Visions for 6G Futures: a Causal Layered Analysis

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***Abstract*—This study extends and deepens the joint 6G vision building stemming from use cases, enabling technologies, key performance indicators (KPIs), key value indicators (KVIs), and business scenario litanies towards the social, the worldview, and the metaphors layers utilizing causal layered analysis (CLA) method. 6G visions are explored from different national perspectives assessing future initiatives from China, Europe, Japan, South Korea, and the US. The multiple ideologies and epistemes of the stakeholders are mapped to create a transformed future vision emphasizing the importance of 6G design from the triple bottom line of sustainability, including social, economic, and environmental perspectives. Collaborative research, harmonized standardization, and anticipatory regulation efforts were found essential in developing trustworthy and general-purpose 6G technologies for users and developers.**

Keywords—causal layered analysis; futures research; policy; scenarios; vision; 6G

I. INTRODUCTION

To make sense of the futures of the sixth generation (6G) empowered by the convergence of mobile, Internet and cloud technologies, business models, and societal impacts, we need to envision 6G from a transdisciplinary perspective [1]. As a potential general-purpose technology [2], 6G will impact the surrounding downstream and upstream industries [3] and have a governing effect on the future society [4]. Thus, different disciplines must jointly create a new conceptual and translational understanding that integrates and moves beyond discipline-specific approaches. The focus of innovation in 6G is shifting from a focal firm-led supply-side innovation toward dynamic cross-layer innovation in platforms [5] and ecosystems [6], highlighting novel multisided service-driven business models that enable value co-creation and co-capture [7].

6G networks are under extensive research aiming at deployment in 2030. As the global vision for 6G will be communicated already in 2023 [8], we need to understand today what 6G may bring for the future service delivery and how they influence us from policy, environmental, societal, technological, legal, and economic perspectives. As the 6G emerges in the next decade, there will be yet another fundamental shift toward empowered people and communities who use, interact with, and develop the networks and services. The first white paper on 6G [9] envisioned 6G as "*the ubiquitous wireless intelligence,"* and the leading European 6G flagship research program Hexa-X [10] imagines 6G to introduce an "*intelligent fabric of technology enablers connecting human, physical, and digital worlds."* Topical vision papers have complemented high-level futures by providing the foresight to use cases, enabling architectures and technologies, and key performance indicators (KPIs) [11], [12], [13]. Recently technology-driven KPI discussions have been widened via key value indicators (KVIs) [14], [10], putting the accent on environmental, societal, and economic forces on sustainability [15], [16]. The early 6G business research has focused on futures scenario building [1], [15] and transactional multisided ecosystem-driven platforms consisting of components, interfaces, data and algorithms [17], [18]. Recent developments in geopolitical tensions are increasingly impacting the future of mobile communications from technological, economic, and societal perspectives. The ongoing technology battle has specifically concerned the leadership in 5G regarding the semiconductors, and concerns over sovereignty regarding artificial intelligence (AI) and digital technologies have become an issue [19].

Thus, the currently available 6G visions are not fully reconciled and come with fundamental intrinsic tensions that may hamper the development of 6G as a global general-purpose technology. This study aims to extend and deepen the 6G visioning stemming from use cases, KPIs, KVIs, and future scenarios to seek an answer to the questions of: *how the introduced 6G visions impact systemic societal changes? Do they lead to changes in worldviews and culture? What kind of new narratives can be found? Moreover, can multiple perspectives be mapped and reconciled to a transformed future vision?* Thus, the paper will examine the 6G through the lenses of causal layered analysis (CLA) [20], which is a comprehensive futures research methodology focused on creating transformative conceptual spaces to create preferable and alternative futures. The data for this study is based on a set of virtual future-oriented business-of-6G white paper expert group workshops organized by the 6G Flagship [1], white papers from adjacent 6G technology workshops [11], and the secondary data from 6G visioning initiatives from China, Europe, Japan, South Korea, the US, and ITU. 6G visions from individual researchers and companies are omitted in this analysis, but the focus is on national-level initiatives. After the introduction, the paper introduces CLA methods and summarizes the key national 6G visions as the data utilized in the research. The third chapter discusses alternative 6G worldviews and reconstructs from multiple perspectives a

transformed future. Chapter IV summarizes key findings and suggests future research.

II. Methods and Data

A. Causal Layered Analysis

Causal layered analysis (CLA) is a futures research method that seeks to integrate empiricist, interpretive, critical, and action learning modes of research [21]. The method expands scenarios' range, richness, and differentiation through alternative worldviews and narratives. CLA has proven helpful in deepening visioning, strategic planning, and policy development. CLA framework comprises four layers [20]: The surface *litany layer* depicts the official unquestioned future consisting of lists of details and contents presented in the available documentation. The following *social systemic layer* explains and analyzes the litany of political, environmental, social, technological, economic, and legal (PESTLE) to grasp the causation and meanings better. The third *discourse and worldview* layer deepens ideological and discursive assumptions and explores different stakeholder views on the litany and system. Finally, the *myths and metaphors* are considered the fourth layer of discovering the unconscious emotive dimensions. In conducting the CLA method, layers of analysis are practiced up and down to ensure different ways of knowing and different perspectives are taken into consideration for breadth. Ideologies and epistemes of the stakeholders are brought into the third worldview and the fourth myth level, in particular. In the next step, the transformed future perspective can be developed by reinterpreting the layers in light of the inflection and reconstructing the more visible upper levels of systems and litany [20] to create reconciled understanding and visions.

B. 6G Visions

This sub-chapter summarizes key findings of the national developments focusing on the 6G futures envisioned by governmental initiatives from China, Europe, Japan, South Korea, and the US. The recent ITU-R 6G activities are discussed.

1) China

China's development of mobile communications has become closely tied to national issues of development and prestige, and wider infrastructure and digitalization strategy initiatives such as China standards 2035, belt and road, digital silk road, made in China 2025. In 2019, China's Ministry of Science and Technology (MOST) established working groups for the 6G policymaking and the R&D from research institutions and enterprises. The IMT-2030 (6G) Promotion Group constituted in June 2019 by the Ministry of Industry and Information Technology (MIIT), is the primary platform for gathering China's industry and academic forces, promoting 6G technology research, developing international views exchanges and cooperation, and a national strategy on standardization. In 2020, the Chinese government announced a package of subsidies and stimulus worth RMB 10 T between 2020 and 2025 on 5G evolution, AI chips, smart factories, and data centers. Group released a 6G white paper on 6G vision and candidate technologies in June 2021 [22]. In the vision of "*Intelligent connection of everything, digital twin*", society will enter an era of intelligence built on balanced, high-quality social services, scientific, precise social governance, and green, energy-saving social development. The vision urges new impetus into the global economy by developing new technology industries to drive high-quality economic growth as global trade shifts from physical products to digital services. The white paper anticipates changes in social structure due to wealth and demographic imbalance. Development towards a more diversified, flattened governance structure was seen to demand a precise, scientific governance model to make accurate, scientific decisions and respond to real-time events enabled by digital twins and AI. White paper depicted eight 6G use cases: the proliferation of intelligence with ubiquitous smart core, immersive cloud XR, digital twins, holographic communications, converged communication and sensing, sensory fusion, intelligent interactions of feelings and thoughts, and seamless global coverage built on native network multilateral security. The antecedents of the successful 6G development were characterized as [22]:

- The successful commercial deployment of 5G
- Native AI intelligence and computing aware
- Expand to higher frequency bands, such as THz, and visible light while improving the efficient use of the spectrum via refarming, aggregation, and sharing.
- Ubiquitous coverage in the land, sea, sky, and space.

2) Europe

The European Commission has set six broad political goals [23] to boost economies and competitiveness: the green deal, fit for the digital age, an economy that works for people, a stronger Europe in the world, promoting our European way of life, and a new push for European democracy. EU pursues a geostrategic and global approach supporting partnerships with like-minded countries and regions. The European smart networks and services joint undertaking (SNS JU), established in November 2021, aims to ensure industrial leadership and foster Europe's technological sovereignty in 6G [24] by implementing the related research and innovation program leading to the conception and standardization around 2025, as well as preparation for early market adoption of 6G technologies by the end of the decade. Smart networks and services partnership R&I program planned to start Q2 2022 with Euro 0.9 B budget. This first work program has strategic orientations [25] to promote an open strategic autonomy through human-centered technologies and innovations, to make Europe the first digitally-led circular, climate-neutral and sustainable, and foster Europe's technological leadership in digital and future emerging enabling technologies. The SNS WP aims to contribute to several European policies: green deal, resilient communication privacy and security, AI, data & cloud computing, blockchain technology, high performance computing, Internet of things, and microelectronic components. Novel types of services and applications are foreseen related to a fusion between the communication and sensing environment, massively scalable immersive environments, digital twins, and holographic communication. The list of KVIs to be adapted into the SNS projects includes:

- Democracy: privacy, fairness, digital inclusion, trust

- Ecosystem: sustainability, business value, economic growth, open collaboration, new value chain
- Innovation: safety, security, resiliency, regulation, responsibility, energy consumption
- United Nations sustainable development goals (SDGs).

Additionally, several national level 6G initiatives have developed visions in Europe including 6G Flagship in Finland [9], [26] in the UK, and [27] in Germany.

3) Japan

The government-supported program has set three policies: global first, creating an ecosystem that generates innovation, and intensive allocation of resources to strengthen R&D capabilities in the fields of their advantage and indispensable to the nation [29]. In Japan, the beyond 5G promotion consortium (B5GPC) was organized in 2020 to share information and promote efforts toward the early realization of 6G among government, academia and industry [29]. Japan aims at gaining infrastructure market share of 30% and a 10% share of the number of essential patents. One of the most fundamental principles of B5GPC is '*Global first*' to promote global standards, policies, and R&D and '*Bidirectional globalization*' to export Japanese technologies, but also to build a hub of excellence, bringing in researchers and engineers, new visions, and technologies for co-creating values for the society. The 6G features are seen to contribute to creating sustainable and new value, such as ultra-low power consumption, ultra-security and reliability, autonomy, and scalability, and further advance 5G KPIs related to data speed, capacity, latency, and density [29]. On the value level, 6G is expected to develop into the backbone of *Society 5.0*, a social infrastructure that integrates cyberspace with the real world. Society 5.0 is seen to transform the socio-economy towards a knowledge-intensive society, where real-time data will be available to all people safely and without impacting the global environment. In the recent white paper [30], from the national institute of information and communications technology (NICT), three 6G scenarios towards 2035 were created: the cybernetic avatar society, the city on the moon, and the transcending space and time.

4) South Korea

The ministry of science and ICT (MSIT) announced South Korea's "*Digital new deal*" project in 2021 aiming to accelerate the digitalization of all industries for Korea's economic growth and to "T*ransform the economy from the fast follower into a pacesetter*" [31]. Project targets include digital accessibility, the digital transition of education, digital transformation of enterprises, integration of 5G and AI into the industry and cyber security. MSIT's R&D action plan prioritizes critical strategic technologies in the digital sector including AI, 6G, and cybersecurity. The plan targets government investment of KRW 200 B for the first five-year phase across ten strategic technologies, including performance KPIs, space communications, new spectrum (THz) and antennas, ultra-precision, AI, and reliability. South Korea is targeting leadership in international standards and patents, and to be the first nation in the world to launch a 6G pilot in 2028 via active public-private cooperation in the early stages of 6G. The 5G Forum [32] is a Korean non-profit organization aiming to globally promote the evolution and convergence of the ecosystem particularly in the context of *Industry 4.0*. 6G Vision stems from three drivers of the future society: a clean and safe society, a sustainable society, and a fair and transparent society. Envisioned key use cases are:

- Internet of experience, inclusive education,
- Augmented human for health and welfare,
- Sustainable automation in industry and labor,
- Embedded AI for safety and transport.

Data-centric networks and services build on delivering truly immersive experience, distributed infrastructure for connected intelligence, and real-time interaction between the physical and digital worlds [33].

5) USA

In 2020, the US "*Clean network initiative"*, addressed the long-term threat to data privacy, security, human rights, and principled collaboration to free the world from authoritarian malign actors [34]. The Alliance for Telecommunications Industry Solutions (ATIS), the North American organizational partner for 3GPP, set up the NextG alliance (NGA) in 2021 to advance North American wireless technology leadership over the next decade through private sector-led efforts [35]. Work is organized across six working groups: applications, greenG, national goals, societal and economic needs, spectrum, and technology. The national 6G roadmap sets six goals:

- Networks must be resilient, secure, privacy-preserving, safe, reliable, and available for people, businesses, and governments. Deployable by critical infrastructures, national security, and military.
- Cost efficiency across the network architecture.
- Life-improving value-creating use cases via transformative forms of human-to-human collaboration and human-machine and machine-machine interactions.
- Increase the robustness, performance, and efficiencies of the 6G via artificial intelligence (AI).
- Increased flexibility, performance, and resiliency for mixed reality, ultra-reliable low latency communication, interactive gaming, and multi-sensory applications built on distributed cloud and communications systems and virtualization technologies.
- Achieve IMT carbon neutrality by 2040 via energy efficiency and ICT as an enabler.

NGA's charter is to advance North American Internet and communications technology ecosystem leadership over the next decade encompassing research and development, manufacturing, standardization, and market readiness [35]. The infrastructure investment and jobs act on August 2021 includes USD 42 B for broadband deployment in unserved and underserved areas. The US senate further stressed the urgency of cyber security in December 2021 by approving three cyber-related bills addressing mobile networks, the future buildout of 6G, and creating a national cyber literacy campaign [36].

6) ITU-R

International level joint 6G vision building for the future mobile communication systems has started at the ITU-R working party 5D (WP5D), which is working on a new draft

report on future technology trends towards 2030 and beyond and a new draft recommendation on IMT vision for 2030 and beyond to be completed in June 2022 and June 2023, respectively. This work brings together the views from different stakeholders and countries for a joint view presenting a collection of technology trends and vision elements for what will become 6G. The work is still ongoing, and several topics are on the table from the countries and stakeholders. To develop these reports, WP5D has invited the views of members and external organizations globally on driving factors such as user and application trends, the evolution of IMT, usage scenarios, capabilities and framework and objectives. ITU 6G futures highlights the importance of anticipating new use cases for IMT and subsequently identifying gaps and new technical enablers necessary in the 2030 timeframe, such as technologies for native AI-based communication. [8].

III. 6G FUTURES

The causal layered analysis of the selected regional and national 6G visions articulates alternative perspectives, ideologies and epistemes as summarized in Table I.

TABLE I. MAPPING MULTIPLE PERSPECTIVES AND FINDING INTEGRATED SOLUTIONS

CLA Layer	**Regional / National 6G Visions**					**Key New Joint Vision Elements**
	USA	***EU***	***Japan***	***South Korea***	***China***	***Transformed***
Litany of surface-level details of the available 6G visions	*KPIs*: capacity, coverage, scale, data rates, latency, determinism, precission and accuracy, service availability, dependability, energy efficiency, materials life-cycle efficiency, EMF awareness *KVIs*: sustainable 6G, 6G for sustainability, trustworthiness, inclusiveness & acceptance, data privacy and security, total cost of ownership *Emerging*: THz, visual light, smart materials, converged sensing, blockchain, quantum computing, *Enabling*: extreme connectivity enablers, semiconductors, spectrum management, multi-lateral security *Embedded*: AI/ML, virtualization, cloud, sensory fusion, immersive XR/VR					6G general-purpose technology Global harmonized standardization, Innovative spectrum sharing approaches, IP licensing policy Sustainability-driven KPIs and KVIs
Social Systemic causation and meanings embedded in the 6G visions	Capabilities: networks of networks, local compute integration, integrated intelligence, integrated sensing, embedded devices, human-machine collaboration, automation, robotics, local trust zones, digital twin, augmented reality, telepresense, sustainable development enablers, digital inclusion, ubiquitous coverage					Triple bottom line accounting for the social, economic & environmental sustainability. Trustworthy 6G and steady rules for AI/ML Anticipatory regulation promoting open innovation and sustainability
	Wireless ecosystem leadership Clean network National security Role of military industry and developers Cyber security	Technology research leadership and sovereignty UN SDGs Industry 4.0+ European values Human centered digital sovereignty	R&D leadership Global standards Spectrum innovations Society 5.0 Avatar society Transcending space & time	Digital new deal Clean & safe society Data centricity Productivity Automation Public-Private-Partnership Education Health	State sovereignty Global initiatives: Belt and road, China standards, digital silk road, made in China 5G leverage Standardization leadership World's factory	
Worldviews, and *discourse* used to legitimate the 6G visions	Competition Innovation Free market	Global partnerships Neo-liberalists Democracy Regional regulation	Functionalism Communityism Social harmony	Nationalism Competition Work ethic Prosperity	Confucian hierarchy Social governance and stability GDP growth	Ecosystem legitimacy Empowered human Citizenry-driven
Myths & metaphors explaining the 6G visions' deep meaning	Rights of man, Democracy, Capitalism	"European way of Life" Stronger Europe	Shintoist society Efficiency Hard work	Confucianism Hierarchy Face	Prestige Superpower China Glorious history	Healing world, Harmonious society advancement

A. Litany

Looking at the surface-level details of 6G at the litany layer, there is a high similarity of KPIs, KVIs and technologies between visions as depicted in Table I. The emphasized emerging technologies seize the novelty via radical new knowledge and disruptions in improved functionality and value creation [37]. Publicly funded basic research is essential for an emerging technology with initial diversity, high uncertainty, significant investments, and complementary assets to achieve commercialization. The enabling technologies commercialize across multiple application segments necessitating coordination, a variety of complementary assets and tailored investments across domains. In addition to public funding, public-private-partnership policies can incentivize innovation. The embedding technologies will further expand the applicability to adjacent businesses. Global standardization and harmonization of regulation and policies play important roles, e.g., in interoperability, security, data privacy, AI rights and novel sharing economy-based platform business models. Towards 6G, the focus of innovations is shifting from a focal firm-led supply-side towards dynamic demand and multisided business models in platforms and ecosystems. The value creation and capture were seen to stem increasingly from complementary assets and capabilities. For China, standards are seen to improve quality and raise international competitiveness, while in the US outcomes are left to the market.

B. Social Systemic

There is a clear correspondence between envisioned novel technology capabilities at the social systemic layer, while key differences were found mainly related to their exploitation. In the US, the competitive free market approach highlights the role of a focal firm or platform, while in the Asian vision the role of society and governmental governance was stressed. In Europe, global partnerships and common UN SDG-founded sustainability goals were emphasized. Policy and regulatory systems are increasingly struggling to cope with the nature and speed of disruptive technologies and innovation, such as AI/ML, distributed ledgers, and quantum computing. Four areas of public policy concerns were seen to guide governments' actions toward developing 6G. The global competition and disparity of policies and legislation between the major geopolitical nodes may lead to technological divergence, compartmentalized innovation ecosystems, techno-nationalism, and market protection. Visions brought policies related to competition, spectrum regulation, data privacy, and trustworthy AI into the discussion.

C. Worldview, Myths and Metaphors

At the worldview, myths and metaphors layers explaining assumptions and views, explored visions reveal concluding differences in the legitimation of 6G for the successful value creation and capture [38] and ability to select the "right thing to do" [39] in the ecosystem within the socially constructed system of norms, values, beliefs, and definitions [40]. From the discursive legitimation perspective, the pragmatic *sociopolitical route* adopted in the Asian visions meant that the innovation complies with established social rules, regulations, and norms. *Passive* discursive legitimation in the Chinese visions were built on the acceptance and familiarity of existing institutions or the absence of alternatives. The *industry* legitimation route noticeable in South Korea and Japan fits the innovation with the industry's institutionalized practices [41]. In the US 6G vision, *performative* legitimation processes drive normative legitimacy and demonstrate the viability of the ecosystem through the processes of strategic action, value realization, adoption, and external intervention. *Active* legitimation may occur via a pragmatic route, meaning that the innovation satisfies ecosystem stakeholders' self-interests and does not influence others negatively. In cases orchestrated by dominant organizations and platforms, legitimacy can be built without discursive and performative processes. The European vision can be seen to stem from the interaction of discursive and performative legitimation processes adopted in US and Asian 6G futures. The 6G *ecosystem identity construction* in Europe is founded on an emerging mutual understanding among ecosystem participants regarding the ecosystem value proposition's central, enduring, and distinctive characteristics. Interdependencies and resources built along with the mobile communications evolution such as joint research initiative, regulation and standardization forums can help cope with the liability of newness in 6G.

D. Proposed New Transformed Vision Scenarios

Utilizing the CLA to analyze different 6G visions from government initiatives, we explored and created new spaces wherein preferable and more innovative futures visions and strategies can take place. The existing 6G visions shared a consensus of characterizing 6G as having can ubiquitous economy-wide impact, driving innovation complementarities across application domains, and being founded on sustained technological improvement across disciplines. Furthermore, as visions agree on the governing effect on the future society, 6G can be envisioned as a *general-purpose technology* (GPT) [2]. The above calls for a common *ecosystem legitimacy* as a collective action among different ecosystem participants to overcome the liability of newness in 6G. As with previous generations, having a common set of *standards* that applies to all industries and geographies developed through collaborative research projects, trials, and demonstrations will ensure consistency, complementarity, extendibility, and economies of scale in the 6G rollout. At the same time, policymakers should pay attention to supporting the value capture of the emerging novel technology innovators. The growing number of stakeholders and licensees will lead to an increasingly complex standard essential patent *licensing* landscape and necessitate a novel, more precise rule for FRAND compliance. The sustainability discussion can be seen to move towards a holistic *Triple bottom line* vision comprising economic, societal, and environmental perspectives. *Anticipatory regulation* methods support reframing regulation to anticipate sustainable development, use of emerging technologies, and novel, innovative business models in a more flexible and timely manner while preventing harm to the public. Following the proposals for harmonized regulation and ethical guidelines for AI, a similar policy for *trustworthy 6G* can be envisioned, focusing on transparency, fairness, accountability, robustness and safety, human agency and oversight, privacy, and data governance as values. The technical processes and their decisions to stakeholders need to be explained if we are to reach user and developer-centric 6G futures. The datasets and AI/ML decisions must be documented in a standardized manner to allow for traceability and auditability. Furthermore, governance mechanisms must support human oversight, and users/developers should be given the knowledge and tools to comprehend and interact with the systems to a certain degree.

IV. Conclusion

The growing number of 6G visions attest to the recognition of both public and private stakeholders exacting more comprehensive and coordinated strategies across multiple industries and technology domains. In addition to the rapidly increasing number of published 6G visions from individual researchers and companies, there are national 6G initiatives, whose visions were analyzed in this paper. These initiatives will lead to a growing need for a bilateral and multilateral strategic, technology and research partnerships and collaborations for joint 6G vision building. At the same time significant developments in geopolitical tensions are driving regional and national 6G agendas. Common themes identified in the national 6G visions analysis are the need for research and leadership in international standards development. Explored visions reveal concluding variance in the legitimation of newness from sociopolitical route in Asia and performative legitimation in the US to ecosystemic approach in Europe. Sustainability is the fundamental driver for 6G visions that

expand towards a holistic triple bottom line balancing economic, societal, and environmental sustainability perspectives. To create trustworthy 6G for users and developers and cope with 6G and the nature and speed of disruptive technologies and innovation, such as AI/ML, distributed ledgers, and quantum compute, a more flexible and fast-moving anticipatory regulation framework and methods are needed. Further research is needed on the timing and sequence of the envisioned 6G technologies, policies, business antecedents, and related stakeholders.

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REFERENCES

[1] S. Yrjölä, P. Ahokangas, and M. Matinmikko-Blue (Eds.), "White Paper on Business of 6G," 6G Research Visions, no. 3, University of Oulu, Oulu, Finland, 2020.

[2] D.J. Teece, “Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world,” Research Policy, vol. 47, no. 8, pp. 1367-1387, 2018.

[3] C. Bekar, K., Carlaw, and R. Lipsey, “General-purpose technologies in theory, application and controversy: a review,” Journal of Evolutionary Economics, vol. 28, no. 5, pp. 1005-1033, 2018.

[4] C. Hogendorn and B. Frischmann, “Infrastructure and general-purpose technologies: A technology flow framework,” European Journal of Law and Economics, vol. 50, no. 3, pp. 469-488, 2020.

[5] A.Y. Hmoud, J. Salim, and M.R. Yaakub, “Platformisation of Mobile Operators Business Model: A Proposition Using Design Science Approach and Grounded Theory Principles,” International Journal on Advanced Science Engineering Information Technology, vol. 10, no. 2, pp. 473-484, 2020.

[6] P. Ahokangas, M. Matinmikko-Blue, S. Yrjölä, H. Hämmäinen, ”Platform configurations for local and private 5G networks in complex industrial multi-stakeholder ecosystems.,” Telecommunications Policy, vol. 45, no. 5, 2021.

[7] W. Lehr, F. Queder, and J. Haucap, “5G: A new future for Mobile Network Operators, or not?” Telecommunications Policy, vol. 45, no. 3, 102086, 2021.

[8] ITU, “Beyond 5G: What's next for IMT? - ITU Hub,” The international telecommunication union (ITU), [Online]. Available: https://www.itu.int/hub/2021/02/beyond-5g-whats-next-for-imt/

[9] M. Latva-aho and K. Leppänen (Eds.), "Key Drivers and Research Challenges for 6G Ubiquitous Wireless Intelligence," 6G Flagship Program, University of Oulu, Oulu, Finland, 2019.

[10] M. Hoffmann, M. Uusitalo, M-H. Hamon and B. Richerzhagen (Eds.), "Deliverable D1.1 6G Vision, use cases and key societal values," Hexa-X program, Feb. 2021.

[11] 6G Flagship White Papers 2020-2021, 6G Research Visions no. 2-13, University of Oulu, Oulu, Finland, 2020-2021.

[12] W. Saad, M. Bennis, and M.A.Chen, "A Vision of 6G Wireless Systems: Applications, Trends, Technologies, and Open Research Problems," IEEE Netw., vol. 34, pp. 134-142, 2019.

[13] H. Viswanathan and P.E. Mogensen, "Communications in the 6G Era," IEEE Access, vol. 8, pp. 57063-57074, 2020.

[14] V. Ziegler and S. Yrjola, "6G Indicators of Value and Performance," 2020 2nd 6G Wireless Summit, Levi, Finland, 2020, pp. 1-5.

[15] S. Yrjölä, P. Ahokangas and M. Matinmikko-Blue, “Sustainability as a Challenge and Driver for Novel Ecosystemic 6G Business Scenarios,” Sustainability, vol. 12, no. 21, 2020.

[16] M. Matinmikko-Blue et al. (Eds), “White Paper on 6G Drivers and the UN SDGs,” 6G Research Visions 2, University of Oulu, Finland, 2020.

[17] S. Yrjölä, P. Ahokangas and M. Matinmikko-Blue, “Platform-Based Business Models in Future Mobile Operator Business,” Journal of Business Models, vol. 9, no. 4, pp. 67-93, 2021.

[18] P. Camps-Aragó, S. Delaere, and P. Ballon, “5G Business Models: Evolving Mobile Network Operator Roles in New Ecosystems,” In 2019 CTTE-FITCE: Smart Cities & Information and Communication Technology (CTTE-FITCE), pp. 1-6, 2019.

[19] L. Moerel and P. Timmers, “Reflections on digital sovereignty,” Research in focus series, EU Cyber Direct, 2021.

[20] S. Inayatullah, "Causal layered analysis a four-level approach to alternative futures relevance and use in foresight," Futuribles, 2019.

[21] S. Inayatullah and I. Milojevic, “CLA 2.0: Transformative research in theory and practice,” Univ. of the Sunshine Coast, Queensland, 2015.

[22] China's IMT-2030 (6G) Promotion Group, “6G white paper on 6G vision and candidate technologies,” June 2021.

[23] The European Commission DG Research and Innovation, “Strategic Plan 2020-2024,” 2020.

[24] The European Smart Networks and Services Joint Undertaking (SNS JU), [Online]. Available: https://digital-strategy.ec.europa.eu/en/policies/smart-networks-and-services-joint-undertaking

[25] SBS JU, “SNS R&I Work Programme 2021-2022,” December 2021, [Online]. Available: https://ec.europa.eu/newsroom/dae/redirection/document/82061

[26] Ofcom 2021 Report: Technology Futures – spotlight on the technologies shaping communications for the future, Jan 2021

[27] Bayern Innovativ, Whitepaper Six Questions about 6G, 2021

[28] Beyond 5G Promotion Consortium. [Online]. Available: https://b5g.jp/en/

[29] The Japanese Ministry of Internal Affairs and Communications, “Beyond 5G Promotion Strategy - Roadmap to 6G,” [Online]. Available: https://www.soumu.go.jp/main_content/000696613.pdf

[30] National Institute of Information and Communications Technology (NICT), ”Beyond 5G/6G white paper, English ver. 1.0,” August 2021.

[31] MSIT, “The Korean Digital New Deal,” [Online]. Available: https://digital.go.kr/front/main/eng.do

[32] The 5G Forum Korea, [Online]. Available: http://www.5gforum.org/html/en/main.php

[33] The 5G Forum, “6G Vision 1.0,” 2021.

[34] The United States government, “The Clean Network,” [Online]. Avilable: https://2017-2021.state.gov/the-clean-network/index.html

[35] ATIS NGA, The Alliance for Telecommunications Industry Solutions (ATIS), NextG alliance (NGA), online: https://nextgalliance.org/

[36] The senate off the United States, “H.R.2685-Understanding Cybersecurity of Mobile Networks Act,“ December 2, 2021.

[37] R. Kapoor and D.J. Teece, "Three Faces of Technology’s Value Creation: Emerging, Enabling, Embedding," Strategy Science, vol. 6, no.1, pp. 1-4, 2021.

[38] R. Biloslavo, C. Bagnoli, M. Massaro, and A. Cosentino, “Business model transformation toward sustainability: the impact of legitimation,” Management Decision, 2020.

[39] G. Palazzo and A.G.Scherer, “Corporate Legitimacy as Deliberation: A Communicative Framework,” J Bus Ethics, vol. 66, pp. 71–88, 2006.

[40] M.C. Suchman, “Managing legitimacy: Strategic and institutional approaches,” Academy of management review, vol. 20, no. 3, pp. 571-610, 1995.

[41] K. Kwak and H.D. Yoon, “Unpacking transnational industry legitimacy dynamics, windows of opportunity, and latecomers’ catch-up in complex product systems,” Research Policy, vol. 49, no. 4, pp. 103954, 2020.