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FRAMEWORK CONTRACT SMART 2019/0024 LOT 2 - EXPLORING, DOCUMENTING, AND ANALYSING DIGITAL POLICY ISSUES

5G SUPPLY MARKET TRENDS

Executive Summary

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Executive Summary

Background and objectives

The importance of 5G infrastructure, its fast roll-out, and technological capabilities, as well as the development of the supply side of 5G infrastructure, has been highlighted by the European Commission (EC) in various initiatives and strategies including the Communications “5G Action Plan for Europe" and ”Secure 5G deployment in the EU: Implementing the EU toolbox”. However, although Europe is home of two of the three major equipment suppliers and is world leader in trial investments in 5G, overall infrastructure investments lag behind other regions and Europe’s vertical industries are only just starting to identify valuable 5G business cases and European equipment providers are facing challenges to sustain their viability, facing increased competition from Chinese, South Korean, and U.S. manufacturers.

Against this background, this study provides an in-depth analysis of plausible developments of the 5G equipment and services supply market looking out to 2030. The study identifies 4 scenarios, determined by factors such as evolving technology, standards readiness, and Radio Access Network (RAN) disaggregation initiatives. Economic, technological, environmental, and societal impacts are analysed for each scenario, covering key EC and stakeholder concerns, including market competition, costs, cybersecurity, energy efficiency, and standards needs. Based upon the results of the scenario impact analysis, the study identifies policy options to facilitate the evolution of a viable 5G supply ecosystem in Europe.

Key trends influencing the future development of 5G

The study team, drawing upon a Horizon Scanning activity and an expert survey, identified the following eight key trends influencing the future development of the 5G supply market. Each trend represents a factor with a high potential impact on the 5G supply market but also a high level of uncertainty regarding the eventual outcome.

Open and interoperable 5G network solutions: The virtualization of the RAN and the development of new RAN architecture (full virtualization of the native 5G core network, Open RAN) are blazing a path for the implementation of open and interoperable solutions in the network.[1] Several initiatives have applied an “Open RAN” model, aiming to replace closed architectures linking proprietary networking hardware and software with more open and modular interfaces.[2] Open and interoperable 5G network solutions could provide an opportunity for new players to enter the RAN market, fostering vendor diversity and increasing the development speed and competition.[3] While open and interoperable network solutions offer notable benefits, trade-offs in terms of performance, costs, energy efficiency, cybersecurity, supplier diversity, and reliability remain areas of active controversy among the 5G community and in the literature.[4]

Emergence and entry of new players: Open and interoperable network solutions are paving the way for new players in the 5G supply market. While Open RAN may set enabling conditions for new network vendors, it is not a singular feature driving emergence or entry. New entrants may emerge from established companies with strong competencies in hardware, baseband provision, or software services. In addition, new key players may also emerge from start-ups or other sectors.

Level of Public R&I investments for EU players: Current European R&I investment in 5G development is low compared with international benchmarks (APAC).[5] Increased R&I investment for European players could help the 5G innovation ecosystems thrive.

1 Pujol et al. (2020b)
2 Plantin (2021)
3 Pujol et al. (2020b); Hofer (2020)
4 See for instance Barford (2021)
5 Taga et al. (2021)

Degree of pan-European cohesion and scale in public initiatives: Government 5G investments in Europe have historically occurred on a national level, creating a challenging environment for achieving pan-Europe public initiatives with high cohesion and at scale. While some European states have launched and are progressing national 5G programmes of variable size, others lag behind.[6] Existing small-scale programmes at the national level focus on research and piloting rather than broader implementation across Europe. Recent active guidance from the European Union, including the 5G Infrastructure Public-Private Partnership (5G-PPP) and the Joint Undertaking on Smart Networks and Services towards 6G (SNS JU) proposal, is beginning to address this challenge.[7] The European 5G-PPP represents a 3.5 billion Euro investment in 5G of which 700 million is public investment.[8]

Policy support for new actors: Funding and financial support for new players entering the 5G supply market could help facilitate 5G deployment and increase the diversity of European 5G supply market actors.

Development of vertical markets and industries: Developments of 5G application possibilities in vertical markets and industries has implications for future 5G supply markets. Ongoing and profound digital transformation of vertical industries, such as health and healthcare, industry 4.0 and manufacturing, automotive and transport, AR&VR&MR and mining, could create a transformational level of demand for 5G supply. Along with the development of vertical markets and resulting novel 5G use cases, the creation of private 5G networks offers another important new revenue stream for incumbent network operators, vendors, and possible new integrators.

Security challenges in 5G networks: As part of a series of digital industrial transformations, 5G networks will become increasingly critical infrastructure for the functioning of public and private sectors. With such expected growth, security challenges are likely to grow in prominence as well[9]. These challenges include threats to the availability and integrity of networks, increased exposure to attack, and high-risk exposure of critical suppliers in the 5G ecosystem.

Universal standards and open specifications: An advancement of 3GPP specifications and releases, along with standard-essential patents (SEPs), could further promote agreements on universal standards for 5G. Universal standards could in turn open the supply market landscape to smaller hardware and solution providers or start-ups, further promoting the diversity of players in the 5G supply market.

Impact analysis of four plausible development scenarios

Based on the trends outlined above, we constructed four plausible scenarios of 5G development in Europe for the time horizon of 2030. The results of the scenario development and impact analysis highlight the current uncertainty and diverging assessment and expectations regarding Open RAN in the short- and medium- terms.[10] While scenario I and II can be considered as pathways which might become reality on the short to medium term, scenario III and IV can be considered rather as medium and long term pathways.

Scenario I: Incumbent players driving 5G

Key Storyline: Incumbent vendors and MNOs are shaping the ecosystem pulled by increasing demand for new services from verticals requiring high performance. Equipment from providers considered a security risk is used outside a core network and in non-sensitive areas only. The adoption of Open RAN for specific applications and in specific regions sets incentives for established vendors to further improve the efficiency of their proprietary solutions. Incumbent network equipment

6 Taga et al. (2021, S. 12)
7 See the SNS proposal: https://digital-strategy.ec.europa.eu/en/news/europe-puts-forward-proposal-joint-undertaking-smart-networks-and-services-towards-6g.
8 Taga et al. (2021, S. 12)
9 European Commission (2019)
10 see Barford 2021; Plantin 2021

vendors continue to operate successfully but new equipment providers emerge, further facilitating network integration. Cloud RAN and vRAN are important intermediate steps for MNOs on their investment paths. In the short run, Open RAN solutions developed mainly exist in niche areas and do not yet serve as game-changers in the 5G ecosystem.

Impact Analysis: In Scenario I, it is assumed that incumbent vendors and MNOs orchestrate the emerging 5G innovation ecosystem. The opportunity for MNOs in a context of more open interfaces is that orchestration efforts bring new equipment suppliers and lower prices. However, only the largest incumbent MNOs—those with enough R&D activities and financial capacities in place—may start to build and orchestrate an incipient ecosystem of new component suppliers. **Supply market competition** in Europe increases slowly. Incumbent vendors may maintain their market share and play a decisive role in the development of Open RAN.

The emergence of new vendors will focus on the increasingly relevant **private-sector networks**. These new networks provide significant opportunities for new vendors, as there are no path dependencies when compared with large European consumer markets. A risk for both MNOs and traditional vendors is that revenue opportunities in these emerging markets may not be realized because of MNOs' and vendors' comfortable position in the large consumer market.

In terms of **costs**, MNOs find it financially feasible (or even beneficial) to invest in vRAN and Cloud RAN as intermediate solutions. In the long run, MNOs gradually introduce Open RAN (even if proprietary) deployments. Traditional vendors anticipate these developments and adjust their prices at least to some extent. As a result, total operating costs decrease for MNOs.

Business models and system integration for the supply chain are likely to remain largely unchanged in the medium term. Only large MNOs may feel confident to explore white-box models and potentially adopt an in-house model of system integration in the future.

The overall pace of **modularisation and decrease of supplier dependency** is moderate. The emergence of **new services and applications** in this scenario may only occur gradually as incumbent MNOs and vendors with their focus on hardware may not be the most suitable actors to introduce new services. The decade-old search of MNOs for a 'killer app' that pushes demand for new generations of mobile communication is a testament to this claim. For 4G, US social media and software companies introduced key services and drove the growth of mobile data. We may therefore expect that services will emerge as a continuation of, rather than a radical departure from, existing services.

Cybersecurity risks can be largely contained as MNOs and incumbent vendors invest in risk mitigation measures, which also secures market advantages for themselves. A strong role of incumbent vendors and MNOs may also be beneficial for **energy efficiency** as system performance might be better tailored to integrated stand-alone solutions.

In terms of **standard-setting measures**, O-RAN standards set by 3GPP complement the RAN standards. While this constitutes an opportunity to increase competition and thus reduce the dependency on few remaining suppliers, the threat in this scenario is that limited involvement of stakeholders in the standardization process jeopardizes acceptance of O-RAN specifications.

The contribution of 5G in Scenario I is expected to be the same as the current contribution of 4G technology to Europe's economic growth, and that **we will not see a boost to turnover or employment** in Europe as evidenced by the previous introduction of new mobile network technologies.

Scenario II: Slow pace of 5G Roll-Out

Key storyline: MNOs and vertical industries struggle to find the right business case for 5G. Consumers demonstrate indifference towards higher broadband speeds offered by highly-priced 5G networks and are contented with service over a wide area with 4G. 5G-based industrial services

emerge only slowly. A fragmented approach to the implementation of cybersecurity requirements in Europe leads to legal uncertainty regarding supplier requirements. A fragmented approach also contributes to long transition periods for any multi-vendor strategies. Simultaneously, conditions for increasing multi-vendor interoperability via standards-based interfaces are not being reached in the medium term. 5G deployment in Europe in consumer and business markets is of modest speed. MNOs slowly start providing end-to-end Open RAN networks, primarily in suburban and rural areas.

Impact analysis: In this scenario **market competition** remains the same or even decreases due to the exclusion of vendors because of geopolitical motivations and/or security concerns. Due to the low uptake of B2B use cases, the overall 5G market size does not expand in Europe and the slow 5G rollout does not provide opportunities for new vendor solutions to be scaled.

For the 5G supply market, this scenario resembles the status quo most starkly in terms of **costs**. Compared with the status quo, equipment prices may even increase if no alternatives for equipment providers manage to enter the market.

In terms of **business models for system integration**, the predominance of the traditional integrated model is unlikely to change in this scenario. Similar levels of **modularity** cause vendor lock-in and hence supplier dependency to persist. Consequently, potential adverse effects from system disaggregation are less likely.

New 5G based **services** cannot be introduced rapidly in an environment sketched by this scenario, and segmented geographical markets may further hamper the roll-out of Europe-wide services. When national policy pushes their introduction, health services may benefit appealingly in this scenario, but their introduction might also be hampered by the lack of performance and diffusion of 5G.

Cybersecurity is not such a big issue in this scenario, as this scenario gives more time to reflect on the risks in advance and mitigate them within traditional, integrated systems and clear overall responsibilities. Despite existing **energy efficiency** inefficiencies of 2G/3G/4G networks an overall slow 5G roll-out in Europe might delay any overall increase in data usage (likely in the opposite case of ubiquitous 5G network availability) leading to decreased energy intensity.

The scenario has negative implications for **standardisation** for both 3GPP and O-RAN Alliance due to a lack of feedback from the applications of 5G standards in practice back into standardisation.

The overall **economic impact for Europe** is negative. The slow 5G roll-out in this scenario may be partly compensated by the favourable conditions for European suppliers of 5G equipment. Nevertheless, the negative effects from a delayed roll-out are larger than the positive effects for European suppliers in this scenario.

Scenario III: Open RAN as a game-changer

Key storyline: In this scenario, it is envisioned that technological progress is impressive and Open 5G platforms enable standardised services on fully virtualised networks in the medium and long term. The demand for new 5G services is created by verticals that are served by MNOs but also new entrants specialised in operating networks. Established MNO, incumbent vendors, verticals, and new entrants build up the 5G innovation ecosystem and new solutions for factories or autonomous driving are on the rise. Open RAN solutions drive suburban offerings and broaden the range of services in rural areas. MNOs face competition by new European and non-European operators who enter the industry to serve specialized areas. New operator entrants, in turn, accelerates interest by verticals. Policy support for pilot projects in collaboration with verticals pushes applications, generating amplifying feedback.

Impact analysis: In this scenario decentralized, disaggregated and fully virtualized Open RAN networks serve Europe. The uncertainties of Open RAN are resolved in the medium term, leading to increased **market competition** and new suppliers in the RAN domain. Development efforts for new

business opportunities for traditional vendors are high to remain competitive. Regarding new vendors, the most plausible outcome from a present perspective is that **non-EU entrants lead absorption of new demand**.

The **costs** for equipment (CAPEX) go down due to competitive pressures. The level of competition is high, and so is the scale of deployments. Operational expenses of Open RAN deployments catches up and may finally even outperform traditional ones. In the longer term, there is a threat of re-consolidation in the market, which could reverse the expected benefits realized by fully virtualized Open RAN networks.

System integration costs remain a key challenge due to increased complexity. High uncertainties regarding overall cost savings bring opportunities for traditional vendors, which could take early leadership in Open RAN and make sure that new players develop under their leadership.

The market for new **services** and applications is characterized by a high level of competition, entry of new players and strong demand by verticals.

Supplier dependency decreases and vendor lock-in in the RAN becomes a problem of the past for MNOs, while challenges at the system integration level increase, because of high modularity.

Cybersecurity risks are a key challenge. While interoperability increases, cybersecurity risks may be exacerbated as the diversity of providers seeking interoperability provides more entry points for hackers, irrespective of the vendor. Increased heterogeneity of networks makes it also more difficult to realise power gains. **Energy efficiency** and energy consumption become a challenge, as it may become more difficult to measure and control energy consumption in each part of the network and energy consumption might increase due to optimisation on flexibility and interoperability.

Interoperability and therefore **standards** will become more relevant. The O-RAN architecture and its specifications would become (defacto) standards for RAN. The O-RAN architecture will attract new suppliers, which might eventually contribute to standardisation both at 3GPP and the O-RAN Alliance. To handle the complexity, MNOs can opt for a subset of suppliers and proprietary implementations of Open RAN solutions.

For Europe, this scenario offers some possibilities (new opportunities for European suppliers, MNOs, service firms, and in particular vertical industry) but also risks (dominance by non-European firms, EU vendors may significantly lose market share).

Scenario IV: 5G for Big Tech

Key storyline: Network virtualisation and disaggregation of software and hardware change the landscape for network equipment, deployment and service provision in the long term. New business models based on Open RAN architectures and interfaces gain momentum and new major players enter the market. Complete 5G solutions encourage companies from vertical industries to enter the market. MNOs are not able to find their role as infrastructure providers for industrial players and are outflanked by Big Tech companies who also offer services to end-users. Big Tech become the "new operators" and will serve as virtual operators.

Impact analysis: In this scenario, foreign Big Tech companies increase their overall dominance in the **market** on demand and supply sides alike. As network functions and elements become increasingly virtual, Big Tech players may leverage their cloud and software capabilities to move into connectivity and supply domains with innovative solutions. Moreover, their financial strength allows them to overtake existing players and new entrants.

However, their specific entry to the markets for B2C connectivity and RAN equipment may be unrealistic. For Big Tech the core network might be more interesting than the RAN because the core network is easier centralised, and closer to their current skills and infrastructure, based on cloud computing in data centres.

The key threat for market competition by Big Tech is on the demand side. As added value will shift from connectivity itself to the cloud, the future value generation of MNOs may decline. Another realistic threat is that Big Tech players dominate the end-user services by offering more value-added OTT services, and MNOs remain stuck offering the least profitable part of the chain, i.e., becoming 'dumb pipes'. Additionally, Big Tech companies may enter the connectivity provision market and increase competition.

In terms of **costs**, the impact on RAN-related OPEX is low. Tech companies only take over a small part of a base station's processing. However, the higher bargaining power and overall dominance of Big Tech threatens to keep the prices of their solutions high.

Concerning business models and **system integration requirements,** the key threat for European MNOs is that foreign Big Tech players become the go-to integration option. On the demand side, Big Tech business models based on their cloud and OTT services help Big Tech to increase their dominance. While a vendor lock-in for the RAN might be substantially reduced, a new reliance on large foreign players threatens to bring a new bottleneck in the supply chain (e.g., at the cloud level).

New services and applications - the main driver for 5G added value and new revenues for firms - would be dominated by non-European Big Tech. A use case that would benefit in particular in such a scenario is Connected and Automated Mobility (CAM). Another area where use cases may benefit from complementary competencies within Big Tech companies is health.

As regards **cybersecurity**, Big Tech is not necessarily more secure than medium or small tech – but the scale of people reached with any single vulnerability is likely to be greater. Concerning **energy efficiency**, Big Tech might be beneficial for energy reduction because large tech companies already manage energy in data centres.

Big Tech companies in this scenario become dominant also in **standardisation**; their influence in the O-RAN Alliance might become bigger, reducing the relevance of existing players. However, they could also start offering non-O-RAN proprietary solutions.

Thanks to the fast roll-out of 5G and the emergence of a vivid services eco-system, Scenario IV offers some opportunities for Europe. Studies on the economic impacts of 5G have shown that these are largest when 5G diffuses fast. If Industry 4.0 is a fast-growing use case, it may provide opportunities for Europe's large manufacturing base in particular. Several industrial firms may extend their product range to 5G based services.

But there are also key risks for Europe associated with this scenario. The fast diffusion of Open RAN may allow non-EU companies to take a good part of the MNOs and suppliers market. Given the weak market position of Europe in many software and services markets, it seems uncertain whether European companies will make the best of these new opportunities. Much will depend on if non-European firms will operate these new businesses via European affiliates or directly from their home countries.

Policy recommendations

Establishing a viable 5G supply ecosystem requires a combination of system-oriented policy measures, which aim to mitigate risks of the scenarios on the one hand while seizing their long-term opportunities on the other hand. The policy measures should ultimately contribute to the following overarching goals:

- The EC and the EU Member States should develop an open and secure 5G ecosystem in the long run, including MNOs, incumbent and new European vendors, software providers including open-source communities, and European users from vertical industries.
- The EC and the EU Member States should promote European digital autonomy and technological sovereignty via the support of collaboration between new and traditional vendors, and a strong approach towards open specifications in the 5G ecosystem.

The study details specific policy recommendations important for the development of a viable 5G ecosystem:

R&D investments are needed across the whole supply chain, from basic research to experimental development to trials to, pilots and large-scale deployment. In particular, the security dimension should be considered. The study recommends supporting R&D projects related to 5G, with a focus on the collaboration between large companies and small companies located in the EU to promote the 5G ecosystem in the EU. New R&D funding initiatives focusing on 5G should in particular target SMEs and start-ups. The development of regional clusters of excellence and smart cities in the area of 5G technologies and services should be encouraged, including partnerships between industry, research organisations, Open-source communities and the private sector. The study also recommends supporting the identification and development of business models or use cases for verticals related to 5G networks and applications.

Standardisation and the resulting standards, testbeds, and certifications are crucial for the development of mobile telecommunication networks, as is shown by the massive efforts in 3GPP and the different generations of 5G standards as well as the creation of the O-RAN Alliance. To avoid fragmentation or a lack of interoperability, the required standards should be developed at the global level. Compliance with the O-RAN Alliance to the Code of Good Practice when developing standards released by the WTO and the EU Regulation No 1025/2012, closer collaboration between 3GPP and the O-RAN Alliance, and a European Certification Scheme applicable for products related to 5G are important cornerstones in this regard.

The ecosystem diversity benefits from the **entry of start-ups** and companies from other domains. In addition, technological sovereignty or digital autonomy, the EU needs to **foster entrepreneurship** in 5G related technologies, business models and services. To address the lack of venture capital in the European small business ecosystem, it is recommended to continue the Enhanced EIC programme (including the EIC Accelerator) and explicitly open it to applications from young, high-risk, R&D-intensive entrepreneurs that focus on 5G-related technologies and business models.

Public procurement can stimulate innovation and growth through public sector demand. The public procurement of networks is becoming increasingly important to strengthen the European supplier landscape. Therein, it is recommended to fully exploit the potential synergies between commercial procurement and standards related to 5G technologies by referencing 3GPP and O-RAN Alliance specifications and standards instead of proprietary specifications. The procurement processes should follow EU-wide public procurement guidelines and recommendations, particularly taking into account the needs of SMEs and start-ups. Finally, the potential synergies between commercial procurement and 5G-related Open-Source technologies need to be considered more strategically and systemically.

Also, the **regulatory framework** plays an important complementary role. All regulations should be based on the principle of technology neutrality. An effective **competition regulation** can promote both the 5G ecosystem as well as digital autonomy or technological sovereignty. Concerning **security,** it is recommended to support risk assessment schemes for vendors in the 5G supply chain based on clearly operationalized and transparent security regulations. Concerning **energy efficiency,** it is recommended that the potential improvement of energy efficiency in the context of 5G are considered in future environmental regulations and standards, e.g. via specifying energy-efficient targets for 5G technologies and networks complemented by financial incentives for energy-efficient solutions.

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