons from the interviews that formed the foundation for this report. Finally, in Chapter VII, we present the vision itself, outlining a forward-looking case for how capabilities, ecosystems, and policies for telecoms in Europe can help promote a more sovereign and competitive future for the industry. Chapter VIII presents a brief conclusion.

## A short note on methodology

The findings contained in this report draw on a combination of desk research and qualitative interviews conducted between February and May 2026. The authors carried out 17 semi-structured interviews with representatives from across the EU public sector, European telecoms industry, and open source ecosystem, including operators, vendors, foundations, standards bodies, EU institutions, regulators, OSS projects/communities, and experts. These conversations were complemented by a review of industry reports, policy documents, and the technical literature on OSS and SDN.

The interviews were conducted under the promise of confidentiality, and quotes are attributed by role specification rather than name unless respondents agreed to be identified.[1] Where relevant to discussions of particular operators, it may be possible to extract attribution to respondents of particular organisations, but interview respondents have reviewed the veracity of those attributions to ensure their accuracy and completeness. All quotes, even where not directly attributed, have been approved for use by the person who provided them.

# Chapter II: The Landscape – The State of Open Source in European Telecoms




This chapter traces how the European telecoms industry arrived at its present relationship with OSS, and why that relationship has become central to questions of digital sovereignty and competitiveness. The story is one of progressive unbundling: from vertically integrated, state-owned monopolies that procured full-stack, hardware-software solutions through a handful of vendors, to successive waves of virtualisation, softwarisation, network disaggregation, and cloudification that loosened those commercial and proprietary ties, reorganising telecoms networks into predominantly horizontal, software-defined layers.

OSS has been both an engine and a beneficiary of this shift, with foundations like the Linux Foundation[2] (LF) emerging to steward critical software for operators and projects such as OpenStack,[3] Kubernetes,[4] Sylva,[5] and the CAMARA (Common API Marketplace And Repository Architecture) Project[6] establishing themselves as deployable industry defaults. This chapter sketches this historical trajectory, surveying the maturity and adoption of OSS (in general terms) across the telecoms software stack, as well as showcasing how engagement varies sharply by operator size and capability. In doing so, the chapter lays the groundwork necessary for understanding the structural challenges and bottlenecks examined in the rest of the report, with some initial references to claims from interview respondents (which are expanded in Chapters III-VI).

## 2.1 The prevailing software-hardware paradigm in the telecoms industry

During the fixed-line era, most telecoms networks and services in Europe existed as large, singular, state-owned enterprises. As national champions operating under public mandates, these enterprises were designed to provide universal connectivity rather than to compete, and their monopoly status gave them both the rationale and the resources to control every layer of the network from infrastructure to end-user services.[7] This led to high degrees of vertical integration in their supply chains. Physical network infrastructure, procured, built, and maintained through rigidly organised supply chains, underpinned the connectivity services they offered and was often co-financed with public money.[8]

Much of this vertical integration was owing to the profitability of the initial business model for delivering connectivity. With physical infrastructure requiring enormous investments, network operators relied on services to cover the costs and bring in profits.[9] In this non-competitive regime, incumbent operators possessed the vast human resources and technical skills necessary to build their own service platforms directly on top of their –

albeit usually publicly financed – passive infrastructure.[10]

The organisations resulting from these monopolised markets were behemoths that wanted full-stack solutions, which vendors like Nokia,[11] Ericsson,[12] LG,[13] and Samsung[14 15] readily supplied with integrated software-hardware packages. These off-the-shelf solutions ensured that for all physical components of the network – from base stations and core network to Operations Support System and Business Support System (OSS/BSS) functions[16] – individual suppliers fully serviced all physical components. But, they also locked the network operators into the vendors' proprietary systems and maintenance contracts that could last up to 30 or even 40 years.[17] In this way, operators were reliant on full-house hardware-software solutions provided by many functionally differentiated vendors.[18]

The landscape changed with the introduction of mobile technologies and liberalised markets. Capturing the new rapidly growing revenues from mobile services became more important than controlling the supply chain, and Nokia, Ericsson, and other vendors became partners – more so than mere suppliers – in this race to capture mobile revenue growth.[19] As mobile services expanded and policy interventions focused on market liberalisation,[20] service providers' revenue began to drop and became insufficient to cover the capital costs required by physical infrastructure buildout and maintenance. This was a structural inevitability – physical telecoms infrastructure exhibited the characteristics of a natural monopoly, where the costs of building and maintaining a network are so high and the returns so low that the market tends toward a single dominant provider.[21] As technology evolved, the boundaries of what constituted natural monopoly shifted local loops from copper to now fibre.[22] Owning that physical layer remained a source of market power throughout these transitions, as whoever controlled the 'pipes' retained a structural advantage over those who depended on it, regardless of what was running through it.[23]

On the other hand, the downstream retail segment – reliant on access to the local network in order to reach the final users – has since become much more competitive, in large part due to regulatory interventions focused on improving consumer welfare and accessibility.[24] As a result, a two-layer market structure emerged across Europe: (1) a wholesale infrastructure layer dominated by incumbent network owners such as Deutsche Telekom (DT)[25] in Germany, Orange[26] in France, Telefónica[27] in Spain, and Telecom Italia Group (TIM)[28] in Italy; and (2) a retail services layer in which a larger number of operators – including challengers like Vodafone[29] or some regional providers – compete for end customers on the basis of price, service quality, and bundled offerings.[30] Today, the ownership of the network, and the 'last mile' in particular, represents a powerful competitive advantage, as this kind of asset is so expensive to replicate that it presents (some) natural monopoly features.[31] However, with the advent of more digitised networks, the ownership of underlying physical assets may not confer such significant advantages for much longer.[32] Thus, the strategic imperative shifted from controlling every link in the supply chain to capturing the explosive revenue growth of mobile services.[33]

## 2.2 Virtualisation and softwarisation

Over a decade ago, the network functions virtualisation (NFV) of telecoms networks began in earnest, setting the industry on course for rapid transformation. The shift was based on a simple realisation; namely, that not every functionality needed to be tied down to a specific 'box' of hardware, but could instead be run virtually over generic hardware shared with other functionalities.[34] More generally, virtualisation is "not limited to servers, but can

work for all kinds of infrastructure elements, such as storage, CPU, GPU, application, network and data centres".[35] Thus, operators began moving away from dedicated hardware boxes to running functions on virtual machines (VMs) over generic IT industry-scale hardware. These virtual machines relied on proprietary solutions – often provided by VMware or Oracle – and eventually, since the 2010s, on open source-based ones like OpenStack.[36]

Once virtualisation was 'en route', it was just a matter of time before 'softwarisation' – the shift from building networks on dedicated, proprietary hardware to using flexible, programmable software running on standard commercial servers[37] – gained ground. SDN moved networking to software-based components connected via application programming interfaces (APIs), applying a new software-based architecture to traditional networking functions.[38] In this context, NFV is the split of the 'functionality' box into hardware and software layers which can then be procured, deployed and managed independently. SDN, on the other hand, is an architecture in which system functionality is split into modules that are connected via APIs.

## 2.3 Disaggregation of the stack and the rise of cloud

As virtualisation and softwarisation progressed in tandem, these trends manifested in the disaggregation of network architectures. Generally speaking, network disaggregation is the separation of proprietary, all-in-one systems into modular, interchangeable parts. As a trend in telecoms, network disaggregation was instrumental in reshaping the more traditional and rigid market structure in the industry. As it happened, disaggregation empowered operators to break down their systems into a number of smaller components, sourcing them from multiple vendors, decreasing the need for predominantly single-vendor solutions, and diversifying their supply chains.[39]

These trends have also given rise to containers, a phenomenon known as 'containerisation'. Operators had gradually begun augmenting and even replacing the functions served by VMs, which enabled them to move away from physical infrastructure by facilitating virtualisation and abstracting real-world resources into a software layer.[40] By contrast, containers have allowed an optimal and efficient implementation of flexible service-based architectures for telecoms network functions, especially given the degree of their scalability and reduced code maintenance compared to older, VM-based models.[41] Kubernetes has established itself as the default container management solution,[42] utilised by solutions such as RedHat's OpenShift[43] or SUSE's Telco Cloud[44]. Another key technology in this area is Docker,[45] an open source platform for building, packaging, and running containers that standardises applications and their dependencies into lightweight, portable container images.

The process of 'cloudification' is the logical next step of network transformation, as it combines existing best practices – e.g., microservices, containers, continuous deployment[46] – to increase operational efficiency at a large scale.[47] The arguments in favour of cloudification and prominence of cloud-based solutions are numerous, given its multi-use and future-proof deployment options, with operators understanding the value of "moving towards unifying different use cases into a single platform".[48] Vendors have also begun to shift their products to the cloud, aided in part by their clients wanting to move away from separate appliances.[49]

Operators might have initially perceived these transformations – virtualisation, softwarisation, containerisation, and cloudification – as a road towards a more cost-

effective alternative to running a full hardware stack. The initial industry narrative often focused on cost reduction, but it soon became evident that NFV and cloud-native did not always yield immediate financial gains.[50] Instead, their value was found in the ability to move away from deterministic hardware models and escape the limitations of physical appliances, increasing the capability for open innovations.[51]

Over time, the need for integrated, pre-packaged solutions coming from single vendors decreased, and operators gained the ability to use the cloud for multiple deployments. The rise of global cloud hyperscalers (AWS,[52] Microsoft Azure,[53] Google Cloud[54]) now defines this evolution, and those hyperscalers' massive R&D spending has dwarfed that of European operators. This has had the dual effect of creating a strategic power imbalance that risks consolidating the digital ecosystem in Europe (in which operators are some of the biggest players) under non-EU, proprietary control.[55]

European operators have long been empowered to decide how they want to build their networks – and in some cases, collaborate more on shared open foundations. However, relying on separate providers for components across hardware, software, cloud, core, transport networks, service platforms, and radio access networks (RAN) has also come at a cost. Having the responsibility for the networks' functioning be diluted among different actors means that the ultimate responsibility for the network's functioning has fallen back on the operators.[56] While larger operators often have the operational and technical capacity to carry this burden, smaller operators have struggled to keep up. This is partly due to the fact that mid- and small-sized operators have outsourced much of their engineering capability to external providers and generally have smaller information technology (IT) teams. Now, they must balance their responsibility for the network's operations with external relationships.[57]

For the rest of the report, we indicate these structural differences between operators by referring to them as belonging to 'tiers'. In the Internet connectivity market, networks are classified based on the nature of their connection to other networks, ranging from the largest (Tier 1) to medium (Tier 2) and small-sized (Tier 3) entities.[58] In the strictest sense, Tier 1s own and control the operating infrastructure – including the routers and switches – which is interconnected with other Tier 1 operators via peering at Internet exchange points.[59] Tier 2s are usually still large but regional players that are "at least one router hop away from the core of the internet", thus becoming more reliant on Tier 1s.[60] Accordingly, Tier 3s are the smallest and most local of the operators, and their connectivity is wholly dependent on the higher tier networks. We use the tier designations in the broadest sense, as they relate to market size and infrastructure capabilities.

In summary, the industry's latest transition is one from hardware-centric, 'black box' monopolies toward a horizontal, software-driven ecosystem where the physical network is separated from the services layer.[61] As the telecoms industry undergoes a technological transformation and starts resembling other digital-native industries, OSS, therefore, becomes ever more relevant,[62] particularly in Europe, where the industry has different market features than in other regions.

## 2.4 The role of the OSS development model

As outlined above, a high degree of vertical integration initially characterised the telecoms industry, while advances in virtualisation and softwarisation – and later containerisation and cloudification – broke it up and accelerated more horizontal integration, particularly over the past decade or more.[63] During this time, there has been a concerted effort and

intentional collaboration that unlocked these advances using open technologies, with the industry's giants utilising OSS and open source modes of governance and cooperation to collectively build the horizontal, disaggregated models that treat open, foundational infrastructure as a shared commodity.

### 2.4.1 The role of de facto standardisation

Open source foundations – the institutions that steward and host critical OSS projects – have acted as central orchestrators of the telecoms industry's transition from proprietary hardware black boxes to disaggregated, software-defined telecoms models. This has accelerated in recent years but took place long before that. Organisations like LF and its subsidiary the Cloud Native Computing Foundation (CNCF) have accelerated innovation through 'code-first' standardisation. This model, to some extent, contrasts with the traditional standardisation processes employed by Standards Developing Organisations (SDOs). Among them, the European Telecommunications Standards Institute (ETSI), the European Committee for Standardization (CEN), and European Committee for Electrotechnical Standardization (CENELEC) (the latter two known together as CEN-CENELEC) are designated as the European Standardisation Organisations.[64] There are also many more international SDOs – including the 3rd Generation Partnership Project (3GPP) and the Institute of Electrical and Electronics Engineers (IEEE).[65] Broadly speaking, all these SDOs focus on developing standards via specifications and formalised participatory processes.[66]

Open source foundations became indispensable for developing code implementations alongside formal standards, establishing de facto industry defaults that are immediately deployable and are often 'upstreamed' into the SDOs.[67] Foundations aim to provide neutral collaboration arenas and build industry consensus on non-differentiating components, like operating systems and containers. Even with some fragmentation in the ecosystem, they have generally seen success in their role as project stewards.[68] These days, there is much more cross-pollination between traditional SDO processes and OSS projects, which is arguably a net positive. An example could be the ETSI Software Development Groups (SDGs) that complement the work of ETSI on standard technical specifications with aligned open source developments to improve the quality of standards and accelerate their adoption.[69]

Now, rather than being viewed as competing paradigms, standards and OSS are increasingly treated as complementary systems.[70] This accelerated in recent years with the success and recognition of projects like CAMARA. In this dual-system approach, the industry uses formal standards (like 3GPP's standard for 6G, or any of the IEEE standards) to ensure interoperability between different implementations, such as the radio interface between a handset and a network.[71] Conversely, the industry employs OSS when it needs to standardise on a single implementation for non-differentiating components.[72] Here, the work of OpenAirInterface[73] also comes to mind – this EU consortium focuses on developing OSS and hardware implementations for 3GPP cellular networks.[74]

### 2.4.2 Increasing maturity of OSS solutions in the telecoms industry

An LF Networking survey reported that 63% of the respondents from the telecoms industry both use and contribute to OSS solutions.[75] That being said, over one third of the respondents classified themselves as active users but not contributors, which one of our respondents exaggeratedly summarised as: "everybody wants to use OSS, but nobody wants to contribute to it".[76] Nonetheless, awareness of the utility of OSS solutions has been growing across the industry. Solutions like the aforementioned OpenStack and

Kubernetes, but also Sylva (unified telco cloud stack), CAMARA (network abstraction through standardised APIs), Open RAN[77] (radio access networks), FreeRADIUS[78] (networking protocol), SONiC[79] (network operating system) and Aether[80] (managed cloud service) are just a few examples of OSS and open standard solutions that have successfully penetrated the telecoms landscape.

In the bygone era of VM dominance, OpenStack was the primary core for the first wave of NFV, enabling the move away from hardware into the realm of virtual. The virtualised architecture presupposed the existence of specific servers, mimicking traditional hardware appliances in a virtual environment. While Kubernetes has displaced OpenStack at the application layer – that is, developers stopped thinking in terms of VMs for deploying their apps – it still plays an important role in managing the infrastructure underneath.[81] This is especially true for private cloud environments, where organisations want partial or full control over their own hardware, although public cloud providers like OVHcloud[82] also rely on OpenStack.[83]

Containers have become the default way of managing and deploying applications, and Kubernetes has established itself as the de facto orchestration standard. With the advent of SDN, almost all cluster management solutions have to be built with Kubernetes in mind. Possessing the knowledge of and familiarity with the ecosystem is critical in today's telecoms landscape.[84] While originally designed by the IT industry for stateless web applications, Kubernetes' architecture lent itself well to the telecoms realm, although it required adaptation to correctly support network functions. By now, however, the ecosystem has caught up to what the telecoms networks need and filled the initial technical gaps.[85]

Some of the other prominent contributions that OSS made in the telecoms realm exist in the infrastructure layer. Among them is Project Sylva, the common OSS reference stack initiated by Orange, DT, Telefónica, TIM, Vodafone, Ericsson and Nokia.[86] Sylva offers a common reference architecture for Communications as a Service (CaaS), abstracting the underlying bare-metal resources or IaaS platforms (currently supporting VMware, OpenStack, and OpenNebula).[87] Sylva, and its use of CaaS, now ranks among the most successful examples of collaborative funding in this space. Unlike previous attempts, Sylva reached production maturity, with the likes of the Orange Telco Cloud now being fully based on a downstream version of Sylva.[88] The project has acted as a pathfinder for building a sovereign European stack, demonstrating that it is possible to have a carrier-grade alternative to proprietary stacks.[89]

There is also CAMARA, which DT initiated in 2022 and the LF now hosts. CAMARA standardises network APIs – abstracting the complexity of telecoms network functions into developer-friendly interfaces that allow third parties to consume network capabilities (quality of service, identity verification, anti-fraud, 5G slicing, and others) without navigating each operator's proprietary implementation.[90] While this was not the first attempt at exposing APIs to make their capabilities usable beyond pure connectivity, it is by far the most successful.[91]

Another of the flagship initiatives in the disaggregation space is Open RAN and specifically the efforts and activities of the O-RAN Alliance.[92] Open RAN aims to separate radio access from the physical infrastructure through the standardisation of protocols and interfaces.[93] It is an approach to mobile network architecture, focused on radio access networks, that opens the interfaces between the components of the RAN, allowing operators to combine hardware and software from different vendors rather than sourcing an integrated system from a single supplier. Many major vendors like Ericsson, LG, Nokia and Samsung, are

members in the O-RAN Alliance. The O-RAN Alliance's specifications have specifically disaggregated two layers of the protocol stack – the Distributed Unit and the Centralised Unit[94] – helping to move the network away from custom proprietary solutions towards open interfaces. The resulting model of a neutral stack with an application layer on top is deceptively similar to more standard IT deployments, and one that signals a shift away from specialised, telecoms-specific software.[95]

In the management and orchestration domain, projects like Open Source MANO (OSM) and Open Network Automation Platform (ONAP) have become vital for operators seeking to reclaim control over their technical foundations. OSM, a project hosted by ETSI, provides a unified orchestration solution that ensures the interoperability and portability of workloads across diverse multi-cloud environments.[96] Similarly, major carriers like DT have leveraged ONAP (hosted by the LF) to build independent radio controllers and orchestration layers.[97]

Further advancing the automation of network functions is Nephio,[98] a project initiated in collaboration with Google and now part of the LF Networking umbrella. Nephio focuses on intent-driven orchestration, addressing the complexities of managing telecoms workloads in multi-cloud and Kubernetes-based environments. By automating the deployment and scaling of cloud-native network functions, it bridges the gap between traditional telecoms operations and modern cloud infrastructure.[99]

Finally, OSS has also made its way into the last mile with customer premises equipment (CPE). This CPE is the routers, modems, and any other telecoms equipment that is placed closer to the customer's end of the network. Here, open source hardware (OSH) projects like SONiC and the prpl Foundation have been making major gains towards establishing vendor-neutral hardware. Players like Orange have adopted SONiC to handle Layer 2 and Layer 3 routing services on their international backbones; that is, deploying vendor-agnostic equipment to control the flow of data on both physically closer devices and disparate networks with more control and flexibility.[100] The ability to build out and customise equipment means that operators may use low-cost industry scale components for producing CPEs with generic functions (for price efficiency) and introducing specific ones for premium features or best-in-class performance (for differentiation).[101] This is beneficial for operators working in low-profit areas, where the cost of equipment is simply too high and would not be returned due to low revenues caused by low average revenue per user (ARPU) or low population density.[102]

### 2.4.3 Open source as an advantage

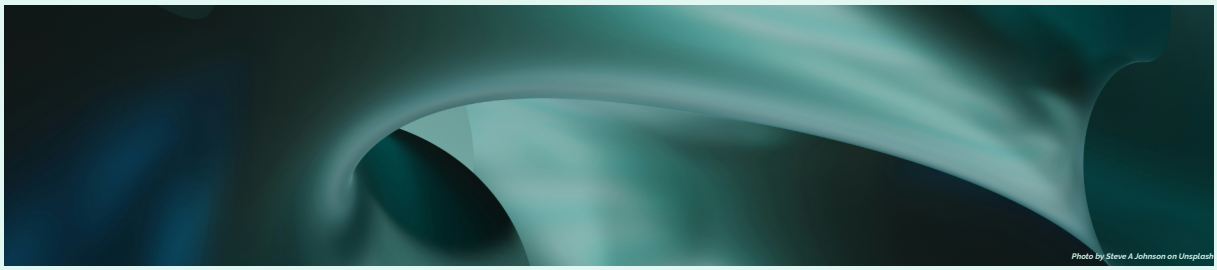
As shown above, OSS and OSH (and initiatives towards openness in general) have become valuable assets for the telecoms industry. Many operators and vendors relying on it for solutions that support cost efficiency, differentiation, and ready deployment across a range of market segments, such as cloud-native infrastructure (OpenStack, Sylva), container orchestration (Kubernetes), network APIs (CAMARA), radio access (Open RAN, OpenAirInterface), management and orchestration (OSM, ONAP, Nephio), and CPE (SONiC, prpl). As the stack becomes disaggregated and increasingly hosted on general-purpose computing platforms, OSS solutions have naturally gained significant traction as foundational elements of this new architecture.

One of the major selling points of OSS solutions in the telecoms space is their ability to free users from lock-in. In the case of operators, this is naturally connected to the disaggregation movement; as operators navigate migrating away from entrenched proprietary software-hardware systems, OSS appears a natural choice.[103] In this regard, the

question of familiarity and activity in the open source ecosystem becomes important. On the one hand, it may seem that the reliability of commercial contracts – and the availability of judicial recourse should these not be fulfilled – means that organisations without active participation in the open source ecosystem may opt for software provided by proprietary vendors. They might do so due to the availability of guaranteed support, preferred over uncertain community feedback and irregular project maintenance.[104] But network operators also benefit from OSS/OSH due to high costs associated with swapping network technologies, and for disaggregated software and hardware, it is much easier and cheaper to replace and assemble it in parts.

The biggest challenge to OSS in the telecoms industry moving forward lies in the question of scaling it to make it competitive with proprietary solutions.[105] While Europe as a whole has secured a commanding technical presence through the flagship OSS projects listed above, the bloc struggles to convert this code into high-scale commercial products.[106] Compounding this discrepancy, Europeans count as the single largest geography in terms of contributions to OSS projects writ large, with around 30-35% of total commits.[107] This shows that the knowledge and skills are present in Europe, while the assets themselves remain largely hosted by non-EU foundations and have been difficult for operators to commercialise.

# Chapter III: Case Studies of Transformation in Progress




OSS adoption varies across the telecoms industry in Europe. The persistence of vertical integration may explain this; telecoms' software-hardware integration endured for decades, particularly in the network domain, and the industry is still paying the price.[108] There is also a degree of structural resistance in the industry when it comes to adopting a more open innovation-friendly mindset. A study looking at the discrepancies between the expectations and attitudes of telecoms leaders shows that operators do not prioritise the right type of thinking – the industry has a "tendency to focus on pricing rather than innovation", in addition to facing "difficulties [in] shifting the industry mindset to one that promotes ecosystem-based collaboration"[109] that is inherent to OSS.

A tiered maturity model – where size, R&D capacity, and market position dictate engagement – fundamentally defines how European operators adopt OSS.[110] Tier 1 carriers, such as Orange and DT, have large in-house developer teams at their disposal, and have somewhat successfully transitioned into active producers and maintainers of shared infrastructure. They sit on governing boards of the biggest OSS projects (e.g. CAMARA, Sylva) and foundations (e.g. CNCF, LF Networking) and contribute code to ensure long-term control over their architectures.

Whereas Tier 1 operators have achieved a degree of technical transparency and emancipation from vendor dependency that allows internal teams to exert direct control over the software stacks they rely on, Tier 2s and 3s struggle in this regard. Engaged Tier 2 and Tier 3 operators have been able to ask their engineers to work with the source code, tweak it to their desire, and have informed discussions with the OSS developers outside the organisation about the operators' specific needs and requirements, but it remains more challenging at their level of capabilities. This feedback and interaction would be hardly possible in a more closed, proprietary system, and hinges on operators' staff having familiarity with the ecosystem.[111]

This chapter grounds those dynamics in three operators who have navigated the transition in markedly different ways. Orange, a Tier 1 carrier from France, has built a fully committed, procurement-driven 'Open Source Factory', participating as user, contributor, funder, and governor. In Germany, DT (also Tier 1) exercises high-visibility leadership in flagship projects like Sylva and particularly CAMARA, while remaining a passive consumer across much of its stack. Finally, Telenor – a mid-sized Tier 2 carrier based in Norway – engages mainly through vendors and procurement, and is now reframing digital sovereignty as a commercial opportunity. Together, these case studies show how scale, engineering capacity, and market position shape what OSS engagement is possible, and why leadership at the top does not automatically generalise downward.

## 3.1 Orange: The 'Open Source Factory' Model [112]

As perhaps Europe's most prominent and innovative telecoms provider, Orange provides a fascinating case study of OSS in Europe's Tier 1 operators. Orange S.A., formerly France Télécom, followed a familiar trajectory, evolving from a state-owned French monopoly into a global telecoms giant.[113] Today, the organisation serves over 315 million customers across 26 countries, driving innovation in fibre, 5G, cybersecurity, and digital services.[114] For many years, Orange followed the traditional software development model of many telecoms providers: substantially dependent on hardware providers, high degrees of vertical integration, waterfall project management and processes, and substantial dependence on an ecosystem of commercial vendors. While some of this is still in place, the trends discussed above have substantially disrupted it, with Orange now at the frontline of responding to these challenges in the European market.

Orange was one of the vanguards of disaggregation, utilising an architectural choice that moved the company away from 'full house' infrastructure and towards a horizontal model. Orange deliberately decided to sever the link between hardware, orchestration, and the network functions running on top, and instead embraced a set of open, shared infrastructure layers – for example, telecoms cloud, lifecycle management, observability, and operations – that sit beneath all network function deployments and that Orange controls rather than hands to individual vendors. The practical mechanism they used was procurement – and specifically, the linking of procurement to OSS and open standards. For example, every time Orange opens a request for proposal (RFP) for a new or renewed network service, it embeds OSS horizontal control points as requirements in the RFP. Vendors who want to sell network functions to Orange must conform to an OSS-based stack rather than delivering their own proprietary management and orchestration tooling.

While this is not new, it is innovative and disruptive in a traditional industry like telecoms, allowing for more collaboration, flexibility, and strategic differentiation across Tier 1 and Tier 2 operators. By forcing OSS to be the lever of control, the linking of procurement and OSS places the burden on the vendors to ensure they are conforming to baseline requirements and innovating on top, rather than reinventing the wheel every time. This was an inversion of the traditional model, where vendors effectively dictated the operational and deployment environments they sold, maintained, or supported. In practice, it helped Orange to ensure disaggregation was practically feasible, building an open ecosystem that enables it to thrive without locking Orange into a single provider and accelerating a trend that was likely to happen more slowly otherwise.

In addition to procurement, Orange has innovated through its movement towards in-house engineering capacity to supervise and contribute to OSS projects. In particular, it has demonstrated leadership in numerous projects which operationalise disaggregation in very concrete ways. Today, the projects underpinning much of Orange's software stack include Project Sylva, SONiC, CAMARA, and the Cloud Native Telco Initiative (CNTI) within the LF, which Orange uses to define and communicate cloud-native requirements to network function vendors.

What makes Orange's model of procurement and disaggregation analytically relevant is its explicit theory of where the company should and should not create value. It allows the company to focus on what matters as telecoms technology is inevitably softwarised, virtualised, cloudified, and containerised – particularly now, in the AI era. Orange has been clear that the core telecoms cloud layer, lifecycle management tooling, and observability infrastructure are not sources of competitive differentiation, but instead commodity components. Investing in proprietary versions of these, or accepting vendor-proprietary

versions, would mean losing control of this critical stack.

Instead, OSS at these foundational layers frees up investment and engineering capacity for what Orange actually wants to compete on: the services and AI-driven network capabilities built on top. This is a major pivot, but one that has been meaningful and successful. It demonstrates clearly the commercially argued case for OSS, not a principled one, wherein it rests on a demonstration that the total cost of ownership of the OSS implementation is competitive with what vendors would otherwise propose. A representative of Orange estimates that, beginning in the mid-2010s, it took three to four years for the company to establish itself credibly, but that this investment of time and resources is now paying off.

The cultural dimension is just as important to Orange as the technical one. The transition required educating staff at all levels – from senior leadership to operational teams – on the difference between OSS, open core, and proprietary software, and on what it means to be accountable for a platform that no single vendor owns end to end. It also required a sustained negotiation with network function vendors, whose business models have historically depended on professional services revenue that automation and OSS are steadily eroding. Getting vendors to adapt their offerings to Orange's OSS-based horizontal stack (as opposed to the reverse) was a significant shift in power in the operator-vendor relationship, and one that happened just as much through cultural change as the imperative for technological innovation.

Orange participates in the open source ecosystem across four levels: using OSS, contributing code, funding projects, and governing projects. This distinguishes Orange from the majority of European telecoms providers (the Tier 2s and Tier 3s, but even some of the Tier 1s), who remain primarily consumers. Orange articulated from the start that Sylva should be a community project under LF governance rather than an Orange-controlled initiative, which was what made it attractive to other operators and vendors.[115] That combination of active governance participation and deliberate community-building is what separates Orange's model from earlier operator-specific platform attempts – such as Verizon's 'do-it-yourself' stack or DT's early containerisation work – which remained too operator-specific to attract broad ecosystem buy-in.

This model is relevant on two levels. First, it is one of the few demonstrated cases in Europe of an operator systematically converting open source strategy from an IT concern into a network operations reality, with commercial metrics to back it up. Second, it reveals what the conditions for replication look like: increased in-house engineering capacity, sustained senior-level commitment, the ability to use procurement strategically as a policy lever with vendors, and a willingness to invest years in cultural transformation before results emerge. Most European operators, particularly smaller ones, lack several of these conditions. As a result, Orange's model is instructive as a benchmark but cannot be assumed to generalise straightforwardly without structural changes in how operators are funded, how they cooperate, and how procurement rules are designed. Nevertheless, it is the most compelling case for the types of innovations and transformations that are possible with OSS and open standards as critical levers.

## 3.2 Open Source Leadership at Deutsche Telekom [116]

DT offers another revealing case study of both the possibilities and limits of OSS engagement among European operators. Like Orange, DT is a Tier 1 operator: a large, historically state-owned carrier from Germany that has evolved into a major international telecoms group. DT emerged in a similar environment to Orange, facing many of the same

challenges over its early decades of operations. Today, DT serves tens of millions of customers across Europe and the United States (U.S.), operating extensive fixed and mobile infrastructure and positioning itself increasingly as a technology and innovation company. It is one of the few European operators with the engineering depth and institutional scale to participate in the governance of OSS projects, rather than simply consume them.[117]

For many years, DT followed the same model as most large European carriers: outsourcing software development and network innovation to a small number of large equipment vendors, principally Nokia and Ericsson, and relying on SDOs to define the interfaces and protocols on which those vendors built. While DT still operates within this model in large parts of its business, it has been active in identifying where OSS gives it strategic leverage and building the institutional infrastructure to act on that. DT's most significant contribution to the open source ecosystem has been its highly active leadership, alongside other operators, the CAMARA project. Initiated and chaired at the board level by DT, the CAMARA project grew from around 22 founding companies to roughly 190 named partners and 480 participating companies, with 50 to 60 (estimated) actively contributing on a regular basis. What makes CAMARA strategically significant beyond DT is its governance model. Rather than being a DT-controlled platform, DT took the project to the LF and structured it as a neutral community with independent funding.

DT also made a deliberate choice to bypass traditional standards bodies like ETSI and 3GPP, which it regarded as too slow and too narrowly telecoms-centric. The goal was explicitly to bring in hyperscalers, application developers, and non-telecoms industries as consumers and contributors. This is something a traditional SDO would have been poorly placed to achieve, and which enabled the project to take off more quickly. CAMARA started with a European GDPR-based core, which shaped its initial governance, before US operators and eventually some hyperscalers joined. The result is a project that DT can credibly claim as both a community asset and a source of thought leadership, with Chief Executive Officer-level visibility internally.

Beyond CAMARA, DT's OSS engagement is active in a small number of targeted areas. Sylva and ONAP are the other main projects where DT holds board seats, has active contributors, and provides financial sponsorship. DT is also a founding member of LF Europe and chairs the LF Networking board – positions that confer meaningful governance influence over the broader telecoms open source ecosystem. Separately, DT has built its own radio controller using ONAP, framed explicitly as a strategic decision to reduce vendor dependency in an area where it considers control over its own tooling important. This is one of the more concrete examples in the interviews of a European operator making a deliberate architectural decision to internalise capabilities that would otherwise be wholly vendor-supplied.

There are some limits to this picture. DT's OSS engagement outside its flagship projects is limited, since operators in general (and DT in particular) are consumers far more than contributors. Only a handful of OSS projects at DT have any active contributors, and the broader organisation relies on OSS in the same way most large enterprises do. The structural explanations offered are consistent with what several other respondents describe: operators have not done serious in-house R&D for approximately 30 years, have outsourced that function to their equipment vendors, and do not have the engineering culture or budget allocation – outside of small innovation units like Group Technology – to rebuild it quickly.[118]

While not having contribution capacity does not negate the value of OSS for a telecoms provider, it was a source of strategic differentiation for operators like Orange. Launching CAMARA required a full year of alignment within the community of founding companies before the project could formally begin, largely because of licensing and intellectual property rights (IPR) concerns. That delay illustrates a broader institutional friction that makes even well-motivated OSS initiatives slow to start within large carriers. DT is explicit that the organisation knows it is reliant on Nokia and Ericsson at the radio/RAN level, and that changing this requires a level of financial commitment that does not currently exist.

DT's case is relevant to this study in a different way from Orange's. Where Orange illustrates what a fully committed, architecturally driven open source strategy looks like when converted from an IT concern into a network operations reality, DT illustrates the more common pattern among Tier 1 European operators: selective, high-visibility leadership in specific strategic projects, combined with passive consumption across the rest of the stack. Even being one among many, DT's leadership in CAMARA is a genuine and consequential contribution to the European open source telecoms ecosystem, and its governance roles across LF Networking and LF Europe give it real influence over how that ecosystem develops.

Despite this, the gap between DT's external governance presence and its internal engineering culture is substantial, and DT's own account makes clear that the conditions for closing it – for example, through sustained investment, cultural change, and relief from the vendor dependency cycle – are not fully in place yet. For policymakers, this gap is as instructive as the leadership itself: it shows that even the most engaged European operators face structural constraints that individual commitment and leadership alone cannot resolve.

## 3.3 The Telenor Experience as a Regional Player [119]

Telenor[120] offers a different vantage point from Orange or DT, and in many ways a more instructive one for understanding how the majority of European operators use OSS. As a mid-sized, internationally operating carrier headquartered in Norway, Telenor sits in what the industry considers an intermediate tier within Tier 2s. As a company, it is large enough to have over 150 million customers across multiple markets, yet considerably smaller in engineering capacity and in-house development depth than the Tier 1s. For this report, Telenor functions less as a model of OSS leadership and more as an honest account of the structural conditions that shape OSS engagement for operators who lack the scale to truly lead it.

Like most operators of its size, Telenor's relationship with OSS is primarily mediated through procurement and vendor relationships rather than direct participation. The majority of its network software – including its OSS components – arrives pre-integrated through equipment providers, systems integrators, and technology providers, who handle both the implementation and the upstream community engagement on Telenor's behalf. Telenor estimates that roughly 55% of the software in the industry's network operations has OSS origins, and that this is likely true in their own software stacks. The organisation notes that this is likely lower than in most other industries, and attributes the gap to the specialised, hardware-integrated nature of traditional telecoms software.

The areas where Telenor does engage more directly with OSS are limited, often narrower and more practical, or focused on specific projects. Its API gateway, developed in-house with a team of around ten engineers, uses OSS components, and some internal IT systems

built on generic, non-telecoms-specific OSS tooling. They are also doing sovereign cloud and AI factory-related work, which in their estimation is using OSS components to a large extent. Nevertheless, governance participation by Telenor in OSS communities is, by its own account, minimal, with most engagement happening at the technical and expert level rather than through formal board seats or funding. (That said, Telenor has held a vice-chair position in the ETSI OSM project.)

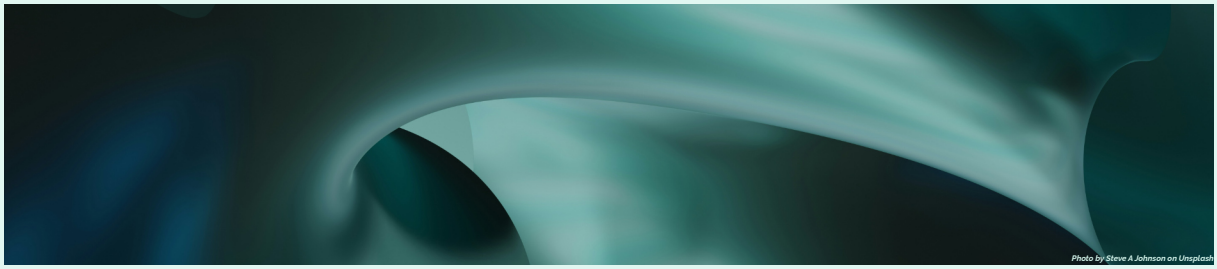
What Telenor's account makes clear is that the scale threshold for meaningful OSS support and participation is higher than the absolute size of an operator might suggest. With development teams numbering in the tens rather than hundreds for any given project, Telenor simply does not have the engineering volume to commit contributors to the upstream communities that underpin the tools it depends on. While organisations like Orange and DT have many more in-house developers and bigger scale to justify this, the gap is not primarily about willingness but about capacity. Without the R&D base to contribute meaningfully, Telenor's role in the open source ecosystem is necessarily that of a well-informed consumer rather than a shaper of it. The organisation also uses OSS as a qualitative criterion in vendor evaluation. For example, it works as a marker of software maturity and a partial hedge against vendor lock-in. But, the organisation also acknowledges that this influence is indirect, exercised through procurement choices rather than direct contribution.

Where Telenor's perspective becomes more forward-looking is in its framing of digital sovereignty as a commercial opportunity rather than purely a compliance question. As a carrier with critical infrastructure status across multiple European markets, Telenor has operated under sovereignty-adjacent requirements for decades – for example, hardware localisation, data residency, personnel residency – long before the current policy vocabulary emerged. What it sees now is a broadening of that logic into new domains: sovereign cloud, AI inference at the edge, distributed edge computing for industrial and public sector customers.

Telenor is also actively exploring a commercial offering in this space, deploying OSS components in partnership with vendors like Red Hat to build sovereign-compliant edge and cloud services for industries including logistics, hospitals, financial services, and industrial operations. This is an example of concrete strategic differentiation with a focus on services, and in a crowded market where the capacity to innovate is limited. One example given is a fish farming enterprise requiring local compute capabilities far offshore, a customer profile that hyperscalers are structurally unsuited to serve. This positions Telenor not as a passive infrastructure provider but as a potential integrator of sovereign digital services in markets where distributed, compliant, locally operated infrastructure has commercial value.

Telenor's relevance here is its typicality. It represents a large cohort of mid-sized European operators that are well-resourced by general business standards, but under-scaled for the kind of deep OSS engagement that Orange or DT can sustain. Its experience illustrates two things that policymakers need to grapple with. First, the conditions for replicating Tier 1 OSS leadership do not exist at Telenor's scale without structural change: more pooled investment, shared engineering capacity across operators, or intermediary models that allow smaller carriers to participate in governance without needing to field their own large contributor teams. Second, the commercial logic of sovereign digital infrastructure is real and is already pulling operators like Telenor towards OSS as a practical tool.

# Chapter IV: Capabilities




The story of open source in the telecoms industry over the last fifteen years is one of industrial innovation and transformation of capabilities on an unprecedented scale. As outlined in Chapter II, the prevailing paradigm before the 2010s was oriented toward waterfall approaches to software development and procurement, with a high degree of vertical integration among Tier 1 operators. Smaller operators, lacking internal technical capability, largely outsourced their R&D.[121] Both were affected by some of the same challenges around technical capability development, with their roles as operators making them largely the stewards of an ecosystem of vendors, rather than the architects of their own stacks.[122]

For this reason, capabilities are central to the capacity for market competition and sustained, ongoing innovation. As this report is focused on open source and OSS specifically, we refer to capabilities not just as general software design and architecture capabilities (both direct development and management of supply chains), but the structures and personnel necessary to evolve and unlock value from adoption and use, support of, and contribution to OSS ecosystems. In this chapter, we consider the changes ongoing in operators as they seek to develop and leverage their capabilities across three dimensions: internal engineering capabilities, strategic procurement, and OSS contribution.

## 4.1 Internal engineering capabilities: real change but widely varied

As telecoms entered the era of NFV and SDN, network services have become progressively managed by software rather than telecoms equipment. Standalone communication applications began to disintermediate operators, threatening the business of equipment providers. With time, innovative services (IoT, edge computing, API commercialisation) started requiring upfront investment that many operators were financially constrained from making.[123] This transition forced many operators to rethink how they organise and deploy their internal engineering capabilities in service of their software supply chains.[124]

With operators choosing to buy software, cloud stacks, and hardware from separate vendors, operators needed to train their staff to manage horizontally integrated software ecosystems. OSS and open standards made it possible for operators to better align their capabilities and cost control centres around a controlled form of vendor mediation.[125] Orange and DT demonstrate this, as does the OSS collaboration that happened through Sylva and CAMARA. Those projects reweighted the long-standing tradeoffs of 'build vs.

buy' – between procurement and purchasing, on the one hand, and engineering and software development, on the other. This tension sits at the heart of how software stacks are built by European operators.[126]

Softwarisation and virtualisation have also meant that European operators of various sizes increasingly outsource physical infrastructure development to equipment vendors like Ericsson and Nokia, in order to redirect more and more of their internal R&D toward software.[127] This reinforces services-led business models and differentiation, but has also led many leading operators to invest more in internal engineering and projects, supporting open innovation.[128] In some cases, it can be a disadvantage – particularly for smaller operators with limited R&D budgets – by reinforcing the effective dominance of Nokia and Ericsson.

Nearly all respondents noted that much of the OSS consumed through operator supply chains arrives pre-integrated in vendors' products, leaving operators with little direct visibility or control over it. This creates a form of dependence wherein vendors and suppliers, rather than operators, mediate OSS adoption. Given the market dominance of the largest of those organisations, operators have limited leverage to change this arrangement.[129] Said one respondent:

> *"... long gone are the days of those big R&D teams. [My view] is that we've outsourced all of that to our vendors. While we may be consumers of open source, a lot of that is coming from, say, Nokia and Ericsson – and Huawei in Asia – the sort of traditional vendors of telco equipment that are providing solutions built on top of open source. But it still comes to us delivered as sort of a silo. And if we want something changed, we yell at our vendor to do something. There's very little, in my view, [attitude of] "Let's build a solution"."*[130]

Consuming network software through integrated vendor stacks prevents operators from developing the in-house software capabilities they need to exercise leverage over vendors and suppliers, reinforcing a cycle of dependence and capability erosion. This dynamic is not unique to Nokia and Ericsson. Any vendor-mediated supply chain that embeds OSS in operators' networks – whether through Huawei, Samsung, Cisco, or smaller specialist suppliers – does so on the vendor's terms rather than the operators', but it is most acute with those ones given their market share in Europe.

Respondents broadly acknowledged this persistence of outsourcing even as new capabilities emerged, but contested it by degrees. Many saw the trend as inevitable or unavoidable,[131] while others saw it as a structural bottleneck inhibiting genuine capability building.[132] One respondent summarised this general phenomenon, commenting that: "... most [operators] have gone through a process where they outsource their own engineering forces. And now they realise that [they] still sometimes struggle to find good people within their own ranks to do new projects, to develop stuff or contribute in the long term with open source technologies, or to adapt them to their business. So, they always rely on third parties."[133]

That said, Tier 1 operators are gradually converting sustained OSS engagement into genuine technical autonomy. They are building internal teams able to evaluate, integrate, operate, and in some cases contribute to the software running in their networks, even where vendors still bring the network functions.[134] Tier 2 and Tier 3 operators are on a different trajectory. Many are realising real value from OSS (e.g., lower costs, reduced lock-in at the margins) but they lack the capabilities (e.g. time, money, technical capacity) to run OSS stacks independently. This reinforces managed services arrangements where

vendors effectively run the network.[135] One respondent suggested that Tier 2 and Tier 3 operators could still get started on capability building by continuing to use OSS in focused domains, for example the sovereign cloud and AI factory work being done by Telenor as a Tier 2.[136]

What unites both trajectories is that the binding constraint is not technology or licensing but what one respondent called 'people competence': the scarce internal skills needed to supervise vendor-mediated supply chains and convert OSS consumption into strategic leverage. Capability, not code, is the bottleneck, and closing that gap is not something smaller operators can do alone through hiring. This is where more strategic use of the procurement function comes into play.

## 4.2 Strategic procurement: 'requirements writers' and the 'pane of glass'

Where software adoption is vendor-mediated, it tends to replicate rather than disrupt the traditional procurement logic it displaces, in the sense that operators gain access to components while the locus of capability remains with the vendor.[137] One respondent likened the traditional procurement dynamic to being a 'requirements writer', noting that this creates a "... vicious circle [wherein] we can't build a real, proper open source infrastructure stack, because our vendors are still building software that doesn't follow the rules".[138]

Where operators have instead begun to develop the engineering depth to engage directly with communities and projects (in practice, largely the Tier 1s) the dynamic shifts and the benefits of open innovation materialise. In these cases, operators engage their vendors from a position of greater knowledge and leverage.[139] One respondent likened this to a 'pane of glass', noting that: "... no matter what technology you have underneath, you need to have a pane of glass that you can use to know what happens. The pane of glass must be under your control, and you need to be able to switch between different suppliers, any piece of your network. When it comes to software, you need to do it very fast, remotely and automatically."[140]

Structural factors and size explain which pattern predominates in an operator's procurement practice. Tier 1s are better positioned to use the pane of glass, while Tier 2s and Tier 3s are more likely to fall into the requirements-writer role.[141] But these tendencies are not set in stone; levers like collaborative vehicles, upstreamed contributions, and reusable procurement requirements give smaller operators ways to exercise control beyond their normal scale.[142] Nevertheless, it is unrealistic to assume that the telecoms industry as a whole, especially Tier 2s and Tier 3s, could move R&D in-house at scale because of huge challenges with cost, scale, and margins.[143]

With more technical capability, it is possible for European operators, even in a highly regulated market like Europe, to gain more choice and control over 'build vs. buy' decisions and tactically leverage OSS components.[144] Orange, for example, links its RFPs to OSS horizontal 'control points' as requirements in the RFP, using procurement as a tool to force compliance with an OSS-based stack as a default.[145] Says one respondent:

> *"[T]oday, what we are trying to do every time we are opening up an RFP for [the] acquisition of a new service or a renewal of a network function service is ... to put those horizontal control points that are open source as a requirement. ... We are spending our*

*life capitalising on things that are very narrow in terms of capability of free use. So the idea is really here to try to use open source as a lever to help us [think] about the reuse of that capitalisation at the scale of [the] company, and for a telecom operator like Orange to [have] a real capitalisation and reuse strategy."*[146]

In mandating OSS horizontal access points in RFPs, Tier 1 operators with more resource and leverage can use procurement as a de facto policy tool to force vendor alignment with a code-first philosophy, bypassing slow, decade-long legacy standardisation cycles.[147] Even for Tier 2 operators, using OSS as a selection criterion in procurement acts as a powerful indicator of a vendor's professional standards and mitigates the risk of long-term vendor lock-in.[148] Operators like Telenor can use procurement as a source of technical autonomy and leverage,[149] even without the engineering and management capability of Orange.[150] Even a lightweight strategic retooling allows smaller operators to become active orchestrators of multi-source environments.[151]

## 4.3 Open source contribution: transformational capability for those who can break the cycle

If procurement determines the terms on which software enters networks, the deeper form of power lies upstream, shaping the OSS communities that underpin modern telecoms stacks. Meaningful capability comes from the ability to engage in this way, by maintaining, forking, and integrating OSS components into production environments. One respondent described how meaningful this type of contribution was in forming capabilities, noting that:

*"... the main reason to contribute is because contribution is a little transfer mechanism. It tells you how the systems work and if the systems work, and you can actively influence their direction, because you have either the capability to do it yourself, or you [can] tell the vendors what you would like to see. ... So, open source is great. It's an important precondition, but it's not a guarantee. And the only guarantee you have is a very active contribution."*[152]

Working upstream is challenging for European operators at scale. Legacy architectures built around dedicated hardware and custom vendor solutions make OSS infrastructure stacks hard to assemble. Most operators lack the capability to shape these communities, defaulting to vendor-mediated adoption and reinforcing the cycle that keeps them from building it.[153] The 'vendor dependence, internal incapability' loop is not irrational at any individual step, but its cumulative effect is to progressively narrow the space in which operators can exercise genuine technical autonomy.

For Tier 2s and Tier 3s, this can be described as a 'developer deficit', whereby projects that Tier 1 operators staff with hundreds cannot be resourced in the same way. This makes external support an economic necessity.[154] Even for Tier 1s, historical software stack failures reinforce the perceived unviability of in-house development. When an operator is stuck in this type of cycle, it makes developing the new capabilities of the open source era – like monitoring dependencies, building an Open Source Programme Office (OSPO), systematically training engineers, and encouraging upstream contributions as part of staff time – seem like an illusory, far-fetched vision.

A small number of operators have broken this cycle. The case studies revealed that getting developers and teams to contribute and engage upstream requires not just investment but a deliberate change in organisational identity.[155] It involves shifting from a procurement-first

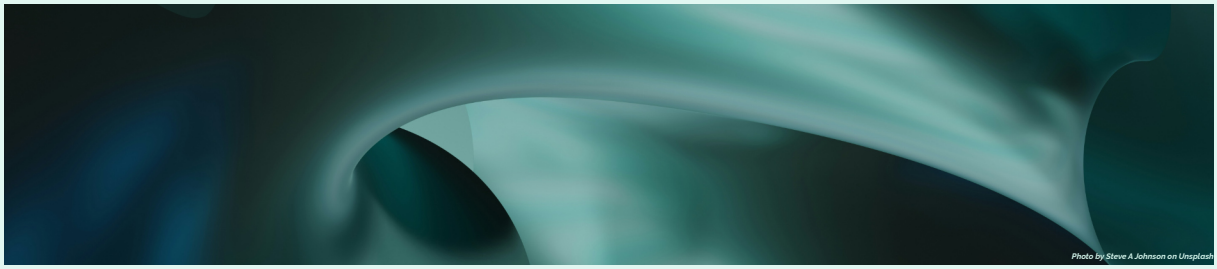
mindset, in which technology is acquired, to an engineering-first mindset, in which technology is built and shaped.[156] Even for a leader like Orange, educating an entire organisation – from the C-suite to operational staff – on software-driven models and continuous contribution was a cultural shift that is still ongoing and took more than five years to start paying off.[157]

For those that can shift the balance of power in this way, OSS acts as a real source of strategic differentiation. Orange and DT are at different points on this spectrum, and the distance between them and the rest of the market is instructive. Both have made substantial commitments to internal software capability, but neither would describe the cultural shift as complete – and most operators have not begun it.[158] Says one respondent: "... it's nice to believe that we're gonna just take all of this OSS and somehow magically build an infrastructure stack that's completely separated from the U.S. players. It's not really possible. ... The telcos, for one, don't have the right types of R&D. There are [still few] software developers inside of telcos."[159]

Operators can continue to utilise capability and procurement rebuilds to continue gaining economic value and network effects from disaggregated software stacks and architectures, but genuine technical autonomy requires engaging upstream. One respondent spells out four dimensions of how this autonomy is realised through contribution: "... when you are in the open source ecosystem, you have four leaders in terms of contribution. The first one is using open source. The second one is committing, or contributing to open source. The third one is funding, or giving money to companies that are developing open source solutions that [you] are using. And the fourth one is governing. So using, contributing, funding and governing."[160]

The capacity to do those four things is scarce precisely because they cannot be procured. Contribution accrues slowly, through sustained engineering presence, and it rests on a prior decision to treat software as something an operator builds and stewards rather than something it acquires. In this view, the binding constraint is not technical or even financial; more accurately, it is the political willingness to take risk and commit to a capability rebuild whose returns might arrive many years later.

# Chapter V: Ecosystems – Navigating Horizontality and Verticality through Cooperation and Competition




The role of OSS in the telecoms industry owes just as much to the individual firms and their capabilities as it does to the ecosystems they have come to share. This includes the cooperation dynamics, institutions, and communities that no single operator or vendor owns, and on which all have come to depend. New forms of collective action are meaningful forces shaping how the industry evolves. This is necessary in Europe, where operators are highly regulated and function under different market and regulatory conditions. The European telecoms industry therefore has features that are distinctly European in character, and which cannot be read off from the experience of more concentrated markets in other regions.

Viewed through this lens, ecosystems are central to understanding innovation and competition in Europe. We define ecosystems not just as the firms and products that populate a market, but the wider web of competitive and collaborative relationships, shared institutions, projects, and communities through which operators and vendors build and unlock value. In this chapter, we examine the features of these ecosystems across three dimensions: the competition dynamics that shape how operators innovate; the cross-operator collaboration that has produced initiatives like Sylva and CAMARA; and the wider vendor community (including equipment providers, systems integrators, small and medium-sized enterprises (SMEs), and other technology providers).

## 5.1 Operator cooperation: competition, consolidation dynamics, and innovation

There is a basic asymmetry between Europe and its global peers. Some respondents mentioned that the base of the telecoms industry in Europe remains highly national. They also acknowledge that some use this fact to argue that operators do not have the scale necessary to compete with global, integrated providers.[161] The narrative remains disputed.

Regardless of one's specific views on consolidation as a remedy, it is clearly the case that given the focus on national or regional markets, Europe as a whole is partly constrained compared to the U.S. when it comes to investment in telecoms innovation. Whereas U.S. operators are less reliant on standardisation due to size, the high number of smaller operators in Europe requires a level of standardisation and coordination that is hard to manage.[162] This makes many operators unable to invest in their own R&D in the same way as in the U.S., forcing operators to compete on cost and network coverage, with limited ability to differentiate on services. They then default to competing on the infrastructure layer, where the returns on innovation are lowest.[163]

As a result, the market has competed itself out of the capacity to invest in the long-term capability building that OSS participation requires. At the same time, OSS provides one of the clear sources of strategic leverage necessary to break this cycle. But the industry is caught in a cycle of low innovation, low profitability, and excessive regulation, making it hard for small businesses to grow and for the industry to attract new talent.[164] One respondent noted that this requires a shift in business models, since margins and revenues for connectivity are not growing at the same rate as for software. They argued that this meant that operators must shift from a 'telco DNA' to a 'techno DNA' to survive. Said the respondent:

> *"My job is to support the transformation of the [operator] from a 'Telco DNA' toward a 'Techco DNA'. The rationale behind that is quite simple: when you are looking at the business and the market that is totally related only to communication, networking, and connectivity, the margin and the revenue are not going up at the same speed or level of what is happening in the ... Software-as-a-Service ecosystem. Today, if we want to differentiate ourselves, betting on our core and networking assets, we need to [embrace] the ingredients of the recipes that made for the success of the digital disruptors."*[165]

Changing this business model in the current regulatory environment will be challenging. European regulation has often prioritised consumer welfare and low prices over the long-term health of the industry. Additionally, the regulatory focus has left many firms with decreasing returns on investment and insufficient funding for high-tech innovation.[166]

Another related and underappreciated competitive dynamic in this landscape is the role of IPR and patent portfolios. In telecoms, standard-essential patents (SEPs) – patents that cover technology incorporated into industry standards – have long been a significant source of competitive leverage, particularly for major equipment vendors.[167] The intersection of OSS and SEP licensing creates genuine complexity: OSS licences and FRAND (Fair, Reasonable, and Non-Discriminatory) licensing commitments do not always sit comfortably together. Nevertheless, licensing portfolios do not constitute a major barrier to open and collaborative innovation per se – 3GPP has been successful in achieving broad cross-industry collaboration in its mobile communications protocols within the remit of FRAND licensing.[168]

Once again, consolidation in Europe – as a response to these conditions – is viewed in a mixed way. The standard argument for consolidation is that Europe's fragmented market – with roughly 170 operators compared to just 5 in the United States – is a major strategic weakness, and consolidation would allow operators to achieve the scale necessary to fund massive network build-outs (like 5G Standalone) and compete with global hyperscalers.[169] Some saw it as conferring small advantages while being unlikely to solve the core problems that operators face. One noted that consolidation may be a 'false promise', with limited evidence that it increases investment, and strong competition remaining the driver of innovation.[170] Another respondent noted that a focus on digital sovereignty could be misused to stifle the resilience and robustness provided by open, competitive markets.[171]

Regardless of one's views, scale alone is unlikely to unlock OSS-driven innovation, whether through consolidation or otherwise.[172] If individual operators cannot match the R&D budgets of hyperscalers and figure out how to contribute more upstream, then consolidation offers at best a partial remedy. The more realistic path to technical autonomy lies in changing what operators attempt to build on their own.[173] Some respondents framed this as a shift away from duplicative, in-house development of commodity infrastructure towards pooled investment in shared, non-differentiating layers.[174] One put it bluntly: the industry needs to stop building fifteen different solutions to the same problem and instead

align on just two or three.[175]

Treating foundational software as a shared cost rather than a source of competitive advantage allows operators to free scarce engineering capacity for the higher-value work where differentiation pays off.[176] This connects the competitive picture back to the business model shift noted earlier. If margins on connectivity are stagnant while value accrues higher up the stack, then competing on services rather than on more OSS-based physical networks is both where the returns to innovation are greatest and where European operators retain the most room to differentiate.[177] The capabilities an operator has accumulated, as well as its past investment choices, shape whether a given operator can take advantage of these levers.

## 5.2 Open source foundations: lessons from cross-ecosystem collaboration

Over the last fifteen years, European operators who compete directly for customers, revenue, market share, and radio spectrum have found ways to work together on shared software infrastructure, pooling investment in foundational layers that none of them initially had a strategic interest in differentiating on.

The antitrust dimension is an unavoidable backdrop to these developments. Operators collaborating on shared infrastructure face misgivings and genuine legal constraints around what can be discussed, agreed upon, and built together without crossing into territory that regulators might view as 'collusion'. This is particularly in a highly regulated space like telecoms. Some respondents identified competition frameworks as a hurdle, noting that operators often view one another primarily as competitors and use competition rules as an excuse to stall open collaboration.[178] Said one respondent: "... because we're a competitor, then antitrust rules come in, and everybody's so scared of the government coming at them with some big antitrust lawsuit, because they've talked to each other as competitors. It really makes it hard for us to actually collaborate."[179]

Such fears might be misguided, since operators are competitors in the retail market but not necessarily competitors at the technical infrastructure layer. But the perception has consequences: antitrust concerns make it difficult for operators to collaborate at that layer without fear of collusion, with some becoming reluctant to talk to one another without lawyers present in innovation meetings, a dynamic that stifles progress. Again, though, this account is contested.[180] Some respondents maintained that there is no evidence of competition rules hindering collaboration around OSS and SDN, suggesting that the chilling effect owes more to operator caution than the rules themselves.[181]

These dynamics explain in part why critical projects in the telecoms industry in Europe have moved more to open source foundations over the last decade.[182] Rather than viewing competition constraints as a reason to stall, industry leaders in Tier 1s increasingly support these neutral governance models, moving projects like CAMARA into them to facilitate collaboration.[183] By hosting collaboration in an openly governed environment, foundations provide the legal and organisational architecture that makes pre-competitive collaboration tractable. This has allowed operators to share the development costs of non-differentiating commoditised infrastructure – such as the 'Telco Cloud' – while maintaining their ability to compete on the high-value services built on that shared base.[184] Ultimately, this creates a 'fair game' environment defined by 'minimal necessary consensus', allowing global partners to contribute as equals on neutral technology while reducing the risk of being

locked into any single vendor's proprietary ecosystem.[185]

LF in particular has played this role across several of the most significant cross-operator projects in European telecoms, including both Sylva and CAMARA. Its value as a neutral governance host lies not just in its legal structure but in its institutional credibility: operators, vendors, and regulators alike treat LF-hosted projects as genuine commons rather than as vehicles for the interests of any single participant.[186] Project Sylva and CAMARA represent different expressions of this collaborative logic.

Project Sylva, initiated by Orange, Deutsche Telekom, Telefónica, TIM, Vodafone, Ericsson, and Nokia, functions as a model for collaboration at the infrastructure layer.[187] In this dynamic, the relationship with vendors is one of carrier-grade partnership, where specialised software companies provide the necessary reinsurance and long-term maintenance that few operators can perform in-house.[188] This makes these vendors active in this ecosystem, creating shared infrastructure that operators themselves also work on. Conversely, Project CAMARA, driven primarily by DT, represents a strategic pivot toward de facto standardisation designed to move faster than traditional bodies like ETSI or 3GPP.[189] Its governance was instead designed to take the project out of the operators themselves by involving hyperscalers (Google, Microsoft) and external developers from the outset to ensure the resulting APIs are simple enough for non-telecoms actors to consume.[190]

While Sylva is about reclaiming the infrastructure foundations of the network, CAMARA is about building a global 'shop window' for network capabilities that requires operators to act as integrators.[191] In both examples, the foundation model supports de facto standardisation.[192] Several respondents described CAMARA's 'code-first, standardise-second' approach as the main reason such projects move faster than bodies like ETSI or 3GPP.[193] Where a standard exists, the instinct is to code it; where one does not, the approach is to code something and let adoption make it the standard.[194] For policymakers, this inverts the usual sequencing of European standardisation, and respondents identified it as a template worth promoting for non-differentiating components.[195]

Foundations are not merely a technical convenience, but an institutional solution to a structural problem: operators that compete in the retail market can still pool investment in the non-differentiating layers beneath it. Neutral and open governance lowers the legal and perceived antitrust barriers to collaboration, while the 'code-first' model lets European projects move faster than traditional standards bodies. But realising these benefits across the wider market depends on operators having the capability and will to participate as equals, and on the ability to navigate sovereignty considerations (more on this later).

## 5.3 The vendor and supplier community: mediating between the operator and the commons

Operators are not monoliths and do not exist in a vacuum. While they collaborate with one another, they depend on an ecosystem of vendors and suppliers to build, integrate, and run their networks. Each of those organisations often has their own commercial incentives determining how they encounter and adopt OSS in their supply chains. The structure of this ecosystem is as decisive as operators' own ambitions. There are three layers to this vendor and supplier community worth considering: the equipment vendors, above all Nokia and Ericsson, whose position as the European telecoms industry's leading providers gives them outsized influence; the systems integrators beneath them, and the related gap in Europe's market for OSS-native integration and SME capacity; and the wider field of

technology providers responding to the trends reshaping the industry. We will focus on the first two in this chapter.

### 5.3.1 Equipment vendors: the dominance of two vendors and its consequences

As the dominant equipment vendors across Europe – a position consolidated by the gradual exclusion of Huawei from select European countries on security grounds[196] – Nokia and Ericsson function as a de facto 'integration layer' for operators on the continent. They are the intermediaries through which operators access not just hardware, but software, services, and OSS components. Whatever the ambitions of operators to engage more directly with OSS communities and build internal capability, the reality for most operators is that much of their relationship with OSS is mediated through one or both of these vendors.

Nokia and Ericsson are not passive conduits for the consumption of OSS in network software. They consume OSS in this way, but are also sophisticated technology companies with their own R&D investments.[197] Both have open source strategies, contribute significantly to OSS projects, and have OSS governance frameworks.[198] Despite this, their commercial positions frequently shape their contributions.[199] One respondent noted that while these vendors are top contributors to foundations, they are most interested in protecting their patent portfolios.[200] Some respondents also described an internal review culture where vendors are hesitant to contribute code that might inadvertently open up patents to the public.[201] This happened in next-generation networking; a respondent noted that while Nokia and Ericsson use OSS stacks for testing and simulation, they are reluctant to contribute back core 5G and 6G intellectual property (IP) because licenses would require them to give away commercial value.[202]

This vendor-mediated OSS adoption means the benefits of openness are real but bounded, with the locus of capability and integration remaining firmly with the vendor rather than the operator. The Sylva adoption paradox illustrates this dynamic well: Sylva was developed precisely to give operators a shared, open cloud-native infrastructure stack that would reduce their dependence on proprietary vendor solutions.[203] Said one respondent:

> *"I don't think we're ever going to solve this [R&D issue]. I think that Project Sylva is the biggest attempt to solve it. But unless there's an effort by the vast majority of telcos around the world that want to force this to happen, it won't happen. And the vendors will still keep building proprietary solutions, because one, it locks it into them, and they can sell top-to-bottom and extract as much value and revenue as they can out of it. But two, it keeps them from burning any R&D money to make anything else."*[204]

Nokia and Ericsson – whose cooperation is essential for the stack to function in production – have been slow to align their own products and delivery models with Sylva, which has complicated its adoption.[205] This shows that even within open frameworks, vendors often create custom, proprietary hooks into hardware to maintain performance, which prevents the use of a standard open source stack in production.[206] This creates a 'chicken-and-egg' situation where operators delay their own investments while waiting for vendors to align their delivery models with open technology stacks.[207]

Commercial incentives are only one side of the concentration problem; the other is risk. A supply chain dominated by a small number of vendors is, by definition, a concentrated one. While concentration can look efficient in commercial terms, it can at the same time be fragile in security and sovereignty terms.[208] This becomes most acute in the move toward

managed services, where operators do not just buy equipment from vendors but hand over the operation of parts of the network itself. As one respondent observed, an operator that outsources its core in this way ceases to be a buyer of components and becomes, in effect, a customer of its supplier, dependent on them not only for the software but for its patching, updates, and day-to-day operation.[209]

The structural response to this is multi-vendor strategy and the deliberate avoidance of dependence on any single supplier for any critical layer of the network. Several respondents treated this not as a preference but as a requirement,[210] with one putting it plainly that operators will increasingly have to build multi-vendor supply chains simply to maintain diversity and resilience.[211] OSS has a role to play here, because it separates the choice of technology from the choice of vendor. It does not eliminate dependency entirely, but can reduce vendor lock-in to more manageable levels and preserve the ability to switch between suppliers, while keeping the underlying stack intact.

### 5.3.2 Systems integrators: the integrator gap and Europe's SME ecosystem

If Nokia and Ericsson represent the top of the vendor ecosystem, the systems integrators that sit beneath them represent a second structural layer. Systems integrators are the firms that assemble, deploy, and manage complex telecoms infrastructure on behalf of operators – incumbents whose expertise, tooling, and commercial relationships have been built around proprietary stacks.[212] An internal skill gap reinforces dependency on systems integrators, as most operators lack the engineering muscle required to manage the technical complexity of disaggregated architectures independently.[213]

This challenge was acute in the potential transition to Open RAN. Implementing open architectures like Open RAN is infrastructure-intensive because it requires additional system integrators to ensure different components work together, making it more complex than traditional black box solutions.[214] Counterintuitively, many of these integrators derive recurring revenue from commissions and professional services tied to proprietary systems. As a result they have limited commercial incentive to accelerate a shift toward the standardised, commoditised layers that Open RAN is designed to foster.[215]

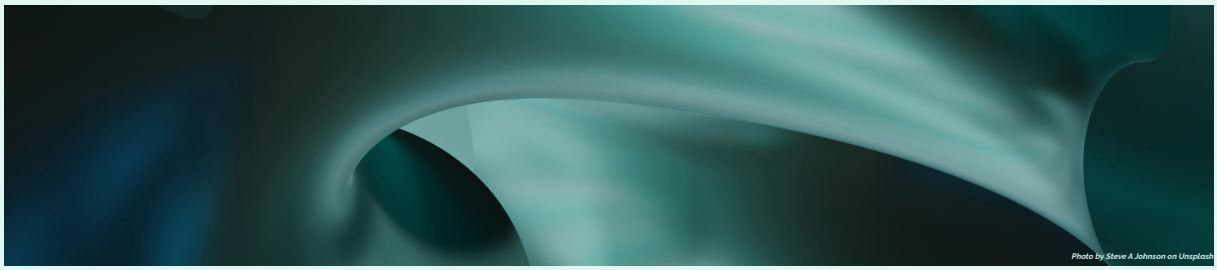
This creates an 'integrator gap': the absence, at meaningful scale, of a layer of integrators that are genuinely oriented toward open source stacks and capable of delivering the integration, customisation, and support work that makes OSS deployments production-ready.[216] Without that layer, operators who want to move toward more open architectures face a choice between doing more of the integration work themselves – which often requires internal capability that many do not have – or relying on incumbents whose incentives are not fully aligned with the transition they are trying to make.[217]

The ecosystem is also seeing the emergence of new 'independent integrator' models, such as the greenfield deployment by 1&1 in Germany,[218] as a necessary strategy to bypass these structural bottlenecks and reclaim technical autonomy.[219] Their value proposition depends, in part, on the complexity of the environments they manage. Moreover, simplification and standardisation, which OSS tends to drive over time, are not straightforwardly in their interest. There are other success stories as well. Respondents

frequently cited Rakuten, from Japan, as a 'greenfield' success story that has successfully packaged its Open RAN platform to sell to other operators, effectively acting as a new type of software-centric system integrator.[220]

What a healthy European ecosystem of systems integrators in telecoms would look like is easier to describe than to build. It would include a layer of specialist firms – smaller than the major equipment vendors, more technically oriented than traditional system integrators – capable of providing the professional services, tooling, and support that OSS deployments require.[221] It would also include OSS-native consultancies and managed service providers who can work across the stack rather than within a single vendor's product family. And it would include a robust community of SMEs contributing to and building OSS projects, creating a competitive, diversified supply chain that reduces operator dependency.

# Chapter VI: Policies – Frameworks and Tools for Building a More Open, Sovereign, and Competitive Telecoms Industry




The preceding chapters examined the capabilities operators are building and the ecosystems they have come to share. This chapter turns to policies, defined as the frameworks, instruments, and interventions through which European institutions and governments can shape how OSS develops across the telecoms industry and supports its operators to expand their services and innovation capacities. The question here is not whether OSS matters to the industry, but the role certain policy approaches are already playing in directing its trajectory in Europe, and how public policy should evolve its support.

European operators work under different regulatory and market conditions than more concentrated markets. Four policy concerns that are often treated separately have begun to converge around shaping telecoms in Europe, and which are inflected by the use of and support for OSS. Each policy concern corresponds to one dimension of this chapter. 'Competitiveness' concerns the ability of European firms, from Tier 1 operators to the SMEs and systems integrators in the wider vendor community, to build and capture value. 'Sustainability' concerns the degree to which the industry in Europe is adequately funded and resourced to unlock its sovereignty and competitiveness capacities. 'Regulatory burden' concerns how the existing body of rules shapes what operators can do, and where simplification might lower the cost of openness. And 'sovereignty' concerns the extent to which European operators and governments retain control over the software and supply chains running critical infrastructure, rather than depending on (predominantly foreign) vendors.

## 6.1 Competitiveness: The role of state-backed industrial policy

An array of public-industrial policies shapes the European telecoms industry, some of which constrain capacities for innovation through compounding effects (more on this in Chapter 6.3). The problem is that these instruments sometimes work against the competitiveness they are meant to build, particularly when it comes to open innovation.

As one of Europe's most critical industries, telecoms is increasingly a part of high-level Brussels-centred policy discussions around competitiveness and how to strengthen the industry.[222] A recent Computer & Communications Industry Association Europe roundtable underscored the need for EU policies that "promote innovation, protect net neutrality, and make better use of available funding", in support of the idea that rules for the industry must not undermine competitiveness.[223] Central to discussions is the forthcoming Digital

Networks Act (DNA), which the EU hopes will modernise, simplify, and harmonise the EU's telecoms and connectivity rules.[224]

One of the goals of the DNA is to improve competitiveness, in line with the recommendations of the Draghi report.[225] While well-intentioned, respondents expressed mixed views on the DNA as it relates to competitiveness and innovation. Some critiqued the proposal for being timid or technically misinformed, arguing that it focuses too heavily on physical infrastructure and market consolidation rather than the services layer where true scale economies exist.[226] Furthermore, while large incumbents use the DNA to advocate for mergers to fund investment, entities like the Body of European Regulators for Electronic Communications (BEREC)[227] maintain that strong market competition is the primary driver for innovation and industry health.[228]

Public procurement is a lever that public institutions can use to mandate the adoption of OSS and foster a more contestable market for European startups and SMEs.[229] Alongside the general revision of the Public Procurement Directives,[230] many respondents expressed that there should be a simultaneous call for procurement reform that supports telecoms innovation in particular.[231] The prevailing view amongst respondents was that traditional procurement is currently a race to the bottom focused on the lowest bidder, which inherently favours established proprietary vendors and makes it difficult for innovative startups to survive in telecoms.[232] Says one respondent:

> *"… [W]hen [vendors[ take the cheapest solution of the hardware, they don't have as much money to spend on R&D, and therefore, you get a software stack that builds the cheap and dirty, nasty hooks into the hardware … Our vendors could solve [this] if they wanted to, because we don't pay our vendors enough, they don't have enough money to spend on R&D to build a software stack that goes on top of a proper open source solution."*[233]

While some identified 'Buy European' procurement preferences as a prerequisite for the commercial success of local technology,[234] others expressed a more concrete need to move beyond 'Buy European' and focus on calls to prioritise sovereign, OSS-based solutions.[235] Such considerations are underway within the scope of the Cloud and AI Development Act (CADA) proposal[236] as part of the proposed Tech Sovereignty Package from the European Commission (EC),[237] but the exact scope of how this will affect procurement in the telecoms industry is still unclear.[238]

Other suggested proposals varied widely in scope. One respondent identified public demand as a strong policy tool for populating the market with European alternatives to global big tech.[239] Another suggested that successful procurement models should also reflect that common software development models are prevalent and increasingly based on neutral industry governance, creating rules that enable operators to more easily collaborate on shared infrastructure while competing on value-add services built on top.[240]

## 6.2 Sustainability: Funding and support for open source in telecoms

The sustainability and continued availability of OSS collaboration in the telecoms industry in the coming years will require it to be funded commensurately with its scale and impact. The specifics of where this funding comes from and how it is distributed is more contested, and it points beyond the foundations themselves to the role of public funding.

When talking about EU funding, many respondents echoed their concerns about fragmentation and the short-term nature of the grants. Typical EC grants under the HE scheme are often restricted to 3-5 year windows.[241] This short-term thinking in EC funding is insufficient for maintaining critical infrastructure, resulting in a research-to-market gap where innovative technologies fail to reach a commercial scale because funding programme design ignores scaling.[242] Moreover, a fragmented funding environment can inadvertently encourage researchers to recycle the work they do outside of the specific EU project and bring it to the EU consortia.

One respondent commented on the fact that these formalised research and innovation funding structures might not be the most effective funding allocation mechanisms, noting that it is high time the EC also considered taking charge and supporting projects that have played a strategic role in the EU for a long time. They stated that:

> *"And what happens is that when funding comes in, researchers basically recycle their work that they've done in the past and put it out as contributions into [EU projects]. It's very difficult to do an oversight of all of this, project officers in the European Commission … often have to sort of navigate through this lever and try to understand whether the money is put to good use, et cetera. … These are mechanisms that require a lot of planning, bureaucratic formatting."*[243]

Beyond research and innovation funding, the EU also has a well-established consortium ecosystem, whereby companies form voluntary groupings to compete for grants awarded by EU programmes. The funding is thus used to conduct next generation research, and has contributed to some major ventures.[244] Several respondents questioned, however, whether this model is well-suited to sustaining strategically important OSS projects, as opposed to funding discrete, time-bound research.[245]

Among the EU funding instruments best focused on industry policy, and well-positioned to support it, the Important Projects of Common European Interest (IPCEI) scheme lends itself quite well to the type of cross-border, innovative projects developed for and by the telecoms industry.[246] IPCEI is a relatively new financial instrument, counting over 10 large-scale projects in microelectronics, batteries, hydrogen and cloud since its launch in 2018.[247] The Important Project of Common European Interest on Next Generation Cloud Infrastructure and Services (IPCEI-CIS)[248] has been particularly advantageous to the telecoms OSS ecosystem, with many of the projects incubated there leading to contributions to projects like Sylva and CAMARA.[249] The real value of IPCEI-style funding lies in the fact that it helps companies in Europe to collaborate on OSS production, even if the companies are not technically OSS technology vendors.[250] It does so by connecting the supply and demand sides of the ecosystem, thus incentivising collaboration and amplifying ecosystem effects.

Respondents also pointed to funding instrument fragmentation as a major inhibitor to companies – particularly small- and mid-sized ones – in applying for EU funding.[251] This is the case both for high-maturity programs like Digital Europe and newer ventures like the IPCEIs. On the need for unified funding in Europe, one respondent argued in favour of Europe leapfrogging hyperscalers and charting a path not reliant on monopolistic structures:

> *"And the only way to make European technology successful is to drive adoption, and to unite a lot of investment behind the same technology, instead of spreading investment out across 15 different alternatives, which are trying to solve the same problem, and*

*none of them becomes big. From my point of view, that's the most important challenge Europe needs to solve without falling into the trap of just rebuilding an ecosystem that sort of mimics the American ecosystem."*[252]

This hints at a related theme: the scaling of successful solutions. One respondent felt indignation at the fact that European technology start-ups prematurely reach the end of their funding in Europe and are forced to sell to American financiers due to lack of exit options. They believed that if the EU offered startups better public support, they could make informed choices about selling or scaling their business in the EU.[253] The EC is aware of this gap and is aiming to unify funding instruments within the upcoming Multiannual Financial Framework (MFF), the EU's 7-year budget plan.[254] The goal is to connect activities across different programmes and make projects of low maturity commercially ready.

The diverse landscape of funding models for OSS projects also creates a complex environment whereby ideological independence clashes with the practicalities of OSS development and maintenance. While some projects abstain from public grants due to a desire for ideological independence, others opt for public funding as a reliable, long-term support system.[255] One respondent admitted that government funding might come with strings attached in terms of control, particularly in areas like critical 5G or next gen, which some projects' governance boards might reject outright. Instead, the respondent argued that the EU should dispense public funding uniformly, so that "all boats rise".[256]

While exact prescriptions differed among respondents, specific, targeted, and well-deployed configurations of public and industrial funding will be decisive in the years ahead. The challenge is to design instruments that combine the long-term stability that OSS infrastructure needs with the flexibility to reach companies beyond those already fluent in EU funding processes. Getting this balance right will shape whether Europe's telecoms industry can sustain OSS collaboration at the scale its strategic importance demands.

## 6.3 Regulatory burden: Navigating the effects of compounding regulation

As operators move away from proprietary siloes, the success of the telcos' disaggregated, software-defined transition increasingly depends on the suitability of the legislative and financial instruments in place. In this context, respondents view regulatory improvement through a systemic lens, focusing on how the total environment of EU oversight can better align with commercial realities. When asked about areas for regulatory improvement, many respondents were complimentary of individual pieces of legislation but preferred to focus on the broader, layered landscape, which they saw as too fragmented.[257]

While recent tech regulations – such as the Cybersecurity Act (CSA), the Digital Markets Act (DMA), the Cyber Resilience Act (CRA), and the Data Act – have aimed to facilitate interoperability and portability, improve competition, or protect data security, they also created compounding regulatory burden, and in some cases simply confusion. Incidentally, many have also had the unintended consequence of promoting OSS-based solutions. The June 2026 EU Open Source Strategy[258] has re-channelled this ambition through a more explicit focus on OSS.

Some respondents highlighted a 'piling up' of overlapping mandates from various instruments – including the Data Act and CSA – as creating an immense compliance burden that stifles technical experimentation.[259] A persistent knowledge gap compounds this among policymakers, who may find concepts like 'cloudified 5G networks' to be 'wishy-

washy'.[260] One respondent spoke in detail to this general phenomenon, commenting:

> *"All these policy frameworks, which are not timed, not standardised, tend to be stacked on top of each other. And there are quite a number of new initiatives ... but then you have all these other traditional, older frameworks coming on top of that. We have expressed our concern on the totality of these laws, which are partly inconsistent, and some of them have very specific requirements on the notification and reporting and structuring, which is not exactly the same as in the other frameworks, despite most of them being motivated by the same intention."*[261]

For many respondents, this lack of harmonisation of rules contributes to a pervasive feeling of 'analysis paralysis', a methodical but slow approach to standardisation that lags behind the more rapid, risk-prone innovation cycles seen in the U.S. or Asia.[262] Beyond the immediate compliance burden, the impacts of overlap, regulatory burden, and regulatory inconsistency are taking a toll on the industry. Smaller operators may lack the capabilities required to independently verify and integrate OSS-specific provisions while satisfying varying national and EU-level security assessments.[263] Some operators have emphasised the need for 'regulatory cleanup' to resolve these conflicting reporting requirements and ensure that policy frameworks serve as a catalyst for scale rather than a structural bottleneck.[264]

## 6.4 Sovereignty: Regaining control of European operators' supply chains and infrastructure

In recent years, EU institutions have reframed digital sovereignty as a holistic approach that prioritises control over the entire stack, from local hardware to AI. In this view, OSS is a key structural enabler of digital sovereignty, supporting its delivery by enabling agency and capacity (on the user side) and autonomy and resilience (on the infrastructure side). The EC made this conceptualisation clear with the proposed Tech Sovereignty Package by placing OSS at its centre. As one respondent put it:

> *"I think so many people believe open source and digital sovereignty are very strongly linked and almost depend on each other, right? You can't be truly sovereign if the code for the software you're using isn't open source, because that still means that whoever owns the code and whoever sort of owns the knowledge about how the code is written and how it works on the inside, can use your technical dependence against you in some way. They [won't] necessarily [do it], but they can theoretically. That risk always exists."*[265]

In an era where networks are evolving, it is understandable that the technical transparency afforded by OSS will be a cornerstone of sovereignty for the industry in Europe.[266] The telecoms industry in particular will feel the impact because its networks sit at the intersection of the Tech Sovereignty Package's main targets – cloud, AI and OSS – and depend on the very infrastructure layers the EC now wants Europe to control. Operators will also increasingly run on the cloud-to-edge, operating system and cybersecurity building blocks that the EU Open Source Strategy names as priority areas for European alternatives.[267] There is thus reason to believe that, if well-funded and supported through policy, the linking of OSS and sovereignty could be hugely meaningful for the telecoms industry in Europe.[268]

At the same time, these dynamics also create dependencies on OSS communities and governance dynamics that do not always align with European priorities around digital sovereignty, supply chain resilience, or regulatory compliance. The optimistic version of

these dynamics is that, as one respondent explained, telecoms stacks are generally 80–85% a common global codebase, with only 5–10% of code being region-specific. This creates a 'minimal necessary consensus' where actors can contribute as equals on neutral technology, regardless of political differences.[269] This creates a chance for the EU to benefit from contributions from other regions and allows European networks to benefit from global innovation, while remaining isolated from external strategic dependencies at the core layers.[270] In this view, OSS provides a framework that allows actors from different continents to benefit from global contributions even when they disagree on specific political convictions.[271]

A few respondents pointed to the tension between foundations' perceived neutrality and the broader context of U.S.-EU tech relations. One respondent called the vendor-neutral conception of OSS projects and foundations a 'fallacy', noting that up to 90% of code contributions often come from employees of major U.S. tech companies,[272] making it difficult for EU companies to compete for influence.[273] The limited financial and human resources mean that Europe has a slim chance of creating the critical mass needed to contribute to and control an OSS project.[274] In this view, the only viable way of gaining control of the vendor-neutral projects is by paying the membership fees necessary to gain seats on governance boards.[275] On the other hand, the underrepresentation of European companies in global foundations might well be due to their strategic underappreciation of foundation membership as a tool of soft influence and an investment with longer returns.

Another major theme in the interviews was the active role the U.S. government has taken in funding and overseeing OSS projects as strategic tools of influence. Respondents highlighted the U.S. Department of War's efforts to build a U.S.-native competitor to European telecom equipment providers through direct funding and oversight of projects like Software Radio Systems/Open Centralized Unit/Distributed Unit (SRS/OCUDU)[276] – an OSS, carrier-grade RAN software platform for 5G, 6G, and AI-powered networks.[277] They also expressed concern about some OSS projects becoming more closed as geopolitical polarisation rises, as they become captured by corporate or state interests to serve as tools of control.[278] Should geopolitical tensions escalate, respondents expressed fears that support infrastructure and access to repositories could be limited or cut off entirely.[279]

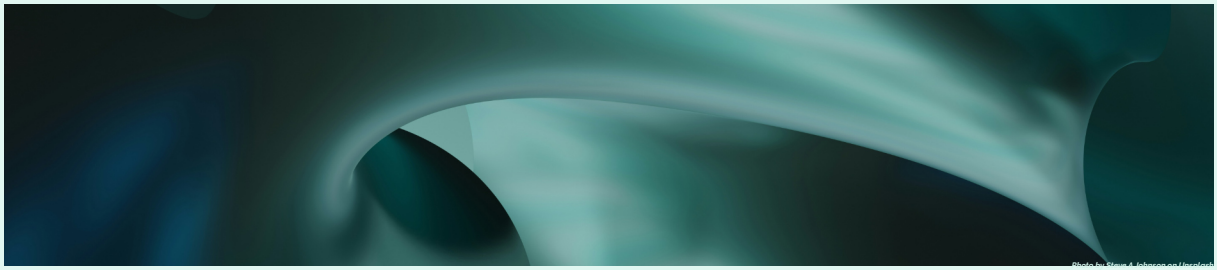
Some approaches to navigating these geopolitical tensions carry almost as much risk as the challenges themselves. The intentional use of OSS to bypass traditional European industrial strongholds initially created deep-seated suspicion within European policy circles. This was the case for Open RAN; in the project's early days, the EC approached it with apprehension, as many in European policy circles perceived the initiative as a U.S. attempt to disrupt the (largely non-American) vendor market and work on a solution that could secure the US's sovereignty in 5G.[280] Since Open RAN's inception, however, the EC's approach has markedly changed, as the EU seeks to facilitate an alternative supply chain for resilience in the face of the piecemeal exclusion of high-risk suppliers like Huawei from certain Member States.[281] Commenting on the gradual shift in the EU's approach, one of the respondents remarked:

> *"Initially, the Commission was not so keen to support Open RAN. It seems that they have changed [their stance] a little bit, because they saw Open RAN as a political discussion in the early days, for the US to be sovereign on 5G, because they have no manufacturers and no US suppliers in 5G. ... I said to the European Commission, "If Open RAN has to be a success, it's better to be a success in Europe than in the rest of the world, because if it delivers on the promises, it will completely change the game."*[282]

The Open RAN case illustrates a wider lesson about how the EU can act on the OSS and sovereignty link. The same architecture that the U.S. has used to pursue its own strategic position[283] – an open, portable software base that lowers the barrier to entry – can serve European aims if the EU shapes how value flows back into the codebase.[284]

But for telecoms, the OSS and sovereignty link is only as strong as the industrial policy behind it. Backed by sustained, contribution-linked public funding and an active European presence in foundation governance, OSS can deliver the agency, autonomy and resilience the Tech Sovereignty Package sets as its goal.

# Chapter VII: A Vision for Open Source in Europe's Telecoms Industry



The preceding chapters showed that the main constraints in fully embracing the open source revolution in Europe's telecoms industry are no longer technical or financial, but structural. Capability is necessary to reinforce and strengthen the ecosystems and policies that enable adoption of, support for, and contribution to OSS and open source communities. Moreover, if the talent and skills gap continues to limit what operators can build, if vendor-mediated supply chains keep the locus of capability with a small number of suppliers, and if the four policy concerns – competitiveness, sustainability, regulatory burden, and sovereignty – fail to converge around a proactive OSS strategy to support Europe's operators, we risk failing to build on the potential for open innovation to drive a sovereign and competitive future for telecoms in Europe.

This chapter seeks to shift a backward-looking perspective and analysis into a forward-looking vision for achieving just that. In doing so, it recommends a series of targeted interventions to help address some key challenges identified in the report so far. As with the rest of this report, the recommendations below are therefore organised across the same three dimensions: capabilities, ecosystems, and policies. Each is set out as a challenge, a vision, and a roadmap, in order to help drive home the concrete understanding of what is necessary for achieving such a vision, and is outlined in sub-chapters 7.2, 7.3, and 7.4. Before that, sub-chapter 7.1 sketches out a narrativised vision for what Europe's telecoms industry might realistically look like by 2040.

## 7.1 Achieving a Sovereign and Competitive Future for Europe's Telecoms Industry: A Vision for 2040

It is possible for the EU to know what the destination for its telecoms industry looks like, because pieces of it exist, which this report has attempted to highlight. As an industry leader, Orange rebuilt its network stack around open control points enforced through procurement, and by its own account needed years before the effort paid off. European operators strongly shaped Sylva and CAMARA, showing that companies who compete fiercely at the retail level can still pool investment in the layers beneath it and work together to meet the realities of network disaggregation and more horizontally integrated ecosystems. Initiatives like the IPCEI-CIS proved that public money tied to upstream contributions can produce durable code and software rather than abandoned prototypes, much of which has advantaged the telecoms industry in particular through its support for edge and cloud computing capabilities.

The challenge is that while these successes are increasingly well-known and understood, they belong to a handful of Tier 1 operators and a small set of projects. This makes sense given their size and capability, but it also means they are the primary beneficiaries. The reasons for this are structural, including systemic issues related to R&D investment, challenges in hiring and retaining the right talent, complicated vendor incentives, and so on. But letting those challenges persist is not the foundation for a strong level of competition, which continues to be a key feature of the EU market and has helped to protect consumers through lower prices and can undoubtedly help drive more innovation in the future. To ensure this happens, these successes must feed into a holistic vision for an industry wherein open innovation is uniquely positioned to advance higher levels of sovereignty and control while enabling strong competition on top of industry-standard open foundations.

Unlocking the potential of OSS as part of a broader portfolio of approaches to innovation in telecoms will undoubtedly strengthen and support the trajectory it is already on, given all the trends highlighted in Chapter II. The timing is right to make this happen, because the frameworks and instruments that will decide the outcome are being drafted right now, and most will be settled well before 2040. In proposal form, the DNA arrived in January 2026 as a directly applicable regulation, meant to knit 27 national markets into something closer to one.[285] The Tech Sovereignty Package of June 2026 put open source at the centre of EU digital policy for the first time, resting on the Commission's own admission that Europe depends on non-EU suppliers for more than 80% of its key digital products.[286] The €409 billion European Competitiveness Fund (ECF) takes effect in 2028 and is being negotiated as of the time of this report's writing.[287]

A realistic vision for 2040 is simply the point at which those conditions exist, and what matters is taking these ingredients – each of which might make a marginal difference on its own – and putting them together in a way that is greater than the sum of their parts. That vision is one where capability sits in a different place than it does today, bolstered by structural interventions in OSS and telecoms software ecosystems, as well as policies (across areas like competitiveness, sustainability, regulatory burden, and sovereignty) that unlock and make fully realised the capabilities Europe has in place in spades. This starts with people but goes all the way through to treating the frameworks now being drafted holistically as an opportunity, as connected levers rather than separate files.

In 2026, the telecoms industry in Europe is highly dependent on consumption of software from two equipment vendors, particularly at the most foundational radio level. Moreover, much of telecoms software has a contributor base dominated by U.S. firms, and foundations governed outside Europe, at a moment when other governments are beginning to treat open source as a matter of strategy. By 2040, if the EU can make the instruments now in negotiation – like the DNA, the EU Open Source Strategy, and the ECF – work together rather than in isolation, then it could help operators build, maintain, and govern a meaningful share of the cloud-to-RAN stack their networks depend on.

Such an intervention – the components of which the following sub-chapters explain – would reduce costs, drive efficiency gains, and unlock more innovation from across the industry, with Tier 1 operators leading the charge and a better-equipped army of Tier 2 and Tier 3 operators better positioned to sustainably procure, leverage, and support (where possible) OSS as part of their business models. The aim should not be for operators of all sizes to embrace the Orange model, which is neither achievable nor desirable. Instead, it should be for the telecoms industry as a whole to gain more sovereignty and competitiveness with open source as a lever, in consideration of Europe's unique market dynamics and political history.

This report is not just making a wish; it is arguing for how a set of decisions already on the table should resolve, which is why it matters that the argument lands now. The recommendations that follow set out how the EU might work to achieve this vision and are organised across the same three dimensions used throughout this report: capabilities, ecosystems, and policies. We hope that by considering them together, the EU institutions might, in the months after this report's release, catalyse useful conversations and mould the frameworks and instruments it has in play in a way that is conducive to such a vision.

## 7.2 Recommendations for Capabilities

The first set of recommendations is premised around the idea of capabilities, and specifically a capability deficit. European operators cannot readily build or maintain the software their networks increasingly depend on, because they lack the engineers to do it and cannot compete for that talent against hyperscalers and dedicated technology firms. An ageing workforce trained on hardware and legacy infrastructure compounds the problem, leaving many operators as passive consumers of open source rather than active contributors. Without deliberate investment in skills, procurement reform, and incentives for the operators best placed to contribute, the industry will remain dependent on capabilities held elsewhere and which position operators predominantly as passive consumers.

### 7.2.1 Recommendation #1: Strengthen capability building for an ageing and underskilled workforce

**Challenge:** The talent and capability challenge is foundational to all European operators, regardless of their size and market value. Even with changing the structural conditions that constrain R&D, operators must compete for software engineers in a market where dedicated tech companies and hyperscalers, particularly those in the U.S., can offer substantially higher salaries, more technically stimulating work, and greater perceived prestige. An ageing workforce compounds this in parts of the industry whose skills are oriented toward legacy infrastructure and hardware management rather than software development and OSS contribution. These two pressures reinforce each other, since operators must reskill an existing workforce and compete for scarce new talent at the same time, with fewer resources than the firms they are bidding against.

**Vision:** Universities, public skills programmes, and operators must integrate OSS development, maintenance and governance into education, training, and reskilling, both in university and public skills programmes, as well as the internal efforts of operators. Operators should see themselves as active contributors rather than passive consumers, and build the internal political will to change processes and invest in the engineering capacity this requires. Operators with more resources must lead this, but should also target and take into account how capability building is diffused into Tier 2 and Tier 3 operators, and the conditions under which this can be made possible.

**Roadmap:** The EU should support, subsidise, or invest in OSS capability building in critical sectors like telecoms as part of broader skills building programmes, particularly those related to OSS which are outlined in the EU Open Source Strategy. The telecoms industry should work to prioritise budgets in a way that allows for compensation packages that compete with AI and hyperscaler roles not only on pay. The EU should introduce a job certification scheme tied to the telecoms industry, building on the skills and contributor-mobility measures in the EU Open Source Strategy, and financially incentivise industry to offer apprenticeships. Established open source ecosystem actors (including open source

foundations, funding organisations, and so on) should come together with operators and vendors to pool project investment into shared skills programmes.

### 7.2.2 Recommendation #2: Reform procurement through industrial policy

**Challenge:** Procurement is one of the strongest levers for driving structural change and the adoption of OSS, but it operates on two distinct tracks that are too often conflated. Public procurement, governed by the Public Procurement Directives and increasingly shaped by instruments like CADA, is controlled by public buyers but can set market-wide signals. Private procurement, the RfPs and vendor contracts operators issue themselves, is controlled by the operators and is where most telecoms purchasing actually happens. Both must adapt to the reality that modern networks run on software developed continuously upstream, often by communities that include direct competitors.

**Vision:** Operators should use their purchasing power and signals from the Public Procurement Directives and CADA deliberately to shift the operator-vendor relationship, rather than waiting for regulation to do it for them. This might be done through industry groups or associations. EU institutions and industry can work together to modernise rules that enable operators' procurement frameworks to embrace open innovation, and public policy should incentivise operators to unlock the economies of scale that come from a productive, compliant, and well-regulated use of OSS, whether built internally or outsourced. Where the operators themselves are the lever, OSS-based horizontal control points and multi-vendor interoperability should become standard contractual requirements across the industry, not the practice of a handful of Tier 1 leaders.

**Roadmap:** The revision of the Public Procurement Directives and CADA should mandate that public tenders prioritise OSS as a first option and reflect the realities of software-defined networking. On private procurement, which is within operators' own control and needs no legislative change, operators should work together to create standard terms that make OSS horizontal control points and multi-vendor interoperability mandatory in new RFPs, following the Orange model of requiring vendors to conform to an operator-controlled open stack rather than accepting proprietary tooling. Awards should turn on total cost of ownership rather than lowest upfront bid, and contracts should require vendors to contribute customisations upstream to close the soft lock-in that persists even with OSS. To extend this discipline beyond the largest operators, industry associations should develop shared model RFP clauses that smaller operators can adopt directly, enable shared dialogue with the public sector, and enable the sharing of best practices.

### 7.2.3 Recommendation #3: Incentivise upstream contribution for operators

**Challenge:** Tier 1 operators are the most likely to have the capability and funding to support upstream contributions, and yet even they struggle to do so in a resource-constrained and highly regulated industry like telecoms. Compared to Tier 2 and Tier 3 operators, they are uniquely well-positioned to contribute more upstream, which has positive spillover effects for the rest of the industry, so there should be more incentives for them to engage, whether through funding, tax incentives, or regulatory support. Smaller operators lack the engineering volume to commit contributors to upstream communities, and expecting them to match Tier 1 activity is unrealistic. The challenge is to define roles for each tier that match its resources and standing, so that the burden of contribution falls where the capability sits while the benefits reach operators of every size.

**Vision:** Tier 1 operators should increasingly function as active producers and maintainers of shared, sovereign infrastructure, with more European operators holding board seats in

major global open source foundations, taking active leadership in existing and new projects, and contributing more upstream. Tier 2 and Tier 3 operators should not be passive bystanders to this but participate at a level proportionate to their means, as informed adopters who shape requirements, test in production, and contribute where they have specific expertise, even if they cannot maintain projects outright. They might do so by pooling resources or coordinating with one another. The industry should treat foundational infrastructure as a shared commodity, with the largest operators carrying the heaviest load and smaller ones benefiting commensurately with their standing and more modest investment.

**Roadmap:** Tier 1 operators should establish internal OSPOs to centralise management of contribution, licensing, and IPR, continue supporting successful projects such as Sylva and Kubernetes, and engage with projects that could become commodity building blocks (SONiC, prpl Foundation, OSM, ONAP), investing in their people as active contributors and maintainers. Tier 2 and Tier 3 operators should engage at a lower but still active threshold, possibly through shared groups, feeding requirements upstream, reporting and fixing issues they encounter in production, and contributing in the narrow areas where they hold expertise, rather than attempting to field full contributor teams. Policymakers should structure public incentives to reflect this asymmetry, rewarding Tier 1 maintenance and governance participation while making lighter forms of engagement viable for smaller operators.

## 7.3 Recommendations for Ecosystems

The second set of recommendations concerns the ecosystems in which that capability would be exercised. Even operators willing to collaborate on shared, non-differentiating infrastructure face obstacles that have little to do with engineering. Moreover, the slow pace of traditional standardisation and the absence of an open source native integrator layer further limit the ecosystem's ability to convert consumption into control.

### 7.3.1 Recommendation #1: Extend multi-vendor discipline into the software layers of the network

**Challenge:** Multi-vendor sourcing is not new to telecoms. Operators have bought different parts of the network from different suppliers for decades, and standardisation exists precisely to make that possible. Vendor concentration is most acute in the radio access network, where Nokia and Ericsson are strongest (alongside a smaller field, including Samsung), while a wider set of vendors serves the rest of the stack, including core, transport, management, charging, and fixed networks. In the software and management layers that increasingly determine control, incumbents have limited commercial incentives to accelerate the shift to open, commoditised components, since their recurring revenue depends on the proprietary complexity that open layers would compress. The result is that operators' well-established multi-vendor discipline on hardware has not yet carried over to software, where lock-in now does the most damage.

**Vision:** The multi-vendor principle that has long governed telecoms hardware procurement should extend fully into the software and management layers. Operators must retain the ability to switch suppliers at every layer of the stack, not only the physical one, because open horizontal control points and interoperable interfaces make vendor substitution real rather than nominal. Disaggregation addresses concentration at the radio layer, and operators and the EC alike can treat Open RAN and comparable efforts as a resilience measure, rather than an attack on incumbents. Vendors should compete on the

quality of their productised offerings, the configuration, hardening, support, and maintenance they provide on top of open software, rather than on locking operators into proprietary management and orchestration.

**Roadmap:** Operators should treat software-layer lock-in with the same seriousness they have long applied to hardware sourcing, requiring open, interoperable control points in procurement so that no single vendor holds the management and orchestration layer. The EC should support RAN disaggregation as a supply-chain resilience measure, recognising that concentration at the radio layer is a legitimate strategic concern distinct from the wider and more competitive vendor field elsewhere in the network. Recognising that vendors – whether Nokia, Ericsson, Red Hat, or others, or occasionally by operators themselves – bring most open source to production, EC and operator policy should strengthen the market for that productisation rather than treat it as a problem, so that operators have credible alternatives to incumbents for support and maintenance.[289]

### 7.3.2 Recommendation #2: Invest in an OSS-native systems integrator layer

**Challenge:** Incumbent integrators built their expertise around proprietary stacks and derive recurring revenue from professional services tied to them, giving them limited commercial incentive to accelerate the shift to open, commoditised layers, as seen in the Open RAN transition. Operators are left choosing between integration work they lack the capability to do themselves and incumbents whose incentives are misaligned. The gap is self-reinforcing: without operators creating steady demand for OSS-native integration, the specialist firms that would meet it have little reason to scale, and without those firms, operators default back to incumbents.

**Vision:** The EU and industry should actively curate a healthy ecosystem of systems integrators, including specialist firms smaller than the major equipment vendors but more technically oriented than traditional integrators, OSS-native consultancies, and managed service providers who work across the stack rather than within a single vendor's product family. The EU should support a robust community of SMEs, leveraging existing organisations and vehicles, to support and build OSS projects, creating a competitive, diversified supply chain that reduces operator dependency. Independent and greenfield integrator models are viable routes to technical autonomy.

**Roadmap:** The EU should use procurement and funding, such as that of HE, Digital Europe, and modalities under the new ECF to create demand for OSS-native integration, including SME set-asides and support for independent integrator models. Operators should also create demand directly, using the private procurement discipline to award integration work to OSS-native firms rather than defaulting to incumbents, since public funding alone cannot sustain the layer without a real market behind it. Funding instruments should connect the supply and demand sides of the ecosystem, in the manner of IPCEI-CIS, to incentivise SME participation and amplify ecosystem effects. The EU should support OSS-native consultancies and managed service providers through the skills and certification schemes proposed previously, building the workforce this layer depends on.

## 7.4 Recommendations for Policies

The third set of recommendations concerns the issue of policies, both how they influence the telecoms industry and how policy can address challenges in capabilities and ecosystems. The regulatory landscape places overlapping compliance and reporting burdens on companies, and has historically been drafted without accounting for how open source is developed and maintained. Funding instruments favour early-stage research over the sustained maintenance and commercial scaling that open source infrastructure requires, and they are difficult to access for the SMEs and first-time applicants who most need them. Supply chain concentration around a small number of vendors persists, leaving the stack exposed to disruption. These are not separate failures but connected ones, and the recommendations below treat them as such, with skills programmes, procurement reform, and a proposed IPCEI for telecoms recurring as levers that cut across capabilities, ecosystems, and policies alike.

### 7.4.1 Recommendation #1: Address the effects of compounding regulatory burden

**Challenge:** Overlapping mandates characterise the EU regulatory landscape, and create compliance and reporting burdens for companies. They fall hardest on smaller operators with the least capacity to absorb them. An open source knowledge gap compounds the challenge among policymakers who have not integrated considerations for OSS in the past, although the June 2026 proposal for an EU Open Source Strategy has shown some promise. Two files in negotiation at the time of writing, the Digital Networks Act and the Digital Omnibus, will largely determine whether this burden eases or deepens.

**Vision:** The EU regulatory landscape should become increasingly clear and harmonised for operators, successfully translating market realities into standardised, coherent compliance frameworks. Policy should help distinguish between pre-competitive infrastructure collaboration and competitive service differentiation in order to encourage contributions to a common OSS telco stack and pool R&D resources for maintaining its building blocks. Policymakers should approach OSS as horizontal infrastructure that warrants cross-cutting policy consideration rather than a sectoral approach, and be brought in line with standardisation and competition policies. The DNA should deliver the harmonisation it promises without adding fresh complexity, and the Digital Omnibus should help resolve rather than merely defer the overlaps between existing instruments.

**Roadmap:** The Digital Omnibus is the primary vehicle for reducing compounding burden, and its simplification of overlapping mandates, from the CRA to the NIS2 Directive, should clarify stakeholder responsibilities rather than postpone obligations, since ambiguity deferred is not burden removed. The DNA should deliver genuine harmonisation as a directly applicable regulation without, as operators have warned, adding red tape through its own provisions, and the EC should coordinate its evaluation with the Digital Omnibus so the two do not create fresh inconsistencies. The DNA should also aid the transition away from high-cost spectrum auctions toward a model that assigns licences at lower cost in exchange for mandatory reinvestment into open source-based infrastructure. Relatedly, the EU should use CADA and its four-tier assurance framework to implement a common, transparent, and operational definition of digital sovereignty as it relates to strategic industries like telecoms.

### 7.4.2 Recommendation #2: Consolidate and lengthen funding and sustainability instruments

**Challenge:** The funding challenge concerns designing instruments that combine the long-term stability that OSS infrastructure needs with the flexibility to reach companies beyond those already fluent in EU funding processes. A research-to-market gap currently hinders SMEs, with existing public funding mechanisms prioritising low-maturity research over the commercial scaling needed to compete globally. Short funding cycles compound this, since the maintenance of shared infrastructure is a continuous commitment that project-based grants ending after a fixed term do not sustain. Existing IPCEIs, including IPCEI-CIS, address parts of this picture but none are dedicated to the specific needs of the telecoms stack.

**Vision:** The EC, in its negotiations with operators, should aim to develop a thriving research and project-based funding ecosystem for telecoms that feeds into regulatory cooperation among different research projects. It should embrace simplified access for first-time applicants and SMEs, longer funding cycles that sustain project maintenance rather than only initial development, and mandated contributions into public codebases. Funding should cover the full path from research to commercial scaling, closing the gap that currently pushes maturing projects and their teams abroad. A dedicated IPCEI for telecoms might sit alongside these instruments, differentiated from IPCEI-CIS and other adjacent IPCEIs, targeting the shared building blocks of the telecoms stack that no existing instrument treats as its primary focus.

**Roadmap:** The EC should utilise the next MFF, and specifically funding from the ECF, to integrate disparate telecoms funding in line with digital infrastructure spending, with dedicated provision for scaling and maintenance rather than research alone. Funding instruments should offer longer cycles and simplified application routes for first-time applicants and SMEs, addressing the research-to-market gap identified above. The framework contracts of EU project funding under the R&D, innovation, and digita programmes should permit OSS licensing-compliant outputs and require recipients to contribute funded outputs back into public codebases. The EU should consider establishing a dedicated IPCEI for telecoms, distinct from IPCEI-CIS and building on its lessons, that ties funding to upstream contribution and focuses on the telecoms-specific shared layers that broader cloud and infrastructure IPCEIs do not prioritise.

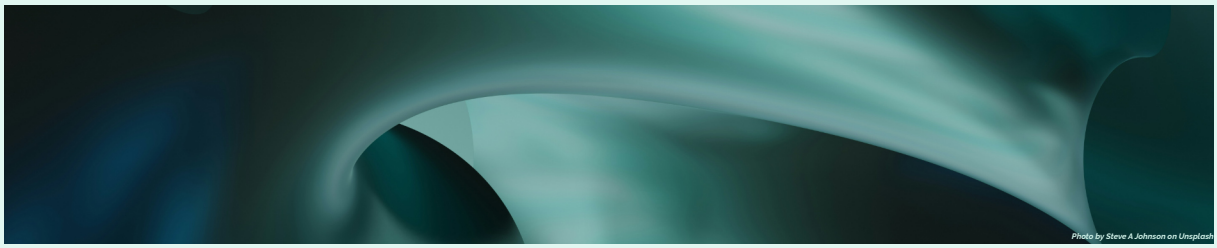
### 7.4.3 Recommendation #3: Address supply chain concentration

**Challenge:** The European telecoms supply chain remains concentrated around a small number of vendors, leaving operators largely dependent on large equipment vendors at the RAN layer and dependent on suppliers whose commercial incentives do not always favour opening or commoditising the stack. EU authorities could now recognise Open RAN, which was initially met with scepticism, as a vital mechanism for breaking concentration by disaggregating RAN into interoperable and multi-vendor components. And yet, disaggregation at the specification level does not by itself deliver a diversified supply chain. The mature OSS implementations that would turn open interfaces into deployable commodity layers remain underdeveloped, European firms contribute little to them, and the same concentration risk applies well beyond the RAN to other critical elements of the stack that have not yet been mapped or addressed.

**Vision:** The vendor stack is disaggregated and built on mature, OSS commodity layers, with European operators and vendors contributing to the implementations that sit beneath open specifications rather than only consuming them. O-RAN specifications are integrated into European SDOs such as ETSI, and the architecture is structured for wide-scale industrial adoption. The approach that worked for the RAN extends to other concentrated layers of the stack, so that supply chain diversification is treated as a continuing exercise rather than a single initiative. Geopolitical tensions or legislative changes in foreign jurisdictions do not impair Europe's access to, or development of, the critical elements its networks depend on.

**Roadmap:** The EC should first invest in a systemic-risk dependency analysis to identify the critical projects and widely reused components on which the stack depends, extending the scope beyond the RAN to the layers that concentration analysis reveals as most exposed. With that mapping in place, the new IPCEI for telecoms should tie funding to upstream contributions to the open source implementations of those components, so that public money converts into durable European influence over the shared layers rather than one-off support.

# Chapter VIII: Conclusion




This report set out to examine the state of open source software in Europe's telecoms industry and to ask what it would take for the industry to build a more sovereign and competitive future. Its central finding is straightforward. The constraint on that future is not the availability of open source, which is already deeply embedded across the telecoms stack, nor a shortage of European technical talent, since Europe remains the single largest contributor geography to open source projects. The constraint is structural: the internal engineering depth, the organisational will, and the structural conditions that let operators convert OSS consumption into genuine control.

The report argues that capability is unevenly distributed and, for now, concentrated at the top of the industry. Orange demonstrated that an operator can rebuild its stack around open control points and use procurement to invert its relationship with vendors, though it took years of sustained investment and cultural change before the effort paid off. Deutsche Telekom showed that a Tier 1 operator can exercise real leadership in flagship projects like CAMARA while remaining a passive consumer across much of its stack. Telenor illustrated the more common reality for mid-sized operators, whose engagement is necessarily mediated through vendors and procurement because the scale required for deep contribution simply is not there.

Challenges in capabilities, ecosystems, and policies are not failures of will so much as reflections of structure: fragmented national markets, decades of outsourced research and development, vendor incentives that favour proprietary complexity, and a regulatory environment that has prioritised low prices over the long-term health of the industry. None of these constraints is immovable, and the core argument of this report is that the moment to move them is now.

The frameworks that will shape the industry's trajectory for the rest of the decade are being drafted and negotiated as this report is written. The Digital Networks Act is attempting to knit fragmented national markets into something closer to one. The Tech Sovereignty Package and its EU Open Source Strategy have, for the first time, placed open source at the centre of European digital policy. The European Competitiveness Fund is consolidating disparate instruments into a single vehicle due to take effect in 2028. Each of these could advance the vision set out here, or each could be shaped in ways that leave the underlying problems untouched.

The recommendations in Chapter VII are offered in that spirit. They are deliberately spread across capabilities, ecosystems, and policies, because no single intervention is sufficient on its own. Skills programmes are worthless without people able to use the funding and governance reforms that accompany them. Procurement discipline works best when the

largest operators lead and smaller ones can follow through shared model terms. A dedicated IPCEI for telecoms converts limited public money into durable influence only if it is tied to upstream contribution. The value of these interventions lies in their interaction, in being greater than the sum of their parts.

The vision this report describes is deliberately bounded. Self-sufficiency is neither achievable nor desirable, because the worth of a largely common global codebase lies in building it with the rest of the world. European firms should give to it and draw from it as equals. What needs to change is where the leverage sits. Today, it rests in large part with a small number of equipment vendors, a contributor base dominated by firms outside Europe, at a moment when other governments have begun to treat open source as an instrument of strategy. If the EU shapes the instruments now in negotiation with intent and coordination, then by 2040 Europe can build, maintain, and help govern a meaningful share of the cloud-to-RAN stack its networks depend on, with operators of every size acting as contributors and active beneficiaries rather than passive consumers.

Open source is not a panacea, and this report has been careful not to present it as one. It is one lever among several, most powerful when combined with capable people, sound industrial policy, and coherent regulation. But it is a lever uniquely suited to Europe's circumstances, because it aligns the industry's need for competition with its need for sovereignty, letting operators cooperate on the shared foundations beneath the market while competing on the services built above them. Realising that potential is not a matter of technology or even, principally, of money. It is a matter of choice. The ingredients are on the table. What remains is to put them together.

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**235**. Interview with Technology Provider #1; Interview with Operator #2; Interview with Operator #1.

**236.** See: "Proposal for the Cloud and AI Development Act (CADA)", European Commission, accessed on 1 July 2026, https://digital-strategy.ec.europa.eu/en/library/proposal-cloud-and-ai-development-act-cada.

**237.** See: "Strengthening Europe's Tech Sovereignty", European Commission, accessed on 1 July 2026, https://digital-strategy.ec.europa.eu/en/policies/eu-tech-sovereignty.

**238.** It is also unclear how the proposed 'open source-first' principle identified in the latest legislative proposal for CADA (at the time of writing) can be operationalised, as it seems to stop short of a full mandate.

**239.** Interview with Expert #2.

**240.** Interview with Open Source Foundation #1.

**241.** Interview with Operator #2.

**242.** Interview with Technology Provider #1; Interview with Operator #2; Interview with Open Source Project #1.

**243.** Interview with Open Source Project #1.

**244.** Interview with Open Source Project #1; Interview with Operator #4; Interview with Technology Provider #2.

**245**. Interview with Open Source Project #1; Interview with Operator #2; Interview with Technology Provider #1; Interview with Technology Provider #2.

**246.** Interview with Technology Provider #2.

**247.** See: "Approved integrated Important Projects of Common European Interest (IPCEI)", European Commission, accessed on 1 July 2026, https://competition-policy.ec.europa.eu/state-aid/ipcei/approved-ipceis_en.

**248.** IPCEI Next Generation Cloud Infrastructure and Services comprises around 1.2 billion euros of public funding, and another 2.1 billion euros of additional national co-investments, forming the cornerstone of the "European Multi-Provider Cloud-Edge Continuum" vision for a decentralised, federated cloud infrastructure. See: "The Important Project of Common European Interest on Next Generation Cloud Infrastructure and Services (IPCEI-CIS)", 8ra Initiative, accessed on 1 July 2026, https://www.8ra.com/ipcei-cis/.

**249.** Interview with EU Institution #2.

**250**. Interview with Technology Provider #2.

**251.** Interview with Operator #2; Interview with EU Institution #2.

**252.** Interview with Technology Provider #1.

**253.** Interview with Industry Association #1.

**254.** Interview with EU Institution #2.

**255.** Interview with Open Source Project #1; Interview with Operator #2; Interview with Technology Provider #2.

**256.** Interview with Open Source Project #1.

**257.** Interview with Operator #4; Interview with Regulator #1; Interview with Operator #2; Interview with Operator #3; Interview with EU Institution #1.

**258.** See: "EU Open Source Strategy", European Commission, accessed on 1 July 2026, https://digital-strategy.ec.europa.eu/en/factpages/eu-open-source-strategy.

**259.** Interview with Regulator #1; Interview with Operator #4.

**260.** Interview with EU Institution #1.

**261.** Interview with Operator #4.

**262.** Interview with Vendor #1; Interview with Open Source Foundation #1.

**263.** Interview with EU Institution #1; Interview with Regulator #1; Interview with Operator #4.

**264.** Interview with Operator #4.

**265.** Interview with Technology Provider #1.

**266.** Interview with Open Source Foundation #1; Interview with Open Source Project #1; Interview with Operator #2.

**267.** Interview with Operator #2.

**268.** Interview with Technology Provider #1; Interview with Operator #2; Interview with EU Institution #2.

**269.** Interview with Open Source Foundation #1.

**270.** Ibid.

**271.** Ibid.

**272.** Interview with Technology Provider #2.

**273.** Only 6 of the top 30 leading organisational contributors to the CNCF projects are EU-based. See: "Top 100 Organisations by Contributions", The Linux Foundation, accessed on 1 July 2026, https://insights.linuxfoundation.org/leaderboards/organizations?collection=cncf.

**274.** Interview with Technology Provider #2.

**275.** Ibid.

**276.** Software Radio Systems (SRS) , "OCUDU: The Linux of RAN and the Next Chapter for Open Networks", SRS, October 14, 2025, https://srs.io/building-ocudu-the-linux-of-ran/.

**277.** Interview with Open Source Project #1.

**278.** Ibid.

**279.** Interview with Operator #2; Interview with Technology Provider #1; Interview with Technology Provider #2; Interview with Operator #1; Interview with Open Source Project #1.

**280.** Interview with Industry Association #1.

**281.** Interview with EU Institution #1.

**282.** Interview with Industry Association #1.

**283.** Interview with EU Institution #1; Interview with Industry Association #1.

**284.** Interview with Operator #2; Interview with EU Institution #2.

**285.** See: "The Digital Networks Act", European Commission.

**286.** See: "Strengthening Europe's Tech Sovereignty", European Commission.

**287.** See: "European Competitiveness Fund", European Commission, accessed on 10 July 2026, https://single-market-economy.ec.europa.eu/access-finance/european-competitiveness-fund_en.

**288.** See: "Cloud and AI Development Act", European Commission, accessed on 10 July 2026, https://digital-strategy.ec.europa.eu/en/policies/cloud-and-ai-development-act.

**289.** The DNA offers a partial lever here. Its supply chain resilience provisions and EU preparedness plan give the Commission a basis for treating RAN disaggregation as a resilience objective, and its move to open-ended, lower-cost spectrum licences could carry conditions requiring reinvestment in open, interoperable infrastructure. But the DNA is not a procurement instrument and cannot mandate interoperability in operators' own purchasing, so it complements rather than substitutes for the private discipline described above.

# Annex I: List of Interviewees (Pseudonymised)

| No. | Code |
|---|---|
| 01 | Interview with Technology Provider #1 |
| 02 | Interview with Expert #1 |
| 03 | Interview with Expert #2 |
| 04 | Interview with Vendor #1 |
| 05 | Interview with Technology Provider #2 |
| 06 | Interview with Regulator #1 |
| 07 | Interview with Vendor #2 |
| 08 | Interview with Operator #1 |
| 09 | Interview with Technology Provider #3 |
| 10 | Interview with Operator #2 |
| 11 | Interview with EU Institution #1 |
| 12 | Interview with Operator #3 |
| 13 | Interview with Industry Association #1 |
| 14 | Interview with EU Institution #2 |
| 15 | Interview with Open Source Foundation #1 |
| 16 | Interview with Open Source Project #1 |
| 17 | Interview with Operator #4 |

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